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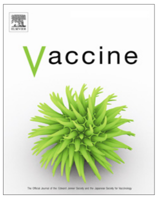

The demand for a COVID-19 vaccine in Ecuador

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ABSTRACT

In Latin America, the country of Ecuador was one of the first and most severely affected by the COVID-19 pandemic. This study aimed to evaluate the demand for a COVID-19 vaccine in Ecuador by estimating individuals' willingness to pay (WTP) for the vaccine, and by assessing the effect of vaccine attributes (duration of protection and efficacy) and individuals' characteristics on this valuation. The sample used (N = 1,050) was obtained through an online survey conducted from April 2 to April 7, 2020. Two levels of vaccine efficacy (70% and 98%) and two levels of vaccine duration of protection (1 and 20 years) were considered. The willingness to pay estimates were obtained using a double-bounded dichotomous-choice contingent valuation format. Survey results show that a very large proportion of individuals (at least 97%) were willing to accept a COVID-19 vaccine, and at least 85% of individuals were willing to pay a positive amount for that vaccine. Conservative estimates of the average WTP values ranged from USD 147.61 to 196.65 and the median WTP from USD 76.9 to 102.5. Only the duration of protection was found to influence individuals' WTP for the vaccine ($p < 0.01$). On average, respondents were willing to pay 30% more for a COVID-19 vaccine with 20 years of protection relative to the vaccine with 1 year of protection. Regression results show that WTP for the vaccine was associated with income, employment status, the perceived probability of needing hospitalization if contracting the virus causing COVID-19, and region of residence.

1. Introduction

In December 2019, a disease with characteristics similar to pneumonia appeared first in the city of Wuhan, China. It was soon thereafter determined that the disease, named the coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO), was caused by the newly discovered severe acute respiratory syndrome coronavirus 2(SARS-CoV-2) [1]. In January 2020, the WHO declared COVID-19 a public health emergency of international concern, and on Wednesday, March 11, 2020, declared a pandemic [2]. By October 28, 2020, COVID-19 had spread worldwide, more than 43 million cases had been confirmed, and more than 1.1 million deaths had been reported [3]. The pandemic has already had very large negative economic effects on the world economy, and a 5.2% contraction in the global gross domestic product (GDP) is expected by the end of the year [4].

Ecuador is one of the countries most affected by the COVID-19 pandemic in Latin America. By June 30, 2020, the country had experienced the 7th highest number of cases, the 6th highest number of deaths in the region, and the highest fatality ratios [5,6]. The first confirmed case of COVID-19 in the country was detected on February 29, 2020, and by July 6, 53,424 cases and 8,026 deaths had been confirmed [7]. Government measures to reduce the spread of COVID-19 as well as unfavorable foreign market conditions for the country's exports have had a substantial negative impact on the Ecuadorian economy [8–10]. The International Monetary Fund (IMF) forecast a contraction in the country's GDP of 6.7% for the year 2020 [10].

As of August 2020, there are no vaccines or treatments approved for mass use by the U.S. Food and Drug Administration (FDA) for COVID-19, but more than 165 vaccines are in development, eight vaccines are in Phase 3 clinical trials and one vaccine has been approved for limited use [11]. Health experts add that the vaccine will take at least one year to develop and will face challenges in mass manufacturing [12]. Moreover, as argued by Schaffer DeRoo et al. [13], "*planning to ensure readiness of both the general public and the health community*" for a successful vaccination cam-

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paign should begin as soon as possible. Part of the planning process involves exploring the demand and acceptability of vaccines by the general public as it is estimated that a vaccine refusal rate greater than 10% could impede the attainment of herd immunity [13]. Thus, only very high acceptance levels of vaccines by the population can ensure the final objective of reaching herd immunity to protect the most vulnerable populations.

Willingness to pay (WTP) is a measure of the maximum amount of money consumers are willing to give up to obtain a product of a given quality and thus can be used to gauge the demand for a novel product or service such as vaccines [14–16]. In the case of vaccines, the WTP value also provides a measure of the monetary value that consumers are willing to pay to avoid the direct and indirect cost of illness [17]. The direct cost of contracting an illness can be very high as they include all medical care costs and even hospitalization in some cases. The indirect cost of illness includes the productive time lost and interferences in the household and personal activities due to contracting a disease [17]. Several studies have evaluated individuals' WTP for hypothetical vaccines, including the human papillomavirus [18], dengue [15,19], HIV [20], influenza, pneumococcal disease [21], and leptospirosis [22]. Most recently, [23], [24] and [25] evaluated individuals' WTP for a COVID-19 vaccine in Chile, Indonesia and Malaysia, respectively.

The main goal of this study is to evaluate the demand of Ecuadorean households for a COVID-19 vaccine. Specific objectives include 1) measuring households' WTP for a COVID-19 vaccine, 2) evaluating the effect of vaccine duration of protection and expected efficacy in households' WTP values, and 3) analyzing the effects of socio-economic variables on households' WTP for a COVID-19 vaccine. The results of this study aim to guide the vaccination efforts of government and public and private health organizations when a COVID-19 vaccine becomes available.

2. Methods

2.1. Data and survey instrument

The data for this study was obtained from a survey of Ecuadorian households [26]. The survey instrument was developed by a research group that included economists and public health professionals from Ecuador and the United States. The survey was designed to measure individual knowledge about COVID-19, risks perceptions of the disease, support for the responses of public and private institutions to the pandemic, level of preparedness, impact of the pandemic on households, socio-demographic characteristics, and a set of contingent valuation (CV) questions to determine if individuals would purchase a COVID-19 vaccine at stated bid prices. The CV questions form the basis for the calculation of WTP values for the vaccine. A pilot test of the survey was first conducted with 100 respondents. The information obtained in the pilot survey was used for the refinement of the final survey instrument.

To measure knowledge about COVID-19, the survey included a set of 15 (yes/no/I do not know) questions about methods to reduce the spread (5 questions), forms of transmission (4 questions), and symptoms of COVID-19 (6 questions) [26]. The responses to these questions were used to calculate a COVID-19 knowledge score. One point was awarded for each correct answer to a question. No points were awarded for incorrect or "I do not know" answers.

Qualtrics conducted data collection via an online survey of a national sample of 1,050 households in Ecuador from April 2 to April 7, 2020, generating 972 complete observations for the analyses of the WTP data [27]. Some additional observations were deleted for regression analysis since some socio-demographic information was missing (51 observations). The target respondents were all Ecuadorean heads of household 18 years and older. The survey was designed to match the distribution of household size estimated by the National Survey of Income and Expenses or Urban and Rural Homes Ecuador 2011–2012 (ENIGHUR-2011–2012) [28] and the household income distribution estimated by Ecuador Central Bank [29]. Income was selected given its high relevance as a determinant of demand. Household size was selected since the survey targeted households' heads. Although the WTP for the vaccine question was not asked for all households' members, it was posited that households' heads would consider the size of the household when decided to accept to purchase or not the vaccine for themselves at a given price.

Approval for the study was obtained from the Institutional Review Board of Texas Tech University, Lubbock, Texas, United States (IRB2020-288) on March 25, 2020. The review process includes a revision of the International Compilation of Human Research Standards by the U.S. Department of Health and Human Services [30].

The World Bank classifies Ecuador as an upper-middle-income country [31]. In 2019, the gross national income (GNI) per capita was $6,080, and 25% of the population was classified as poor [31]. The majority of the population in Ecuador (60.80%) is not covered by any health insurance, 38.80% is covered by public health insurance (compulsory social security, voluntary social security, rural social security, police insurance, military insurance), and only a marginal fraction is covered with private health insurance (0.40%) [33]; therefore, the majority of the population has to rely on the national public health system and private for-profit health providers for their health care needs. Although the national public health system should provide health services at no cost to all individuals without public health insurance, problems persist in the financing and delivery of health functions [32]. In response to the pandemic, the Government of Ecuador declared a health emergency in March 2020. Among the provisions, all private health insurance companies and prepaid medicine companies are prohibited from limiting adequate coverage, evaluation and treatment to users or patients affected by COVID-19 [34]. However, this provision is for the duration of the emergency, and up to two months after it (November 2020). There are no provisions related to the coverage insurers must provide to their users for COVID-19 related treatments or a vaccine after that date. There have also been some recent announcements from the government regarding negotiations to acquire and distribute the COVID-19 vaccine [35].

2.2. Contingent valuation questions

The survey section containing the contingent valuation questions began by providing respondents with the description of a hypothetical vaccine to prevent COVID-19 Appendix A. The vaccine description included specific information about two key vaccine characteristics: efficacy and duration of protection. Vaccine efficacy refers to the reduction in the infection risk for an individual receiving a vaccine during an outbreak relative to an unvaccinated individual [36]. Vaccine duration of protection refers to the length of time a vaccine induces immunity in an individual [37]. It is important to highlight the fact that both the efficacy and duration of protection of a COVID-19 vaccine were unknown at the time the survey was conducted; thus, their values were selected based on the experience with vaccines for other diseases.

Two levels of vaccine efficacy (70% and 98%) and two levels of vaccine duration of protection (1 and 20 years) were considered. The 70% efficacy was selected based on the average efficacy offered by vaccines against the flu, whereas the 98% efficacy was selected based on the highest efficacy reported for other vaccines [15,38]. Protection duration of 1-year was selected based on the assumption that the coronavirus would become a seasonal disease, such as the flu, requiring a vaccine every year. The 20-year protection duration scenario assumes, in contrast, a vaccine with a very long duration of protection as some research has reported that coronavirus mutates very slowly [39,40]. Therefore, descriptions of four vaccines were randomly assigned to survey respondents with all the combinations of efficacy and protection duration levels (70% efficacy and 1 year of protection, 70% efficacy and 20 years of protection, 98% efficacy and 1 year of protection, and 98% efficacy and 20 years of protection).

A double-bounded dichotomous choice format was utilized for the contingent valuation questions. Surveyed individuals were initially asked if they would purchase a COVID-19 vaccine at an initial randomly assigned price bid (PI). If they indicated yes, they were subsequently asked if they would be willing to purchase it at a higher price bid (PSH). Alternatively, if the respondents were not willing to buy the vaccine at the initial price bid, a lower price bid (PSL) was offered. Initial price bids used were USD 20, 80, 200, 400, and 600. Follow up bids also included USD 10 for respondents that would not buy the vaccine at the USD 20 initial bid price and USD 800 for respondents that would buy the vaccine at USD 600 (see Fig. 1). The bid values were selected based on recent studies using CV methods to evaluate the demand for hypothetical vaccines [15] (Fig. 1). More specifically, the bids used in [15] for Colombia, a neighboring country of similar economic conditions, were expressed first as a proportion of that country's monthly minimum wage in year 2014. Similar proportions were subsequently used with Ecuador's current minimum wage to calculate the bid prices used in this study. The bid values were also validated and seemed appropriate based on the test surveys since some respondents were willing to buy the vaccine even at the highest bid prices.

The four possible responses to the price bid scenarios are (1) "yes" followed by a "no," (2) a "yes" to both price bids, (3) a "no" followed by a "yes," and (4) "no" to both price bids. The sequence of questions defines the following ranges for the true WTP values at four discrete outcomes of the bidding process:

$$D = \begin{cases} PI \le WTP < PSH & (response\ outcome\ 1) \\ PSH \le WTP & (response\ outcome\ 2) \\ PSL \le WTP < PI & (response\ outcome\ 3) \\ WTP < PSL & (response\ outcome\ 4). \end{cases} \tag{1}$$

2.3. Statistical analyses

Parametric and nonparametric methods were used for the analyses. The parametric approach for estimation uses parametric forms for the choice probabilities corresponding to the components of equation (1) [41,42]. The probability that a respondent i answers "yes" to the first bid and no to the second bid ($Pr^{yn}{}_i$) is

$$Pr^{yn}{}_i = Pr(PI_i \le WTP_i < PSH_i) = G(PSH_i, \boldsymbol{\theta}) - G(PI_i, \boldsymbol{\theta}), \tag{2}$$

in which $G(., \boldsymbol{\theta})$ is a parametric statistical cumulative density function with parameters $\boldsymbol{\theta}$. The probability that a respondent answers "yes" to both bids ($Pr^{yy}{}_i$) is

$$Pr^{yy}{}_i = Pr(PSH_i \le WTP_i) = 1 - G(PSH_i, \boldsymbol{\theta}) \tag{3}$$

Similarly, the probability that a respondent answers "no" to the first bid and "yes" to the second bid ($Pr^{ny}{}_i$) is

$$Pr^{ny}{}_i = Pr(PSL_i \le WTP_i < PI_i) = G(PI_i, \boldsymbol{\theta}) - G(PSL_i, \boldsymbol{\theta}) \tag{4}$$

Finally, the probability that a respondent answers "no" to both bids ($Pr^{nn}{}_i$) is

$$Pr^{nn}{}_i = Pr(WTP_i < PSL_i) = G(PSL_i, \boldsymbol{\theta}) \tag{5}$$

Given a sample of N individuals, the log-likelihood becomes:

$$\begin{aligned} \mathrm{L} = \sum_{i=1}^{N} & d_i^{y_i^1=1, y_i^2=0} \ln\left(G(PSH_i, \boldsymbol{\theta}) - G(PI_i, \boldsymbol{\theta})\right) \\ & + d_i^{y_i^1=1, y_i^2=1} \ln\left(1 - G(PSH_i, \boldsymbol{\theta})\right) + d_i^{y_i^1=0, y_i^2=1} \ln\left(G(PI_i, \boldsymbol{\theta})\right. \\ & \left. - G(PSL_i, \boldsymbol{\theta})\right) + d_i^{y_i^1=0, y_i^2=0} \ln\left(G(PSL_i, \boldsymbol{\theta})\right), \end{aligned} \tag{6}$$

in which d_i indicates the individuals belonging to the ith bidding process outcome, and y_i^1 and y_i^2 are used to denote the responses (1 = Yes or 0 = No) to the first and second binary choice questions, respectively [41,43]. Estimation of the parameters in equation (6) requires assuming a specific distributional form for $G(., \boldsymbol{\theta})$. Five statistical distributions were considered (normal, Weibull, log-normal, exponential and log-logistic) [41,43]. The "best" model was selected using the Akaike information criterion (AIC), and the ratio of the maximum likelihood method proposed [44,45].

Explanatory variables can be introduced into the procedure by modeling some components of the parameter vector $\boldsymbol{\theta}$ as a function of the explanatory variables. For example, the log-normal distribution is defined by two parameters (μ and σ); thus $\mu = \boldsymbol{X_i}'\boldsymbol{\beta}$, in which $\boldsymbol{X_i}'$ is the vector of explanatory variables. The vector of explanatory variables included vaccine efficacy and duration of protection, socio-demographic characteristics of the households, knowledge about the disease, perceptions regarding the probability of infection hospitalization and death if contracting the disease, and health insurance availability [15,17,23].

The nonparametric procedure for the estimation of mean WTP values is based on methods proposed originally by [46]. The procedure involves first the estimation of a nonparametric WTP distribution function, which in turn can be used to estimate a lower bound of the mean WTP values [47,48]. Although the approach only provides a lower bound estimate of the mean WTP values, it does not really on distributional assumptions [49]. Statistical analyses were performed using MATLAB and STATA [41].

3. Results

3.1. Summary statistics

Sample descriptive statistics are presented in Table 1. The average age of respondents was 33, and the majority were males (61%) and college-educated (72%). Most of the respondents reported having jobs (92%) and health insurance (53%). The majority (86%) of respondents lived in urban areas, including Pichincha Province (42%), which contains the country's capital (Quito), followed by Guayaquil Province (18%), in which the second-largest city (Guayaquil) is located.

Concerning respondents' knowledge about the disease, the average knowledge score was 11.27 out of a maximum of 15 possible points (approximately 75%). Respondents average perceived probabilities of contracting the virus that causes COVID-19, being hospitalized, and dying if contracting it were approximately 34%, 33%, and 24%, respectively (Table A1).

Forty-six % of respondents indicated that they would purchase the COVID-19 vaccine at the initial bid price, and 64% of respondents answered "yes" to the follow-up questions (Table A2). Overall, most individuals (85%) responded that they were willing to pay for the vaccine. This proportion was calculated by including a) all respondents that answered "yes" to at least one of the willingness to purchase questions, and 2) a sub-group of respondents that answered yes to a follow-up question about any possible positive willingness to pay values for the vaccine (this question was directed to the group of individuals that answer "no" to both willingness to purchase questions).

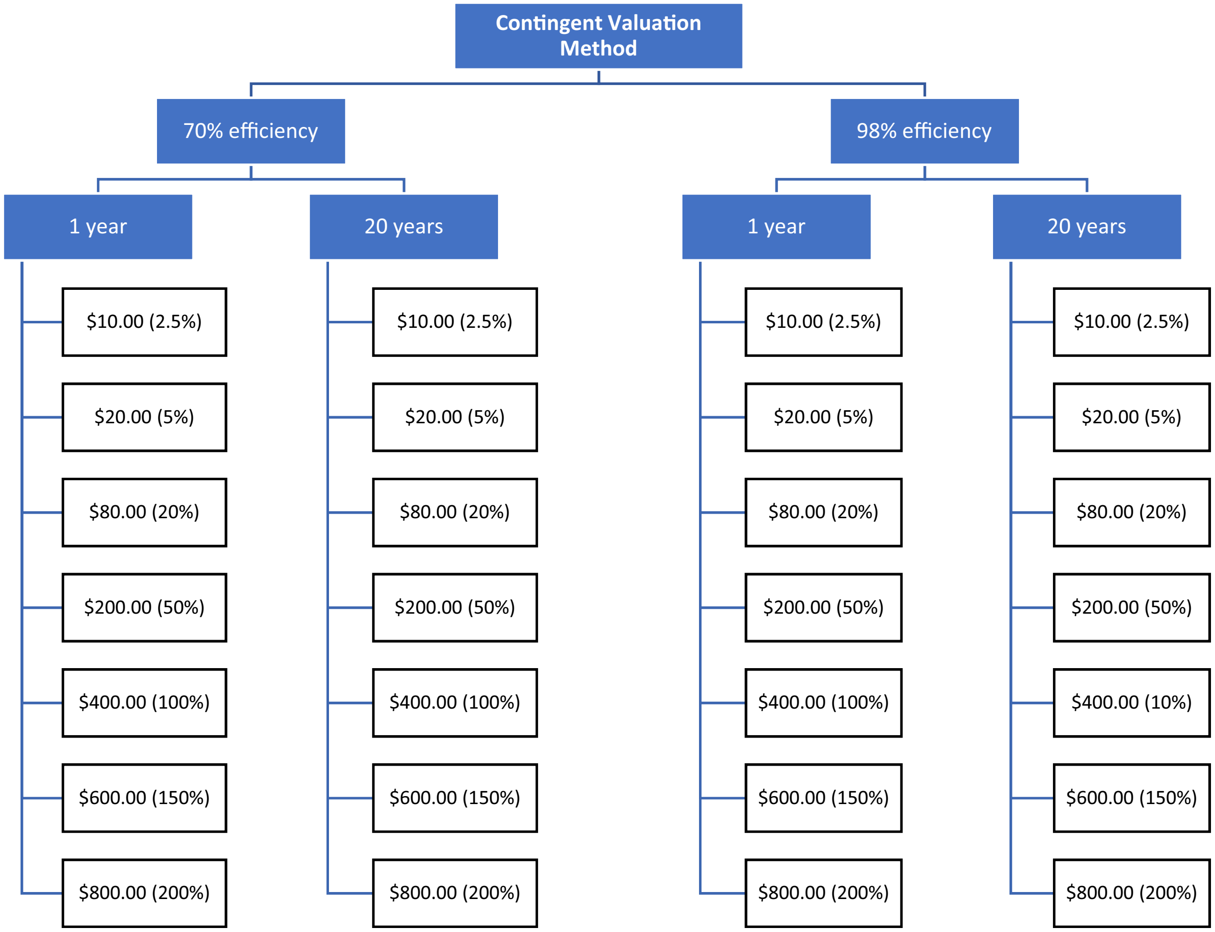

Fig. 1. Contingent valuation study design (percentages in parentheses are relative to monthly minimum wage in the country).

Table 1
Characteristics of survey respondents.

Characteristic	Mean	Standard deviation
Age	33.21	11.43
Household size	4.13	1.94
Income	827.39	711.36
Gender (0 = Male, 1 = Female)	0.39	0.49
College education (0 = No, 1 = Yes)	0.72	0.45
Health insurance (0 = No, 1 = Yes)	0.53	0.49
Employment status (0 = Other, 1 = Employed)	0.74	0.44
Location of residence (Rural = 1, Urban = 0)	0.14	0.35
Region of residence		
Pichincha Province	0.42	0.49
Guayas Province	0.18	0.39
Sierra and Amazon Region	0.22	0.42
Costa and Galapagos Region	0.17	0.37

Note. Sample size n = 972. Sierra and Amazon region excludes Pichincha Province. Costa and Galapagos Region excludes Guayas.

3.2. Mean willingness to pay values, vaccine characteristics, and aggregate demand model

The log-normal distribution had the smallest AIC value among the five statistical distributions considered (see Table A3). The ratio of the maximum likelihood method also indicated the log-normal distribution was the preferred model compared to the log-logistic and the Weibel distribution (the three distributions had similar AIC values); therefore, the log-normal model was used as the parametric model for further analyses. To estimate mean willingness to pay values, we estimated two models including only as covariates vaccine attributes (i.e., the components of $\boldsymbol{X_i}'$) (Table 2). The first specification (Model 1) uses dummy variables to denote vaccines with a longer duration of protection (20 years) and a high level of efficacy (98%). In the second specification (Model 2), both protection duration and efficacy entered linearly into the model. In both models, only the variable related to the protection duration was statistically significant at the 5% level.

In Model 1, the estimated coefficients can be interpreted as the difference in the mean WTP values between vaccines with different characteristics; thus, according to the model respondents are willing to pay 30% ($(e^{0.259} - 1) \times 100\%$) more dollars for a COVID-19 vaccine with 20 years of protection relative to the vaccine with 1 year of protection ($p < 0.05$). In Model 2, estimated coefficients refer to the effect of an additional unit of the attribute on average willingness to pay values for the vaccines; therefore, it is estimated that each additional year of vaccine protection increases individual WTP by approximately 1.4%.

Average WTP values for each type of vaccine are shown in Table 3. The vaccine with the lowest mean WTP value was the one with the lowest levels of efficacy (70%) and duration of protection (1 year), and it was estimated to be at least at $147.61 (non-parametric lower bounds). In contrast, the vaccine with the highest mean WTP value is the one with the highest levels of protection (98%) and duration of protection (20 years), with a lower bound estimated at $196.65. However, it is important to note that estimated average WTP values are only statistically different between vaccines with short (1 year) and long protection duration (20 years), as indicated by the previously discussed regression results (Model 1). Estimated parametric WTP mean values assum-

Table 2
Estimation results of willingness to pay models for a COVID-19 vaccine in Ecuador.

Variable	Model 1	Model 2	Model 3
Constant	4.342***	4.260***	3.479***
	(0.112)	(0.392)	(0.545)
Duration of protection	0.259**	0.014**	0.259**
	(0.127)	(0.007)	(0.128)
Efficiency of protection	0.028	0.001	0.053
	(0.127)	(0.005)	(0.127)
Contracting probability			−0.001
			(0.003)
Hospitalized probability			0.006**
			(0.003)
Death probability			0.005
			(0.004)
Age			0.003
			(0.006)
Household size			−0.003
			(0.033)
Income (thousands of dollars)			0.337***
			(0.101)
Gender (Female = 1, Male = 0)			−0.039
			(0.134)
College education (Yes = 1, No = 0)			0.120
			(0.156)
Health insurance (Yes = 1, No = 0)			0.226
			(0.140)
Employment status (Employed = 1, Other = 0)			0.274*
			(0.164)
Knowledge score			0.0002
			(0.038)
Region of residence			
Pichincha			−0.300
			(0.183)
Guayas			−0.357*
			(0.213)
Sierra and Amazon			−0.170
			(0.202)
Sigma (σ)	1.686***	1.686***	1.621***
Sample size	972	972	921
Wald Chi^2	4.21	4.21	44.68
P-value (Prob > Chi^2)	0.12	0.12	0.0002
Log likelihood	−1156.06	−1156.06	−1059.061

Notes. The parametric model used is a log-normal distribution with parameters μ and σ, $\mu = \boldsymbol{X_i}'\boldsymbol{\beta}$.
Standard errors in parenthesis.
***indicates significance at 1%, ** indicates significance at 5%, and * indicates significance at 10%.

Table 3
Mean willingness to pay for hypothetical COVID-19 vaccine (n = 972).

Attribute	Parametric mean WTP	Parametric median WTP	Nonparametric lower bound mean WTP
70% efficacy 1 year protection	318.80 (35.74)	76.93 (8.62)	147.61 (15.37)
70% efficacy 20 years protection	412.93 (44.99)	99.64 (10.85)	176.79 (17.60)
98% efficacy 1 year protection	327.81 (36.61)	79.10 (8.83)	152.96 (16.36)
98% efficacy 20 years protection	424.59 (46.84)	102.46 (11.30)	196.65 (18.59)

Notes. Parametric mean and median for the log-normal distribution equal $e^{(\boldsymbol{X_i'}\beta+\frac{\sigma^2}{2})}$ and $e^{(\boldsymbol{X_i'}\beta)}$, respectively. Numbers in parenthesis are standard errors.

ing the log-normal distribution were approximately twice the value of the estimated nonparametric lower bounds and ranged from USD 318.80 to USD 424.59 (Table 3). Moreover, the estimated parametric median values were always lower than the estimated means (both parametric and nonparametric), which indicates that the distribution is positively skewed.

Estimated Turnbull WTP distribution functions are shown in Table 3. The estimated nonparametric CDFs are not continuous but rather step functions; thus, they can be interpreted in relation to the upper value of the bid ranges. For example, according to the CDF for the vaccine with 1 year of protection and 70% efficacy, 13.03% of individuals were willing to pay USD 10 or less for the vaccine, 20.48% USD 20 or less, and 46.35% USD 80 or less.

3.3. Respondent characteristics associated with willingness to pay

To assess the effect of respondents' characteristics, we estimated an additional model (Model 3, Table 2) that includes both vaccine characteristics as in Model 1 and a vector of respondents' characteristics. The effect of the protection duration of the vaccine remained significant ($p < 0.05$), even after including the additional covariates, and the estimated coefficient is unchanged. Income, employment status, and the estimated probability of being hospitalized were found to be positively associated with individuals WTP for the vaccine ($p < 0.10$). A 1% increase in the estimated probability of being hospitalized if contracting the disease was found to be associated with a 0.6% increase in the average WTP for the vaccine, a $100 increase in income associated with a 4% increase, and employment with a 31.5% increase (relative to unemployed individuals). Region of residence of the individuals was also found to affect WTP for the vaccine ($p < 0.1$). More specifically, individuals living in the Guayas Province were estimated to be willing to pay approximately 30% less than individuals living in other provinces of the Costa Region. The coefficient on the Pichincha Province was very close to being significant ($p = 0.10$), suggesting that individuals living in the Pichincha Province would be willing to pay about 26% less than individuals living in other provinces of the Costa Region.

Of the total sample, 15% of respondents (n = 147) answered "no" to both bids and to a follow-up question asking them if they would be willing to pay any amount. The reasons given for not being willing to pay any amount are shown in Fig. 2. Most of the respondents (83%) in this group seem to be willing to accept a vaccine but not willing to pay any amount, as 63% indicated that the government should provide it for free and that the prices given were too high (20%). Only a small percent of respondents seemed to reject vaccines based on beliefs related to lack of trust and confidence in the vaccines (approximately 17%, including "Other" reasons). When extrapolated to the entire sample of respondents, this indicates that only approximately 2.6% of total respondents do not accept vaccines and that 97.4% do accept them.

4. Discussion

This study provides insights into household demand and the private economic benefits of a potential vaccine for SARS-CoV-2, the virus responsible for COVID-19. Conservative estimates of the mean WTP for a vaccine in Ecuador range between USD 147.61 and USD 196.65. Previous studies on WTP for hypothetical vaccines have reported a wide range of values likely due to differences in the characteristics of the disease and the populations of study (e.g., income levels). For example, respondents in Indonesia were reportedly willing to pay only USD 2.08 for an Ebola vaccine [50], whereas in the United States, a sample of mothers was willing to pay between USD 560 and 660 for vaccinating their daughters against human papillomavirus [51]. Although, the lower bound mean WTP values for the COVID-19 vaccine are similar to those found in Chile (USD 184.72), parametric estimates are larger (almost double) than that found in Chile another Latin American country [23]. Data collection for this study and the Chilean study [23] was conducted at almost the same time (April and May

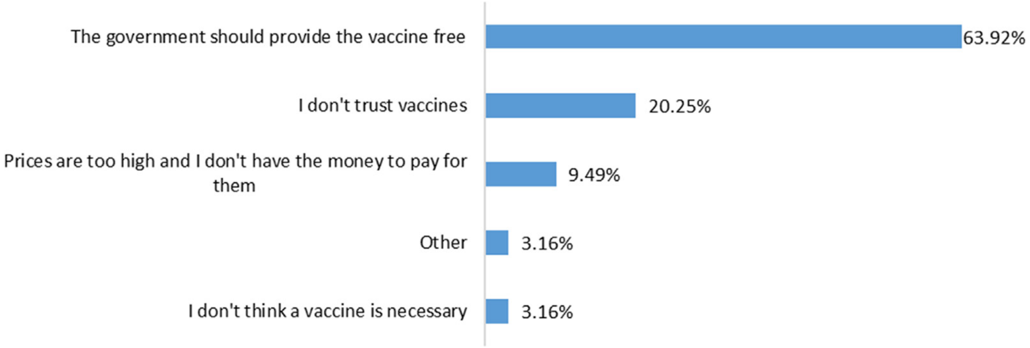

Fig. 2. Reasons for rejection of bid scenarios for a COVID-19 vaccine (n = 147).

2020); however, the specific conditions of COVID-19 in both countries were different at that time. Ecuador experienced a peak in the number of deaths due to COVID-19 around April 5 (400 deaths per day), whereas at that time, Chile was reporting approximately 8–10 deaths per day [52]. The situation was especially critical in Guayaquil, its second largest city, where it was reported that corpses were abandoned on the street as the government and funeral homes were overwhelmed [53].

The estimated mean WTP values for Ecuador are also significatively larger than those found in Asia (Indonesia USD 57.20, and Malaysia USD 30.66). Differences could be due to cultural, health, and economic conditions in each country, as well as the situation of COVID-19 at the time of data collection. Data collection for the studies in Asia took place between late March and early April 2020. At that time, reported number of cases and number of deaths in Indonesia and Malaysia were significantly lower than in Ecuador. For example, Malaysia reported 3–5 deaths per day from April 3 to 12, and Indonesia reported 0–27 deaths per day during March 25 to April 6, with populations that are also larger than in Ecuador (Malaysia population is 32 million and Indonesia's population is 270.63 million) [54,55].

The estimated mean WTP value for the vaccine with the highest level of efficacy and protection (at least USD 196.65) can be interpreted as the value individuals place on preventing COVID-19. Since estimated benefits of the vaccine exceed current predicted retail costs, which range from a few USD to USD 70 for a regimen [56], individuals in Ecuador would, on average, realize private benefits from receiving the vaccine.

The estimated mean WTP value can also be used to provide an estimate of the aggregate benefit for the entire country of preventing COVID-19. For this calculation, we do not include individuals not willing to pay any value for the vaccine (estimated at 15%) which leaves a total of 14.52 million individuals; therefore, a conservative estimated aggregate value of preventing COVID-19 is at least USD 2,855 million which is approximately 2.7% of Ecuador's GNI [23].

It is estimated that a very large proportion of individuals (at least 97%) are willing to accept a COVID-19 vaccine, and at least 85% of individuals are willing to pay a positive amount. This acceptability estimate is higher than all others reported in the literature. Studies from China [57], France [58], and the United States [59] report acceptability rates of 76–77%. In Chile, [23] the acceptability rate was 90.6%, although this rate only included individuals willing to pay a positive amount for the COVID-19 vaccine; thus, it is similar in magnitude to our estimated lower bound of individuals willing to pay a positive amount for the vaccine. These very high levels of acceptance suggest high levels of acceptance and trust in a potential vaccine, which is key for a population-wide vaccination campaign.

Study results revealed that the duration of protection provided by the vaccine was a very important determinant of the individual WTP for the vaccine. Individuals were willing to pay 30% more for a vaccine with 20 years of protection relative to a vaccine with only 1 year of protection (see Table 3). This result is consistent with various studies that have identified the duration of protection among the most important attributes affecting individuals' WTP for vaccines [22,51,60]. Previous studies on WTP for COVID-19 in other countries did not explore the effect of vaccine attributes on individual WTP for the vaccine.

Our regression analyses did not find evidence that the vaccine efficacy influenced individuals' WTP for the vaccine, which is in contrast with previous studies that have identified efficacy as an important attribute affecting WTP for vaccines [22,51,60]. However, this result needs to be interpreted with caution as we only included two relatively high efficacy levels (70% and 98%) in the contingent valuation questions; thus, this only indicates that individuals were not willing to pay different values for vaccines between these two efficacy levels. Individuals might have different WTP values for vaccines with lower efficacy levels [22,60].

We only found a few respondent characteristics to be associated with their WTP for the vaccine, including income, being employed, the perceived probability of needing hospitalization if contracting COVID-19, and region of residence. The estimated effect of income on WTP for the vaccine implies some large differences in WTP values when comparing individuals. For example, between individuals in the second decile of the income distribution (average monthly income of USD 300) and individuals in the ninth decile of the distribution (average monthly income of approximately USD 1,500), the difference in income levels would result in approximately a USD 156 difference in average WTP values for a vaccine with 98% efficacy and 20 years of protection (USD difference calculated by using the parametric model and estimating mean WTP values at the specified values of explanatory variables and using average values for all other explanatory variables). Previous studies have also found the WTP for vaccines to be positively associated with income levels [15,21,23]. This positive association may contribute to justifications for subsidized vaccination for lower-income individuals.

Being employed was also found to be associated with a very large increase in the average WTP for the vaccine (31.5% higher relative to that of unemployed individuals). This value might reflect the fact that economic costs from time lost working if contracting the disease are higher for individuals that have a job. Employment status was found to be an important determinant of WTP in Chile [23].

Individuals living in the Pichincha and Guayas Provinces, where the two largest cities in the country are located, were found to be willing to pay significantly less than individuals living in other provinces (26 and 30% less, respectively). This result was somewhat unexpected, especially for Guayas Province, the country's epicenter of the pandemic during the data collection period. This result might have been because people living in larger cities might believe they have more access to medical services, or that people not living in larger cities believe their access to medical services is deficient.

Our regression analyses included as covariates three variables related to perceptions regarding the probabilities of contracting the disease and being hospitalized and dying if contacting the disease; however, only the variable related to the perceived probability of being hospitalized was found to be positively associated with individuals WTP for the vaccine. This result highlights the need for governments to generate and provide accurate information on the spread of the disease and its effects, including hospitalization and mortality rates. Perceived mortality rates by survey respondents (24%) are almost 4 times higher than the fatality rate currently reported (6.16%) [61]. It is also important to mention that although perceived risk or perceived susceptibility to a contagious disease has been found to be associated with willingness to pay for vaccines in previous studies [62], the role of risk and susceptibility perceptions in vaccine decisions is still not very well understood [63]. There is, for example, some ongoing debate whether risk is only cognitive or also affective. If risk includes an affective component, emotions could override rational decision making based on cognitive risk assessments only [63].

Aggregate demand curves for the COVID-19 vaccines in Ecuador are shown in Fig. 3. These curves were generated using the Turnbull CDF results shown in Table 4 and show the estimated fraction of the population willing to pay a given price for the vaccine. At least 87% of the population is willing to pay USD 10 or less for the vaccines. The proportion is higher (95%) for the vaccine with higher duration and efficacy; thus, a vaccine price of about USD 10 would be needed to achieve the very high levels of vaccination needed to achieve herd immunity reported by some researchers. The fraction of the population willing to pay for vaccines reduced to approximately 50% when the price was USD 80 (i.e., the median). According to the results, there is still a large proportion of the population willing to pay large values for the vaccines, for example, approximately 20% of individuals are willing to pay USD 400 for the vaccine.

Table 4
Turnbull willingness to pay distribution functions (n = 972).

	Turnbull CDF			
Duration (years)	1	20	1	20
Efficiency (%)	70	70	98	98
Bid Range ($)				
0–10	0.130	0.103	0.099	0.053
10–20	0.205	0.244	0.197	0.133
20–80	0.464	0.459	0.545	0.465
80–200	0.705	0.633	0.721	0.663
200–400	0.829	0.785	0.823	0.766
400–600	0.891	0.864	0.871	0.818
600–800	0.964	0.932	0.930	0.887
800+	1.000	1.000	1.000	1.000

Our analyses have several limitations. Even though the study used an established online panel of Ecuadorian individuals, and the distribution of income and household size in the sample were similar to those in the population, the sample differed from the population across other important characteristics including education, region, and location of residence [26]; therefore, generalizability of the results should be done with caution. For example, according to Ecuador's National Institute of Statistics and Census [64], 33% of the population live in rural compared to only 14% in our sample. Similarly, 16.5% of individuals in the population are estimated to have college education [64] compared to 72% of sample respondents in our sample, even though education level was not found to be associated with WTP for the vaccine.

Another concern is the use of hypothetical vaccine scenarios at a specific point in time. The use of hypothetical scenarios might lead to biases in individual responses, although some recent evidence suggests stated preferences methods can be accurate for prediction of actual vaccination uptake [65,66]. Preferences for the vaccine might also change through time as more people get infected, knowledge about the disease and its management improves, treatments for disease are developed; and even when a vaccine becomes available, as more and more individuals in the population get vaccinated. Future research can be conducted to evaluate the dynamics of WTP for a vaccine in the population.

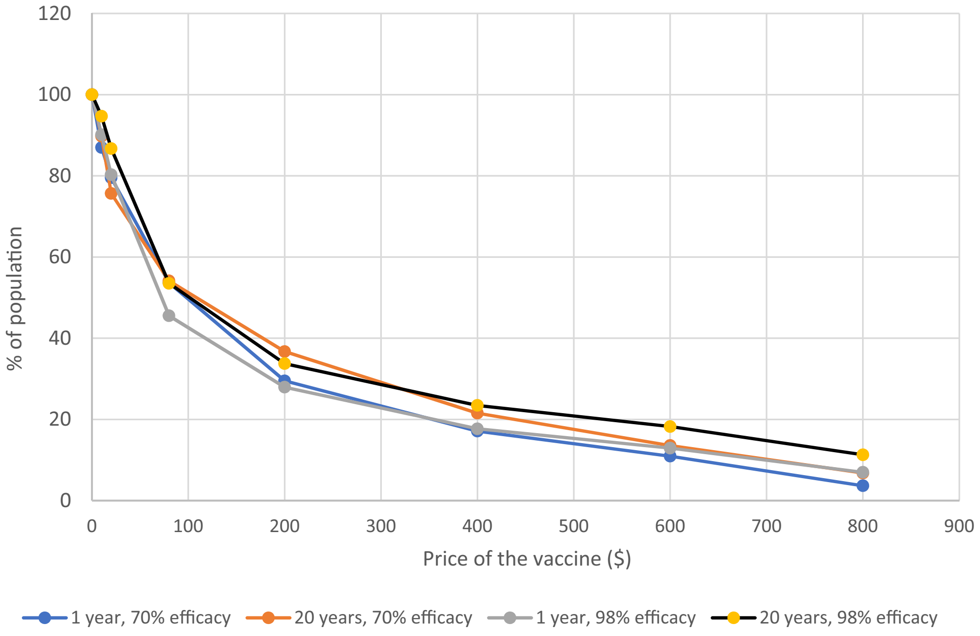

Fig. 3. Aggregate demand curves for the COVID-19 vaccine.

Finally, although this is the first study to explore the effect of a COVID-19 vaccine attributes on demand, only the efficacy and duration of protection attributes were considered. Future research could explore the effect of other vaccine attributes that have been found to affect vaccine acceptability and demand such as the number of doses of the vaccine needed and risks of side effects [22]. Moreover, a more comprehensive definition of efficacy can be considered encompassing not only the ability of a vaccine to prevent a disease but also the reduction of symptoms associated with the disease if infected [67].

5. Conclusions

The rapid spread of COVID-19 throughout the world and its large negative economic effect have spawned a global vaccine race, the discovery of which is crucial. However, only high levels of vaccine acceptance and uptake can ensure we reach herd immunity. Therefore, every country must evaluate its readiness and design national plans and policies for the distribution of the vaccine, especially in developing countries with insecure and poorly funded health systems. The plans should include aspects related to both the logistical aspects (e.g., production, transportation, storage, distribution, and geographic coverage) and issues related to public demand and acceptability.

The results of this study have several implications for the deployment of a COVID-19 vaccine in Ecuador. While the results indicate that 97.4% of the population in Ecuador would accept a vaccination, 15% of the population would not pay for the vaccine (mainly for ideological and economic reasons). This last group is critical, as it can jeopardize the success of the vaccination campaign. Moreover, depending on the vaccine price, some subsidies might be needed to provide the vaccine for the poorest individuals that cannot afford it. In contrast, given that a large proportion of individuals is willing to pay for the vaccine, the private sector can also play an important role in accelerating vaccine deployment and extend coverage. Our results also indicate that communication and information about COVID-19 and the vaccine should be considered when planning for the immunization campaign. While most public discussion centers around COVID-19 vaccine development and countries are still fighting the disease, it is paramount for public health leaders to be planning for a successful vaccine deployment.

6. Contributions

Conceptualization, methodology, OS, CC, DH, PG, IB; formal analysis investigation, resources, writing – original draft preparation, OS, CC, DH; writing – review and editing, OS, CC, DH, PG, IB. All authors attest they meet the ICMJE criteria for authorship.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Tables A1, A2 and A3.

Table A1
Respondents' perceptions and knowledge regarding COVID-19.

Variable	Mean	Standard deviation
What do you think is your probability of contracting COVID-19?^{a} (n = 949)	33.96	24.00
What do you think is your probability of being hospitalize in case of contracting COVID-19? ^{a} (n = 935)	32.77	26.67
What do you think is the mortality rate in case of contracting COVID-19? ^{a}(n = 953)	23.25	17.24
Knowledge score with respect to recommendation to reduce spread, forms of transmission and symptoms of COVID-19 (n = 972)	11.27	1.87

Notes. ^{a} Sample size as noted because of respondents skips.

Table A2
Responses to double-bounded dichotomous questions (n = 972).

Question	Responses			
First discrete choice question	Yes		No	
Percentage of respondents (%)	45.78		54.22	
Second discrete choice question	Yes	No	Yes	No
Percentage of respondents (%)	44.49	55.51	18.98	81.02

Table A3
Log-likelihood and AIC by statistical distribution.

Distribution	Log-likelihood	AIC
Normal	−1,258.4	2,526.8
Log-normal	−1,080.0	2,170.0
Log-logistic	−1,082.5	2,175.0
Weibull	−1,085.0	2,180.0
Exponential	−1,154.4	2,316.8

Notes. Models estimated using as explanatory variables vaccine duration and efficiency.

References

[1] World Health Organization. Novel Coronavirus (2019-nCoV) Situation Report 1; 2020.

[2] Gumbrecht J, Howard J. WHO declares novel coronavirus outbreak a pandemic; 2020. https://www.cnn.com/2020/03/11/health/coronavirus-pandemic-world-health-organization/index.htm.

[3] John Hopkins University. COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU); 2020. https://coronavirus.jhu.edu/map.html.

[4] The World Bank. The Global Economic Outlook During the COVID-19 Pandemic: A Changed World; 2020. https://www.worldbank.org/en/news/feature/2020/06/08/the-global-economic-outlook-during-the-covid-19-pandemic-a-changed-world.

[5] World Health Organization. Novel Coronavirus (2019-nCoV) Situation Report 172; 2020.

[6] El Comercio. La letalidad por el nuevo coronavirus de Ecuador es la más alta de Sudamérica; 2020. https://www.elcomercio.com/actualidad/peru-chile-brasil-covid-19.html.

[7] Ministerio de Salud Pública del Ecuador. Boletin N 128; 2020.

[8] Vicepresidencia de la República del Ecuador. Otto Sonnenholzner: Lo económico se puede recuperar, las vidas no; 2020. https://www.vicepresidencia.gob.ec/otto-sonnenholzner-lo-economico-se-puede-recuperar-las-vidas-no/.

[9] Fiallo M. ¿Cómo afecta el coronavirus a la economía de Ecuador?; 2020. https://es.panampost.com/mamela-fiallo/2020/03/13/coronavirus-economia-ecuador/.

[10] International Monetary fund. Request for purchase under the rapid financing instrument and cancellation of arrangement under the extended fund facility—press release; staff report; and statement by the executive director for ECUADOR; 2020.

[11] The New York Times. Coronavirus Vaccine Tracker; 2020. https://www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html.

[12] Dunn A. A potential coronavirus vaccine funded by Bill Gates is set to begin testing in people, with the first patient expected to get it today; 2020. https://

www.businessinsider.com/inovio-coronavirus-vaccine-trial-starts-in-philadelphia-kansas-city-2020-4.

[13] Deroo SS, Pediatrics C, George T, Pudalov NJ, George T, Sciences H, et al. Planning for a COVID-19 Vaccination Program 2020;323:2458–9. https://doi.org/10.1001/jama.2020.8711.

[14] Lusk JL, Hudson D. Willingness-to-pay estimates and their relevance to agribusiness decision making. Rev Agric Econ 2004;26:152–69. https://doi.org/10.1111/j.1467-9353.2004.00168.x.

[15] Lee JS, Mogasale V, Lim JK, Carabali M, Sirivichayakul C, Anh DD, et al. A multi-country study of the household willingness-to-pay for dengue vaccines: Household surveys in Vietnam, Thailand, and Colombia. PLoS Negl Trop Dis 2015;9:1–15. https://doi.org/10.1371/journal.pntd.0003810.

[16] Ughasoro MD, Esangbedo DO, Tagbo BN, Mejeha IC. Acceptability and willingness-to-pay for a hypothetical ebola virus vaccine in Nigeria. PLoS Negl Trop Dis 2015;9:1–15. https://doi.org/10.1371/journal.pntd.0003838.

[17] Cropper ML, Haile M, Lampietti J, Poulos C, Whittington D. The demand for a malaria vaccine: Evidence from Ethiopia. J Dev Econ 2004;75:303–18. https://doi.org/10.1016/j.jdeveco.2003.02.006.

[18] Munoz N, Kjaer SK, Sigurdsson K, Iversen OE, Hernandez-Avila M, Wheeler CM, et al. Impact of Human Papillomavirus (HPV)-6/11/16/18 Vaccine on All HPV-Associated Genital Diseases in Young Women. J Natl Cancer Inst 2010;102:325–39. https://doi.org/10.1093/jnci/djp534.

[19] Harapan H, Anwar S, Bustamam A, Radiansyah A, Angraini P, Fasli R, et al. Willingness to pay for a dengue vaccine and its associated determinants in Indonesia: A community-based, cross-sectional survey in Aceh. Acta Trop 2017;166:249–56. https://doi.org/10.1016/j.actatropica.2016.11.035.

[20] McNeil SA, Shinde V, Andrew M, Hatchette TF, Leblanc J, Ambrose A, et al. / 14 influenza clinical severity and vaccine effectiveness in the prevention of. Euro Surveill 2013;2014(19):1–6.

[21] Hou Z, Chang J, Yue D, Fang H, Meng Q, Zhang Y. Determinants of willingness to pay for self-paid vaccines in China. Vaccine 2014;32:4471–7. https://doi.org/10.1016/j.vaccine.2014.06.047.

[22] Arbiol J, Yabe M, Nomura H, Borja M, Gloriani N, Yoshida SI. Using discrete choice modeling to evaluate the preferences and willingness to pay for leptospirosis vaccine. Hum Vaccines Immunother 2015;11:1046–56. https://doi.org/10.1080/21645515.2015.1010901.

[23] García LY, Cerda AA. Contingent assessment of the COVID-19 vaccine 2020;38:5424–9. https://doi.org/10.1016/j.vaccine.2020.06.068.

[24] Harapan H, Wagner AL, Yufika A, Winardi W, Anwar S, Gan AK, et al. Acceptance of a COVID-19 vaccine in Southeast Asia: A cross-sectional study in Indonesia. Front Public Heal 2020:8.

[25] Wong LP, Alias H, Wong P-F, Lee HY, AbuBakar S. The use of the health belief model to assess predictors of intent to receive the COVID-19 vaccine and willingness to pay. Hum Vaccin Immunother 2020:1–11.

[26] Carpio CE, Hudson D, Sarasty O, Borja I, Carrión C, Guerrero-Ochoa P. Resultados de Encuesta: Conocimiento, Percepciones, Respuestas y Efectos Relacionados a la Emergencia Sanitaria Producida por el COVID-19. El Caso de Ecuador. 2020.

[27] Qualtrics. ESOMAR 28 28 Questions to Help Research Buyers of Online Samples; 2014.

[28] INEC. Encuesta Nacional de Ingresos y Gastos de los Hogares Urbanos y Rurales Ecuador 2011-2012; 2020.

[29] Banco Central del Ecuador. Reporte de Pobreza , Ingreso y Desigualdad; 2017.

[30] HHS. International Compilation of Human Research Standards. Off Hum Res Prot; 2020. https://www.hhs.gov/ohrp/international/compilation-human-research-standards/index.html.

[31] The World Bank. Data for Ecuador, Upper middle income; 2020. https://data.worldbank.org/?locations=EC-XT.

[32] Eckhardt M, Santillán D, Faresjö T, Forsberg B, Falk M. Universal health coverage in rural Ecuador: a cross-sectional study of perceived emergencies. West J Emerg Med 2018:889. https://doi.org/10.5811/westjem.2018.6.38410.

[33] INEC. Encuesta Nacional de Empleo, Desempleo y Subempleo; 2019. https://www.ecuadorencifras.gob.ec/documentos/web-inec/EMPLEO/2019/Marzo/Boletin_mar2019.pdf.

[34] Ecuador Ministry of Health. Acuerdo Ministerial 00126-2020 2020. https://www.salud.gob.ec/wp-content/uploads/2020/03/SRO160_2020_03_12.pdf.

[35] Teleamazonas. Ecuador busca adquirir 14 millones de vacunas contra COVID; 2020. https://www.teleamazonas.com/2020/10/ecuador-busca-adquirir-14-millones-de-vacunas-contra-covid/.

[36] Halloran ME, Haber M, Longini IM, Struchiner CJ. Am J 1991;133:323–31.

[37] Orenstein WA, Bernier RH, Dondero TJ, Hinman AR, Marks JS, Bart KJ, et al. Field evaluation of vaccine efficacy. Bull World Health Organ 1985;63:1055–68.

[38] Centers of Disease Control and Prevention. CDC Seasonal Flu Vaccine Effectiveness Studies; 2020. https://www.cdc.gov/flu/vaccines-work/effectiveness-studies.htm.

[39] O'Donnell T. Oxford scientist says if coronavirus vaccine is effective it will likely be seasonal; 2020. https://news.yahoo.com/oxford-scientist-says-coronavirus-vaccine-172827584.html.

[40] Kekatos M. Coronavirus mutates slower than the flu say experts - which will give scientists longer to develop an effective vaccine; 2020. https://www.dailymail.co.uk/news/article-8208379/Coronavirus-mutating-slowly-giving-scientists-time-develop-vaccine.html.

[41] López-Feldman A. Munich Personal RePEc Archive Introduction to contingent valuation using Stata Introduction to Contingent Valuation using Stata∗; 2012.

[42] Zapata SD, Carpio CE, Isengildina-Massa O, Lamie RD. The economic impact of services provided by an electronic trade platform: The case of MarketMaker. J Agric Resour Econ 2013;38:359–78.

[43] Cameron T. A new paradigm for valuing non-market goods using referendum data: maximum likelihood estimation by censored logistic regression. J Environ Econ Manage 1988:355–79.

[44] Cameron A, Trivedi P. Microeconometrics: Methods and application. New York: Cambridge University Press; 2009.

[45] Raqab MZ, Al-Awadhi SA, Kundu D. Discriminating among Weibull, log-normal, and log-logistic distributions. Commun Stat Simul Comput 2018;47:1397–419. https://doi.org/10.1080/03610918.2017.1315729.

[46] Turnbull BW. The empirical distribution function with arbitrarily grouped, censored and truncated data. J R Stat Soc Ser B 1976;38:290–5. https://doi.org/10.1111/j.2517-6161.1976.tb01597.x.

[47] Day B. Distribution-free estimation with interval-censored contingent valuation data: troubles with Turnbull?. Environ Resour Econ 2007;37:777–95.

[48] Haab TC, McConnell KE. Referendum models and negative willingness to pay: alternative solutions. J Environ Econ Manage 1997;32:251–70.

[49] Carpio CE, Ramirez OA, Boonsaeng T. Potential for tradable water allocation and rights in Jordan. Land Econ 2011;87:595–609.

[50] Mudatsir M, Anwar S, Fajar JK, Yufika A, Ferdian MN, Salwiyadi S, et al. Willingness-to-pay for a hypothetical Ebola vaccine in Indonesia: A cross-sectional study in Aceh. F1000Research 2019;8:1441. https://doi.org/10.12688/f1000research.20144.2.

[51] Brown DS, Johnson FR, Poulos C, Messonnier ML. Mothers' preferences and willingness to pay for vaccinating daughters against human papillomavirus. Vaccine 2010;28:1702–8. https://doi.org/10.1016/j.vaccine.2009.12.024.

[52] IHME. COVID-19 Projections; 2020. https://covid19.healthdata.org/ecuador.

[53] Dube R, de Córdoba J. Ecuador City Beat One of World's Worst Outbreaks of Covid-19; 2020. https://www.wsj.com/articles/ecuador-city-beat-one-of-worlds-worst-outbreaks-of-covid-19-11593532974.

[54] WHO. WHO Coronavirus Disease (COVID-19) Dashboard; 2020. https://covid19.who.int/.

[55] The World Bank. Total Population; 2020. https://data.worldbank.org/indicator/SP.POP.TOTL.

[56] Loftus P. Covid-19 Vaccine Makers Signal Prices; 2020. https://www.wsj.com/articles/covid-19-vaccine-makers-signal-prices-11596648639.

[57] Fu C, Wei Z, Pei S, Li S, Sun X, Liu P. Acceptance and preference for COVID-19 vaccination in health-care workers (HCWs) 09.20060103. MedRxiv 2020;2020. https://doi.org/10.1101/2020.04.09.20060103.

[58] Detoc M, Bruel S, Frappe P, Botelho-Nevers E, Gagneux-Brunon A. Intention to participate in a COVID-19 vaccine clinical trial and to get vaccinated against COVID-19 in France during the pandemic 04.23.20076513. MedRxiv 2020;2020. https://doi.org/10.1101/2020.04.23.20076513.

[59] LX/Morning Consult. National Tracking Poll #200395; 2020. https://www.nbcwashington.com/wp-content/uploads/2019/09/LX_COVID_Vaccine_Poll_crosstabs.pdf.

[60] Cameron MP, Newman PA, Roungprakhon S, Scarpa R. The marginal willingness-to-pay for attributes of a hypothetical HIV vaccine. Vaccine 2013;31:3712–7. https://doi.org/10.1016/j.vaccine.2013.05.089.

[61] Pan American Health Organization. COVID-19 Information System for the Region of the Americas; 2020. https://paho-covid19-response-who.hub.arcgis.com/pages/paho-ecuador-covid-19-response.

[62] Rajamoorthy Y, Radam A, Taib NM, Rahim KA, Wagner AL, Mudatsir M, et al. The relationship between perceptions and self-paid hepatitis B vaccination: A structural equation modeling approach. PLoS ONE 2018;13:e0208402.

[63] Freimuth VS, Jamison A, Hancock G, Musa D, Hilyard K, Quinn SC. The role of risk perception in flu vaccine behavior among african-american and white adults in the united states. Risk Anal 2017;37:2150–63.

[64] INEC. Encuesta Nacional de Ingresos y Gastos de los Hogares Urbanos y Rurales; 2020. https://www.ecuadorencifras.gob.ec/encuesta-nacional-de-ingresos-y-gastos-de-los-hogares-urbanos-y-rurales/.

[65] de Bekker-Grob EW, Donkers B, Bliemer MCJ, Veldwijk J, Swait JD. Can healthcare choice be predicted using stated preference data?. Soc Sci Med 2020;246:112736.

[66] Lambooij MS, Harmsen IA, Veldwijk J, de Melker H, Mollema L, van Weert YWM, et al. Consistency between stated and revealed preferences: a discrete choice experiment and a behavioural experiment on vaccination behaviour compared. BMC Med Res Method 2015;15:19.

[67] CDC. How Well Flu Vaccines Work; 2020. https://www.cdc.gov/flu/vaccines-work/vaccineeffect.htm.