

## Utilizing Multiple Linear Regression Models to Predict Intentions to Vaccinate for COVID-19

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### ABSTRACT

*The purpose of this research is to develop a multiple linear regression model to predict the intention to vaccinate for COVID-19. An anonymous cross-sectional online survey utilizing Qualtrics software was conducted. Descriptive statistics and inter-correlations between predictors and criterion variables were presented. Multiple linear regression was used to analyze associations among predictors and criterion variables. Overall, results indicated that while 79% of participants reported their intentions to get vaccinated against COVID-19 when a vaccine becomes available, 21% reported not being likely to. Further, results showed that six socio-demographic, health-related, and belief factors had positive effects on intentions to vaccinate for COVID-19. Specifically, the predictive variables of the belief in the effectiveness of the COVID-19 vaccine, political party affiliation, previous influenza vaccinations, employment status, perceived knowledge of COVID-19 and the COVID-19 vaccine, as well as education level have crucial roles in predicting the dependent variable of the intention to vaccinate for COVID-19.*

*This research contributes to our understanding of the various factors that influence the decision to vaccinate for COVID-19. Overall, the proposed regression model with the variables present in this study represents a strong effect and explains the proportion of the variability in the intention to vaccinate with over 70% accuracy. These results have important practical as well as theoretical implications for public health policymakers. With significant percentages of the population that are still hesitant to vaccinate, future studies should focus on finding this missing link and implementing any social/public health policies to level up individual intentions.*

**Keywords:** COVID-19, intention to vaccinate, multiple linear regression model, Mathematical model, health-related issues, effectiveness of vaccine

### 1. Introduction

Declared on March 11th, 2020 by the World Health Organization (WHO) as a global pandemic, the novel coronavirus (COVID-19) has approximately over 110 million reported cases worldwide (Worldometer 2021). COVID-19 has affected 181 countries with approximately over a million confirmed cases. Within the United States alone, there have been more than 28 million confirmed cases. Out of the reported cases within the United States, fatality rates are alarmingly high, with more than 490,000 total deaths (CDC, 2021).

Defined as “the decision to delay vaccination or refusal to vaccinate despite available vaccination services,” vaccine hesitancy is growing increasingly common in the United States (Lucia et al., 2021; Callaghan et al., 2019). Another opposition to the vaccine is known as an “anti-vaxxer.” The term anti-vaxxer refers to groups of people who oppose the use of vaccines for various reasons. These groups of people believe that vaccines are unsafe, while some believe that the use of vaccines infringes on their human rights.

Mathematical modeling and analysis of infectious diseases have been significant since its inception. Generally, Scientists are proposing research models to determine the etiology of infectious diseases and the transmission rates of infectious

pathogens. In addition, they are used to predict multiple factors ranging from the impact of interventions during an epidemic to the demographic and behavioral characteristics of individuals that contract infectious diseases (Grassly, 2008). This is an integral aspect of combating COVID-19. Scientists and researchers analyze models to determine specific measures that are necessary to take to ensure the safety of the general population. For instance, the Susceptible Exposed Infected Recovered Death (SEIRD) model is used to predict the effectiveness of quarantining for COVID-19 in countries such as India (Tiwari et. al., 2020). Furthermore, scholars are investigating the effects of social distancing in controlling the impact of the COVID-19 epidemic (Neufeld et al., 2020).

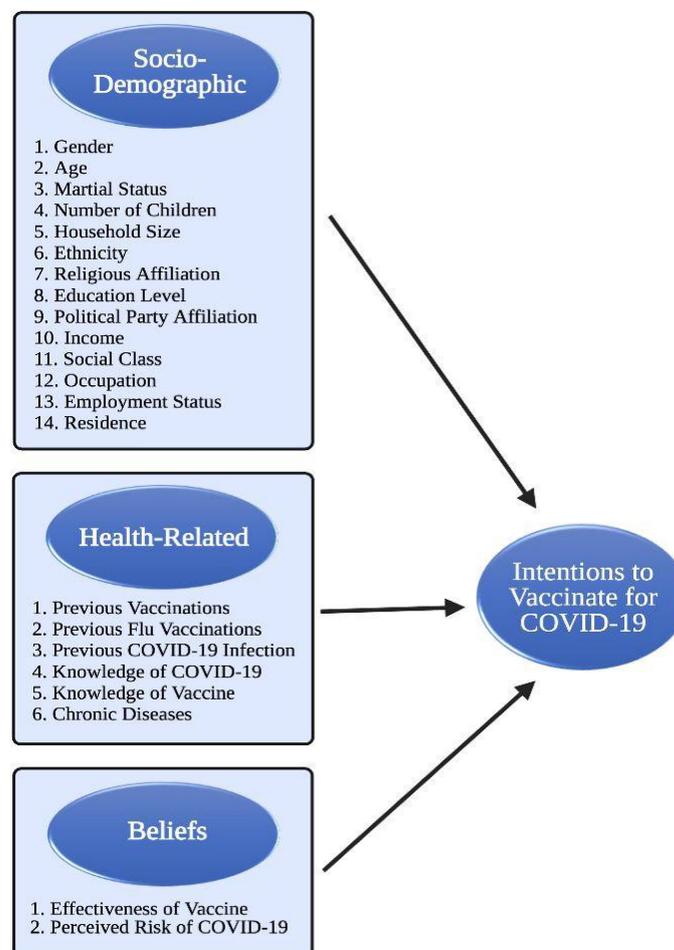
Due to the number of cases and fatality rates, identification of specific factors that influence intentions to vaccinate is essential to alleviate the negative stigma around vaccinations. This understanding could potentially increase the willingness to vaccinate, which can increase the possibility of immunization. To date, there is a dearth of research that comprehensively predict this intention by integrating individual differences (socio-demographics, socio-economics, socio-politics) with health-related and belief factors. Due to varying demographics within different countries/regions, most studies investigating factors associated

with intentions to have COVID-19 vaccination have been conducted outside the United States (i.e., Sherman et al., 2022; Wong et al., 2021; Rhodes et al., 2021). Thus, the main objective of this study is to propose and empirically test the comprehensive model of individual differences in demographic characteristics, health-related issues, and beliefs that influence the intentions to vaccinate for COVID-19 in the United States. These individual differences and perceived risks have been regarded to play important roles specific to infectious diseases such as COVID-19 (Edwards et al., 2022; Li, 2022). Further, we use the findings in this study to develop a multiple regression to mathematically model to generalize and predict intention to vaccinate for COVID-19 based on the demographics and characteristics the individual possesses.

## 2. Methods

An anonymous cross-sectional online survey utilizing Qualtrics software was conducted. Subjects were drawn from a convenience sample of both undergraduate and graduate students enrolled at a large Northeastern university in the United States. The survey was submitted to and approved by the University Institutional Review Board (IRB). The survey describes its objective in trying to understand and gain insight into the intention to vaccinate against COVID-19. The questionnaire survey contained questions on demographic characteristics (e.g., gender, age, education, marital status, family size, ethnicity, income, social class, and employment). The survey also included questions on socio-economic, socio-cultural, socio-political, geography, and health-related questions, as well as questions regarding the intention to get the COVID-19 vaccine. Based on previous literature on individual differences, health, and beliefs, the research model is presented in Figure 1.

**Figure 1: Proposed Conceptual Model**



Data from the survey was collected for approximately five weeks. Participants were informed at the beginning of the survey that their participation was voluntary, and they confirmed consent to participate in the research. Correlations between the independent questionnaire variables and the intention to receive vaccination for COVID-19 were evaluated using multiple linear regression analyses. Data analysis and multiple regression analyses were also conducted using SPSS software version 25.

### 2.1. Reliability of the questionnaire

To ensure the reliability of the questionnaire, the internal consistency reliability (Cronbach's alpha) was assessed for three multi-item scales. The Cronbach's alpha value for intentions to vaccinate was  $\alpha = 0.99$ . The Cronbach alpha value for the belief that the COVID-19 vaccine will be safe and effective was  $\alpha = 0.82$ . Finally, Cronbach's alpha value for the measure of worry, regarding being infected with COVID-19 was  $\alpha = 0.78$ . Cronbach's alpha values of 0.7 or higher indicated acceptable

internal consistency (Hair et al., 1998; Taber, 2017). All three of the values in this study were above 0.7, therefore, the multi-item scales were considered reliable.

## 2.2. Data Characteristics

The demographic profile collected from respondents is reflective of the general population. A total of 220 responses were received. However, thirteen responses were incomplete and thus were eliminated for further analysis. 207 responses were usable. Out of this, a little over half (about 55%) of the respondents were male (n = 114), and approximately 45% of respondents were

female. The majority of respondents (76.3%, n = 158) were in the category of 18-34 years old. Less than a quarter of respondents (14.7%) indicated previous COVID-19 infection (n = 34). About 6% of respondents stated that they experience at least one chronic disease (n = 14). Overall, more than half (61.6%) of respondents have had received previous vaccinations (n = 143) and approximately half (47%) received Influenza (flu) vaccine last year (n = 108). Table 1 displays various socio-demographic characteristics of the respondents, along with percentages and frequencies.

**Table 1: Sample Characteristics**

Characteristics	Percent and Frequency (n)
<b>Gender</b>	
Male	55.1% (n = 114)
Female	44.4% (n = 92)
Others	0.5% (n = 1)
<b>Age</b>	
18-34	76.3% (n = 158)
35-50	15.9% (n = 33)
51-64	5.3% (n = 11)
65+	2.4% (n = 5)
<b>Marital Status</b>	
Single	75.8% (n = 157)
Married	22.2% (n = 46)
Divorced	1.4% (n = 3)
Widowed	0.5% (n = 1)
<b>Number of Children</b>	
None	80.7% (n = 167)
1	6.3% (n = 13)
2	9.2% (n = 19)
3+	3.9% (n = 8)
<b>Household Size</b>	
1	12.1% (n = 25)
2	10.6% (n = 22)
3	17.4% (n = 36)
4	35.3% (n = 73)
5+	24.6% (n = 51)
<b>Ethnicity</b>	
African American	5.3% (n = 11)
Asian/Pacific Islander	31.4% (n = 65)
Caucasian/White	50.2% (n = 104)
Hispanic	6.8% (n = 14)
Native American	0.5% (n = 1)
North Africa/Middle East	1.4% (n = 3)
Others	2.9% (n = 6)
<b>Religion</b>	
Buddhism	9.2% (n = 19)
Catholicism	25.6% (n = 53)
Christianity	23.7% (n = 49)
Islam	4.8% (n = 10)
Judaism	10.1% (n = 21)
Hinduism	3.9% (n = 8)
Others (e.g., Atheist)	20.8% (n = 43)
<b>Education</b>	
Less than High School	1.0% (n = 2)
High School or Equivalent	5.8% (n = 12)
Some College	30.9% (n = 64)
Undergraduate Degree	24.2% (n = 50)
Graduate Degree or Higher	38.2% (n = 79)
<b>Political Party Affiliation</b>	
Democrat	36.7% (n = 76)
Republican	18.4% (n = 38)
Independent	33.8% (n = 70)
Others	11.1% (n = 23)
<b>Income</b>	
<\$32,000	16.4% (n = 34)
\$32,000 to \$53,000	11.6% (n = 24)

\$53,001 to \$106,000	24.6% (n = 51)
\$106,001 to \$373,000	37.2% (n = 77)
>\$373,000	10.1% (n =21)
<b>Social Class</b>	
Working Class	17.4% (n = 36)
Middle Class	75.8% (n = 157)
Upper Class	6.8% (n = 14)
<b>Occupation</b>	
High-Risk Workers	8.7% (n = 18)
Educators	14.5% (n = 30)
Businessman	26.1% (n = 54)
Others	50.7% (n = 105)
<b>Employment Status</b>	
Employed	57% (n = 118)
Unemployed	43% (n = 89)
<b>Residence</b>	
Long Island: Nassau	54.6% (n = 113)
Long Island: Suffolk	15.9% (n = 33)
New York City	12.5% (n = 26)
New Jersey	3.4% (n = 7)
Others	13.5% (n = 28)

### 2.3. Descriptive statistics

Descriptive statistics for items assessing medical history and intention of getting COVID-19 vaccination are reported in Table 2. Table 3 shows the zero-order correlations between predictors and criterion variables, and the inter-correlations among the predictors. There were significant zero-order correlations between all predictors and intention to vaccinate for COVID-19, except infection with previous COVID-19 and

chronic diseases. There were significant inter-correlations among beliefs in the effectiveness of COVID-19 vaccinations and previous vaccinations, previous flu vaccinations, perceived risk, and knowledge of COVID-19 & its vaccine. There were also significant inter-correlations between perceived risks of COVID-19 and previous COVID-19 infection as well as knowledge of COVID-19 & its vaccine.

**Table 2: Descriptive statistics for categorical items measuring medical history and intention of getting COVID-19 vaccination**

Items	Level	Percent and Frequency (n)
Have you had COVID-19 previously?	Yes	16% (n=33)
	No	75% (n=156)
	Not sure	8% (n=18)
Have you had any previous vaccinations?	Yes	68% (n=142)
	No	31% (n=65)
Have you received Influenza (flu) vaccine last year?	Yes	52% (n=108)
	No	47% (n=99)
Do you have any chronic diseases?	Yes	7% (n=15)
	No	93% (n=193)
Do you intend to get vaccinated against COVID-19 when the vaccine becomes available?	Yes	79% (n=164)
	No	21% (n=43)

Note that not all values and percentages add up to 100% (n = 207) due to rounding

**Table 3: Means, Standard Deviations, Zero-order and inter-correlations between Health-related, Beliefs, and Intention to Vaccinate for COVID-19**

	M	SD	PV	PFV	PCI	KCV	CD	CV	PR
<b>Health-related</b>									
PV	1.31	0.46							
PFV	1.47	0.50	0.25**						
PCI	1.92	0.49	0.01	-0.13					
KCV	2.06	0.80	0.10	0.09	0.08				
CD	1.93	0.25	0.02	0.06	-0.12	0.15*			
<b>Beliefs</b>									
CV	3.48	0.84	0.21**	0.29**	0.03	0.18*	-0.06		
PR	3.39	0.87	-0.01	-0.11	0.21**	-0.20**	-0.13	0.44**	
INT	3.87	1.23	0.24**	0.31**	0.03	0.16*	-0.10	0.76**	0.44**

\*Significance level of \*P-Value < .05; \*\*P-Value < 0.01;

PV = Previous Vaccinations

PFV = Previous Flu Vaccinations

PCI = Previous COVID-19 Infection

KCV = Knowledge of COVID-19 & Vaccine

CD = Chronic Diseases

CV = COVID-19 Vaccine

PR = Perceived Risk of COVID-19

INT = Intention to Vaccinate for COVID-19

**3. Results**

**3.1. Multiple regression analysis**

Multiple linear regression analysis was used to assess the association between two or more independent variables and a single continuous dependent variable. The multiple linear regression equation is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + e$$

Y is the predicted or dependent response variable, X1 through Xk are k distinct independent or predictor variables,  $\beta_0$  is

the y-intercept on the y-axis or the value of Y when all of the independent variables (X1 through Xk) are equal to zero,  $\beta_n$  is the regression parameter associated with the independent predictor variable Xn (n = 1, ..., k) respectively, and e is the residual or error term.  $\beta_1$  through  $\beta_k$  are the estimated regression coefficients.

Table 4 shows the unstandardized coefficients (b) as well as the t-values and p-values for the listed independent variables. The results and statistical outputs were generated using the SPSS software.

**Table 4: Multiple Regression Results for Predicting the Intention to Vaccinate**

Independent Variable	Unstandardized Coefficient	T-value	P-value (two-tail)
<b>Socio-Demographic</b>			
Gender	0.28	1.10	0.27
Age	0.42	1.48	0.14
Marital Status	-0.18	-0.44	0.66
Number of Children	-0.05	-0.19	0.85
Household Size	0.06	0.56	0.58
Ethnicity	0.11	0.95	0.35
Religion Affiliation	0.03	0.46	0.64
Education Level	0.21	1.71	0.09*
Political Party Affiliation	0.41	3.09	0.00***
Income	0.08	0.74	0.46
Social Class	0.44	1.53	0.13
Occupation	0.01	0.07	0.94
Employment Status	0.62	2.21	0.03**
Residence	0.01	0.12	0.91
<b>Health-Related</b>			
Previous Vaccinations	0.25	0.98	0.33
Previous Flu Vaccinations	0.74	2.97	0.00***
Previous COVID-19 Infection	-0.04	-0.21	0.84
Knowledge of COVID-19 & Vaccine	0.32	2.06	0.04**
Chronic Diseases	0.19	0.45	0.65
<b>Beliefs</b>			
Effectiveness of Vaccine	1.18	11.37	0.00***
Perceived Risk of COVID-19	0.05	0.70	0.48

\*Significance level of P-Value < 0.10; \*\*P-Value < .05; \*\*\*P-Value < 0.01

The results from the standardized coefficients ( $\beta$ ) from Figure 2 suggest that six variables exert positive and significant effects on the intention to vaccinate for COVID-19 ranging from 0.1 to 0.01 level of significance (P-value). Belief in the effectiveness of the COVID-19 vaccine had the strongest effect on the intention to vaccinate for COVID-19 ( $\beta = 0.71$ , p-value < 0.01), followed by political party affiliation ( $\beta = 0.48$ , p-value < 0.01), previous flu vaccination ( $\beta = 0.31$ , p-value < 0.01), current

employment status ( $\beta = 0.23$ , p-value < 0.05), knowledge of COVID-19 and the COVID-19 vaccine ( $\beta = 0.19$ , p-value < 0.05), and educational level ( $\beta = 0.17$ , p-value < 0.10), respectively.

The proposed regression model produces an impressive  $R^2$  of 0.713 or 71.3% of the variability in the dependent variable. This means that the proposed model explains the proportion of the variability in the intention to vaccinate with 71.3% accuracy.

### 3.2. Multiple linear regression model to predict intention to vaccinate

$$Y = \beta_0 + 0.21(\text{Education}) + 0.62(\text{Employment}) + 0.41(\text{Politics}) + 0.74(\text{Flu}) + 0.32(\text{Background Knowledge}) + 1.18(\text{Belief in Effectiveness of Vaccine})$$

Note: The multiple regression equation only shows the significant independent variables to predict the criterion variable of intention to receive the vaccine for COVID-19. Other factors were excluded from the regression equation due to their insignificant values.

### 4. Discussion and Implications

This study is one of the first to propose and empirically test the comprehensive model of intention to vaccinate for COVID-19. It examines the demographics, clinical, and behavioral predictors among college students on their intention to receive the COVID-19 vaccine. It is interesting to note that this study's findings were consistent with the results of previous studies mostly conducted outside the United States (e.g., Kwok et al., 2021; Rhodes et al., 2021; Sherman et al., 2021). More importantly, additional predictors of the intention to receive a future COVID-19 vaccine were included in this proposed comprehensive research model.

The results suggest that overall six factors consisting of education level, political party affiliation, previous influenza (flu) vaccination, background knowledge of COVID-19 and the COVID-19 vaccine, as well as the belief in the effectiveness of COVID-19 vaccine exert positive and significant effects on intention to vaccinate. Note that all significant values have positive relationships between dependent variables and their predictors.

Specifically, the belief in the effectiveness of the COVID-19 vaccine plays the strongest role in predicting the intention to vaccinate. This result is interesting providing that a previous study found that although college students had positive attitudes towards vaccines and agreed they would likely be exposed to COVID, only half would be willing to get the COVID-19 vaccine (Lucia et al., 2021). The study result is alarming given that COVID-19 is still considered an epidemic in many countries. This result has strong public policy implications in which government must inform, educate, and communicate that the COVID-19 vaccines are safe, effective, and has no harmful side effects. This means that the more confident people have about the vaccine for safety, effectiveness, and side effects consequences, the more likely they intend to get vaccinated. This is true, especially for vaccine hesitancy among young and college students.

A strong relationship was also found in the political party affiliation. People that are affiliated with the Democratic party were shown to have more intentions to vaccinate for COVID-19 compared to Republican and Independent voters. This study's results are quite interesting because the findings confirm the assertion that political conservatism and identifying as Republican are associated with anti-vaccine attitudes (Whitehead and Perry, 2020). This is also consistent with previous literature showing that risk perceptions and preferences for risk mitigation may vary by political inclinations (Bruin et al., 2020). Bruin et al. (2020) reported that overall, Democrats perceived more risk associated

with COVID-19 than Republicans, including getting infected, being hospitalized, and dying if infected. Thus, the present study's results on political party affiliation have strong public health implications. Besides promoting and communicating the effectiveness of the COVID-19 vaccine to Republicans and Independents affiliated, state and federal governments should seek public endorsements by party elites that show to affect Independents and *Republicans' COVID-19 vaccination* intentions and attitudes.

The results also highlight the importance of general health-related factors such as receiving influenza (flu) vaccine last year and knowledge of COVID-19 in general, as well as the COVID-19 vaccine, having positive relationships with the intention to get vaccinated. The results are consistent with the recent study that examine the health-related and individual perceived risk of contagious diseases (Gabaneli, et al., 2022). This means that recipients of the influenza vaccine last year are more likely to be willing to vaccinate against COVID-19. Knowledge of COVID-19 and vaccines also increases the intention to vaccinate. Essentially, the more knowledge people have about COVID-19 and the COVID-19 vaccine, the more likely they will get vaccinated. One of the important implications for public policy is that the government should provide information regarding COVID-19 and the COVID-19 vaccine to the public.

Some of the socio-demographics such as employment status and education level play positive and important roles in the intention to get vaccinated. Specifically, the employed respondents were more willing to receive the COVID-19 vaccine. This might stem from the fact that many firms and/or organizations have started to mandate COVID-19 vaccination to employees, especially in workplaces like government agencies (city, state, etc.). Some sectors such as health workers have implemented vaccine mandates for employees. However, there is much discussion about whether the vaccine mandates would be lawful and ethical, specifically in certain professions or age groups (Gostin et al., 2021). In addition, the more educated an individual is, the more likely they were to receive the COVID-19 vaccine.

### 5. Limitations and Future Research

One limitation of this study is that response bias could have influenced results because non-responders might have declined to take the survey due to not supporting the vaccine (i.e., anti-vaxxer). Another limitation is due to the majority of participants in the survey being from the Northeast region, findings might not be generalized for the perceptions of low-income and/or uneducated individuals who do not have access to the Internet.

Despite these limitations, the present findings are consistent with existing literature and offer insightful information. This study shows that while 79% of participants reported their intentions to get vaccinated against COVID-19 when a vaccine becomes available, 21% reported not being likely to. Future studies should focus on finding this missing link and implementing any public health policies to level up individual

intentions. Further research with a larger sample size may result in a more accurate portrayal of the general population. In addition, future research that incorporates other independent variables may be effective in predicting intentions to vaccinate even though the present study's results show a very good predictive power of over 70%. This means that to increase the predictive power of the regression model, there must be some other additional variables that need to be included. Extending this study outside of the Northeast region, and possibly other countries may be effective in predicting intentions to vaccinate as well. Additionally, this research may benefit from a longitudinal study to determine

possible changes that may result from long-term events. Perhaps, a systematic meta-analysis of epidemiological studies will benefit this research area as it enables researchers to derive conclusions that can potentially provide communities with a better understanding of unified factors that ultimately affect the intention to vaccinate against COVID-19.

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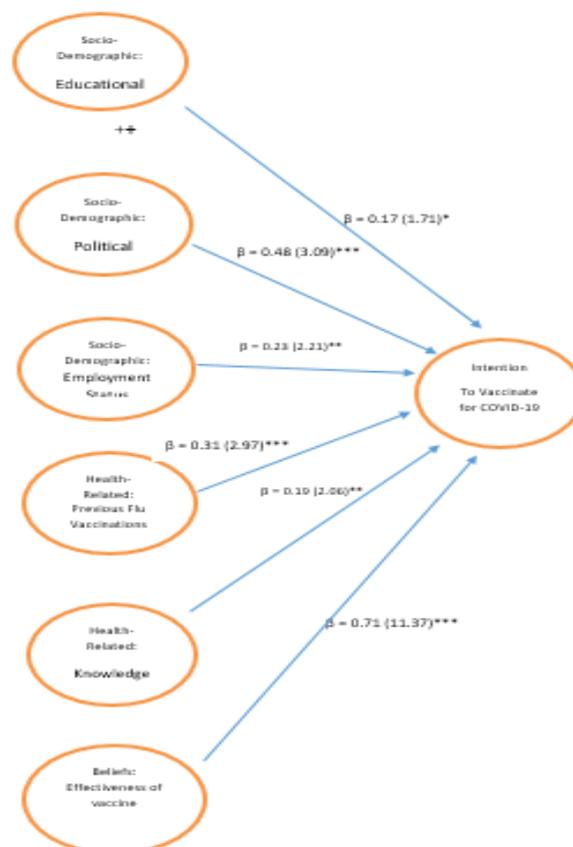
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**Figure 2: Standardized Multiple Regression Coefficients Results**



Note: Only significant constructs with  $\beta$  and t-value shown in the finalized model

\*Significance level of P-Value < 0.10; \*\*P-Value < .05; \*\*\*P-Value < 0.01;

## APPENDIX: Measurement Scales

### Health-Related

Previous Vaccinations\*

Previous Flu Vaccinations\*

Previous COVID-19 Infection\*

Chronic diseases\*

Knowledge of COVID-19\*\*

Knowledge of COVID-19 vaccine\*\*

### Beliefs

#### Effectiveness of Vaccine ( $\alpha = .82$ )\*\*\*

1. The COVID-19 vaccine will be effective.
2. The COVID-19 vaccine will be safe.
3. The COVID-19 vaccine won't cause any harmful side effects.

#### Perceived Risk of COVID-19 ( $\alpha = .78$ )\*\*\*

1. I adhere to government COVID-19 guidelines.
2. I am worried about getting COVID-19 compared to others.
3. I am often worried about getting infected with COVID-19.

#### Intention to Vaccinate for COVID-19 ( $\alpha = .99$ )\*\*\*

1. I intend to get vaccinated when the COVID-19 vaccine is available.
2. I predict I would get vaccinated when the COVID-19 vaccine is available.
3. I plan to get vaccinated when the COVID-19 vaccine is available.

### Socio-Demographic

1. Indicate your gender \_\_\_\_?
2. Indicate your occupation \_\_\_\_?
3. Indicate your marital status \_\_\_\_?
4. Indicate number of children \_\_\_\_?
5. Indicate your family size \_\_\_\_?
6. Indicate your ethnicity \_\_\_\_?
7. Indicate your religion \_\_\_\_?
8. Indicate your education \_\_\_\_?
9. Indicate your political party affiliation \_\_\_\_?
10. Indicate your household annual income before tax \_\_\_\_?
11. Classify yourself \_\_\_\_?
12. Indicate your occupation \_\_\_\_?
13. Indicate your employment status \_\_\_\_?
14. Where do you reside \_\_\_\_?

\* Dichotomous Likert-type items anchored by 1 = Yes; 2 = No

\*\*Likert-type items anchored by 1 = Very good knowledge; 5 = Very little knowledge

\*\*\*Likert-type items anchored by 1 = Strongly Agree; 5 = Strongly Disagree