Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
ABSTRACT

Objectives: Amid a pandemic, vaccines represent a promising solution for mitigating public health and economic crises, and an improved understanding of individuals’ vaccination intentions is crucial to design optimal immunization campaigns. This study predicts uptake rates for different COVID-19 vaccine specifications and identifies personal characteristics that moderate an individual’s responsiveness to vaccine attributes.

Methods: We developed an online survey with contingent specifications of a COVID-19 vaccine, varying in effectiveness, risks of side effects, duration of immunity, and out-of-pocket cost. Using population-averaged logit models, we estimated vaccine uptake rates that account for uncertainty, heterogeneity across respondents, and interactions between vaccine and personal characteristics.

Results: We obtained 3047 completed surveys. The highest uptake rate for an annual vaccine, 62%, is predicted when vaccine effectiveness is 80% to 90%, side effects are minimal, and the vaccine is provided at zero cost, with decreases seen in the uptake rate for less effective vaccines, for example, 50% for 50% to 60% effectiveness. Moreover, we found that Americans’ response to vaccine effectiveness depends on their self-reported concern, that is, concerned respondents report a higher willingness to get vaccinated. Our findings also indicate that COVID-19 vaccine uptake rates decrease with vaccine cost and that responsiveness to vaccine cost is moderated by income.

Conclusions: Although providing the COVID-19 vaccine at zero cost will motivate many individuals to get vaccinated, a policy focused exclusively on vaccine cost may not be enough to reach herd immunity thresholds. Although those concerned with COVID-19 will participate, further evidence is needed on how to incentivize participation among the unconcerned (43%) to prevent further pandemic spread.

Keywords: contingent scenarios, preference heterogeneity, vaccine uptake.

Introduction

Amid a pandemic such as COVID-19, a vaccine represents a promising solution that will limit the inequitable impacts of the disease on both the health and finances of citizens across diverse occupations, regions, and races. Nevertheless, once a vaccine is available, there may be underconsumption of vaccines by segments of the population for whom it is either too costly or not desired. Although a vaccine against COVID-19 is highly anticipated in other countries (eg, Chile and China), national polls in the United States predict an uptake rate of 60% to 65%. This may pose a continued public health threat of virus transmission. Therefore, it is imperative that we understand the anticipated vaccine uptake rate and individual preferences for immunizations to facilitate effective policy design.

We conducted a survey-based study to investigate Americans’ preferences for a COVID-19 vaccine and thus provide valuable information for designing and implementing immunization campaigns amid a pandemic. In particular, the objective of our study is twofold. First, we predict uptake rates for different vaccine specifications. Following previous studies on preferences for vaccines against different illnesses, our survey included contingent specifications of a vaccine that could vary in terms of its effectiveness, risk of side effects, duration of immunity, and out-of-pocket cost. Although national polls have elicited Americans’ intention to receive a COVID-19 vaccine, to the best of our knowledge, we present the first study on individual preferences (ie, predicted uptake rates and willingness to pay) for different COVID-19 vaccine specifications. Second, using population-averaged logit models, we investigate how personal characteristics and concern levels moderate individual preferences for vaccine attributes such as vaccine effectiveness and out-of-pocket costs. Our findings are timely and relevant for designing and executing vaccination campaigns that are representative of American preferences to mitigate morbidity, loss of life, and economic damages.
Methods

Survey and Experimental Design

Following best practices (see Boyle and Johnston et al), we designed a web-based survey to investigate individual intentions to get vaccinated against COVID-19 under contingent scenarios. Our survey also elicited respondents’ concern about COVID-19, actual immunization behaviors, and sociodemographic information to control for heterogeneity among respondents. We administered the survey in May 2020 using a snowball sampling strategy, with initial contact made through social media advertising.

Our survey included contingent behavior questions where a vaccine against COVID-19 was available to the public, and respondents were given the choice to take it or not (see Kim et al for a similar approach and Appendix 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.05.007 for a comparison against other elicitation approaches). Vaccine attributes (effectiveness, side effects, duration of immunity, and cost) were randomly varied across choice tasks and respondents. Vaccine effectiveness could take 4 levels: (1) 50% to 60%, (2) 60% to 70%, (3) 70% to 80%, and (4) 80% to 90%. We selected intervals of 10 percentage points to reflect the inherent uncertainty about vaccine effectiveness, consistent with past average effectiveness levels for vaccines for respiratory illnesses such as influenza (20%-60%) and pneumonia (60%-70%). Other intervals were excluded because they did not represent credible scenarios when we implemented our survey at the beginning of the pandemic, for example, 90% to 100%. The probability of experiencing mild side effects could take 4 levels—(1) less than 25%, (2) 25% to 50%, (3) 50% to 75%, and (4) 75% to 100%—and for moderate side effects could take 3 levels: (1) 0% to 1%, (2) 1% to 10%, and (3) 10% to 20%. For moderate side effects, we excluded any probability above 20% based on hesitancy from healthcare providers consulted in our design and pretesting stages that such a vaccine will be approved for public distribution. We excluded the risk of severe adverse effects as an attribute but included the Centers for Disease Control and Prevention disclaimer “As with any medicine, there is a very remote chance of a vaccine causing a severe allergic reaction, other serious injury, or death.” The duration of immunity could be 1, 3, or 6 years, and the out-of-pocket cost $50, $100, $150, $200, $250, $300, or $400. Those values were determined in pretesting stages based on the willingness to pay for a COVID-19 vaccine reported by selected participants at our institutions. Appendix 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.05.007 shows an example of the contingent behavior questions. Each respondent was asked to perform 4 choice tasks.

We included follow-up questions to further investigate respondents’ intentions to get vaccinated. We elicited the certainty levels of respondents regarding their answer to each contingent behavior question using a 0 to 10 scale varying from very unsure to very sure. We also included follow-up questions for those respondents who provided the same “Yes” or “No” response in the 4 individual choice tasks. These questions allow us to probe reasons why respondents would take the vaccine or not, apart from the vaccine attributes.

Analytical Framework and Econometric Modeling

Empirically, the probability that individual $i$ would choose to get vaccinated in the contingent scenario $k$, that is, $Pr(Y_{ik} = Yes)$, can be modeled using a logit specification as follows:

$$Pr(Y_{ik} = Yes) = \frac{1}{1 + e^{-\beta \theta_{ik} + Z_{ik} \delta + \alpha + u_{ik}}}$$

where $X$ is the vector of vaccine attributes included in the contingent scenarios and $Z$ is the vector of individual characteristics (Table 1). $\beta$ and $\delta$ represent the coefficients to be estimated. The idiosyncratic error term is represented by $u$. To control for potential intracluster correlation among choices of a given respondent, we estimated population-averaged logit models, which include an average latent parameter for all respondents (ie, $\alpha^*$). allowing us to predict vaccine uptake rates for different groups (eg, concerned vs unconcerned individuals).

Given our objective of predicting COVID-19 vaccine uptake rates for different vaccine specifications, we evaluate 3 hypotheses regarding individual responses to vaccine attributes. We hypothesize that binary indicators of vaccine effectiveness (effective: 60%-70%, 70%-80%, 80%-90%) have a positive effect relative to the excluded category of 50% to 60% effectiveness. In contrast, we expect negative effects associated with higher probabilities of experiencing side effects (mild risk, 25%-50%, 50%-75%, 75%–100%; moderate risk, 1%-10%, 10%-20%) and for higher out-of-pocket costs. We also control for duration of immunity (duration) given that previous studies have found that longer durations of immunity have a positive effect on the choice to get vaccinated.

In addition to the vaccine-specific characteristics, we control for heterogeneity among the respondents because personal characteristics may influence individuals’ vaccination decisions. We predict a positive effect of “concerned” because people who are worried about themselves or close contacts being infected may perceive the vaccine as a means to mitigate that concern. Similarly, we expect that individuals who received the flu vaccine in the last year are more likely to get a COVID-19 vaccine, because they have demonstrated risk aversion and proactive vaccination to stay healthy. The effects of other characteristics such as age, education, sex, race, and household size remain to be empirically estimated. We also interact vaccine effectiveness with concern levels and out-of-pocket cost with income given that those personal characteristics can moderate individuals’ response to those vaccine attributes.

To address the potential coverage bias stemming from our convenience sampling approach, we correct for weighting using an iterative proportional fitting (raking) procedure. We generate weights using 5 population parameters, along 3 dimensions: sex-age groups (male/female × 3 age groups: 18-39, 40-59, 60+), regions (Northeast, South, Midwest, West), and race-flu vaccination status groups (2 race categories: non-Hispanic white or all others × 2018 flu vaccination) based on the 2018 American Community Survey and Centers for Disease Control and Prevention FluVaxView Report. We incorporate flu vaccination status to capture attitudes toward vaccines, in the spirit of Mercer et al who incorporated political variables to reduce bias in poll estimates.

We estimate 2 (weighted) population-averaged logit models. Model 1 presents the results from our raw data. Model 2 follows the best practice of correcting for respondents’ uncertainty regarding vaccination by recoding positive responses as negative when their certainty level was less than 8 in a 0 to 10 scale (Appendix 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.05.007 for discussion). We use the models to predict the probability that the average respondent will get...
Table 1. Sociodemographic characteristics.

| Variables       | Definition                                                                 | Unweighted | Weighted | Population mean* |
|-----------------|-----------------------------------------------------------------------------|------------|----------|------------------|
|                 | Mean | SD      | Min | Max | Mean | SD      | Min | Max |                |
| Income          | Household income in 2019 measured in intervals of $50 000¹                   | 2.385      | 1.202   | 1   | 5   | 2.263 | 1.142 | 1   | 5   | 1.757         |
| Concerned       | If the respondent is concerned or very concerned about COVID-19 (1 = yes; 0 = otherwise) | 0.703      | 0.457   | 0   | 1   | 0.570 | 0.495 | 0   | 1   | —             |
| Flu vaccine     | If the respondent received the influenza vaccine in the last 12 months (1 = yes; 0 = otherwise) | 0.659      | 0.474   | 0   | 1   | 0.450 | 0.498 | 0   | 1   | 0.453       |
| Age             | Age of respondent in years                                                  | 49.743     | 15.340  | 18  | 86  | 48.634 | 15.092 | 18 | 86  | 38.2²       |
| Education       | If the respondent has an undergraduate or graduate degree (1 = yes; 0 = otherwise) | 0.698      | 0.459   | 0   | 1   | 0.630 | 0.483 | 0   | 1   | 0.301       |
| Female          | If the respondent is female (1 = yes; 0 = otherwise)                        | 0.720      | 0.449   | 0   | 1   | 0.513 | 0.500 | 0   | 1   | 0.508       |
| White           | If the respondent is white (1 = yes; 0 = otherwise)                         | 0.943      | 0.232   | 0   | 1   | 0.705 | 0.456 | 0   | 1   | 0.602       |
| Household size  | Household size                                                              | 2.937      | 1.541   | 1   | 20  | 3.045 | 1.659 | 1   | 20  | 2.63         |

Max, maximum; Min, minimum; SD, standard deviation.

*Source: US Census Bureau, 2018 American Community Survey 1-year estimates: Table DP05 (median age, female, white non-Hispanic); Table S1501 (education, 18+); Table S1901 (income); Table S1101 (household size).

¹Under the assumption that income is uniformly distributed within each interval, multiplying by $50 000 represents the average income.
²Source: Centers for Disease Control and Prevention. Flu Vaccination Coverage, United States, 2018 to 2019 Influenza Season. https://www.cdc.gov/flu/fluview/coverage-1819estimates.htm. Accessed July 1, 2020.
³Population age is reported for the median citizen.

vaccinated under different vaccine specifications: \( P(Y_k = \text{Yes} | X, Z, \hat{\beta}, \hat{\delta}) \), where \( \hat{\beta} \) and \( \hat{\delta} \) are estimated coefficients from equation 1, \( Z \) is the vector of individual characteristics for the average respondent, and \( X \) represents the set of vaccine attributes. The indicators representing characteristics of the vaccine specification of interest are set equal to 1, while other indicators are set equal to zero. As customary in the literature,⁵ we interpret those probabilities as vaccine uptake rates by expressing them in percentage terms. We also estimate monetary values for each level of vaccine attributes by multiplying the corresponding coefficients by the negative reciprocal of the estimated coefficient of vaccine cost (ie, \( -\hat{\beta}_k/\hat{\delta}_{\text{COST}} \), where \( k \) represents vaccine attributes other than cost).

Results

Our sampling procedure yielded 3047 completed surveys. Table 1 shows a profile of the average respondent relative to the US population. Our sample has low representation by males (28%) and minority groups (6%), and the average age, education, and income profile are above population averages. Sampling weights correct for the misrepresentation of several groups, with the exception of income and education that remain above the population average, which is a common finding in internet-based surveys.³⁰,³¹

Appendix 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.05.007 reports the estimated coefficients from the population-averaged logit models. Given that logit coefficients are difficult to interpret, in Table 2, we report the marginal effect of each covariate on the probability of taking the vaccine. Additionally, in Table 3, we report monetary values assigned to vaccine attributes.

Main Effects

Estimated marginal effects suggest that individuals are responsive to the vaccine effectiveness, high risks of experiencing moderate side effects, the duration of immunity, and out-of-pocket costs (Table 2). In contrast, individuals seem indifferent to the risk of experiencing mild side effects. The probability of taking the vaccine increases by 0.066 as vaccine effectiveness increases from 50% to 60% to 60% to 70%, 0.13 when it increases to 70% to 80%, and 0.153 for 80% to 90%. Model 2 yields similar marginal effects of vaccine effectiveness. The only reaction to side effects is observed when the risk of experiencing moderate side effects increases to 10% to 20%, with a decrease in the probability of getting vaccinated of almost 0.03. In the case of duration of immunity, the probability of getting vaccinated increases by 0.015 with each additional year. Finally, as expected, the out-of-pocket cost has a negative effect on the likelihood of getting vaccinated, approximately 0.001 for each additional dollar.

The probability of getting vaccinated also varies with individual characteristics. Income has a positive effect, increasing the probability by approximately 0.035 when moving to the next income bracket (increments of $50 000). The major difference in the likelihood of getting vaccinated is between individuals who...
are concerned about COVID-19 and those who are not, with a gap of 0.411 between their probabilities of receiving the vaccine. Similar to Eilers et al.\(^8\) and de Bekker-Grob,\(^7\) we find that the probability of getting vaccinated is greater for individuals who received the influenza vaccine in the last 12 months than those who did not, by almost 0.2. Consistent with documented immunization behaviors,\(^32\)-\(^34\) our results also show that white respondents are more likely to get vaccinated than other ethnic groups, with a differential in the probability of getting vaccinated of almost 0.1. Finally, we found that the probability of getting vaccinated decreases with age and household size and increases with education.

Table 3 shows marginal monetary values for changing vaccine attributes. The average person would pay approximately $48 to increase the vaccine effectiveness from the base range of 50% to 60%-70% to 70%-80% and more than $60 if the effectiveness is 80%-90%. In contrast, the value of the vaccine would decrease by more than $30 if the risk of moderate side effects increases from 0% to 1%-10% to 10%-20%. Findings also indicate that each additional year of immunity increases the value of the vaccine by more than $15.
Interaction Effects

To facilitate the interpretation of interaction terms, we predict the uptake rates for different vaccine specifications at different costs by income and at varying levels of vaccine effectiveness by level of concern. Figure 1 shows predicted uptake rates for 2 vaccine specifications based on the interaction of household income and out-of-pocket cost (Model 1). Both vaccine specifications are similar in terms of risk of mild side effects (0%-25%), risk of moderate side effects (0%-1%), and duration of immunity (1 year), only differing from each other in the level of effectiveness (50%-60% or 80%-90%). For simplicity, we plot the top and bottom income brackets in text only. The comprehensive set of interactions is presented in Appendix 4 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.05.007; nevertheless, Appendix 5 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.05.007 shows predicted uptake rates for the same vaccines using the uncertainty-corrected model (Model 2).

As expected, the predicted uptake rates decrease as out-of-pocket cost increases. Nevertheless, individual responsiveness to vaccine costs varies across income brackets, with the uptake rate decreasing more rapidly for individuals with lower levels of income. As shown in Figure 1, the uptake rate for a vaccine with 50% to 60% effectiveness at 0 cost is approximately 50%, regardless of the level of household income. If the cost of the vaccine increases to $400, the uptake rate decreases to less than 15% for individuals with income below $50 000. In contrast, the uptake rate at a cost of $400 is above 31% for an individual with income between $150 000 and $200 000. For a vaccine with effectiveness of 80% to 90%, the uptake rate is approximately 62% at 0 cost, with minimal differentials across income brackets. Nevertheless, there is a substantial gap in uptake rates when vaccine cost increases. At a cost of $400, the uptake rate decreases by approximately 16 percentage points for individuals with an income of $150 000 to $200 000. For individuals with income below $50 000, the uptake rate decreases by more than 30 percentage points.

Uptake rate curves are parallel in Appendix 5 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.05.007 panels a and b because the interaction term between vaccine cost and income is statistically insignificant in the uncertainty-corrected model (Model 2 in Appendix 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.05.007). This suggests that responsiveness to vaccine cost is similar across income levels after considering individuals’ uncertainty. These uptake rates are more conservative, with the highest rate at 56% for a vaccine with 80% to 90% effectiveness at 0 cost among individuals with income between $150 000 and $200 000. At a cost of $400, 21% of individuals with income below $50 000 would get vaccinated. Uncertainty-corrected uptake rates remain below 42% for a vaccine with 50% to 60% effectiveness, even when it is available at 0 cost.

We also find a significant interaction between vaccine effectiveness and personal concern, suggesting that concerned individuals are more responsive to vaccine effectiveness than those who are not concerned. The uptake rate among concerned individuals increases by 21 percentage points (64%-85%) when vaccine effectiveness increases from 50% to 60% to 80% to 90%. Among unconcerned individuals, the uptake rate would increase by 7.5 percentage points (28.7%-36.2%). Compared with people who are not concerned, concerned individuals are 35 percentage points more likely to receive a vaccine with 50% to 60% effectiveness at 0 cost and almost 49 percentage points more likely when the vaccine has an effectiveness of 80% to 90% (Fig. 2). When correcting for response uncertainty, the uptake gap for a vaccine with 80% to 90% effectiveness is above 46 percentage points (70.7% vs 24.2%).

Our findings are robust across alternative model specifications (not reported). For instance, we include the number of cases and the number of deaths at the state level as control variables to account for local COVID-19 incidence. Nevertheless, these variables were not individually significant and nor did they affect the estimated results, so we opt to report the parsimonious models’ results only.

Reasons to Reject the Vaccine

Of the 3047 respondents, 30.8% rejected each vaccine specification presented to them, 46.2% consistently provided positive
responses, and 23% provided mixed responses across vaccine specifications. We asked respondents with consistent responses about their reasons to receive or reject the vaccine. The main reason to reject the vaccine is that the individual would prefer to build antibodies in a form other than the vaccine, followed by the other reason option in which they could state their own reasons in an open-ended format (Fig. 3). Among these responses, several of the answers we provided were echoed in greater detail: for example, why costs were too cumbersome, personal experiences of adverse side effects from vaccines, and concerns about the safety of a vaccine rushed to market. New replies included arguments for free vaccines, distrust for the government or vaccine manufacturers, and conspiracies regarding tracking devices. Excluding “other,” vaccine cost and side effects are the second and third most popular reasons to reject the vaccine, respectively. Few respondents reported that they do not believe in vaccines, and even less reported religious reasons to reject the vaccine. We also elicited reasons to receive the vaccine. Those responses suggest that individuals would receive the vaccine primarily to protect themselves (43.4%) and others within their household or care (44.2%).

Discussion and Conclusions

Using contingent behavior questions, we investigated personal intentions to get vaccinated against COVID-19 during the first wave of infection in the United States. We employed a “take-it-or-leave-it” approach: comparing one vaccine specification with the option to opt out. We chose this design to represent the most likely scenario of initial vaccine distribution amid a pandemic. This parsimonious approach places less cognitive and emotional burden on respondents, who may already be overwhelmed by virus’ impact or mitigation responses such as curfews and lockdown. Because vaccines with different effectiveness gradually emerge, it is important to understand how vaccine attributes and personal characteristics influence impending immunization behaviors.

Our predicted uptake rates suggest that there is a substantial share of the population who would not receive a COVID-19 vaccine, even if it is highly effective and distributed at 0 cost. Our findings also indicate that vaccine attributes and personal characteristics influence impending immunization behaviors. Consistent with previous studies (eg, de Bekker-Grob et al7; Determann et al11; Eilers et al8), we found that effectiveness is the most relevant vaccine attribute for choosing to get vaccinated, followed by duration of immunity. Additionally, we evaluated the heterogeneity of responses to effectiveness and cost. We found that individual responsiveness to vaccine effectiveness is exacerbated by concerns about the pandemic and that, although individuals are responsive to vaccine cost, such responsiveness is moderated by household income.

From a public health perspective, it is concerning that a substantial share of the population does not intend to get vaccinated against COVID-19, even if it is relatively effective and at 0 out-of-pocket cost. According to our results, subsidizing the vaccine would motivate individuals to get vaccinated, particularly those with low levels of income. Nevertheless, subsidies alone would not be enough to reach universal vaccine usage in the United States. One concern for our methodological approach is that it overrepresents Americans with higher education and income. To the extent that the weighting procedure did not account entirely for this bias, our results represent an upper bound of the uptake rate given reduced vaccine hesitancy observed among higher income and educated groups. In spite of this, our predicted results are consistent with nationally representative polls by Gallup4 (July 20-August 2) and National Public Radio and Public Broadcasting Service NewsHour Marist Poll5 (August 3-11) and suggest that the current policy of providing vaccines at 0 cost will not be enough to reach even a conservative herd immunity threshold of 70% in the United States. Moreover, we anticipate that manufacturer-specific uptake rates will be lower for vaccines of lower effectiveness.

Figure 3. Reasons for rejecting all vaccine specifications (n = 939).
effectiveness, all else equal. Hence, as Americans continue getting free vaccines, policy makers may also need to design and implement complementary strategies to motivate individuals who currently do not intend on getting vaccinated to participate in immunization campaigns. According to our descriptive analysis of reasons for nonparticipation, responses to preference for building “natural immunity” and observation of longer-term side effects among early vaccinators may be important considerations.

Among individual characteristics related to the choice to get vaccinated, our results suggest that concern about COVID-19 is the most influential. García and Cerda² found high acceptance levels for a COVID-19 vaccine in Chile (90.6%), where 99.1% of respondents believed they were at risk of being infected. In contrast, a substantial share of our respondents were not concerned about COVID-19, most of whom do not intend on getting vaccinated. Based on this finding, we pose 2 questions for future studies: (1) Do individual concerns reflect actual health risks? (2) How do individuals form health risk perceptions amid a pandemic? We need further information to assess whether individuals misestimate the health risks imposed by pandemics. If they do, those misperceptions could lead to suboptimal rates of vaccination, which could prolong pandemic-related crises, or lead to private and public overspending on immunization. Identifying factors that influence those concerns is equally important to design public policies aimed at aligning perceived and actual risks. As our results show, vaccine attributes, economic constraints, and personal concerns should be considered when designing responsive, optimal immunization programs.

### Supplemental Material

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jval.2021.05.007.

### Article and Author Information

**Accepted for Publication:** May 23, 2021

**Published Online:** August 4, 2021

doi: https://doi.org/10.1016/j.jval.2021.05.007

**Author Affiliations:** Department of Economics, Fairfield University, Fairfield, CT, USA (Vásquez); Department of Business Economics, Sacred Heart University, Fairfield, CT, USA (Trudeau).

**Correspondence:** Jennifer M. Trudeau, PhD, Department of Business Economics, Sacred Heart University, West Campus, E-1127, 3135 Easton Turnpike, Fairfield, CT 06825, USA. Email: trudeau@sacredheart.edu

**Author Contributions:** Concept and design: Vásquez, Trudeau

Acquisition of data: Vásquez, Trudeau

Analysis and interpretation of data: Vásquez, Trudeau

Drafting of the manuscript: Vásquez, Trudeau

Critical revision of the paper for important intellectual content: Vásquez, Trudeau

Statistical analysis: Vásquez

Administrative, technical, or logistic support: Trudeau

**Conflict of Interest Disclosures:** The authors reported no conflict of interest.

**Funding/Support:** This research was supported by a grant from Fairfield University’s Mahoney Fund.

**Role of the Funder/Sponsor:** The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

**Acknowledgment:** The authors are grateful for grant support from Fairfield University’s Mahoney Fund.

### Ethics Approval

The questionnaire and methodology of this study was granted approval by Fairfield University Institutional Review Board under protocol no. 3758 and Sacred Heart University’s Institutional Review Board under protocol no. 200416A.

### REFERENCES

1. Fadda M, Albanese E, Suggs LS. When a COVID-19 vaccine is ready, will we all be ready for it? Int J Public Health. 2020;65(6):711–712.

2. García LY, Cerda AA. Contingent assessment of the COVID-19 vaccine. Vaccine. 2020;38(34):5424–5429.

3. Leng A, Miallard E, Wang S, Nicholas S, Liu R, Wang J. Individual preferences for COVID-19 vaccination in China. Vaccine. 2021;39(2):247–254.

4. O’Keefe MS. One in three Americans would not get COVID-19 vaccine. Gallup. https://news.gallup.com/pol/317038/one-three-americans-not-covid-vacci.aspx. Accessed September 5, 2020.

5. NPR/PBS NewsHour/Marist poll. Marist College Institute for Public Opinion. http://maristpoll.marist.edu/wp-content/uploads/2020/08/NPR_PBS-NewsHour_Marist-Poll_USA-NOS-and-TABLES_202008121039.pdf#page=3. Accessed September 5, 2020.

6. Tyson A, Johnson C, Funk C. U.S. public now divided over whether to get COVID-19 vaccine. Pew Research Center. https://www.pewresearch.org/science/2020/09/17/u-s-public-now-divided-over-whether-to-get-covid-19-vaccine/. Accessed September 5, 2020.

7. de Bekker-Grob EW, Veldwijk J, Jonker M, et al. The impact of vaccination and patient characteristics on influenza vaccination uptake of elderly people: a discrete choice experiment. Vaccine. 2018;36(11):1467–1476.

8. Eilers R, de Melker HE, Veldwijk J, Krabbe FPM. Vaccine preferences and acceptance of older adults. Vaccine. 2017;35(21):2823–2830.

9. Kim D, Canh DC, Poulos C, et al. Private demand for cholera vaccines in Hue, Vietnam. Value Health. 2008;11(1):119–128.

10. Liao CH, Liu JT, Pwu KF, Yoo SL, Chow J, Tang CH. Valuation of the economic benefits of human papillomavirus vaccine in Taiwan. Value Health. 2009;12(suppl 3):S74–S77.

11. Sadique MZ, Devlin N, Edmonds WJ, Parkin D. The effect of perceived risks on the demand for vaccination: results from a discrete choice experiment. PLoS One. 2013(8):e254149.

12. Shono A, Kondo M. Parents’ preferences for seasonal influenza vaccine for their children in Japan. Vaccine. 2014;32(39):5071–5076.

13. Verotl F, Kesuels R, Delva W, Beutels P, Willem L. Drivers of vaccine decision-making in South Africa: a discrete choice experiment. Vaccine. 2019;37(15):2079–2089.

14. Boyle KJ. Contingent valuation in practice. In: A Primer on Nonmarket Valuation. Berlin, Switzerland: Springer. 2013:131.

15. Johnston RJ, Boyle KJ, Adamowicz W, et al. Contemporary guidance for stated preference surveys. J Assoc Environ Resour Econ. 2017;4(2):319–405.

16. Kim SY, Sagiraju H, Russell LB, Sinha A. Willingness-to-pay for vaccines in low- and middle-income countries: a systematic review. Ann Vaccines Immun. 2014;1(1):1001.

17. CDC seasonal flu vaccine effectiveness studies. Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases (NCIRD). https://www.cdc.gov/vaccines/work/effectiveness-studies.htm. Accessed April 15, 2020.

18. About pneumococcal vaccines. Centers for Disease Control and Prevention. https://www.cdc.gov/vaccines/vpd/pneumo/hcp/about-vaccine.html#. Accessed April 15, 2020.

19. Neuhaus JM, Kalbfleisch JD, Hauck WW. A comparison of cluster-specific and population-averaged approaches for analyzing correlated binary data. Int Stat Rev Int Stat Rev. 1991;59(1):25–35.

20. Neuhaus JM. Statistical methods for longitudinal and clustered designs with binary responses. Stat Methods Med Res. 1992;1(3):249–273.

21. Dettmann D, Korfage IJ, Lambooij MS, et al. Acceptance of vaccinations in pandemic outbreaks: a discrete choice experiment. PLoS One. 2014;9(7):e102505.

22. de Bekker-Grob EW, Hofman R, Donkers B, et al. Girls’ preferences and acceptance of rotavirus vaccination in young children: a discrete choice experiment in Hong Kong. PLoS One. 2018;21(5):622–628.

23. Wong CKH, Man KKC, Ip P, Kwan M, McGhee SM. Mothers’ preferences and willingness to pay for human papillomavirus vaccination for their daughters: a discrete choice experiment in Hong Kong. Value Health. 2018;21(5):622–629.

24. Kolenikov S. Calibrating survey data using iterative proportional fitting (raking). STATA J. 2014;14(1):22–59.

25. Ruggles S, Flood S, Goeken R, et al. IPUMS USA: version 10.0 [dataset]. IPUMS. 2021;38(34):5424–5429.

26. Flu vaccination coverage, United States, 2018-19 in FLU/REVIEW/cases-and-coverage-1819estimates.htm. Accessed June 15, 2020.

27. Philippine Obstetrical and Gynecological Society. 2020;38(34):5424–5429.
29. Hall J, Kenny P, King M, Louviere J, Viney R, Yeoh A. Using stated preference discrete choice modelling to evaluate the introduction of varicella vaccination. *Health Econ.* 2002;11(5):457–465.

30. Bandilla W, Bosnjak M, Aldorfer P. Survey administration effects? A comparison of web-based and traditional written self-administered surveys using the ISSP environment module. *Soc Sci Comput Rev.* 2003;21(2):235–243.

31. Boas TC, Christenson DP, Glick DM. Recruiting large online samples in the United States and India: Facebook, Mechanical Turk, and Qualtrics. *Polit Sci Res Methods.* 2020;8(2):232–250.

32. Almario CV, May FP, Maxwell AE, Ben W, Ponce NA, Spiegel BM. Persistent racial and ethnic disparities in flu vaccination coverage: results from a population-based study. *Am J Infect Control.* 2016;44(9):1004–1009.

33. Lu PJ, O’Halloran A, Williams WW, Lindley MC, Farrow S, Bridges CB. Racial and ethnic disparities in vaccination coverage among adult populations in the U.S. *Vaccine.* 2015;33(suppl 4):D83–D91.

34. Marin MG, Johanson Jr WG, Salas-Lopez D. Influenza vaccination among minority populations in the United States. *Prev Med.* 2002;34(2):235–241.

35. Arafa JE, Léon CJ, Hanemann MW. Emotions and decision rules in discrete choice experiments for valuing health care programmes for the elderly. *J Health Econ.* 2008;27(3):753–769.

36. de Bekker-Grob EW, Ryan M, Gerard K. Discrete choice experiments in health economics: a review of the literature. *Health Econ.* 2012;21(2):145–172.

37. Khubchandani J, Sharma S, Price JH, Wiblishauser MJ, Sharma M, Webb FJ. COVID-19 vaccination hesitancy in the United States: a rapid national assessment. *J Community Health.* 2021;46(2):270–277.

38. Iboi EA, Ngonghala CN, Gumel AB. Will an imperfect vaccine curtail the COVID-19 pandemic in the U.S.? *Infect Dis Model.* 2020;5:510–524.

39. Omer SB, Yildirim I, Forman HP. Herd immunity and implications for SARS-CoV-2 control. *JAMA.* 2020;324(20):2095–2096.

40. Randolph HE, Barreiro LB. Herd immunity: understanding COVID-19. *Immunity.* 2020;52(5):737–741.