Journal of Information & Optimization Sciences
ISSN 0252-2667 (Print), ISSN 2169-0103 (Online)
Vol. 44 (2023), No. 5, pp. 937–956
DOI : 10.47974/JIOS-1272

A multinomial logistic regression analysis of factors associated with COVID-19 vaccine hesitancy among Namibian higher education students

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Abstract

Coronavirus disease well known as COVID-19 is an infectious disease caused by the SARS-CoV-2 virus. Several vaccines began to rise in late 2020 and Namibia started administering the COVID-19 vaccine around March 2021. Despite the availability of the vaccination services, there were delays in the acceptance of the vaccination that might result in slow rate of vaccine coverage and hence become an obstacle in ending the COVID-19 pandemic. The main objective of this study is to identify factors associated with COVID-19 vaccine hesitancy among Namibian higher education students by fitting a multinomial logistic regression model. The data was collected using an online anonymous self-administered questionnaire. The study found factors such as field of study, COVID-19 status, trust information from public health experts on COVID-19 vaccine hesitancy and mandating the COVID-19 vaccine for the public to be significant factors associated with COVID-19 vaccine hesitancy. Education on the safety and effectiveness of the vaccine should be the main focus during vaccination campaigns. The result of this study could be used as an input in developing a better understanding and redirecting the focus of the vaccine to avoid failure of the vaccination programme.

Subject Classification: *62J12.*

Keywords: *COVID-19, Vaccine hesitance, Multinomial regression.*

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.

1. Introduction

Coronavirus disease well known as COVID-19 is an infectious disease caused by the SARS-CoV-2 virus (World Health Organisation 2021). COVID-19 was discovered in Wuhan, China in November 2019. Ever since the first case was reported in 2019, World Health Organization has recorded 352,796,704 confirmed positive cases including 5,600,434 deaths globally, as of 25 January 2022. COVID-19 has spread around the world within a short period of time. World Health Organization declared the corona virus outbreak a global pandemic on 11 March 2020, due to an increasing number of positive cases. Global preventative efforts such as adhering to social distancing, wearing a mask, sanitizing, controlled gatherings and travelling were put in place to help curb the spread of the disease. However, COVID-19 catastrophic effects continued to affect the economy, health, and lives of all the citizens. Several studies in different countries have been conducted on COVID-19 patients and its transmission. For instance, Bhatnagar et al. (2021) conducted a descriptive analysis of COVID-19 patients in the context of India. The authors found a significant relationship between sex and transmission type (imported from other countries or communicated from locals) of the patients. COVID-19 pandemic also affected different parts of the society including higher learning institutions around the world, which led a transformation of teaching models that have been used for hundreds of years. Sahoo et al. (2021) stated that e-learning is a first step forward, however it has significant adoption and training issues. Aspects such as internationalization of higher education has been affected as students will not be able to travel to partner countries, but new technologies have been adopted that allows co-teaching of courses using online technology, allowing students from partner countries to conduct research, develop and discuss case studies through webinars and video conferencing (Sahasrabudhe, Shaikh & Kasat 2020).

The whole world set out to scientific and medical research to find the vaccine for the novel coronavirus and several COVID-19 vaccines began to rise in the late 2020. A study conducted by Singh et al. (2020) pointed out that emergency situation could result before a proper vaccine was invented. COVID-19 vaccination is an effective way to neutralize the burden of COVID-19 pandemic, however its effectiveness strongly depends on the willingness to get vaccinated (Alwi et al. 2021). Vaccination campaigns that reach many people are an effective strategy to combat the pandemic, however there is a widespread distrust of the vaccine safety and effectiveness (Public Health Ontario [PHO] 2020). Namibia has started

administering the COVID-19 vaccine such as Sputnik light, AstraZeneca, Sinopharm, Jonson & Jonson around March 2021. According to the WHO, so far, at least one dose of the COVID-19 vaccine has been administered to 773, 702 Namibians as of 24 January 2022. Several companies and organizations in Namibia are campaigning to encourage the citizens to get vaccinated against COVID-19 (WHO 2021).

Vaccine hesitancy is defined as the delay in the acceptance, or refusal of the vaccination despite the availability of the vaccination services, which may result in slow rate of vaccine coverage (Soares et al. 2021). Vaccine hesitancy might be a result of different factors such as poor communication and media, chronological influences, theology, culture, politics, consciousness about the safety or effectiveness of the vaccine, and prior vaccination experience. The World Health Organization recognized that vaccine hesitancy is a barrier to global health, and it will be an obstacle in ending the COVID-19 pandemic. Refusal to get vaccinated slows down the COVID-19 vaccine rollouts and the fight to end the pandemic. Nhongo (2021) indicated that the refusal to get vaccinated has a negative impact on the Namibian economic growth. Citizen's different opinions and concerns towards the vaccine tend to challenge governments campaigns to get the nation vaccinated.

With the rising of COVID-19 cases in Namibia, and overwhelming effects of the pandemic on everyday life, it is important to understand how the vaccine is accepted among students from different Namibian Universities, with different believes about the COVID-19 vaccine. A report published on the WHO website on the 11 August 2021 reports on a recent WHO/Namibia survey that was carried out in Namibia on adherence to COVID-19 public health measures. The results show that 1/3 of the respondents were unwilling to get the COVID-19 vaccine because they are concerned about the safety of the vaccine. The survey further shows that only 1.6% of the population was fully vaccinated as of 28 July 2021. According to a WHO representative Dr. Charles Sagoe-Moses, the COVID-19 situation is worsening with more than 4 million deaths around the world, Namibia was one of the top 5 countries that contributed to the 76% of the deaths in the WHO Africa Region. It is, therefore, important to identify the hesitant population segment and understand the possible reasons for hesitating, in order to develop and use suitable communication that targets the hesitant population (Sovicona et al. 2021).

Several investigations around the world have been carried out to assess people's willingness to be vaccinated against COVID-19. For instance, Fares et al. (2021) conducted an observational study to assess

the perception and attitude of healthcare workers in Egypt towards the COVID-19 vaccine. The association of participants perception and attitude with their decision regarding COVID-19 vaccination were done using Chi-Squared test, further the significant variables were tested using univariate multinomial regression. The dependent variable had 3 categories, hesitant, accept and refusal to get vaccinated. The result of the study shows that 51% of the respondents were undecided, 28% refused and 21% accepted the vaccine. The study results further revealed that COVID-19 risk (93%), safety (57.5%) and effectiveness of the vaccine (56.25%) was variables that increased vaccine acceptance. On the same note, the reasons for vaccine hesitancy were absence of enough clinical trials (92.4%) and fear of side effects of the vaccine (91.4%). However, results of the research cannot be generalized and hence there is a need for region specific evidence-based research.

Sovicona et al. (2021) conducted a cross-sectional study to measure the attitude of medical students in Slovakia towards the COVID-19 vaccine. The authors fitted the multiple logistic regression to determine COVID-19 status predictors. The result of the study indicates that the attitude of medical students towards COVID-19 vaccination was compliance with the vaccination, 38.8% and 24% of the study participants were concerned about the effectiveness of COVID-19 vaccine and serious side effects which might result from COVID-19 vaccine, respectively. Their result further reveals less association between contracting COVID-19 and having COVID-19 vaccine. The result of the study also shows that those with strong fear of COVID-19 vaccination side-effects were likely not to take the COVID-19 vaccine (Sovicona et al. 2021).

In general, multiple studies on the factors affecting vaccine acceptance have been conducted in different states and the results obtained cannot be generalized because of the diversity in most possible factors of COVID-19 vaccine hesitancy which differs from region to region. Difference in independent variable might have been caused by cultural differences, religion, political unrest in some countries. Given the number of circumstances that will result in vaccine hesitancy, interventions should therefore be addressed based on the concerns of local population. In Namibia, there is little research done on this area. Furthermore, despite multiple studies carried out on vaccine hesitancy, there were limited studies that used multinomial logistic regression in this area. For example, the study carried out in Zimbabwe by Mundagowa et al. (2021) fitted an ordinary logistic regression, did not consider the possibility of the dependent variable having more than two categories. It is with this

understanding the motive of this study to be carried out to access the association between vaccine hesitance and several independent variables among Namibian higher education [Namibia University of Science and Technology (NUST), University of Namibia (UNAM) and the International University of Management (IUM)] students by fitting a multinomial logistic regression model.

Multinomial Logistic Regression model is an extension of the binary logistic regression model that is used when dependent variable has more than two nominal categories. It uses a maximum likelihood estimation to assess the probability of categorical membership on a dependent variable based on multiple independent variables (El-Habil 2012). This research demonstrated the use of multinomial logistic regression model in identifying factors associated with COVID-19 vaccine hesitance amongst students. The findings of the study will be useful to the government and decision-making bodies to redirect the focus of COVID-19 vaccination to ensure the vaccine is accepted.

2. Data and Methods

2.1 *Study Design and Data Collection*

An observational web-based anonymous survey targeting Namibian higher education students was conducted.

The sample was calculated using the following formula:

$$n = \frac{z^2 p(1-p)}{\varepsilon^2}, \tag{1}$$

where z represents the z-score (1.96 at 5% level of significance) of the confidence level; p represents the population proportion, for this study since there was no prior knowledge on student's vaccine perception, it was assumed that 50% of the population will hesitate to get the vaccine; ε represent the margin of error (0.05), it's the acceptable error rate in the estimate. Using Expression (1) and the values of the components of the formula stated above,

$$n = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2} \approx 385$$

approximately a total sample of was computed. However, only 336 responses were received from the survey and hence only the responses obtained from 336 students was analysed in this study.

The questionnaire adapted from Reno et al. (2021) was designed using Google Forms and the links to the questionnaire were shared with

the student's representative council (SRC) representing the portfolio of information and publicity from all the institutions to ensure representative sample and reduce coverage bias. Furthermore, to increase the response rate, the link to the questionnaire was also distributed electronically on different social media platforms (Facebook, WhatsApp, and Telegram). Data were collected from 30 September 2021 to 10 October 2021. The study exclusion criteria included refusal to participate in the study and it also automatically excluded students with no internet connection. Written consent was not required for this study as an individual participant's voluntary completion of the online questionnaire was recognized as consent.

2.1.1 Variable identification

2.1.1.1 Dependent variable

Students were asked to rate their willingness to get vaccinated against COVID-19. The dependent variable is categorical, the options are "Surely not likely", "not likely", "not sure", "likely" and "surely likely". For the purposes of analysis, the categories were merged into 3 main categories. "Surely not likely" and "not likely" was combined to form one group "Refuse" while, "likely" and "surely likely" was combined to form one group "Accept". The third category was "Hesitant", to represent students that are not sure about the decision of getting vaccinated.

2.1.1.2 Independent variable

The independent variables included socio-demographic characteristics of the students, that is, Institution, Field of study, Year of study, Mode of study, Highest level of Education, Sex, Age, Residential Area, Ethnic group, Family size, Employment Status, Comorbidities, and COVID-19 diagnosis. Respondents were also asked to rate their level of agreement with the following independent variables; There is adequate information on vaccine safety; Institution encourages students to take the vaccine; Concern about side effects that might result from taking COVID-19 vaccine; Concern about vaccine effectiveness; Requiring to know more about COVID-19 vaccine; The COVID-19 vaccine should be mandatory for the general public; Trusting information received from the public health experts about the COVID-19 vaccine; Get COVID-19 vaccine only if it became mandatory by the public health system.

Data extracted from Microsoft Forms was statistically analysed using IBM Statistical Package for Social Science (SPSS) Statistics for Windows version 27 (IBM Corp., Armonk, N.Y., USA) and R software.

2.2 *Multinomial Logistic Regression*

Multinomial logistic regression, which can be referred to as multinomial regression is used for predicting a nominal scaled dependent variable given some independent variables. It is an extension of the binary logistic regression that allows the dependent variable Y to have more than two categories. One of the categories should be considered as a reference category (Agresti 2002) and all the logits are constructed in comparison to resulting with multiple logistic regression models. Multinomial logistic regression can have nominal and/or continuous independent variables.

Let Y be the response variable with m categories with $P(Y = j \mid \boldsymbol{x}) = \pi_j(\boldsymbol{x})$, where $j = 1, 2, \ldots, (m - 1)$, $\pi_j(\boldsymbol{x})$ is the multinomial probability of an observation falling in the j^{th} category for a given set of predictor variables $\boldsymbol{x}$ and $\sum_{j=1}^{m} \pi_j(\boldsymbol{x}) = 1$. The multinomial logistic regression model consists of $m - 1$ logit functions with the logit of the j^{th} category in reference to the baseline category k is given by

$$\log\left[\frac{\pi_j(x)}{\pi_k(x)}\right] = \boldsymbol{\beta}_j'\boldsymbol{x}, \tag{2}$$

where $j = 1, 2, \ldots, (m - 1)$ and $\boldsymbol{\beta}_j$ is a vector of regression parameters for the j^{th} logit functions (Dobson and Barnett 2008). The model parameters were estimated using maximum likelihood estimation (Dobson and Barnett 2008; El-Habil 2012).

2.2.1 Goodness of fit

Once the model is fitted, it is important to know how the model best fits the response variable in the data. In this study, the likelihood ratio chi-squared statistic given by the following expression was employed to test for the goodness of the fit of the model.

$$C = 2[LL_1 - LL_0], \tag{3}$$

where LL_1 and LL_0 are the log-likelihood function for the final selected model and the null (intercept only) model, respectively (Dobson and Barnett 2008).

3. Results

3.1 *Descriptive Analysis*

The sample included 336 students, of which 61% were female and 39% were male. Mean age was 23 years, ranging from 18 to 41 years. A total of 115 (34.2%) respondents were from NUST, 124 (36.9%) and 96 (28.5%)

were from UNAM and IUM, respectively. Some of the characteristics of the respondents were reported in Table 1. Furthermore, the result of the survey shows that a total number of 187 (55.7%) of the students were surely not likely or not likely to take the vaccine, and 61(18.2%) were unsure whether they will get vaccinated or not, however 88 (26.2%) of the students were surely likely, likely or have been vaccinated (see Figure 1).

The concerns about the effectiveness of the vaccine shows that about 26% of the students were neutral about the effectiveness of the COVID-19

Table 1

Sample socio-demographic features and comparison to vaccine hesitancy

Variable		Refuse	Hesitant	Accept
		n=187 (%)	n=61 (%)	n=88 (%)
Institution	NUST	70(60.9)	16(13.9)	29(25.2)
	UNAM	75(60.5)	25(20.2)	24(19.4)
	IUM	42(43.3)	20(20.6)	35(36.1)
Sex	Female	116(56.6)	43(21.0)	46(22.4)
	Male	71(55.0)	18(14.0)	40(30.0)
Age Group	15-20	39(61.9)	11(17.5)	13(20.6)
	21-25	120(57.1)	35(16.7)	55(26.2)
	26 and Older	26(46.4)	12(21.4)	18(32.1)
Residential	Rural	34(52.3)	12(18.5)	19(29.2)
	Suburban	51(60.7)	8(9.5)	25(29.8)
	Urban	99(54.1)	41(22.4)	43(23.5)

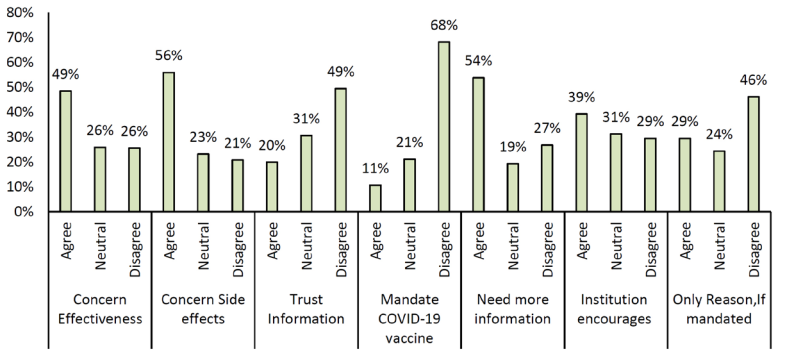

Figure 1

Attitude towards COVID-19 vaccine

vaccine and the same percentage of them were not concerned about the effectiveness of the vaccine, and the remaining 49% of them had indicated their concern about the effectiveness of the vaccine (see Figure 1).

In terms of the concern about the serious side effects that may occur as a result of the COVID-19 vaccine, Figure 1 shows that more than half of these students, 56% were concerned about the serious side effects caused by the vaccine. The large representation may also lead to a reduced rate of vaccine uptake due to the fear of side effects. The result of this study further indicated that 68% of the students do not agree that COVID-19 vaccine must be mandatory for the public, and only 11% agree (see Figure 1). Furthermore, about 54% of the students indicated that they need more information on the COVID-19 vaccine and only 20% of the students trust the information on COVID-19 vaccine provided by public health experts.

The cross tabulation of independent variables versus the dependent variables presented in Table 2 indicates that 45.5% of the students with comorbidities had indicated their refusal to get vaccinated. The result

Table 2

Sample characteristics in comparison to the dependent variable

Variable		Vaccine Hesitancy		
		Refuse	Hesitant	Accept
		n (%)	n (%)	n (%)
Comorbidities	Present	15(45.5)	4(12.1)	14(42.4)
	Absent	172(56.8)	57(18.8)	74(24.4)
COVID-19_ Status	Yes	28(41.2)	5(7.4)	35(51.5)
	No	159(59.3)	56(20.9)	53(19.8)
Field of study	Tourism/ Management/ Agriculture	16(35.6)	7(15.6)	22(48.9)
	Health and Science	44(57.7)	14(17.1)	24(29.3)
	Law/ Education	56(58.9)	20(21.1)	19(20.0)
	Management/ Human / Social / Business	40(65.6)	8(13.1)	13(21.3)
	Engineering/Computer	26(56.5)	12(26.1)	8(17.4)
Year of Study	Year 1-2	91(59.9)	31(20.4)	30(19.7)
	Year 3-4	91(51.7)	28(15.9)	57(32.4)
	Above 4th year	3(60.0)	1(20.0)	1(20.0)

Contd...

Mode of Study	Full Time	133(55.9)	45(18.9)	60(25.2)
	Part Time - Distance	52(54.2)	16(16.7)	28(29.2)
Highest level of education	High School	141(56.6)	48(19.3)	60(24.1)
	Bachelor's Degree /Higher	23(56.1)	4(9.8)	14(34.1)
	Diploma /Less than high school and Other	21(47.7)	9(20.5)	14(31.8)
Family Size	1-2 Members	46(59.0)	13(16.7)	19(24.4)
	3-4 Members	68(50.4)	21(15.6)	46(34.1)
	More than 4 members	71(59.2)	26(21.7)	23(19.2)
Employment Status	Employed	30(50.0)	7(11.7)	23(38.3)
	Unemployed	154(56.6)	53(19.5)	65(23.9)

in Table 2 further shows that 56.8% and 59.3% of students with no comorbidities and who were never infected with COVID-19, respectively, had indicated their refusal to get vaccinated.

3.2. *Results of multinomial logistic regression*

The model fitting information presented in Table 3 shows the overall measure of the multinomial model fitted in the current study.

The intercept only row presented in Table 3 shows the model with no variable added and the final row represents information about the variables added in the model. Based on the Akaike Information Criteria (AIC), which measures the goodness of fit of the estimated model and the Bayesian Information criteria (BIC), a type of model selection among a class of parameters, the model with the lowest AIC and BIC (final model) was selected. The final row represents information that the variables added in the model statistically significantly improved the model compared intercept alone (i.e., no variable added). Similarly, looking at the

Table 3

Model fitting information

	Model Fitting Criteria			**Likelihood Ratio Tests**		
Model	**AIC**	**BIC**	**-2 Log Likelihood**	**Chi-Square**	**df**	**p-value**
Intercept only	390.095	397.675	386.095			
Final model	303.994	379.793	263.994	122.101	18	<0.001

Table 4
Likelihood ratio tests of the final model selected

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	p-value
Constant	303.994	379.793	263.994	.000	0	.
Field of study	310.048	355.528	286.048	22.054	8	0.005
Sex	306.109	374.328	270.109	6.115	2	0.047
COVID-19 Status	319.508	387.728	283.508	19.514	2	<0.001
Effectiveness	320.675	388.894	284.675	20.681	2	<0.001
Trust	330.256	398.475	294.256	30.262	2	<0.001
Mandatory	308.117	376.336	272.117	8.122	2	0.017

likelihood ratio test result presented in Table 4, since the p-value<0.001 the null hypothesis which states no statistically significant difference between the two models were rejected. This indicates that the full model predicts the dependent variable better than the intercept-only model alone.

The likelihood ratio tests presented in Table 4 checks the contribution of each variable to the model. This test was obtained by taking the difference between -2 Log Likelihoods computed for the models with and without the effects (also called reduced model). The statistically significant variables have a p-value less than 0.05. The variables field of study, sex, COVID-19 status, concern on the effectiveness, trust on the information from public health experts, COVID-19 vaccine should be mandated for the general public were found to be a significant predictor of the dependent variable. The following section presents how each category of the independent variables affect the dependent variable.

3.2.1 Parameter Estimates

In Tables 5 and 6, the parameter estimates and their corresponding odds ratio and confidence interval (CI) for the two multinomial logistic regression fitted using the final model selected were given. The Cl presented in Table 5 represents the CI for individual multinomial odds

Table 5

Fitted multinomial logistic regression model result, model 1: estimated coefficients for the comparison between refuse and accept

Vaccine Hesitancy		Estimate $\hat{\beta}$ (se)	Odds ratio, $e^{\hat{\beta}}$, (95% CI)
Refuse/ Accept	Constant	1.535(0.560)	
	Field of Study 1	-1.929(0.635)	0.145 (0.042, 0.504)
	Field of Study 2	-0.911(0.581)	0.402 (0.129, 1.255)
	Field of Study 3	-0.363(0.586)	0.696 (0.221, 2.192)
	Field of St. 4	0.036(0.621)	1.036 (0.307, 3.501)
	Sex: female	0.523(0.335)	1.688 (0.876,3.253)
	COVID-19 Status: Positive	-1.354(0.373)	0.258 (0.124, 0.536)
	Effectiveness: Agree	1.345(0.336)	3.839 (1.986, 7.418)
	Trust: Agree	-2.060(0.394)	0.127 (0.059, 0.276)
	Mandatory: Agree	-1.245(0.518)	0.288 (0.104, 0.794)

ratio given the other predictors in the model for refusing to get vaccinated relative to accepting the vaccine. If the CI includes zero, it indicates the insignificance the regression coefficient given the other predictors in the model.

As can be seen from Table 5, the odds ratio of 0.145 for field of study 1 (Tourism/ Management/ Agriculture) indicates that the odds of refusing the vaccine over accepting the vaccine reduces by 85.5% as compared to students from field of study 5 (Engineering/Computer science). This means, students from Tourism/Management sciences/Agriculture tend to accept the vaccine more as compared to students from Engineering/ Computer science.

Looking at the COVID-19 Status, the odds ratio of 0.258 indicates that the odds of refusing the vaccine over accepting for students who were infected with COVID-19 reduces by 74.2% as compared to students who were never infected by COVID-19. Thus, students who were infected by COVID-19 tend to accept the vaccine as compared to students who were never infected by COVID-19.

For the concern about the effectiveness of the vaccine, the odds ratio of 3.839 indicates that odds of refusing the COVID-19 vaccine over accepting for students who indicated that they are concerned about effectiveness of the vaccine were about 4 times the odds of refusing the COVID-19 vaccine over accepting for students who were not concerned about the effectiveness of COVID-19 vaccine. Thus, the odds of refusing to

get vaccinated was highly associated with concern on the effectiveness of the vaccine. This means if a student was concerned with the effectiveness of the vaccine, they had a high possibility of refusing to get vaccinated.

For the variable trust information on COVID-19 vaccine from public health experts, the odds ratio 0.127 indicates that students who trust the information reduces the chance of refusing the vaccine over accepting by 87.3% as compared to those who do not trust the information on COVID-19 vaccine. Thus, students who trust information on COVID-19 vaccine they tend to accept the vaccine more as compared to students who do not trust information from health experts on COVID-19 vaccine.

Lastly, for the variable about mandating COVID-19 for the general public, the odds ratio 0.288 indicates that students who agree that the vaccine must be mandatory for the public reduces the likelihood of refusing to be vaccinated over accepting by 71.2%. That means students who agree that the vaccine must be mandated for the public, tend to accept

Table 6

Fitted multinomial logistic regression model result, model 2: estimated coefficients for the comparison between hesitant and accept

Vaccine Hesitancy		**Estimate $\hat{\beta}$ (se)**	**Odds ratio, $e^{\hat{\beta}}$, (95% CI)**
Hesitant	Constant	1.176(0.623)	
	Field of Study 1	-2.187(0.724)	0.112(0.027, 0.464)
	Field of Study 2	-1.596(0.661)	0.203(0.055, 0.741)
	Field of Study 3	-1.046(0.655)	0.351(0.097, 1.269)
	Field of Study 4	-1.033(0.729)	0.356(0.085, 1.484)
	Sex: female	1.012(0.417)	2.751(1.215,6.226)
	COVID-19 Status: positive	-1.997(0.556)	0.136(0.046, 0.403)
	Effectiveness: Agree	0.477(0.403)	1.611(0.732, 3.547)
	Trust: Agree	-1.523(0.475)	0.218(0.086, 0.554)
	Mandatory: Agree	-1.628(0.714)	0.196(0.048, 0.795)

the vaccine more than students who disagreed that the vaccine must be mandatory for the public.

Results presented in Table 6 show the parameter estimates for the second model fitted for the hesitant response category with the acceptance of the vaccine as a reference category. The interpretation of the results presented in Table 6 are similar to the results presented in Table 5. For instance, the odds ratio of 0.112 for field of study 1 (Tourism/ Management/ Agriculture) indicates that students from faculty 1 reduces the chance of hesitating the vaccine over accepting the vaccine by approximately 89%. Thus, students from Tourism/Management sciences/Agriculture tend to accept the vaccine more as compared to students from Engineering/ Computer Science. Similarly, for the sex variable, the odds ratio of 2.751 indicates that the odds of hesitating the vaccine over accepting the vaccine for female student were approximately three times the odds of hesitating the vaccine over accepting the vaccine for male students. This means females tend to hesitate the vaccine more over accepting the vaccine compared to males.

Results presented in Table 6 also indicate that students who were never infected by COVID-19 tend to hesitate the vaccine over accepting the vaccine as compared to students who were infected by COVID-19. In other words, students who were never infected by COVID-19 had a low possibility of accepting to get vaccinated. The result in Table 6 also indicates that students who trust information on COVID-19 vaccine tend to accept the vaccine more than those students who do not trust information from health experts on COVID-19 vaccine. Furthermore, students who agree that the vaccine should be mandated for the general public tend to accept the vaccine more than students who disagreed that the vaccine should be mandatory for the general public.

4. Discussions

COVID-19 pandemic is a devastating issue that up to date continues to negatively affect life's world widely. Different strategies were put in place to manage and control the virus, but they have not been effective in ending the pandemic. Vaccinations were invented in the public health industry to help curb viruses. Vaccine hesitancy is an ongoing matter and is highly present in developing countries and a better understanding of its causes, within a given segment of the population will be a useful background evidence that will support the development of effective and targeted vaccination campaigns. Therefore, this study was intended to

determine the factors associated with COVID-19 vaccine hesitancy among Namibian students.

The result of this study reveals that 55.5% of the students were surely unlikely or unlikely to get vaccinated, 18% were hesitant and 26% of the students accepted that vaccine, this result goes in line with a study conducted by Wake (2021) who accessed the acceptance rate of COVID-19 vaccine in African adults, the result of the author show that the chance of acceptance of the vaccine was low, 24.28% among adults in the Northern Africa. In another study by Omar & Hani (2021), who accessed intension to get vaccinated among Egyptian adults indicates that about 25% of the Egyptian adults accepted to get vaccinated. This goes in hand with a result of 21% of COVID-19 vaccine acceptance that was found by Fares et al. (2021) in a study of accessing COVID-19 perception and attitude among health care workers in Egypt. This shows that COVID-19 vaccine acceptance around the world is an issue, and it needs to be addressed.

The results of the current study revealed that the likelihood to refuse or hesitate the COVID-19 vaccine was associated with field of study, sex of the respondent, COVID-19 status, concern about the effectiveness of the vaccine, trust information on COVID-19 vaccine from public health experts. Regarding sex females, the study found that females increased the likelihood to refuse the vaccine, concerning COVID-19 status, students who were once infected by COVID-19 increases the likelihood to accept the vaccine. The study that was carried out by Omar& Hani (2021) also found that vaccine hesitancy was associated with females from universities and postgraduates. This shows that females tend to reduce COVID-19 vaccine acceptance. Further studies in this direction should be conducted to explore more on the predictors of vaccine hesitancy among females' respondents.

This study findings show that high odds of refusing and hesitating the vaccine were associated with concern about the effectiveness of the vaccine, this can be explained by the fact that 72.3% of the students do not trust information on COVID-19 vaccine from public health experts and 56% were concerned about serious side effects from the COVID-19 vaccine. These similar results were obtained by most of the studies reviewed in this area. For instance, Mundagowa et al. (2021) carried out a study that assessed Zimbabweans COVID-19 vaccine hesitancy, the results of the authors show that 76% were uncertain about the effectiveness of the vaccine, and 55.0% were concerned about the safety of the COVID-19 vaccines, 61.0% of the respondents lack trust in the government's effort to provide COVID-19 vaccine that was effective. This contradicts the results

found in a study by Sovicona et al. (2021) who estimated the medical students of Slovakia's attitude towards COVID-19 vaccination. Their result shows that only 24% were concerned about serious side effects and only 38% were concerned that the vaccine may not be effective. Medical students have a better knowledge on vaccines, and they tend to accept them and have high trust on in the vaccines.

It is important to build confidence in the COVID-19 vaccine because its safety and efficiency were strongly associated with intention to take the vaccine. The result of the study shows that females tend to increase the odds for both refusing and hesitating the vaccine. The current study results also revealed that mandating COVID-19 vaccine could help increase vaccine acceptance. Several countries have been making COVID-19 vaccines mandatory for health care workers and other essential or high risk works. Some countries have considered making COVID-19 shots compulsory for the public. Mandating the COVID-19 vaccine in different countries differs depending on age, career and social statues. In Indonesia all adults are expected to be vaccinated, refusal can lead to heavy fines or restrictions from using government services. Australia plans to mandate the COVID-19 vaccine for all citizens over the age of 14 as from February of 2022. Croatia, Egypt, Fiji, France, Ghana, Hungary, and Italy plan to mandate these vaccinations for all government institutions workers and the public servants that may require their services. In Namibia, a certain national petroleum company requires its worker to be vaccinated or provide weekly negative COVID-19 results. However, this kind of action has also raised criticism and resistance from the people in different parts of the world.

4. Conclusions

The study findings identified the predictors of vaccine hesitancy, it shows that the variables; Field of study, Sex, COVID-19 status, Concern about the effectiveness of the vaccine, Trust information by the health experts on COVID-19 and Mandate COVID-19 vaccine for the general public were found to be a significant predictors of Vaccine hesitancy.

Despites the COVID-19 pandemic situation, only small percentage of the students accepted to get vaccinated. Female respondents tend to refuse and hesitate the vaccine more as compared to males. Students who were never diagnosed with COVID-19 tend to increase the likelihood of refusing to get vaccinated. Students who were concerned about the effectiveness of the vaccine had high rates of refusing and hesitating to get

vaccinated. Students who were concerned about serious side-effects from the COVID-19 vaccine tend to refuse the vaccine and students who agreed that the vaccine should be mandated for the general public tend to accept the vaccine more than students who do not agree that the vaccine should be mandated for the general public.

4. Limitations of the study

The current study focused on factors associated with COVID-19 vaccine hesitancy among of higher education students. All students from different campuses of the three higher educations in Namibia (NUST, UNAM and IUM) were the targeted population. Students were selected as the study population because their opinions play an important role in the public and their opinion towards the vaccine encourages vaccine intake to the general public. However, this study population may not reflect the true opinion of the entire population in Namibia. Further studies in this area could consider the general population to get a better understanding of their opinion towards COVID-19 vaccine.

There was a lack of previous research studies on the topic in Namibia, which could have allowed further analysis and comparison. Limitations in the internet availability to conduct the surveys and only students with internet access were included in the study. Where possible, researchers in the same area could consider telephone interviews to cover respondents in rural areas where there is no proper access to the internet. Another limitation of this study was due to lack of control over the identity of the respondents. This could be because of the approach taken to share the link to the questionnaire among the target group that could be accessed by anyone else other than the intended study population. Thus, the data collected may not be 100% from students, however, in this study the authors relied entirely on the honesty of the respondents. This problem could be minimized through sharing the link to the questionnaire on the platform which could be only accessed by individual students. The platforms could be student's kiosk or eLearning/Moodle or Microsoft teams. In this study, the natural ordering of the response category was disregarded, however, one could consider the natural ordering of the response variable and fit the ordinal logistic regression to the dataset and the result could be compared with the results presented in the current study.

Disclosure statement

The authors have declared no conflict of interest.

Acknowledgement

The authors acknowledge Journal's editor for the feedback provided.

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Received February, 2022

Revised July, 2022