Taylor & Francis
Taylor & Francis Group

Expert Review of Pharmacoeconomics & Outcomes Research

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ierp20

Acceptability and willingness to pay for a hypothetical vaccine against SARS CoV-2 by the Brazilian consumer: a cross-sectional study and the implications

Isabella Piassi Dias-Godói, Túlio Tadeu Rocha Sarmento, Edna Afonso Reis, Ludmila Peres Gargano, Brian Godman, Francisco de Assis Acurcio, Juliana Alvares-Teodoro, Augusto Afonso Guerra Júnior & Cristina Mariano Ruas

To cite this article: Isabella Piassi Dias-Godói, Túlio Tadeu Rocha Sarmento, Edna Afonso Reis, Ludmila Peres Gargano, Brian Godman, Francisco de Assis Acurcio, Juliana Alvares-Teodoro, Augusto Afonso Guerra Júnior & Cristina Mariano Ruas (2021): Acceptability and willingness to pay for a hypothetical vaccine against SARS CoV-2 by the Brazilian consumer: a cross-sectional study and the implications, Expert Review of Pharmacoeconomics & Outcomes Research, DOI: 10.1080/14737167.2021.1931128

To link to this article: https://doi.org/10.1080/14737167.2021.1931128

Published online: 14 Jun 2021.

Submit your article to this journal

Article views: 16

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=ierp20

EXPERT REVIEW OF PHARMACOECONOMICS & OUTCOMES RESEARCH
https://doi.org/10.1080/14737167.2021.1931128

Taylor & Francis
Taylor & Francis Group

ORIGINAL RESEARCH

Check for updates

Acceptability and willingness to pay for a hypothetical vaccine against SARS CoV-2 by the Brazilian consumer: a cross-sectional study and the implications

Isabella Piassi Dias-Godói [a,b], Túlio Tadeu Rocha Sarmento [c], Edna Afonso Reis [b,d], Ludmila Peres Gargano [c,e], Brian Godman [f,g,h,i], Francisco de Assis Acurcio [c,e], Juliana Alvares-Teodoro [c,e], Augusto Afonso Guerra Júnior [c,e] and Cristina Mariano Ruas [e]

[a]College of Public Health, Institute of Health and Biological Studies, Universidade Federal do Sul e Sudeste do Pará, Marabá, Pará, Brazil; [b]Researcher of the Group (Cnpq) for Epidemiological, Economic and Pharmacological Studies of Arboviruses (EEPIFARBO) - Universidade Federal Do Sul E Sudeste Do Pará; Avenida Dos Ipês, Marabá, Pará, Brazil; [c]SUS Collaborating Centre for Technology Assessment and Excellence in Health, Sala 1042, Faculdade De Farmácia, Universidade Federal De Minas Gerais, Av. Presidente Antônio Carlos, 6627, Campus Pampulha, Belo Horizonte, Minas Gerais, Brazil; [d]Department of Statistics, Exact Sciences Institute, Universidade Federal De Minas Gerais, Belo Horizonte, Brazil; [e]Programa De Pós-Graduação Em Medicamentos E Assistência Farmacêutica, School of Pharmacy, Universidade Federal De Minas Gerais, Belo Horizonte, Brazil; [f]Department of Pharmacoepidemiology, Institute of Pharmacy and Biomedical Sciences, Glasgow, UK; [g]Division of Clinical Pharmacology, Karolinska Institute, Karolinska University Hospital, Stockholm, Sweden; [h]Health Economics Centre, Liverpool University Management School, Liverpool, UK; [i]School of Pharmacy, Department of Public Health and Pharmacy Management, Sefako Health Sciences University, Pretoria, South Africa

abstract

Introduction: The new coronavirus pandemic has appreciably impacted morbidity and mortality, as well as having an economic impact worldwide. New vaccines are a potential way forward to reduce transmission rates and subsequent infection. In Brazil, vaccines are being distributed via the public sector; however, in the future, they will be available in the private market. Information about consumers' willingness to pay (WTP) for a hypothetical vaccine against SARS CoV-2 can help future price setting discussions.

Methods: A cross-sectional study was conducted with consumers in the five regions of Brazil regarding the WTP for a hypothetical vaccine against SARS CoV-2 with a 50% efficacy.

Results: A total of 1402 individuals over 18 years of age who declared not having COVID-19 at the time of the survey were interviewed. The acceptability for this hypothetical vaccine was 80.7%. In addition, the amount of WTP by Brazilian consumers for a hypothetical SARS CoV-2 vaccine was estimated at US$ 22.18(120.00 BRL).

Conclusion: This study can contribute to decision-making to inform potential pricing for a hypothetical SARS CoV-2 vaccine.

ARTICLE HISTORY
Received 31 March 2021
Accepted 13 May 2021

KEYWORDS
SARS cov-2; willingness to pay; vaccine; brazil; contingent valuation; covid-19

1. Introduction

SARS-CoV-2 infection was designated as a pandemic by the World Health Organization (WHO) on 11 March 2020 [1–4]. Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus, named SARS-CoV-2, and can be transmitted directly from droplets and aerosols expelled by an infected person's speech, cough or sneeze, or indirectly such as hand contact with objects contaminated with the virus and subsequently from hand contact with the mucosa of the eyes, mouth and nose [5–7]. Most people infected with the COVID-19 virus will experience mild to moderate respiratory illness with symptoms such as a cough, shortness of breath, headaches and body aches, malaise, and fever, and might recover without requiring special treatment. However, older people, and those with comorbidities such as cardiovascular disease, diabetes, chronic respiratory diseases or cancer are more likely to develop more severe symptoms [6]. In the most severe cases, patients may have breathing difficulties and need mechanical ventilation as well as potential constant medical monitoring in intensive care units [8,9]. This fact is reflected in the higher Case Fatality Rate (CFR) of the disease in elderly patients with mortality rates up to 90 times higher in individuals over the age of 65 when compared to individuals aged 18 to 29 years [10,11].

According to WHO (2021), until 21 April 2021, 138,688,383 cases of the disease were confirmed in the world and 2,978,935 deaths have been recorded [12]. The worldwide CFR is 2.20%, and the deaths registered only in Brazil currently represent approximately 11% of those occurring across the world [13]. However, there are major concerns with the under-reporting of new cases and deaths including Brazil [11,14–16]. In Brazil, the emergent epicenter of COVID-19, until 21 April 2021, 14,122,79 cases (incidence of 6,491 cases/100,000 inhabitants) and 381,475 deaths were confirmed, with a CFR of 2.50% [17]. The epidemiological impact of COVID-19 is variable according to each region of Brazil. Highest for Northeast and Southeast with 3,241,814 and 5,219,208 confirmed cases and the Midwest with higher

CONTACT Isabella Piassi Dias-Godói isabellapiassi@gmail.com Institute of Health and Biological Studies, Universidade Federal do Sul e Sudeste do Pará,Pará,Brazil
© 2021 Informa UK Limited, trading as Taylor & Francis Group

Article Highlight

- The COVID-19 pandemic represented, until this moment, 14,122,795 confirmed cases and 381,475 deaths between March of 2020 and April of 2021, highlighting the Brazil as country with the most cases and deaths in Latin America, according to WHO.
- In Brazil, COVID-19 healthcare is available free of charge throughout the national territory by Public Health System, and a safe and effective vaccine for COVID-19 prevention represents an important strategy for the control of the disease.
- This study estimated the WTP of Brazilian consumers for a hypothetical SARS-CoV-2 vaccine through an analysis of contingent valuation.
- 50% of the interviewees were willing to pay US$ 22.18 (120.00 BRL) for a hypothetical vaccine against SARS-CoV-2 infection.
- The study can contribute for discussions about the pricing of COVID vaccines to be adopted into the market in Brazil.

incidence of 9,129 cases per each 100,000 inhabitants until April 21 [17,18].

Up to January 2021, at least four vaccines had their randomized clinical trial (RCT) results published [19–22], even if preliminary, and had received the Emergency Use Authorization use in some countries including the United States of America, the United Kingdom and Brazil [23–25]. The first vaccines to receive conditional marketing authorization by the European Medicines Agency (EMA) and the U.S. Food and Drug Administration (FDA) were Cominarty® (Pfizer-BioNTech), Covishield® (Oxford-AstraZeneca) and Moderna COVID-19 Vaccines [23,24,26]. In March 11, the EMA recommended the use of Janssen-Cilag™ COVID-19 vaccine [27]. The European Commission has already concluded contracts for 2.265 billion doses with AstraZeneca, Sanofi-GSK, Johnson and Johnson, BioNTech-Pfizer, CureVac and Moderna (160 million doses). However, the rollout has been slow to date across Europe with the exception of the UK [28,29].

In Brazil, CoronaVac™ and Covishield® (Oxford-AstraZeneca™) vaccines received the emergency use authorization by the National Sanitary Surveillance Agency (ANVISA) on 17 January 2021, while Cominarty® and Covishield® received the definitive approval in 23 February and 12 March, respectively [25]. Ad26.COV2.S®, the vaccine produced by Janssen™, was the latest vaccine to receive emergency use authorization in Brazil on March 31 [30]. Besides those, the manufacturer of Sputnik V (Gamaleya) also applied for a use authorization in the country; however, until April 2021, there was no decision by ANVISA [31,32]. CoronaVac is a Chinese inactivated-virus vaccine produced by Sinovac, which is being produced in partnership with the biological research center Butantan in Brazil. Its Phase 3 RCT results, there was an overall efficacy of 50.38%, 78% efficacy for mild cases and 100% for moderate and severe cases of Sars-CoV-2 [33]. Covishield®, in its turn, is a vaccine developed in a partnership between Oxford University and AstraZeneca pharmaceuticals [19].

The National Immunization Program (PNI) created in 1973 by the Brazilian Ministry of Health has as its main objective the reduction of infections in the country. As a result, several vaccines are available free for the Brazilian people, according to the vaccination calendar and campaigns. PNI is considered one of the most important Brazilian health programs [34,35] and is carried out in a tripartite manner, with the participation of the Union, the states, the Federal District and the municipalities [36]. In the context of vaccination against COVID-19, the Brazilian Ministry of Health meets periodically with representatives of state and municipal health departments to discuss the actions to be developed in the vaccination campaign involving the vaccines approved for emergency use in the country [36]. In addition, the National Immunization Plan has an objective to prioritize vaccinations among health professionals and the population most vulnerable to SARS-CoV-2, such as the elderly and individuals with comorbidities, which started in January of 2021 and consisted of four phases [37].

The Brazilian Ministry of Health signed a contract with Butantan guaranteeing, besides the exclusive right over all doses produced or imported by the institution, over 100 million doses, which will be incorporated into the PNI, and the CoronaVac vaccine presented, approximately, protection of 50% [38]. On the other hand, the vaccine produced by the pharmaceutical company Astrazeneca in partnership with the federal entity Fundação Oswaldo Cruz (FIOCRUZ) has shown an overall efficacy of 70.4%, ranging from 62% to 90% with different dosing regimens [19]. This adenoviral vaccine was the subject of a contract with the Brazilian Ministry of Health, which also signed an agreement for 70 million doses of Pfizer/BioNTech™ and 38 million doses of Janssen™ vaccine [39,40]. Recently, the Brazilian Association of Vaccine Clinics reported that private laboratories are interested and are negotiating with an Indian company, Bharat Biotech, involving the purchase of 5 million doses of a vaccine against COVID-19. This vaccine has not yet completed Phase III clinical trials and will be assessed by ANVISA for use in the country in the future [41]. In parallel, in March 2021, the bill allowing the private sector to buy vaccines against the coronavirus was approved by Brazilian government [42,43].

Until February 2021, no vaccine had gone through a pricing process by the Medicines Market Regulation Chamber (CMED), which reinforces the need for pharmacoeconomic studies that contribute to this discussion. In Brazil, CMED is responsible for the economic regulation of medicines including vaccines commercialized in the country. CMED evaluates and establishes the prices of medicines that will be marketed in the country [44]. However, the approval and registration of new medicines including vaccines for commercialization is conducted by ANVISA [45]. A new technology is only introduced onto the Brazilian market upon compliance with the criteria established by Resolution No. 2 of March 5 2004 guidance [46]. Thereafter, its pricing is defined by CMED. As a vaccine against SARS-CoV -2 infection will be a new product, this technology would be classified as category I. Further, its price cannot be higher than the lowest price of a number of countries including Australia, Canada, France, Greece, Italy, New Zealand, Portugal, Spain and the United States of America [46].

In the context of limited healthcare resources and growing demand in Brazil [47], it is essential to emphasize the

importance of undertaking studies in an economic context to support the process of rational decision-making [48,49]. Priority setting is crucial in countries such as Brazil where the public health system caters for over 210 million inhabitants [50]. Accordingly, studies that seek to identify the value of technologies of clinical interest for a given country, such as a vaccine for the prevention of COVID-19 in Brazil, may contribute to future decision-making regarding their pricing.

The field of pharmacoeconomics has provided a considerable number of methodologies for health technologies assessment, ranging for instance, from cost-utility and cost-effectiveness to consumer preference valuation depending on the situation and objectives [51]. In health economics, estimating the consumer preference for a product can be of great relevance in determining the feasibility of providing a technology in a public health system context. To determine the consumer preference on a given product, there are some common methodologies., which include revealed preference and declared preference studies. In revealed preference techniques, the researchers observe the behavior and the choices of potential consumers, instigating discussions about the actual price of a good [52]. For medicines currently unavailable on the private market, including currently the COVID-19 vaccine in Brazil, revealed preference studies are impossible to conduct. Instead, declared preference studies can be useful in this scenario. In this methodology, the researchers create a hypothetical market with a new product and ask to participants what would be their likely behavior, i.e. whether buying it or not and how much are they willing to pay for it [53].

Willingness to pay (WTP) is a methodology that seeks to estimate the maximum individual value to be allocated to a specific program, clinical services, or interventions, or treatment to identify its monetary value. WTP studies enable decision makers to assess a point value, ranges of values, or the positive or negative response to a presented value, contributing to a better perception of an individual's preferences in health decision-making processes [54]. This approach is based on the application of a questionnaire, with prior presentation of the characteristics of the evaluated intervention to the interviewee and aspects relevant to the clinical context [55,56].

In recent years, this methodological approach has enhanced deliberations regarding the potential value of new vaccines, i.e. the first-approved dengue vaccine in Brazil, and to hypothetical scenarios for Zika and Chikungunya as well as Chagas Disease in the country [55–58]. Some published studies already assessed the WTP for a vaccine against SARS-CoV -2 infection [59–61]. However, we didn't find any published article assessing this WTP in the Brazilian context. We believe it would be important to evaluate the WTP for a hypothetical vaccine for SARS-CoV-2 infection with Brazilian consumer involving the different regions in the country. This is because Brazil is the country with the most cases and deaths in Latin America associated with SARS-CoV-2 infection with 14 million confirmed cases to date [12,13,17]. Consequently, we sought to estimate the Brazilian consumers' WTP for a hypothetical vaccine to COVID-19 prevention to contribute to the debate and pharmacoeconomic reviews focusing on demand and potential prices for this type of medicine in Brazil starting with the private market.

2. Materials and methods

This study was performed to estimate the WTP of the Brazilian Consumer for a hypothetical vaccine to prevent COVID-19 via a contingent valuation analysis. A questionnaire with open and closed questions was used to collect data relevant.

2.1. Design and study location

Considering the scenario of the pandemic for the new coronavirus across the country in which face-to-face research is not feasible, the Google Forms online tool was used to enable participants to access the research instrument prepared by the team.

According to Brazilian Institute of Geography and Statistics (IBGE), in 2021 Brazil has approximately 212 million of inhabitants among five regions (5,570 municipalities) [50]. The average monthly income was US$ 443.25 2.398 BRL in the first quarter of 2020 [50], and the Gross Domestic Product *per capita* was US$ 6,209.58 (33,593.82 BRL) in 2018 [50]. The nominal household monthly income *per capita* was US$ 265.93 (1,438.67 BRL) in 2019 [62].

2.2. Data collection instrument

The WTP technique involves the application of a questionnaire which includes a prior presentation of the disease and the technology applied to the context to be evaluated by the respondent as part of their decision-making process [57].

The questionnaire (Supplementary Material) used in this study was developed by the research team, building on previous publications [55,56,63]. It comprised the following five sections: (1) Questions to test participants' knowledge regarding SARS CoV-2 disease; (2) Information on the disease, intervention, and alternatives for preventing the disease; (3) Questions to assess their understanding of the information provided; (4) *Discrete Choice, Bidding* Game, and *Open-Ended* Questions including questions to identify whether individuals would pay U$18.48 (100.00 BRL) for a single dose of the hypothetical SARS CoV-2 vaccine as well as questions to estimate the range of values that respondents would pay for the technology; and (5) a socioeconomic questionnaire [57].

For the discrete choice technique, the value of US$18.48 (100.00 BRL) was established for a single dose of SARS CoV-2 vaccine. This choice was derived based on the Brazilian market involving single-dose vaccines, in consultation with the Price List of the Drug Market Regulation Chamber (CMED) and through the factory price (FP) of vaccines in Brazil [64].

The efficacy of vaccine protection (50%), as well as the possibility of local adverse events (e. g. swelling at the site of

application and pain) and information on the disease, epidemiological data, and criteria for vaccination were included in the initial stage of the interview. The hypothetical efficacy adopted in this study was selected considering the least percentual of 50% according to WHO recommendations for a vaccine for COVID-19 prevention [65].

2.3. Sampling and selection criteria

The method of online survey was chosen due to the difficulty in undertaking a face-to-face study amid the ongoing COVID-19 outbreak. We used a simplified snowball sampling technique, in which sample recruitment was conducted among Brazilian residents of the five regions of the country (North, Northeast, South, Southeast, Midwest).

If there is a greater uncertainty that 50% of the respondents would agree to pay US$18.48 (100.00 BRL), a minimum of 625 respondents would be required in this survey to achieve a margin of global error of 4 percentage points at a 95% confidence level. This guided the initial number of people to approach for this study.

As a criterion for participation, individuals had to possess and declare an income, with individuals under 18 years of age and those without income being excluded. Interviewees may or may not have a history of COVID-19; however, at the time of the interview, they were excluded if they had symptoms or were diagnosed with the disease, which is in line with other similar studies [55–57,63,66]. Individuals who would not use the vaccine or would not use it even if it were free, and those who were willing to pay more than twice their declared monthly income, were excluded from the sample as established for this approach [57] and observed in similar studies [55,56,63].

2.4. Data analysis

The WTP for the hypothetical vaccine for the prevention of COVID-19 was estimated by the median value of the variable 'maximum amount you would pay for the vaccine' and declared by individuals who were willing to pay any amount greater than or equal to zero. Other studies have applied this methodological approach [55,56,63]. In addition, the inference methodology was used in complex samples, applied when the individuals in the original sample were not taken from the population by simple random sampling and there is a need to estimate the parameters of the variables of interest with weighting by some group variable [67]. In the case of estimating the median of the variable 'maximum amount that would pay for the vaccine', the Bootstrap resampling method was used in the groups of 'household income per dependent', with sample size proportional to the distribution of the Brazilian population in the ranges *per capita* household income in 2019 [68].

The WTP among the groups defined by the covariates was compared using the Mann–Whitney test (two groups) or the Kruskal–Wallis test (three or more groups). The level of significance chosen was 5%. The individuals were stratified by their *per capita* wage income expressed by number of monthly minimum wages (MW). For comparative purposes, the conversion value provided by the Brazilian Central Bank (2020: US $1 = 5.41 BRL) was adopted [69]. At time of survey, 1 MW was US$ 193.16 (1,045 BRL).

Finally, the statistical analysis was added with graphs and frequency tables of categorical responses and statistics of numerical synthesis of quantitative variables, e.g. age, gender, education level and if had a risk factor for worsening COVID-19. Statistical and graphical analyses were produced using Microsoft Excel® 2007 and R. For comparative purposes, the conversion value provided by the Brazilian Central Bank (2020: US$1 = 5.41 BRL) was adopted [69].

2.5. Ethics statement

All interviews were conducted after the interviewees had read and signed an informed consent form. The questionnaire and the consent form were available for the respondent by Google Forms. In addition, all researchers of the project signed a confidentiality agreement prior to the interviews. This study was approved by the Ethics and Research Committee of the Federal University of Minas Gerais (UFMG), under CAAE registration number 66,860,617.8.0000.5149.

3. Results

3.1. Population characteristics

The study was conducted among 1,402 individuals. The participants were mostly female (63.8%), aged between 25 and 49 years (60.5%), with higher education or postgraduate education (70.9%), were employees at the time of the survey (74.8%), with *per capita* household income above two minimum wages (69.9%) (Table 1).

The vast majority of participants reported that they had not had COVID-19 previously (92.4%). Approximately, 30.0% of the participants reported the death of a relative or close friend due to COVID-19 and 28.2% responded that they had a risk factor for worsening COVID-19 infection. 65.9% of the participants were resident in the Southeast of Brazil, 3.8% in the North, 7.3% on the Northeast, 17.9% in the Midwest, and 5.1% in the South.

Table 1. Characteristics of respondents (n = 1402).

Variable	N	(%)
Age in years [mean (SD)]	37.2	12.9
Women	894	63.8
Age between 25 and 49 years old	848	60.5
Complete college or more	995	70.9
Currently working	1049	74.8
Per capita household income above 2 minimum wages	981	69.9
No had COVID-19	1295	92.4
Reported that other people in the household or friends died associated to Covid-19	423	30.2
Reported that has a risk factor for worsening COVID-19 infection	395	28.2
Acceptability for this hypothetical vaccine to COVID-19 prevention	1131	80.7
Acceptability for this hypothetical vaccine only if it was available for free	39	2.8
The country of discovery of the vaccine against COVID-19 makes no difference	931	66.4

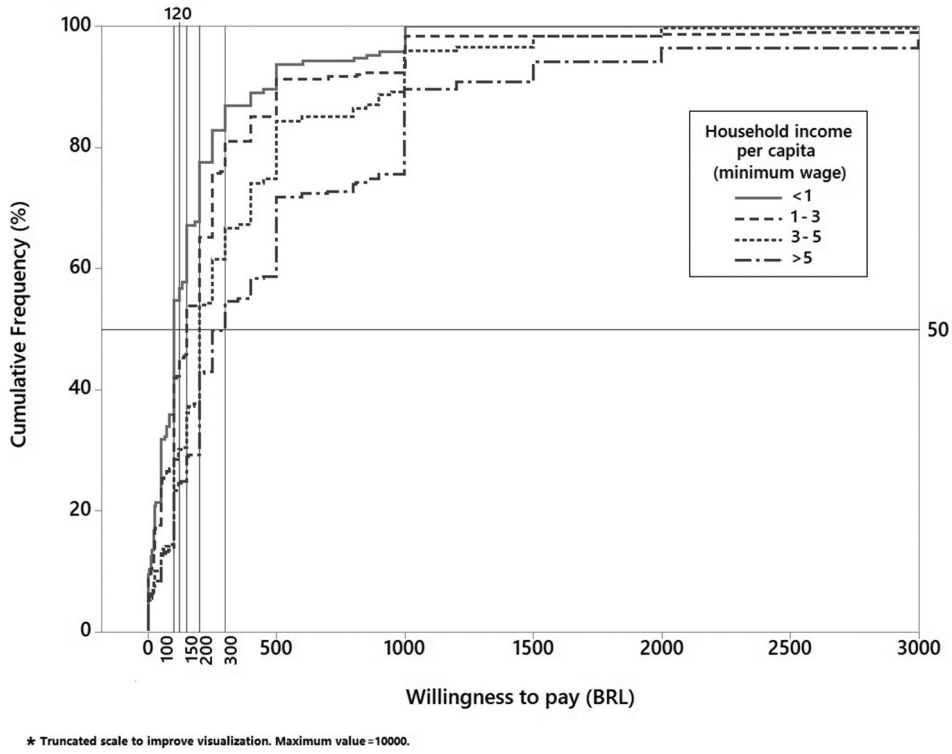

Figure 1. Cumulative frequency of the maximum value of WTP for a hypothetical vaccine against SARS-CoV-2 infection by household income *per capita*.

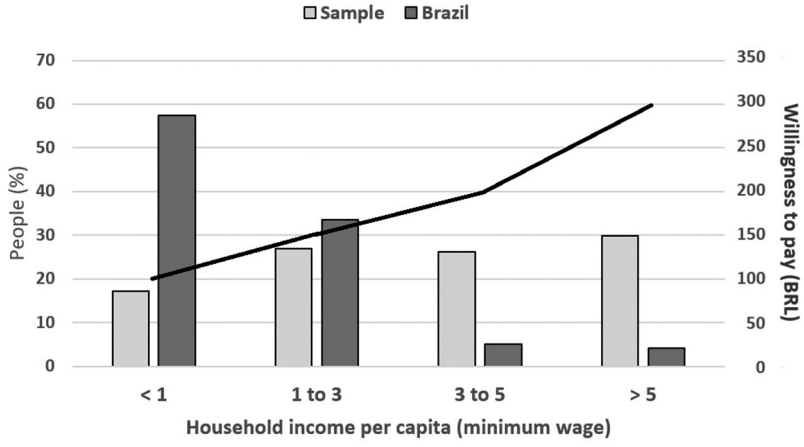

Figure 2. Boxplots of the maximum value of WTP for a hypothetical vaccine against SARS-CoV-2 infection according household income *per capita* of sample and Brazilian profile.

3.2. WTP for a hypothetical SARS CoV-2 vaccine

Of the 1,402 study participants, 271 (19.3%) said they would not be vaccinated even if the hypothetical vaccine was free. The main reasons were efficacy (39.2%), safety (50.9%), and other factors (9.9%).

After descriptive analysis of the data, 280 individuals did not meet the eligibility criteria, with 271 respondents declaring, as mentioned, that they would not use this vaccine even if it was available free of charge, three individuals reporting a disposition value of twice their monthly family income and six participants presented with a COVID-19 diagnosis at the moment of the interview. As a result, 1,122 interviewees were eligible to participate in the WTP analysis.

The minimum and maximum value of the variable 'maximum amount you would pay for the vaccine' were US$0.00 (0.00 BRL) and US$1,848.43 (10,000.00 BRL), respectively. It was observed that the median 'maximum amount you would pay for the vaccine' varied significantly ($p < 0.001$, Kruskal–Wallis test) among respondents in the four ranges of household income *per capita*, showing an increasing profile of the median value of WTP with an increase in income (Figure 1).

Figure 2 shows the median of the 'maximum amount who the respondent would pay for the vaccine' per household income *per capita*, ranging from US$ 18.48 (100.00 BRL) for individuals with an income of up to 1 times the minimum wage, up to US$ 55.45 (300.00 BRL) for those with an income

of 5 times the minimum wage or more. Considering the difference between the income profiles of the research participants and the income profile of the Brazilian population (Figure 2), the median of the 'maximum amount that would pay for the vaccine' was calculated with weighting for the *per capita* household income, resulting in a WTP of US$ 22.18 (120.00 BRL) (95% CI: 18.18 to 27.73). It means that 50% of the interviewees reported a maximum WTP of US$22.18 or less.

In addition to *per capita* household income, a statistically significant difference (p-value <0.05) was also found in the WTP declared by individuals according to their level of education ($p < 0.001$). However, other variables were evaluated and did not present a statistically significant relationship with the maximum value of WTP ($p > 0.05$). These included previous history with COVID-19 infection ($p = 0.561$), gender ($p = 0.106$), age ($p = 0.261$), comorbidities ($p = 0.421$) and mortality associated with COVID-19 in either family or friends ($p = 0.864$).

Additionally, WTP was estimated for the hypothetical vaccine against SARS-CoV-2 infection according to the participant's region of residence, also with weighting per household income *per capita*. The WTP value among residents of the Midwest region was estimated at US$ 36.97 (200.00 BRL). This figure changed to US$ 18.48 (100.00 BRL) and US$ 25.88 (140.00 BRL) for residents of the North and Southeast regions, respectively. The WTP value for both South and Northeast regions was US$ 27.73 (150.00 BRL).

4. Discussion

We believe this is the first study to assess the WTP of the Brazilian consumers for a hypothetical vaccine against SARS-CoV-2 infection, with a efficacy of 50% to prevent this infection, to help guide decision-making in CMED when new vaccines will be available to purchase in the private market in the country.

We did not find significant differences comparing the maximum valued applied to WTP for this hypothetical vaccine ($p > 0.05$) with age, gender, previously history with COVID-19 infection, comorbidities and mortality associated with COVID-19 among family members and friends. However, participants with a higher family income were willing to pay more for the vaccine than those who have lower purchasing power (Figure 2), similar to the findings in other studies conducted in Brazil using this methodological approach [55,56,63]. Consequently in countries such as Brazil, where most people are low-income earners, companies should be cautious about pricing vaccines against COVID-19 because even if it is a serious infection, people would not buy the vaccine if the price was too high [62].

The vaccination against SARS-CoV-2 infection in Brazil started on 20 January 2021. Until 21 April 2021, 27,106,024 people had already received the first vaccine's dose, whose immunization plan also includes the application of a second dose, already applied to 10,667,806 individuals [37,70,71]. On average, 429,248 doses were applied per day. If this rate goes on, it would only be possible to vaccinate the entire population, estimated at 211.755.692 people, after a period of 2.35 years [50]. When considering a vaccination coverage scenario of 69.3%, a value pointed out by Kwok and collaborators (2020) as necessary to achieve herd immunity in the Brazilian population, the vaccination program would last more than 1.63 years [72]. This reinforces that the Ministry of Health foresees vaccination against SARS-CoV-2 infection over a year (end of 2021) for the totally of the Brazilian population [37].

It should be noted that some vaccines incorporated in the PNI by the SUS system are available free of charge in accordance with the Ministry of Health recommendation for specific age groups such as the flu vaccine with annual campaigns for elderly people. It can be expecteded that in view of the new variants associated with the coronavirus [73,74], there will be a need for annual vaccination campaigns, which may not include the entire population by PNI, considering the costs and clinical benefits for different age groups. In this context, similar to the situation with vaccines against influenza, if individuals are not included in priority groups for future vaccination campaigns against COVID, they should be able to purchase the vaccines in private pharmacies and clinics making discussions about pricing necessary with studies such as these.

The willingness to pay estimated in this study, after considering the income distribution of individuals in the sample, was US$ 22.18 (120.00 BRL). This value is similar to those found in other studies performed in Brazil using the same methodological approach and developed by this group of researchers. This included the first dengue vaccine (120.00 BRL) approved in the country, and for hypothetical vaccines against chikungunya (120.00 BRL) and zika (100.00 BRL), respectively [55,56,63]. All arboviruses, targets of the aforementioned studies, are also considered of great relevance to public health in Brazil and have, in the majority of cases, a higher percentage of asymptomatic cases, similar to available evidence on COVID-19 [75]. In addition, they have common aspects such as viral etiology, low mortality rates and, mainly, the similarity of the vaccine efficacy profile considered in the studies, including 50% for the prevention of COVID-19 and 60% for the dengue vaccine [63]. These aspects can help in understanding the similarity of the WTP values found between the present study and the other published studies [55,56,63]. In addition, the WTP value was defined from the median of the maximum values presented by the interviewees. Notably, this criterion, which has been established in literature [55,56,63], is intended to avoid discrepant values from the population profile scenario of a study.

In a study with a similar methodology, Harapan and collaborators (2020) estimated the WTP for a hypothetical vaccine against COVID in Indonesia at US$ 30.94 (500,000 IDR) [61]. It is noteworthy that Harapan et al. (2020) also conducted data collection in a virtual manner due to the isolation imposed during the COVID-19 pandemic. However, the efficacy considered was 95%, appreciably higher than the percentage considered in our study (50%). In another assessment of WTP for

a hypothetical SARS-CoV-2 vaccine in Chile, the median value estimated was also considerably higher than that observed in Brazil and Indonesia studies, being US$ 184.72, which is equivalent to 1.22% of GDP *per capita* from the country. According to the authors, the value was high and may have been influenced by the income profile, incidence of COVID-19 in the country, employment status and the presence of comorbidities of the participants. Efficacy data for the assessed vaccine was not declared [59].

Dong and colleagues (2020) estimated a willingness to pay in China at US$ 66.09 (446 CNY) for a vaccine with 50% effectiveness against SARS-CoV-2 with protective effect of six months after three doses [60]. In a sensitivity analysis, the authors identified a WTP of US$ 301.75 (1948 CNY) for the vaccine in a scenario with 90% effectiveness and 18 months of protection and US$ 15.18 (98 CNY) for the comfort of using a single dose [60].

Brazil is a country of continental dimensions and this fact, along with the sociodemographic disparities between the regions of the country, has a great impact on public health and in the formulation of policies to address ongoing health problems. During the COVID-19 pandemic, it was possible to observe that, at certain times, some regions of the country had a marked increase in incidence, while others had stable number of cases [18]. Aspects such as the considerable distance between the country's capitals and urban centers can hinder the large flow of people between states and contribute to a reduction of interregional transmission [76,77].

Most deaths were driven by the state of Sao Paulo, Brazil's most populous, which recorded 1,021 new deaths in only one day (March, 23, 2021), far above other states[17]. Additionally, infrastructure inequalities between regions may negatively impact in the ability of dealing with COVID-19. An example of this was the oxygen crisis which occurred in Manaus, where individuals with severe symptoms of COVID-19 requiring mechanical ventilation could not access oxygen supplementation due to lack of oxygen cylinders in Amazonas state [78]. Another infrastructural problem faced by the country in COVID-19 pandemic is insufficient diagnostic testing of individuals and this aspect directly impacts on the formulation of public policies to retain contagion and treat patients [11,14–16].In addition, problems related to infrastructure, such as the low number of beds in intensive care units in certain regions of the country, have made it difficult to treat patients with COVID-19 [79]. However, Brazil is not unique in this regard [11].

According to WHO forecasts, in August 2020, a vaccine against the new coronavirus should cost approximately US$ 10.00 (approximately 55.00 BRL) [69,80]. According to this forecast, it is estimated that Brazil would spend approximately 4 billion BRL for the immunization of vulnerable people [80,81]. Considering the scenarios of exclusive availability of a vaccine against SARS-CoV-2 to thousands of Brazilians, from PNI, or the possibility for consumers to buy the vaccine in the private market, reinforces the necessity to establish a value that is feasible, according to the economic and social particularities of Brazil. It is essential to organize a national vaccination, considering the rationality of public spending. The country has an universal complex and public system health for approximately 210 million people, with many health demands on its budgetary limitations [62]. These aspects should be considered in discussions about the price of a vaccine for COVID-19 in Brazil.

For many of these government contracts, the cost for each dose depends on the amount ordered and the budget earmarked to fund the development and production. In Brazil, the agreement signed with the Ministry of Health involved the purchase of more than 200 million doses of the AstraZeneca™ vaccine with a cost price of US$ 3.16 per dose [82], while the estimated price for CoronaVac is US$ 10 per dose [83]. However, the values of government agreements do not necessarily reflect the cost to the private market. For instance, the market price established by the company of Sputnik V vaccine was US$ 1.85 per dose (10 BRL) [84]. In this context, it is not yet clear how the acquisition and distribution of doses by the private market will work, since it will depend on the rules of the bill that is currently being processed in Brazil. This bill foresees that the doses acquired must be delivered to SUS until the vaccination of the priority groups is completed and, afterward, the private market can keep 50% of the doses it acquires, which cannot be marketed directly to individuals [42,85].

Some economic studies can contribute to technology pricing discussion applied to its incorporation in a public health system (government purchase) as cost-effectiveness analysis [86], and to private market such as the WTP approach [55–58,63]. In this last analysis, it is essential to consider the socioeconomic and epidemiological aspects of a region along with the purchasing power of an individual in the region [56,58]. This study demonstrated the profile of Brazilian people and its WTP for a hypothetical vaccine against COVID-19 associated with a number of variables including income range, education level, and locality, and can be useful in decisions regarding the purchasing and selling price of a vaccine against SARS-CoV-2 in Brazil.

Considering the mutation capacity of SARS-CoV-2, a long period without sufficient vaccine coverage and wide viral circulation may favor the appearance of new variants of the virus, such as those already identified in Denmark, United Kingdom, South Africa and Brazil [73,74,87,88]. New variants of the virus can not only become more contagious and lethal, but also put the advances in the development of vaccines against COVID-19 at risk. For this reason, it is essential to make doses of the vaccine readily available to the population through the National Immunization Program, and to regularly reevaluate the effetiveness of the vaccines against the new variant. In addition, make the vaccine available via the private sector if there are concerns with the roll-out of any vaccine in the public sector due to logistical issues.

Consequently, despite the previously reported status of COVID-19 vaccination by SUS, some points need to be discussed regarding the availability of a vaccine in the private sector. Considering in the near future the need for vaccination

campaigns for COVID (the emergence of new variants) in which free vaccination may be associated with only a few priority groups, as is the case for vaccination to prevent influenza in Brazil by SUS, the private market is important to enable individuals access to the vaccine if they wish to purchase it. The vaccine against SARS-CoV-2 may also not be available free of charge to the entire population. Several vaccines are offered by SUS, but the private sector has been successfully engaged with and optimized vaccination strategies in many countries similar to Brazil. This is especially in cases where vaccines are only available for specific age groups such as the Human Papillomavirus vaccine (HPV), which is currently only free of charge for girls aged from 9 to 14 years old and boys from 11 to 14 years old by SUS.

Overall, methodologies such as WTP are a useful tool to help with discussions about the pricing of goods but they cannot be the only parameter in the decision-making process. In this kind of methodology, it is also common to find a difference between the WTP and the actual price of a good. This difference is called consumer surplus and, when positive (price lower than WTP), indicates the feasibility of practicing that price [89]. That said, we expect that the findings of the this study can contribute to discussions about the pricing of the vaccine especially for the private market, helping to identify values in which exists a good cost-benefit ratio [90].

Additionally, this study highlights the 'Differential pricing' approach, a practice whereby the manufacturers charge different prices for the same product in different markets [91]. In this context, the theory of Ramsey pricing demonstrates that the absolute prices of a product in a market are constrained by regulations associated to cover the predetermined costs and the need to consider welfare-maximizing price differentials across consumer groups [91,92]. This reinforces the relevance of conducting economic studies involving different countries and individuals associated with a specific product. We believe that WTP studies combined with other economic analysis will help guide pricing and reimbursement decisions in Brazil for new medicines the private market.

Limitations of this study include the fact that this is a hypothetical vaccine and the efficacy estimated of 50% may not reflect reality, as observed in recently approved vaccines in Brazil with protection estimated at 76% against severe cases or higher [30]. However, one of the vaccines against COVID-19 approved in Brazil, CoronaVac, presented, approximately, protection of 50% [33,93]. In addition, in our study, the frequency of individuals with family incomes less than 5 times the minimum wage was 38.95%, which is low compared with the average rate of 87.9% for Brazil [94]. In addition, the respondents' willingness to pay were constrained within the attributes and levels presented in this study. Lastly, the random sample used may not be fully generalizable to population of Brazil. Despite these limitations, we believe this study should contribute to discussions around the pricing COVID-19 vaccines in the country for private market.

5. Conclusion

Brazil is highlighted in Latin America with, approximately,13,746,000 confirmed cases and 381,475 deaths associated with infection up to April 21, a serious public health problem in the world [13]. The present study revealed the monetary value of a hypothetical vaccine against SARS-CoV-2 infection of US$ 22.18 (R$120.00 BRL).

Considering the possibility of different SARS-CoV-2 variants in the future, the importance for annual national vaccinations for COVID-19 prevention, and the possible scenario of free immunization for specific groups as elderly people such as influenza vaccine (annual campaigns), we believe such studies can contribute to pricing discussions in the private sector. We also believe that vaccines against COVID-19 should be seen as cost-effective. Studies such as this, combined with budget impact analyses and specific cost-effectiveness analyses, can inform the optimal use of healthcare resources. In addition, prices and effectiveness obtained with these new vaccines need to be evaluated and compared to other vaccines with similar burden. This can help contribute to political decisions on acceptable and reasonable prices, essential for countries such as Brazil with universal healthcare systems. Brazil constitutes one of the largest markets for SARS-CoV-2 vaccine and there are appreciable competing demands on available resources, especially given the current economic situation in the country.

Declaration of interest

LPG received financial support by FAPEMIG. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

Reviewer disclosures

Peer reviewers on this manuscript have no relevant financial or other relationships to disclose.

Author contributions

IPDG, TTRS, EAR, LPG, AAGJ and CMR undertook the study and EAR conducted the analysis, with BG contributing to the literature review. AAGJ, BG, CMR, JAT and FAA subsequently revised the draft and produced the final and revised manuscripts. All authors approved the final and revised manuscripts. All authors also agree to be accountable for all aspects of the work.

ORCID

Isabella Piassi Dias-Godói http://orcid.org/0000-0002-0568-6625
Túlio Tadeu Rocha Sarmento http://orcid.org/0000-0001-6503-7558
Edna Afonso Reis http://orcid.org/0000-0003-1465-9167
Ludmila Peres Gargano http://orcid.org/0000-0002-0666-7776
Brian Godman http://orcid.org/0000-0001-6539-6972
Francisco de Assis Acurcio http://orcid.org/0000-0002-5880-5261
Juliana Alvares-Teodoro http://orcid.org/0000-0002-0210-0721
Augusto Afonso Guerra Júnior http://orcid.org/0000-0001-5256-0577
Cristina Mariano Ruas http://orcid.org/0000-0003-0275-8416

Funding

LPG received financial support (Scholarship) from Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG).

References

Papers of special note have been highlighted as either of interest (•) or of considerable interest (••) to readers.

1. PAHO. OMS afirma que COVID-19 é agora caracterizada como pandemia [WHO characterizes COVID-19 as a pandemic] 2020 [cited 2020 Dec 04]. Available from: https://www.paho.org/bra/index.php?option=com_content&view=article&id=6120:oms-afirma-que-covid-19-e-agora-caracterizada-como-pandemia&Itemid=812
2. WHO. Naming the coronavirus disease (COVID-19) and the virus that causes it: World Health Organization; 2020 [cited 2021 Mar 1st]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it
3. WHO. Operational considerations forcase management of COVID-19 in health facility and community. Technical Documents. 2020 [cited 2021 Mar 1st]:[https://apps.who.int/iris/bitstream/handle/10665/331492/WHO-2019-nCoV-HCF_operations-2020.1-eng.pdf?sequence=1&isAllowed=y
4. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese center for disease control and prevention. JAMA. 2020 04;323(13):1239–1242.
5. Lotfi M, Hamblin MR, Rezaei N. COVID-19: transmission, prevention, and potential therapeutic opportunities. Clin Chim Acta. 2020 Sep;508:254–266.
6. WHO. Coronavirus: WHO - World Health Organization; 2020 [cited 2021 Feb 18]. Available from: https://www.who.int/health-topics/coronavirus#tab=tab_1
7. WHO. Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations: World Health Organization; 2020 [cited 2021 Mar 1st]. Available from: https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations
8. Perrotta F, Corbi G, Mazzeo G, et al. COVID-19 and the elderly: insights into pathogenesis and clinical decision-making. Aging Clin Exp Res. 2020 Aug;32(8):1599–1608.
9. Clerkin KJ, Fried JA, Raikhelkar J, et al. COVID-19 and cardiovascular disease. Circulation. 2020 May;141(20):1648–1655.
10. CDC. Older adults and COVID-19: CDC; 2020 [cited 2020 Dec 04]. Available from: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/older-adults.html
11. Ogunleye OO, Basu D, Mueller D, et al. Response to the novel corona virus (COVID-19) pandemic across Africa: successes, challenges, and implications for the future. Front Pharmacol. 2020;11:1205.
12. WHO. Brazil: WHO coronavirus disease (COVID-19) dashboard | WJO coronavirus disease (COVID-19) dashboard: WHO - World Health Organization; 2020 [cited 2021 Jan 27]. Available from: https://covid19.who.int/region/amro/country/br
13. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020 05;20(5):533–534.
14. Sefah IA, Ogunleye OO, Essah DO, et al. Rapid assessment of the potential paucity and price increases for suggested medicines and protection equipment for COVID-19 across developing countries with a particular focus on Africa and the implications. Front Pharmacol. 2020;11:588106.
15. Godman B, Haque M, Islam S, et al. Rapid assessment of price instability and paucity of medicines and protection for COVID-19 across Asia: findings and public health implications for the future. Front Public Health. 2020;8:585832.
16. Haque M, Kumar S, Charan J, et al. Utilisation, availability and price changes of medicines and protection equipment for COVID-19 among selected regions in India: findings and implications. Front Pharmacol. 2020;11:582154.
17. Brasil. Coronavírus brasil: ministério da saúde; 2020 [cited 2021 Jan 1]. Available from: https://covid.saude.gov.br
18. Brasil. Ministério da saúde. boletim epidemiológico especial – doença pelo coronavírus COVID-19: ministério da saúde; 2020 [cited 2021 Feb 18]. Available from: https://www.gov.br/saude/pt-br/media/pdf/2020/novembro/13/boletim_epidemiologico_covid_38_final_compressed.pdf
19. Voysey M, Clemens SAC, Madhi SA, et al. Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. Lancet. 2021 01;397(10269):99–111.
20. Polack FP, Thomas SJ, Kitchin N, et al. Safety and efficacy of the BNT162b2 mRNA Covid-19 Vaccine. N Engl J Med. 2020 12; 383(27):2603–2615.
21. Baden LR, El Sahly HM, Essink B, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 Vaccine. N Engl J Med. 2021 02; 384(5):403–416.
22. Logunov DY, Dolzhikova IV, Shcheblyakov DV, et al. Safety and efficacy of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine: an interim analysis of a randomised controlled phase 3 trial in Russia. Lancet. 2021 Feb;397(10275):671–681.
23. FDA. FDA takes additional action in fight against COVID-19 by issuing emergency use authorization for second COVID-19 vaccine: FDA; 2020 [cited 2021 February 17]. Available from: https://www.fda.gov/news-events/press-announcements/fda-takes-additional-action-fight-against-covid-19-issuing-emergency-use-authorization-second-covid
24. EMA. Treatments and vaccines for COVID-19: authorised medicines EMA. 2021 [cited 2021 Feb 17]. Available from: https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/coronavirus-disease-covid-19/treatments-vaccines/treatments-vaccines-covid-19-authorised-medicines#covid-19-vaccines-section
25. ANVISA. Autorização de Uso Emergencial de Vacinas contra a COVID-19 [Emergency use authorizations of COVID-19 vaccines]: gerência-geral de medicamentos e produtos biológicos; 2021 [cited 2021 Feb 17]. Available from: https://www.gov.br/anvisa/pt-br/assuntos/noticias-anvisa/2021/confira-materiais-da-reuniao-extraordinaria-da-dicol/1-apresentacao-ggmed-coronavac.pdf
26. Agência europeia recomenda aprovação da vacina de Oxford [Internet]. Agência brasil, EBC - empresa brasileira de comunicação; 2021 [cited 2021 Feb 19]. Available from: https://agenciabrasil.ebc.com.br/internacional/noticia/2021-01/agencia-europeia-recomenda-aprovacao-da-vacina-de-oxford
27. EMA. EMA recommends COVID-19 Vaccine Janssen for authorisation in the EU. 2021 [cited 2021 Apr 22]. Available from: https://www.ema.europa.eu/en/news/ema-recommends-covid-19-vaccine-janssen-authorisation-eu
28. Ritchie H, Ortiz-Ospina E, Beltekian D, et al. Coronavirus (COVID-19) vaccinations: our world in data; 2021 [cited 2021 Mar 1st]. Available from: https://ourworldindata.org/covid-vaccinations
29. Manavis S Why has the Covid-19 vaccine had such high uptake in the UK?: newStatesman; 2021. Available from: https://www.newstatesman.com/science-tech/coronavirus/2021/04/why-has-covid-19-vaccine-had-such-high-uptake-uk
30. Brasil. Anvisa aprova uso emergencial da vacina da Janssen [ANVISA approves emergency use of Janssen COVID-19 vaccine] Brasília: ministério da Saúde; 2021 [cited 2021 Apr 16]. Available from: https://www.gov.br/anvisa/pt-br/assuntos/noticias-anvisa/2021/anvisa-aprova-uso-emergencial-da-vacina-da-janssen

31. Gomes PH, Falcão M Anvisa pede a ministro suspensão do prazo para decidir sobre importação da vacina Sputnik V [Anvisa asks to ministry to suspend deadline to decide about Sputnik V importation] Brasília: G1; 2021 [cited 2021 Apr 22]. Available from: https://g1.globo.com/bemestar/vacina/noticia/2021/04/20/anvisa-pede-a-ministro-suspensao-do-prazo-para-decidir-sobre-importacao-da-vacina-sputnik-v.ghtml
32. Ferrari M Anvisa recebe pedido de registro definitivo de vacina da Pfizer contra Covid-19 [Pfizer applies to receive definitive use authorization for its COVID-19 vaccine]: CNN Brasil; 2021 [cited 2021 Feb 19]. Available from: https://www.cnnbrasil.com.br/saude/2021/02/06/anvisa-recebe-pedido-de-registro-definitivo-de-vacina-da-pfizer-contra-covid-19
33. Cruz EP Taxa de eficácia geral da Coronavac é de 50,38% [Global efficacy of Coronavac is 50.38%] Brazil: Agência Brasil; 2021 [cited 2021 Feb 18]. Available from: https://agenciabrasil.ebc.com.br/saude/noticia/2021-01/taxa-de-eficacia-geral-da-coronavac-e-de-5038
34. Scliar M. Programa Nacional de Imunizações Brazil: ministério da Saúde; 2003 [cited 2021 Feb 18]. Available from: https://bvsms.saude.gov.br/bvs/publicacoes/livro_30_anos_pni.pdf
35. Domingues CMAS, Maranhão AGK, Teixeira AM, et al. The brazilian national immunization program: 46 years of achievements and challenges. Cad Saude Publica. 2020;36(2):e00222919.
36. CONASEMS. Confira as orientações do Ministério da Saúde sobre vacinação contra a Covid-19 [Check the orientations of Health Ministry about COVID-19 immunization] Brazil: CONASEMS; 2021 [cited 2021 Jan 26]. Available from: https://www.conasems.org.br/confira-as-orientacoes-do-ministerio-da-saude-sobre-vacinacao-contra-a-covid-19/
37. Brasil. Plano preliminar de vacinação contra a COVID-19 prevê quatro fases [Vaccination schedule organized in for phases]: ministério da Saúde; 2021 [cited 2021 Jan 24]. Available from: https://www.gov.br/saude/pt-br/assuntos/noticias/vacinacao-contra-a-covid-19-sera-feita-em-quatro-fases
38. Brasil. Pazuello apresenta cronograma para entregar 230,7 milhões de doses de vacinas contra a Covid-19 até julho [Pazuello presents schedule to deliver 230 million doses of vaccine until july] Brazil: ministério da Saúde; 2021 [cited 2021 Feb 18]. Available from: https://www.gov.br/saude/pt-br/assuntos/noticias/pazuello-apresenta-cronograma-para-entregar-230-7-milhoes-de-doses-de-vacinas-contra-a-covid-19-ate-julho
39. CNN. Ministério da Saúde negocia 70 milhões de doses de vacina da Pfizer [Health Minister to buy 70 million of COVID-19 vaccine doses from Pfizer] Brazil: CNN Brasil; 2020 [cited 2021 Feb 17]. Available from: https://saude.estadao.com.br/noticias/geral,ministerio-da-saude-e-pfizer-avancam-em-compra-de-70-milhoes-de-doses,70003543591
40. Leal A Saúde assina intenção de compra de vacinas da Pfizer e da Janssen Brasília: EBC - Agência Brasil; 2021 [cited 2021 Mar 4]. Available from: https://agenciabrasil.ebc.com.br/saude/noticia/2021-03/saude-assina-intencao-de-compra-de-vacinas-da-pfizer-e-da-janssen
41. Simões E, Boadle A Private Brazilian clinics to buy COVID-19 vaccine from India's Bharat: reuters; 2021 [cited 2021 Mar 4]. Available from: https://www.reuters.com/article/health-coronavirus-brazil-india-idUSL1N2JF0U8
42. Piovesan E, Brandão F Câmara aprova projeto que autoriza estados, municípios e setor privado a comprar vacinas [Chamber approves law project that allows states, cities and private market to buy vaccines] Brasília: câmara dos Deputados; 2021 [cited 2021 Mar 26]. Available from: https://www.camara.leg.br/noticias/731990-camara-aprova-projeto-que-autoriza-estados-municipios-e-setor-privado-a-comprar-vacinas/
43. Brasil. Lei 14.125 de 10/03/2021 [Law number 14,125, 03/10/2021] Brasília: governo Federal; 2021 [cited 2021 Mar 26]. Available from: https://legis.senado.leg.br/norma/33304607.
•• **Important to complement our knowledge of willingness to pay approach**
44. ANVISA. Câmara de Regulação do Mercado de Medicamentos (CMED). 2021 [cited 2021 Feb 18]. Available from: http://portal.anvisa.gov.br/cmed
45. ANVISA. Registro de novos medicamentos: saiba o que é preciso: ANVISA; 2018 [cited 2021 Feb 19]. Available from: http://antigo.anvisa.gov.br/resultado-de-busca?p_p_id=101&p_p_lifecycle=0&p_p_state=maximized&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=1&_101_struts_action=%2Fasset_publisher%2Fview_content&_101_assetEntryId=5062720&_101_type=content&_101_groupId=219201&_101_urlTitle=registro-de-novos-medicamentos-saiba-o-que-e-preciso&inheritRedirect=true
46. ANVISA. Resolução nº 2, de 5 de março de 2004 [Resolution number 2, March 5, 2004]: ANVISA - Agência Nacional de Vigilância Sanitária; 2004 [cited 2021 Feb 18]. Available from: http://antigo.anvisa.gov.br/resolucao-n-2-de-5-de-marco-de-2004
47. Machado CV, LDd L, Baptista T. Políticas de saúde no Brasil em tempos contraditórios: caminhos e tropeços na construção de um sistema universal [Health policies in Brazil during contraditory age: paths and obstacles in building a universal system]. Cad Saúde Pública. 2017;33.
48. De Oliveira GL, Guerra Júnior AA, Godman B, et al. Cost-effectiveness of vildagliptin for people with type 2 diabetes mellitus in Brazil; findings and implications. Expert Rev Pharmacoecon Outcomes Res. 2017 Apr;17(2):109–119.
49. Llp DL, Guerra Júnior AA, Santos M, et al. The assessment for disinvestment of intramuscular interferon beta for relapsing-remitting multiple sclerosis in Brazil. Pharmacoeconomics. 2018 02; 36(2): 161–173.
50. IBGE. Estimativas da População Residente no Brasil e Unidades da Federação com Data de Referência em 1 º de julho de 2020 [Estimatives of Brazilian population as of 1st July] 2020 [cited 2021 Feb 03]. Available from: https://ftp.ibge.gov.br/Estimativas_de_Populacao/Estimativas_2020/POP2020_20201030.pdf
51. Brasil. Ministério da Saúde. Avaliação de Tecnologias em Saúde [Health Technologies Assessment]. In: Saúde M, editor. Brasília. 2009. p. 112.
52. Beshears J, Choi JJ, Laibson D, et al. How are preferences revealed? J Public Econ. 2008 August 01;92(8):1787–1794.
53. Kimenju SC, Morawetz UB, De Groote H Comparing contingent valuation method, choice experiments and experimental auctions in soliciting consumer preference for maize in Western Kenya: preliminary results 2005 [cited 2021 Apr 16]:[https://www.researchgate.net/publication/254549821_Comparing_Contingent_Valuation_Method_Choice_Experiments_and_Experimental_Auctions_in_soliciting_Consumer_preference_for_maize_in_Western_Kenya_Preliminary_results
54. Mould Quevedo JF, Contreras Hernández I, Garduño Espinosa J, et al. El concepto de willingness-to-pay en tela de juicio. Revista de Saúde Pública. 2009;43(2):352–358.
55. Muniz Júnior RL, Godói IP, Reis EA, et al. Consumer willingness to pay for a hypothetical Zika vaccine in Brazil and the implications. Expert Rev Pharmacoecon Outcomes Res. 2019 Aug;19(4):473–482.
• **Important to complement our knowledge of willingness to pay approach**
56. Sarmento TTR, Godói IP, Reis EA, et al. Consumer willingness to pay for a hypothetical chikungunya vaccine in Brazil and the implications. Expert Rev Pharmacoecon Outcomes Res, 2019 Dec: 1–8. DOI: 10.1080/14737167.2020.1703181.
• **Important to complement our knowledge of willingness to pay approach**
57. Haab T, Ke M. Valuing environmental and natural resources: the econometrics of non-market valuation. Cheltenham, UK: Edward Elgar Pub; 2003.
•• **Important to complement our knowledge of willingness to pay approach**
58. Athie TS, Nascimento GC, JMLd C, et al. Willingness to pay for a hypothetical chagas disease vaccine in Northern Brazil: a cross-sectional study and the implications. J Comp Eff Res. 2021;10(8):659–672.
59. García LY, Cerda AA. Contingent assessment of the COVID-19 vaccine. Vaccine. 2020 07;38(34):5424–5429.

60. Dong D, Xu RH, Wong EL, et al. Public preference for COVID-19 vaccines in China: a discrete choice experiment. Health Expect. 2020 12; 23(6): 1543–1578.
61. Harapan H, Wagner AL, Yufika A, et al. Willingness-to-pay for a COVID-19 vaccine and its associated determinants in Indonesia. Hum Vaccin Immunother. 2020 12; 16(12): 3074–3080.
62. IBGE. IBGE divulga o rendimento domiciliar per capita [IBGE publishes domestic per capita earnings] Brazil 2020 [cited 2021 Jan 27]. Available from: https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/26956-ibge-divulga-o-rendimento-domiciliar-per-capita-2019
63. Godói IP, Santos AS, Reis EA, et al. Consumer willingness to pay for dengue vaccine (CYD-TDV, Dengvaxia. Front Pharmacol. 2017;8:41.
•• **Important to complement our knowledge of willingness to pay approach**
64. ANVISA. Lista de preços de medicamentos [Price list of drugs and health technologies]: CMED - Câmara de Regulação do Mercado de Medicamentos; 2021 [cited 2021 Feb 18].
65. WHO. Draft landscape of COVID-19 candidate vaccines 2020 [cited 2020 Dec 04]. Available from: https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines
66. Jimoh A, Sofola O, Petu A, et al. Quantifying the economic burden of malaria in Nigeria using the willingness to pay approach. Cost Eff Resour Alloc. 2007 May;5(1):6.
•• **Important to complement our knowledge of willingness to pay approach**
67. Lumley T. Complex Surveys: a guide to analysis using R. New Jersey, USA: John Wiley & Sons; 2010.
68. IBGE. Números do Censo 2021 [2021 Census numbers] Brazil 2021 [cited 2021 Jan 27]. Available from: https://censo2021.ibge.gov.br/sobre/numeros-do-censo.html
69. UOL. Bolsa tem alta de 0,78% e dólar sobe 0,76%, a R$ 5,415, após o Carnaval Brazil: universo Online; 2021 [cited 2021 Feb 18]. Available from: https://economia.uol.com.br/cotacoes/noticias/redacao/2021/02/17/bolsa-dolar-fecha.htm
70. Galdeano A Covid-19: n ú mero de vacinados no Brasil chega a 2,4 milhões [COVID-19: 2.4 million people vaccinated in Brazil] Brazil: terra; 2021 [cited 2021 Feb 03]. Available from: https://www.terra.com.br/noticias/coronavirus/covid-19-numero-de-vacinados-no-brasil-chega-a-24-milhoes,a64a7b23278fb8b8c67c413e937fa17bowyx0fsd.html
71. Record. Vacinômetro: 27.106.024 brasileiros tomaram a primeira dose [Vaccinometer: 27,106,024 Brazilian already took the first COVID-19 vaccine dosis]: R7; 2021 [cited 2021 Apr 22]. Available from: https://noticias.r7.com/jr-na-tv/videos/vacinometro-27106024-1280-brasileiros-tomaram-a-primeira-dose-20042021
72. Kwok KO, Lai F, Wei WI, et al. Herd immunity - estimating the level required to halt the COVID-19 epidemics in affected countries. J Infect. 2020 06; 80(6): e32–e33.
73. Conti P, Caraffa A, Gallenga CE, et al. The British variant of the new coronavirus-19 (Sars-Cov-2) should not create a vaccine problem. J Biol Regul Homeost Agents. 2020 12;35(1(Suppl 1)):1.
74. Tang JW, Toovey OTR, Harvey KN, et al. Introduction of the South African SARS-CoV-2 variant 501Y.V2 into the UK. J Infect. 2021 Jan;82(4):e8–e10.
75. Esakandari H, Nabi-Afjadi M, Fakkari-Afjadi J, et al. A comprehensive review of COVID-19 characteristics. Biol Proced Online. 2020;22(1):19.
76. Brockmann D, Helbing D. The hidden geometry of complex, network-driven contagion phenomena. Science. 2013 Dec;342 (6164):1337–1342.
77. Lin S, Qiao Y, Huang J, et al. Research on the influence of effective distance between cities on the cross-regional Transmission of COVID-19. medRxiv. 2020;2020(3):27.20044958.
78. G1. Crise do oxigênio no Amazonas: entenda quanto falta e as ações para repor o insumo [Oxygen crysis in amazonas: understand the situation] Brazil: G1; 2021 [cited 2021 Feb 17]. Available from: https://g1.globo.com/am/amazonas/noticia/2021/01/15/crise-do-oxigenio-no-amazonas-entenda-o-quanto-falta-e-as-acoes-para-repor-o-insumo.ghtml
79. Thornton J. Covid-19: lack of testing in Brazil is a "major failure," says MSF. BMJ. 2020 07;370:m2659.
80. UOL. OMS prevê vacina a US$ 10 a dose. Brasil gastaria R$ 4 bilhões com vulneráveis [WHO estimates vaccine at US$ 10. Immunizatino of vunerable on Brazil would cost 4 billion BRL] 2020 [cited 2021 Feb 18]. Available from: https://noticias.uol.com.br/colunas/jamil-chade/2020/08/24/oms-preve-vacina-a-us-10-a-dose-brasil-gastaria-us-4-bi-com-vulneraveis.htm
81. ICTQ. Covid19: OMS revela valor estimado da vacina. Brasil já tem preço calculado [COVID-19: WHO reveals estimated price for the vaccine. Brazil already knows how much will pay for them] Brazil: ICTQ; 2020. [cited 2021 Mar 10]. Available from: https://www.ictq.com.br/farmacia-clinica/1951-covid-19-oms-revela-valor-estimado-da-vacina-brasil-ja-tem-preco-calculado
82. Vasconcelos G Vacina de Oxford custará US$ 3,16 por dose aos cofres públicos, diz Fiocruz Brazil: o Globo; 2020 [cited 2021 Feb 18]. Available from: https://valor.globo.com/brasil/noticia/2020/11/12/vacina-de-oxford-custara-us-316-por-dose-aos-cofres-publicos-diz-fiocruz.ghtml
83. Garrett JG Vacina do Butantan custa 10 dólares por dose e será paga pelo SUS Brazil: exame; 2020 [cited 2021 Feb 17]. Available from: https://exame.com/brasil/vacina-do-butantan-custa-10-dolares-por-dose-e-sera-paga-pelo-sus/
84. V S. The cost of one dose of the Sputnik V vaccine will be less than $10 for international markets 2020 [cited 2021 Feb 18]. Available from: https://sputnikvaccine.com/newsroom/pressreleases/the-cost-of-one-dose-will-be-less-than-10-for-international-markets/
85. Júnior J Projeto autoriza estados, municípios e setor privado a comprarem vacinas contra Covid-19 [Law project allows stated, cities and private market to buy COVID-19 vaccines]: portal da Câmara dos Deputados; 2021 [cited 2021 Mar 26]. Available from: https://www.camara.leg.br/noticias/731344-projeto-autoriza-estados-municipios-e-setor-privado-a-comprarem-vacinas-contra-covid-19
86. Brasil. 2014. Diretriz de Avaliação Econômica [Economics assessment guideline]. In: Saúde M. editor. 2 ed. Brasília. Ministério da Saúde: 134
87. Kirby T. New variant of SARS-CoV-2 in UK causes surge of COVID-19. Lancet Respir Med. 2021 02;9(2):e20–e21.
88. MAKONI, Munyaradzi. South Africa responds to new SARS-CoV-2 variant: land borders have been closed and restrictions continue as a new variant stresses the health system. Lancet. 2021;397:267.
89. Murphy CB Consumer Surplus Definition: investopedia; 2021 [cited 2021 Apr]. Available from: https://www.investopedia.com/terms/c/consumer_surplus.asp
90. Price C. Cost–benefit analysis and willingness to pay for landscape. In: Price C, editor. Landscape Economics. Cham: Springer International Publishing; 2017. p. 133–149.
91. Danzon PM. Differential pricing of pharmaceuticals: theory, evidence and emerging issues. Pharmaco Economics. 2018 December 01;36(12):1395–1405.
92. Ramsey FP. A Contribution to the Theory of Taxation. Econ J. 1927;37(145):47–61.
93. BBC. Coronavírus: a eficácia da coronavac e demais vacinas explicada em 4 gráficos Brazil: BBC Brasil; 2021 [cited 2021 Feb 23]. Available from: https://www.bbc.com/portuguese/brasil-55655588
94. IBGE. Pesquisa Nacional por Amostra de Domicílios (PNAD) 2018. [cited 2021 Mar 08]. Available from: https://www.ibge.gov.br/estatisticas/sociais/populacao/9171-pesquisa-nacional-por-amostra-de-domicilios-continua-mensal.html?=&t=o-que-e