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RESEARCH PAPER

Quantitative Effects of Public Perception on Demand for Covid-19 Vaccines: A Behavioral Economics Approach in Iran

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Abstract
In this study, using the behavioral economics approach and following Hursh method, we address the question of the extent to which the framing of questions about the demand for Iranian and foreign vaccines can influence COVID-19 vaccination intentions. The number of final respondents was 496, and the results showed that demand for foreign vaccines was higher than demand for Iranian vaccines at all levels of efficacy. When vaccine efficacy was 90%, demand for Iranian and foreign vaccines was 68.9% and 50.7%, respectively. The main model results showed: 1- Framing the vaccine development process increased the minimum efficacy required by people for Iranian vaccines by more than seven percentage points. This value confirms people's concern about the Iranian vaccine development process. 2- People's belief in the effectiveness of the flu vaccine decreased their minimum effectiveness by more than four percentage points. 3- Higher well-being of individuals' subjective socioeconomic status increased the rate of reduction in individuals' required minimum efficacy (from -4.29 percentage points to -7.58 percentage points). 4- The very high willingness of individuals to be vaccinated reduced the minimum effectiveness required to more than eight percentage points. The coverage curve estimate also indicated that at a 60% coverage rate, the level of information and promotion should be about 96.8% for the Iranian vaccines and 89.3% for the foreign vaccines.
Keywords: Behavioral Economics, COVID-19, Foreign Vaccines, Framing Effect, Iranian Vaccines.
JEL Classification: D910, D12, I12.

1. Introduction

The pandemic of corona disease has resulted in tens of thousands of people dying every day around the world. Iran is no exception to this pandemic, and several hundred people die every day on average. This issue has led to countries around the world vying to find different treatments for this disease. The most definitive long-term solution to control and eradicate COVID-19 is vaccination. Efforts to develop vaccines in some developed countries have made them available to the public. As a developing country, to support national production, Iran is trying to develop Iranian vaccines and make them available to the public as soon as possible. Due to the development of foreign vaccines by other countries and making them available in the consumer market, people's demand for foreign vaccines is natural. However, given the concerns about the vaccine development process, we should also be aware of what level of demand will formed by the community for the Iranian vaccine development process. Since achieving full vaccination coverage will likely end the nationwide corona disease pandemic, we should consider the vaccination coverage rate along with the level of vaccine demand to achieve the highest vaccination coverage rate. By applying the psychology of individuals' behavior in economic contexts, such as the demand curve, behavioral economics provides an empirical approach to quantify attitudes toward COVID-19 vaccination and explain how biases and cognitive behaviors can influence rational behavior. Vaccine acceptance by members of society requires an examination of human behavior in receiving the vaccine. In this regard, the most important and challenging question in vaccine development for each person who will receive the vaccine is the level of efficacy and immunity they expect from the vaccine. Therefore, behavioral economics can determine the demand for Iranian and foreign vaccines in the context of one of the types of cognitive biases called the framing effect of the development of Iranian and foreign vaccines based on hypothetical purchasing situations. It is possible to estimate the vaccination coverage rate and the solution to achieve the highest coverage rate by modeling the demand curves. The simulation of demand using the information on the development process of Iranian and foreign vaccines in the form of hypothetical purchase situations assumes that respondents express their desire to purchase hypothetical goods (Iranian and foreign vaccines in this case) and provide a picture of consumption trends. Assessing individual differences (related to conspiracy theories, corona disease prevention measures, vaccine history, and demographic characteristics) in individual demand may reveal key factors for correcting misconceptions and misunderstandings about vaccine development. Therefore, this work aims to extract the demand curves for Iranian and foreign vaccines by using psychological criteria, such as vaccine question framing, based on the method of Hursh et al. (2020). Then, using a linear mixed-effects model, the effects of the vaccine development process and individual characteristics on the minimum efficacy required for vaccine acceptance are evaluated. Finally, by calculating the coverage rate using individual demand level information and within the demand function framework, a practical solution is explored to achieve the highest expected coverage rate (Hursh et al., 2020).

Many previous domestic papers have estimated the demand curve for various commodities within the framework of conventional economics. However, the difference between this study and previous research is that the estimation of the demand curve was done within the framework of behavioral economics and taking into account the framing effect bias.

The remainder of this paper is organized as follows. Section 2 provides the theoretical foundations, and Section 3 reviews the previous studies on the subject matter. In Section 4, the research model, the variables, and then the data are elaborated. Section 5 analyzes the results in detail, and finally, Section 6 concludes the paper.

2. Theoretical Foundations

Behavioral economics refers to an approach to understanding the behavior and decision-making of individuals by combining the behavioral sciences (psychology) with the principles of conventional economics. This approach emphasizes psychological cooperation in economics or economic behavior. This approach shows how the mechanisms described by cognitive psychology can explain systematic deviations from neoclassical economic forecasts (e.g., status quo bias and loss aversion) (Strickland et al., 2021). Behavioral economics helps explain how biases and cognitive behaviors can influence rational behavior (Hursh et al., 2020). The main theories of behavioral economics operate within the framework of a single concept. This concept is referred to as cognitive bias. A cognitive bias refers to a systematic (i.e., non-random and therefore predictable) deviation from rationality in judgment or decision-making. In other words, a cognitive bias is a type of irrational behavior that is predictable (because it is systematic). Cognitive biases underlie many beliefs and behaviors that are dangerous or problematic for individuals, such as superstition, pseudoscience, prejudice, poor consumer choices, etc. (Blanco, 2017). One type of cognitive bias is called the framing effect. This type of bias is favored by many behavioral economists, where the choice between two options, A and B, is under the influence of choosing either A or B as a presupposed option. Imagine, for example, that Iran is preparing for an outbreak of an unusual Asian disease that is expected to kill 600 people. Two alternative programs have been proposed to combat this disease. Suppose that the precise scientific assessment of the consequences of the plans is as follows: a- If Plan A is adopted, 200 people will be saved; b- If Plan B is adopted, there is a one-third chance that 600 people will be saved and a two-thirds chance that none of the people will be saved. In this framework, most respondents prefer Plan A, indicating risk aversion. Other randomly selected respondents are asked a question in which different explanations of the options follow the same problem. a- 400 people will die if Plan AA is approved; b- if Plan BB is approved, there is a one-third chance that no one will die and a two-thirds chance that 600 people will die. A clear majority of respondents favor the BB plan, a high-risk option. This example shows that while there is no fundamental difference between these two types of framing, the introduction of clever forms produces different evaluations in people's minds. In this frame, the certainty of saving people is disproportionately attractive, while accepting the certain death of people is disproportionately aversive. Using this example, we can see that proposing different forms of a type of framing has a great advantage in people's choices, especially for decisions that matter significantly (Kahneman, 2003). Therefore, the framing effect can be classified as one of the types of cognitive biases in economic frameworks such as the demand curve to determine the level and direction of individual demand. Thus, behavioral economics is a field that analyzes human decision-making, combining the concepts of behavioral psychology and consumer demand theory. A new and effective method for data collection in behavioral economics is the hypothetical purchase task (HPT). It shows the response to consumption of goods (demand) by placing respondents in hypothetical situations when the price increases. The HPT is a questionnaire used to determine what people are willing to buy when a certain price of goods increases (Khan, 2020). Behavioral demand simulation is conducted with an HPT questionnaire. Jacobs and Bickel (1999) introduced this technique. It is a general form of the respondent indicating how many units of goods they will consume over a wide range of prices. HPT data provide all kinds of sensitive and revealing initiative criteria to quantify the value of goods and their motivation for consumption at the individual, group, market, and population levels when measuring actual consumption in the laboratory or "real world" market is impractical, immoral, illegal, or impossible. Although the HPT method has evolved from the behavioral psychology approach of behavioral economics, its conceptual foundation is fully rooted in traditional microeconomics (Roma et al., 2016).

3. Literature Review

Among the previous studies, we can mention the research in the field of demand of behavioral economics_for foreign items based on the hypothetical purchase status of various goods:

Hayashi and Belsington (2020) attempted to analyze the behavioral economic demand for text message dependence. To conduct this analysis, they considered two areas. 1- They used the self-perception of text message dependency scale, which includes three subscales (emotional response, excessive use, communication), to assess participants' level of text message dependence. 2- The hypothetical text message demand status; it is considered as the possibility of additional payment to continue sending and receiving text messages in case the monthly credit limit for receiving or sending text messages expires. Using the self-perception scale, they divided users into two categories dependent and non-dependent users of text messages and compared the demand situation of the two groups of users in terms of the intensity and elasticity of their demand for text messages. The results showed that text message-dependent users had high demand intensity and lower demand elasticity for social interaction with text messages, indicating excessive and persistent behavior of individuals (resembling impulsive behavior).

Hayashi et al. (2019) analyzed behavioral demand for a text message during (hypothetical) driving. To conduct this research, participants completed two demographic questionnaires and the hypothetical demand situation as the scenario of sending a text message while driving. They presented participants with the scenario of sending a text message while driving as a hypothetical situation. They evaluated the probability of a quick response to a text message versus waiting (for a response to a text message) to reach the target when the penalty for responding to a text message while driving is estimated to be one to three hundred dollars. They considered the probability of a quick response or waiting for two destinations of 15 and 60 minutes and calculated and recorded the demand for a text message response for the two conditions of a delay of 15 and 60 minutes. The research results showed that drivers who received a text message more frequently than drivers who received fewer text messages demanded more intense social interaction (with the text message; highest demand at the lowest fine) and lower elasticity (lowest sensitivity to a slight increase). The results of this study demonstrated that behavioral demand analysis is potentially useful for understanding and predicting texting behind the wheel.

In a review of the availability of effective medications for MS, Jarmolowicz et al. (2020) found that many MS patients do not successfully take their medication and considered the possibility that these patients do not receive treatment recommendations because they do not value these treatments despite their effectiveness. With this in mind, they examined MS patients' demand for effective treatments. They used behavioral economic models to examine patients' willingness to purchase effective medications for this disease. The research results showed that this willingness to purchase was significantly associated with knowledge and awareness of MS and drug selection and adherence decisions (e.g., adherence to disease-modifying therapies).

Using criteria such as demographic information, daily exercise habits outside and inside the club, and physical activity habits, and using two HPT scenarios: 1- purchase quantity scenario and 2- participant purchase probability scenario, Brown et al. (2021) addressed the question of how much a person values the opportunity to exercise at a gym. They also studied the relationship between the demand indicators (e.g., demand intensity and demand elasticity) created by each demand quantity situation and demand probability situation based on physical activity criteria separately. The research results showed that there was a strong negative correlation between the demand indices and a significant correlation between the demand indices and the mentioned sports criteria in both situations. These correlations were all positive, except for those related to the elasticity of demand, as lower values indicate a lower sensitivity to price changes and therefore a higher value of the product.

Using hypothetical purchase situations, Schwartz et al. (2021) developed a demand situation in two groups of patients (those who had used opium in the past two months and those who had not used opium for at least 18 months) as part of a seven-drug treatment plan (and an age difference control). They found that participants who had been abstinent for a long time had significantly higher price elasticity and intensity of demand than participants who had recently used opium in terms of heroin (a highly addictive painkiller derived from morphine). The relationship between age and cigarette demand intensity was also negative; the older people are, the less likely they are to buy cigarettes at zero price. The relationship between income and cocaine demand intensity is also negative. Thus people with higher incomes were less likely to use cocaine at zero price. Using demand analysis, this research has provided a clinical tool to assist in treatment planning or as a target for treatment.

Strickland et al. (2021) provided examples of policies to reduce transmission and improve treatment for the COVID-19 pandemic. They interpreted the discounting criteria and demand frameworks of behavioral economics, which have been widely used and validated in behavioral psychology, using four samples and seven experiments to examine 1- participation in social distancing, 2- cooperation using the face mask, 3- preparation for a diagnostic test, and 4- vaccination intentions. Within these cases (behavioral mechanisms for disease prevention), they evaluated specific experimental manipulations characterized by cognitive psychology approaches to behavioral economics (e.g., framing effects) to provide clear and transferable implications for general policy design. The results of this study show that people are more likely to engage in social distancing when certain activities are perceived as high risk. Postponing until testing (rather than postponing until results) increased the likelihood of testing, and framing vaccine safety in a positive way improved vaccine acceptance.

4. Research Methods

4.1 Research Model

Following Hursh and Silberberg (2008) and Hursh et al. (2020), we used an exponential demand function proportional to the ratio of participants in vaccine acceptance at each efficacy level to estimate demand for Iranian and foreign vaccines (Hursh and Silberberg, 2008). The general form of the aggregate demand Q is as follows:

$$Q = Q_0 e^{k(e^{-\alpha\theta}-1)} \quad (1)$$

where Q is the quantity of observed acceptance per vaccine efficacy. The maximum Q_0 means the maximum acceptance of the vaccine at an efficacy of 100%, $\theta = 0$. This means that an efficacy of 100% implies a price of zero for the vaccine. The constant k is the range of percent acceptance of the vaccine in log units. The unconstrained parameter α is the rate of change in demand elasticity. In other words, the rate of decrease (elasticity or e) in vaccine acceptance is determined by the increase in hospital risk (decreased efficacy) along with the domain parameter k. θ corresponds to the psychological scale of risk perception, expressed as a decrease in the probability of hospitalization as a percentage of efficacy. By deciding to reduce the risk of hospitalization by 100%, the individual has demanded 100% efficacy of the vaccine; it represents the zero price of the product. In this simulation of demand, θ is the price of the product and a regulator of acceptance reduction in the exponential model. The basis of the calculations are hypothetical prices, but efficacy is used only to represent the psychological criteria in horizontal axis of the demand curves.

Table 1. Hypothetical Effectiveness and Hypothetical Prices

Psychological criteria	
Hypothetical effectiveness	**Hypothetical prices**
100%	0
90%	10
80%	20
70%	30
60%	40
50%	50
40%	60
30%	70
20%	80

10%	90
0%	100

Source: Research finding.

The parameters of the demand function are estimated from the questionnaire data, and the result of the demand function is an exponential decay. The response pattern of the respondents was based on the choice of minimum efficacy, which was chosen by the respondents such that the vaccine applicant wanted higher efficacy levels of the vaccine by choosing the minimum efficacy, but did not accept lower efficacy levels. For this reason, according to Hursh et al. (2020), the behavioral pattern of respondents is equal and exponential. In this way, at the highest efficacy (100% efficacy or a vaccine price of zero), we are dealing with the highest demand from people, and at the lowest efficacy (zero efficacy or a vaccine price of 100), we are dealing with the lowest demand from people.

To test a linear mixed effect model, we use the following general form:

$$y_{ij} = \beta X_{ij} + Z_{ij} b_i + \varepsilon_{ij} \qquad i = 1,2 \; j = 1,\ldots, m \tag{2}$$

where i is two sets of observations for Iranian and foreign vaccine development processes. j is the number of observations of individuals in each of the processes. y_{ij} is the value of the dependent variable (minimum required efficacy) for observations (individuals) j in each group (of the vaccine development process). β is the parameter of the fixed effects coefficients. X_{ij} is the value of the covariates for observations j in group i. b_i is the random effect coefficient for group i. Z_i is the random effect variable (a random term was considered for the vaccine development framework parameter). ε_i is the error vector for observations j in group i (Fox and Weisberg, 2015).

In this model, the minimum efficacy required for each Iranian and foreign vaccine scenario is a within-subject measure; we calculate it as the individual median value between the individual's last accepted efficacy and the individual's first unacceptable efficacy. The minimum required efficacy values indicate the need for higher vaccine efficacy for vaccine acceptability, which is a dependent variable in a linear mixed-effects model. To account for covariates, we evaluated linear mixed-effects models of required minimum efficacy scores for: 1- The effect of framing the Iranian vaccine development process; 2- The main effects of individual characteristics; 3- The interactions between the development process and individual characteristics. We interpreted the fixed effects estimate (β) for the main effects models as the change in the minimum value of required efficacy by increasing by one unit (continuous variable) or categorical variables. The fixed effect values of the interaction model reflect interactions between the framing effect of Iranian vaccine development (level 1) and individual characteristics (level 2). We designed the main effects models and the interaction models separately, but each included all fixed effects in a multivariate model. All models included the term random effect (random slope) for the Iranian vaccine development framework parameter and the term random y-intercept. We performed all analyses in R software using two-domain tests with error levels of 0.1, 0.05, and 0.01.

In the third step, using the exponential demand function framework and the available information from the sample (493 individuals), by calculating the vaccination coverage rate at each level of effectiveness, we examined the impact of the information required to advertise Iranian and foreign vaccines.

5. Description of Variables

5.1 Dependent Variable

We considered the minimum efficacy required for each Iranian and foreign vaccine applicant as a within-subject variable. For each Iranian and foreign vaccine scenario, we calculated it as the individual median value between the last efficacy accepted by the subject and the first efficacy not accepted.

5.2 Independent Variables

We considered the following variables:

1- The Iranian vaccine development process framing (in the form of a dummy variable, considering the foreign vaccine development process as the reference group),

2- Generic Conspiracist Beliefs Scale (GCB) and the Economic and Social Conservatism Scale (SECS), where higher scores indicate higher conspiracy belief and conservatism, respectively, with the maximum score for conspiracy belief being 85 and the maximum score for conservatism being 130,

3- Belief in the efficacy of the influenza vaccine, belief that the vaccine causes autism, and receipt of the vaccine in the past three years (in the form of dummy variables),

4- Consistent adherence to social distance, consistent mask-wearing, subjective socioeconomic status, income, and employment (in the form of categorical variables),

5-The level of vaccination expected by the society, the willingness of individuals in case of vaccination of treatment personnel and authorities (on a Likert scale of 11 and 7 degrees, respectively),

6- Age and gender of individuals.

5.3 Descriptions of the Data

Following Hursh et al. (2020), we used two scenarios for the hypothetical purchase situation of Iranian and foreign vaccines by describing the information about the development process of Iranian and foreign vaccines. Questionnaire participants read instructions and information about access to Iranian and foreign COVID-19 vaccines. The process of foreign vaccine development was described as follows:

Suppose the COVID-19 vaccine that is available to you belongs to the COVAX program, which includes one of the types of foreign vaccines (such as AstraZeneca of South Korea, AstraZeneca of Russia, Sinopharm of China, Sputnik of Russia, Covaxin of India, etc.). These vaccines have undergone preclinical processes, phase 1, 2, and 3 clinical trials, and coordinated surveillance processes, and have been approved by the regulatory authorities of the countries producing foreign vaccines. Their necessary and general documents have been approved by the World Health Organization. Therefore, they are subject to precise evaluation criteria.

The process of Iranian vaccine development has been described as follows:

Let us assume that the COVID-19 vaccine available to you belongs to the Iranian vaccine development program (domestically produced) such as CovIran Barekat, SpikoGen, etc. These vaccines have undergone preclinical processes, phases 1, 2, and 3 clinical trials, and coordinated surveillance processes and have been approved by the regulatory and supervisory authorities of the Food and Drug Administration and the Iranian Ministry of Health. They have even been included in the World Health Organization's (WHO) COVID-19 vaccine candidate list, but WHO will approve their necessary and general documents in the future. In other words, these vaccines, unlike foreign vaccines, have not yet met the exact evaluation criteria, but WHO will approve them in the future.

Both guidelines state that the vaccine is the only freely available Covid-19 vaccine and is now prescribable. After studying the instructions and information described in the Iranian and foreign vaccine scenarios, the question of whether participants receive the vaccine through a range of vaccine efficacies (practically defined for participants as a percent reduction in risk of hospitalization) was answered (0 to 100% efficacy). In this framing, based on the approach of Hursh et al. (2020), the individual responded to the details of vaccine acceptance by choosing the Iranian or foreign vaccines (I get the vaccine for free), which is the same choice of 100 to zero percent efficacy. However, if the individual did not accept the vaccine, this was considered non-acceptance at all levels of efficacy.

After completing the questions about applying for the vaccines in Iran and abroad, respondents (samples at convenience) also completed the criteria for the GCB Scale and the SEC Scale to measure conspiracy beliefs and social and economic conservatism, vaccination history, COVID-19 prevention behavior, and demographic information. Five hundred twelve individuals completed the questionnaire. Respondents completed the questionnaire from July 21-27, 2021. There were 16 individuals excluded from the demand function analysis, linear mixed effects model, and coverage curves because they did not correctly respond to the vaccine scenarios domestically and internationally. Their responses in the linear mixed effects model would have been unusable because of the unknown set of dependent variables. The final sample included 496 individuals for foreign vaccines and 493 for domestic vaccines. Because individuals are at daily risk for Corona disease, the questionnaire authors included all different groups of people in Iran. Convenience sampling was used. As for the linear mixed effects model, we benefited from the individuals who answered both scenarios correctly because we used the minimum required efficacy of both scenarios. The final sample for the linear mixed effects model consisted of 493 individuals. The reliability of the questions in each section of the questionnaire was tested using Cronbach's alpha criterion. Cronbach's alpha for the first and second parts of the questions (foreign and Iranian vaccine demand scenario) was 0.87, the third part of the questions was 0.85, the fourth part of the questions was 0.78, the fifth part of the questions was 0.47, the sixth part of the questions was 0.68, the seventh part of the questions was 0.66, and the eighth part of the questions was 0.9. Most of the questions in the ninth part were individual questions such as age, gender, income, and employment. In these questions, there is no group adjustment to measure structure, and Cronbach's alpha is not appropriate for measuring the reliability of these types of questions. The low value of Cronbach's alpha in the fifth part is because there is no conceptual correlation between the questions in this part and the questions do not measure a specific structure.

6. Results Analysis

6.1 Descriptive Statistics

The average age of the respondents is 42.8 years. 82.9% of the respondents were male, the rest were female or did not want to indicate their gender. 78.4% of respondents were employed (salaried and self-employed). 29.5% of the people reported an income of more than ten million Tomans. The average scale of SEC is 77.1. The mean score of the GCB scale is 58.07 (standard deviation of 11.19). We asked about the subjective socioeconomic status of respondents at four levels: 1- My family has problems buying the things it needs (total percentage: 17.2%); 2- My family has only enough money for the things we need (total percentage: 39.1%); 3- My family has no problem to buy the things we need and sometimes we can buy certain things (total percentage: 38.6%); 4- My family has enough money to buy almost everything it wants (total percentage: 0.05%). They chose their family's financial capabilities in the form of phrases that best described their family's socioeconomic status.

The questionnaire consisted of 9 sections; the first and second sections were dedicated to the demand for foreign and Iranian vaccines (domestic production). We described the respondents' information in the seventh, eighth, and ninth sections in the first paragraph. We presented the descriptions of the other variables in the other five sections in the following tables.

Table 2. Descriptive Statistics on Respondents' Willingness to Receive the Iranian Vaccine

Response scale	Very true of me	True of me	Somewhat true of me	Neutral	Somewhat untrue of me	Untrue of me	Very untrue of me	Prefer not to answer
Willingness to get the Iranian vaccine if the medical staff is vaccinated	0.35	0.16	0.14	0.08	0.07	0.05	0.13	0.02
Willingness to get the Iranian vaccine if the authorities are vaccinated	0.36	0.14	0.11	0.09	0.05	0.04	0.18	0.04

Source: Research finding.

Table 3. Descriptive Statistics on Compliance with Health Protocols

Response scale	Never	Rarely	Sometimes	Often	Always
Washing hands	0.02	0.10	0.09	0.42	0.36
Avoiding touch of the face	0.04	0.19	0.16	0.42	0.19
Consistent mask use	0.00	0.04	0.03	0.23	0.70
Observance of social distancing	0.02	0.12	0.11	0.52	0.23
Avoiding gatherings of more than 50 people	0.03	0.06	0.06	0.37	0.48
Avoiding gatherings of more than 10 people	0.03	0.15	0.16	0.46	0.20

Source: Research finding.

Table 4. A- Descriptive Statistics on Coronavirus Infection Prevention Behaviors

Response scale	Yes	No	Prefer not to answer
Suspected of coronavirus-infected	0.32	0.32	0.03
Getting a coronavirus test	0.56	0.56	0.01
Being close to an infected person	0.66	0.66	0.02
Health anxiety	0.83	0.83	0.02
Having health insurance	0.93	0.93	0.01

Source: Research finding.

Table 4. B- Descriptive Statistics on Behavior for the Prevention of Coronavirus Infections

Response scale	Always	Often	Sometimes	Rarely	Never	Prefer not to answer
Following the health protocol	0.38	0.55	0.04	0.03	0.00	0.00

Source: Research finding.

Table 5. A- Descriptive Statistics on Vaccination History and Individual Beliefs

Response scale	Yes	No
Belief in the effectiveness of the flu vaccine	0.7	0.3
Been vaccinated in the last three years	0.19	0.81
The belief that rubella vaccine is necessary for children	0.96	0.04
The belief that the MMR[1] vaccine is safe for children	0.87	0.13
The Belief in the effectiveness of the MMR vaccine	0.95	0.05
The Belief that the vaccine causes autism	0.13	0.87

Source: Research finding.

Table 5. B- Descriptive Statistics on the Expected Percentage of Vaccinations among Different Groups of Individuals

Expected percentage of vaccination	100	90	80	70	60	50	40	30	20	10	0
Colleagues	0.19	0.27	0.18	0.12	0.08	0.05	0.03	0.03	0.01	0.02	0.01
Population	0.07	0.25	0.23	0.18	0.10	0.07	0.03	0.03	0.01	0.02	0.00
Friends	0.19	0.30	0.17	0.13	0.07	0.05	0.04	0.03	0.01	0.03	0.01

Source: Research finding.

6.2 Results of Estimating the Demand Curves

In the exponential demand function, vaccine efficacy levels (used here as an alternative to vaccine prices described in detail in Section 4.1) and vaccine acceptance percentages represent vaccine demand values. The demand curves were estimated based on each participant's minimum[2] effectiveness, such that those choosing the minimum effectiveness for vaccine acceptance would want a higher, but not a lower, vaccine effectiveness. The results of estimating the demand curves are based on the exponential demand function of Hursh and Silberberg (2008). The coefficient of determination of the overall demand curves is higher than 99%. The value of parameter numbers in the Iranian vaccine demand curve is k = -1.51 and $a =$

[1]. Measles/Mumps/Rubella

[2]. In this section, the minimum effectiveness is based on the selection of the lowest effectiveness chosen by the person and is not considered as a median of two numbers.

-0.0177. The parameter numbers in the foreign vaccines demand curve are k = -2.37 and a = -0.0114. The demand intensity in foreign vaccines demand curve ($Q_0 = 90.4$) is higher than the Iranian vaccine demand curve ($Q_0 = 67.6$). The demand model is compatible with all 11 points of the value of demand in each efficacy. The final results of the overall demand curves show that the demand for foreign vaccines is higher than the demand for domestically produced vaccines at all efficacy levels. For example, at 50% efficacy, demand for Iranian vaccines was 8.7% and demand for foreign vaccines was 15.1%. At 70% efficacy, Iranian vaccine demand was 21.7% and foreign vaccines demand was 32.8%. At 90% efficacy, Iranian vaccine demand was 50.7% and foreign vaccines demand was 68.9%. On the one hand, the results show that the demand for both Iranian and foreign vaccines is lower at lower efficacy and people would accept the vaccine at higher hypothetical efficacy regardless of the development process. On the other hand, the results show that even if the efficacy is 90%, the demand for vaccines does not exceed 70%. This shows that at least 30% of people do not accept the vaccine, which can be an alarm signal for society. Although the demand for Iranian vaccines is generally unacceptable, we should consider that despite the non-approval of Iranian vaccines by the World Health Organization, the demand for Iranian vaccines (considering 68.9% for the acceptance of foreign vaccines at 90% effectiveness) was considered acceptable by the public. From another perspective, we can say that public confidence in domestically produced vaccines is high. In general, we extracted an overall demand curve for Iranian and foreign vaccines from the questionnaire data. To express the difference in the value of vaccine acceptance at different efficacy levels, we have plotted separately the demand for foreign and domestic (Iranian) vaccines at hypothetical efficacy levels of 50%, 70%, and 90% in Figures 1 to 3, respectively. The levels of demand and their confidence intervals[1] at 50%, 70%, and 90% effectiveness are also shown in Table 6.

1. Bias corrected and accelerated confidence interval was used.

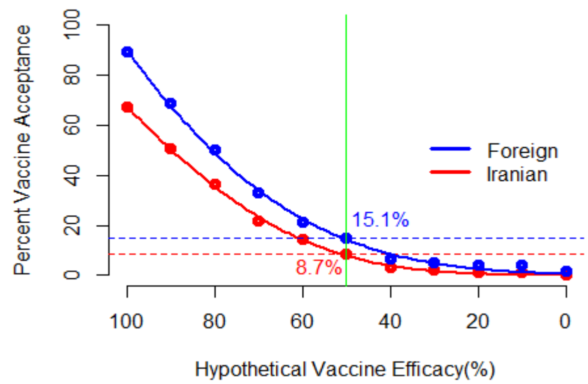

Figure 1. Level of Foreign and Domestic (Iranian) Demand at 50% Effectiveness
Source: Research finding.

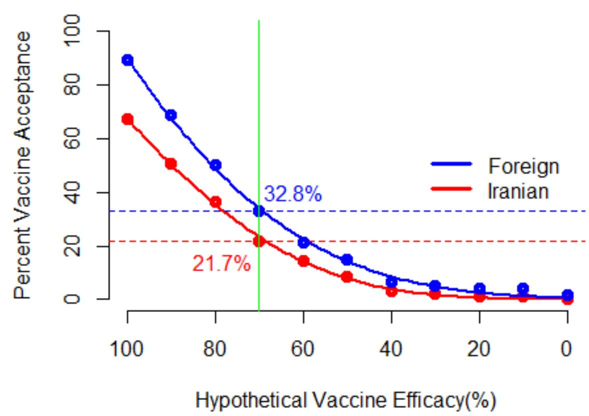

Figure 2. Level of Foreign and Domestic (Iranian) Demand at 70% Effectiveness
Source: Research finding.

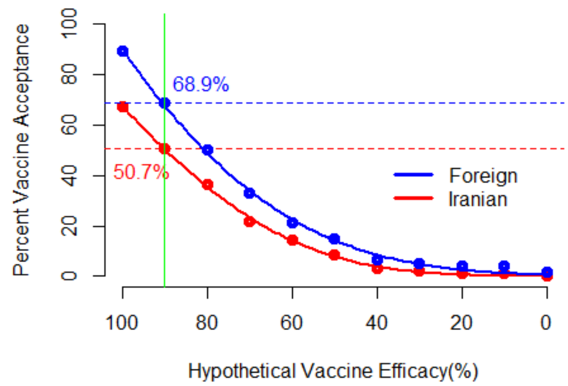

Figure 3. Level of Foreign and Domestic (Iranian) Demand at 90% Effectiveness
Source: Research finding.

Table 6. Levels of Foreign and Domestic (Iranian) Demand and Their CI (95%)

Efficacy	Level of domestic demand	Confidence Interval	Level of foreign demand	Confidence Interval
50%	8.7	(6.4, 11.1)	15.1	(12,18.3)
70%	21.7	(18.4, 24.9)	32.8	(28.8, 36.8)
90%	50.7	(46.4, 54,9)	68.9	(65.5, 72.3)

Source: Research finding.

6.3 Results of Linear Mixed Effects Models

We used the linear mixed effects model to examine the effects of a variable under the heading "framing effect of the vaccine development process" and 13 variables of individual characteristics on the minimum efficacy variable required for vaccine acceptance. These characteristics included belief in vaccine-induced autism, receipt of the vaccine in the past three years, consistent mask-wearing, adherence to social distance, expected community vaccination, age, gender, the GCB scale, the political and social conservatism scale, individuals' willingness to be vaccinated when vaccinated by officials, willingness to be vaccinated when vaccinated by treatment staff, influenza vaccine belief, and subjective socioeconomic status. In this model, we assessed the main and interaction effects of the variables under two separate models, which were linear mixed-effects models.

We considered the main model (so-called the reduction model) as the model (3) to investigate the separate effects of the variables on the minimum efficacy required for vaccine acceptance by individuals. In total, we included a total of 14 covariates in the main model. Ten variables in the model were removed from the final model because they did not have a significant effect at all significance levels. We considered the main model, which included four variables (the effect of framing Iranian vaccine development, willingness to receive Iranian vaccines if treatment staff are vaccinated, subjective socioeconomic status, and belief in influenza vaccine efficacy) as covariates and minimum efficacy required by the individual as the dependent variable:

$$minimum_{ij} = \beta_0 + \beta_1 vaccine\ development_{ij} + \beta_2 Willingness\ to\ get\ vaccinated_{ij} + \beta_3 Subjective\ Socioeconomic\ Status_{ij} + \beta_4 Belief\ in\ the\ effectiveness\ of\ the\ flu\ vaccine_{ij} + Z_{ij}b_i + \varepsilon_{ij} \quad (3)$$

The interaction model (also referred to as the full model) examines the effects of variables that interact with the framing effect variable, which is considered the product of the variables in the framing effect variable (development process). It includes the separate effects of the variables and the interaction effects with the effect of framing the vaccine development process. In the analysis of the interaction model, the coefficients of the interaction of the variables with the framing effect that are statistically significant can be analyzed and the other coefficients cannot be. In general, the interaction of 4 variables (the same variables as the main model) entered the interaction model. Since the interaction of the two variables with the variable of framing effect had no significant effect, we removed two variables from the final model. We consider the final model as Model 4 below:

$$minimum_{ij} = \beta_0 + \beta_1 vaccine\ development_{ij} + \beta_2 Willingness\ to\ get\ vaccinated_{ij} + \beta_3 Vaccine\ Development * Willingness\ to\ get\ vaccinated_{ij} + Z_{ij}b_i + \varepsilon_{ij} \quad (4)$$

In general, the results of the main model showed that the Iranian vaccine development process increased the minimum expected effectiveness of individuals by more than seven percentage[1] points ($p < 0.001$, $\beta = 7.90$). Since people in the process of Iranian vaccine development want effectiveness more than seven percentage points higher than the demand for foreign vaccines, we can say that this increase confirms

[1]. Numerical difference between two percent: the percentage of minimum efficacy of the Iranian vaccine development process and the percentage of minimum efficacy of the foreign vaccines development process.

people's concerns about the process of Iranian vaccine development. We tested respondents' willingness to receive Iranian vaccines at seven levels in the case of vaccinating treatment staff (the first level is the lowest level of willingness to receive the vaccine as a variable reference). Very high willingness (level 7) and high willingness (level 6) reduced the minimum effectiveness required of individuals to receive the vaccine by more than eight percentage points ($p < 0.01$, $\beta = -8.30$) and more than ten percentage points ($\beta = -10.34$, $p < 0.01$), respectively. We tested subjective socioeconomic status at four levels (the first level was considered a variable reference). The second level for people who stated that their family had only enough money for their needs reduced the minimum effectiveness by more than 4 percentage points ($p = 0.076$, $\beta = -4.29$). The third level of results showed that individuals who stated that their family had no problems buying the things they needed and could sometimes buy certain things had their required minimum effectiveness reduced by more than five percentage points ($P = 0.016$, $\beta = -5.79$). The fourth level of results showed that individuals who reported that their family had enough money to buy almost everything reduced their minimum effectiveness by more than seven percentage points ($p = -7.58$, $\beta = -7.58$). We can say that with the higher subjective socioeconomic well-being of the individuals (level 4 is the highest level of subjective well-being), the rate of reduction of the minimum effectiveness required by the individuals increased (from -4.29 percentage points to -7.58 percentage points). Belief in the efficacy of the influenza vaccine reduced the required minimum efficacy by more than four percentage points ($p = 0.028$, $\beta = -4.057$).

In the interaction model, we accounted for the interaction of covariates with the effect of framing the process of Iranian vaccine development. That is, people's willingness to be vaccinated, in the case of the treatment staff's vaccination, decreases or increases under the influence of framing process of Iranian vaccines development. The results of the interaction model showed that the very high willingness (level 7) and high willingness (level 6) of people to receive the Iranian vaccine in the case of vaccination by the treatment staff were significantly associated with the framing effect of the Iranian vaccine development process ($p < 0.001$, $\beta = -16.74$), ($p < 0.001$, $\beta = -13.5$). This means that the very high willingness (level 7) and high readiness (level 6) of the individual to receive the Iranian vaccines reduces the minimum efficacy to about 16.74 percentage points and 13.5 percentage points, respectively, in the case of vaccinating the treatment staff under the influence of the Iranian vaccine development process.

We have presented the results of the two main and interaction models separately in Table 7 below.

Table 7. Results of the Main Effect and Interaction Models for the Minimum Efficacy Required by the Individual

Variable	Main effect model		Interaction model	
	β(90%95%99%CI)	***p***	**β(90%95%99%CI)**	***p***
Vaccine development	**7.90** (5.88, 9.91)	8.04e-14	**16.92** (11.76, 22.08)	3.87e-10
Willingness to be vaccinated (level 2)	**-3.11** (-11.71, 5.49)	0.48	**-8.51** (-18.52, 1.49)	0.097
Willingness to be vaccinated (level 3)	**-10.51** (-17.92, -3.09)	0.006	**-12.57** (-21.14, -4.00)	0.004
Willingness to be vaccinated (level 4)	**-9.73** (-16.84, -2.61)	0.008	**-9.14** (-17.36, -0.91)	0.03
Willingness to be vaccinated (level 5)	**-9.95** (-16.13, -3.77)	0.001	**-8.38** (-15.49, -1.27)	0.02
Willingness to be vaccinated (level 6)	**-10.34** (-16.42, -4.25)	0.001	**-5.90** (-12.81, 1.00)	0.09
Willingness to be vaccinated (level 7)	**-8.3** (-13.57, -3.02)	0.002	**-1.48** (-7.51, 4.55)	0.6
Subjective socioeconomic status (level 2)	**-4.29** (-9.00, 0.40)	0.076	-	-
Subjective socioeconomic status (level 3)	**-5.79** (-10.47, -1.11)	0.016	-	-
Subjective socioeconomic status (level 4)	**-7.58** (-15.53, 0.35)	0.064	-	-
Belief in the effectiveness of the flu vaccine	**4.05** (-7.63, -0.47)	0.028	-	-
Vaccine development*willingness to be vaccinated (level 2)	-	-	**7.42** (-2.66, 17.51)	0.15
Vaccine development*willingness to be vaccinated (level 3)	-	-	**0.29** (-8.34, 8.94)	0.94
Vaccine development*willingness to be vaccinated (level 4)	-	-	**-4.11** (-12.41, 4.17)	0.33
Vaccine development*willingness to be vaccinated (level 5)	-	-	**-6.99** (-14.16, 0.17)	0.057
Vaccine development*willingness to be vaccinated (level 6)	-	-	**-13.5** (-20.47, -6.53)	0.0001
Vaccine development*willingness to be vaccinated (level 7)	-	-	**-16.74** (-22.82, -10.66)	1.25e-07

Source: Research finding.

6.4 Coverage Curve

According to Hursh et al. (2020), the coverage curve in this section includes two components: coverage rate and efficacy, where the value of coverage at each efficacy level was calculated as the product of the percentage of vaccine acceptance at hypothetical efficacy (as a non-percentage, as an example 90, not 0.9). Here, the percentage of efficacy indicates the amount needed to advertise each Iranian (domestic) and foreign vaccine. Then, based on the exponential demand function (1) and using both components, we estimated the value of coverage and the effectiveness of the coverage curve as the following curves in Figure 4. The value of coverage expected by individuals is an estimate of the level of security expected by the population. Here, we considered the highest coverage level expected by individuals and, in other words, the safety level expected by the population, which is about 60%. The results show that at the highest coverage level expected by individuals, i.e., at a coverage level of 60%[1], the impact of messages and advertisements for Iranian vaccines should be 96.8% and for foreign vaccines 89.3%. This means that the level of advertising of Iranian vaccines should be 7.5% higher than the level of advertising of foreign vaccines and that more efforts should be made to influence the advertising of vaccines through health education campaigns. We have presented the coverage curves in Figure 4.

[1]. This coverage rate was chosen because it was the highest common rate expected by domestic and foreign vaccines applicants.

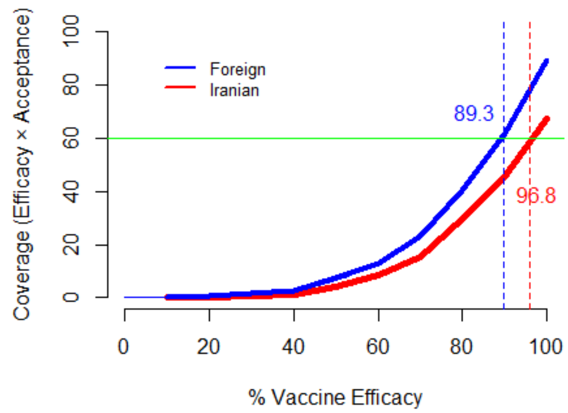

Figure 4. Coverage Curves; the Magnitude of the Effect of Advertising on Demand for Domestic and Foreign Vaccines at a 60% Coverage Rate
Source: Research finding.

7. Conclusion

This study aimed to investigate people's tendencies toward different vaccination intentions for COVID-19 vaccination. To investigate people's demand, the two scenarios of Iranian (domestic) and foreign vaccines were surveyed in such a way that domestically produced vaccines have not yet been confirmed by the World Health Organization and do not meet the exact evaluation criteria. However, they will certainly be approved by the World Health Organization in the future, and the foreign vaccines were approved by the World Health Organization and met the strict evaluation criteria. Estimation of the demand curve showed that a) the demand for Iranian vaccines is lower than the demand for foreign vaccines at all efficacy levels. For example, at 50% efficacy, demand for Iranian vaccines was 8.7% and demand for foreign vaccines was 15.1%. At 70% efficacy, demand for Iranian vaccines was 21.7% and demand for foreign vaccines was 32.8%. At 90% efficacy, the demand for Iranian vaccines was 50.7% and the demand for foreign vaccines was 68.9%. b) The intensity of demand for foreign vaccines is higher than the intensity of demand for Iranian vaccines.

Next, using data from 493 individuals, we examined how the development of Iranian vaccines and the characteristics of individuals affect the required minimum effectiveness in the Iranian and foreign vaccine scenarios. Using the multivariate linear mixed effects model, we evaluated the main and interaction effects of the variables in two separate models, which are linear mixed effects models. The results of the main effect model showed that the effect of framing the vaccine development process increased the minimum effectiveness for receiving the Iranian vaccine by more than seven percentage points ($p < 0.001$, $\beta = 7.90$). This increase reflects people's concerns about Iranian vaccine development, as people's expected minimum effectiveness to accept Iranian vaccines increased. We tested respondents' willingness to be vaccinated with Iranian vaccines at seven levels. We considered the first level, the lowest willingness to be vaccinated, as a variable reference. Very high (level 7) and high willingness (level 6) reduced the minimum effectiveness for receiving the vaccine by more than eight percentage points ($p < 0.01$, $\beta = -8.30$) and more than ten percentage points ($\beta = -10.34$, $p < 0.01$), respectively. We tested subjective socioeconomic status at four levels (the first level as a variable reference). The second level for people who stated that their family had only enough money for their needs reduced the minimum required effectiveness by more than 4 percentage points ($p = 0.076$, $\beta = -4.29$). The third level of results showed that the minimum required effectiveness of individuals who stated that their family had no problem buying the things they needed and could sometimes buy certain things decreased by more than five percentage points ($P = 0.016$, $\beta = -5.79$). The fourth level of results showed that the minimum effectiveness of people who stated that their family has enough money to buy everything they want decreased by more than seven percentage points ($p = -7.58$, $\beta = -7.58$). Belief in the effectiveness of the flu vaccine decreased the minimum required effectiveness by more than four percentage points ($p = 0.028$, $\beta = -4.057$). In the interaction model, we accounted for the interaction of the covariates with the effect of the Iranian vaccine development framing. That is, people's willingness to be vaccinated, in the case of the treatment staff's vaccination, decreases or increases under the influence of the framing process of Iranian vaccine development. The results of the interaction model showed that the very high willingness (level 7) and high willingness (level 6) of people to receive the Iranian vaccine were significantly associated with the effect of framing the development of Iranian vaccines ($p < 0.001$, $\beta = -16.74$), ($p < 0.001$, $\beta = -13.5$). This means that individuals' very high willingness (level 7) and high willingness (level 6) for Iranian vaccines, in the case of vaccinating treatment staff, reduced minimum effectiveness by about 16.74 percentage points and 13.5 percentage points, respectively, under the influence of Iranian vaccine development.

Finally, we estimated the curves of vaccine coverage at each efficacy level for both the Iranian and foreign vaccine development processes using the exponential demand function. The coverage level at each point on the curve indicates the estimated level of certainty that the population expects. Thus, with a coverage rate of 60%, the promotion and information rate for Iranian vaccines should be at least 96.8% and for foreign vaccines at least 89.3%. The results show that the rate of publicity, information, and awareness should be 7.5% higher for Iranian vaccines than for foreign vaccines.

The main finding of the present paper is how framing of the question would affect the vaccination intentions of individuals. For this reason, one of the most important factors for public acceptance of vaccines is the study of human behavior and beliefs to promote and encourage people to receive the vaccine. This confirms the effective role of behavioral economic theories and models in decision-making and policy-making. By studying the psychology of individual behavior in accepting different vaccine orientations, behavioral economics also provides a practical solution to inform people through health education campaigns in different ways. Identifying the vulnerabilities in informing people about vaccine acceptability provides an essential and practical framework for targeting the right message to reach the desired point of people's collective safety.

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