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Maastricht University

## Faculty of Sciences School for Information Technology

Master of Statistics and Data Science

### Master's thesis

**Vaccine confidence and attitudes towards COVID-19 vaccination in Vietnam**

**Azeb Gerezgiher Gebru**

Thesis presented in fulfillment of the requirements for the degree of Master of Statistics and Data Science,  
specialization Biostatistics

### SUPERVISOR :

dr. Pietro COLETTI

### SUPERVISOR :

Le Xuan HUNG

Transnational University Limburg is a unique collaboration of two universities in two countries: the University of Hasselt and Maastricht University.



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## Abstract

**Background:** Covid-19 is an infectious disease caused by the SARS-CoV-2 virus. The majority of people infected by Covid-19 have mild to moderate respiratory symptoms and recover without therapy. However, some people can become critically ill and require medical assistance. Elder people with underlying medical disorders including cardiovascular diseases, diabetes, chronic respiratory disease, and or cancer are more likely to become severely sick. In Vietnam, the first case of Covid-19 was detected in January 22, 2020, in Ho Chi Minh City. During the start of the study there were 255 cases with more than 125 recoveries and no deaths. Vaccination is the most effective method of managing the Covid-19 pandemic over the long term.

**Objectives:** The aim of the study was to describe the level of vaccine confidence and attitudes towards Covid-19 vaccination, and explore factors associated with the willingness to receive Covid-19 vaccine.

**Methods:** A cross-sectional survey has been conducted between 23 December 2020 and 11 January 2021 before the Covid-19 vaccine is rolled-out in Vietnam. The study involved health care workers from across the country who volunteered to take part and had access to the internet. Socio-demographic characteristics and Covid-19 vaccine related attitudes were assessed. Willingness to get a Covid-19 vaccine was measured in time by the respondent's answer to how long they would get a Covid-19 vaccine when available. Ordinal logistic regression models conducted to explore the socio-demographic and Covid-19 vaccine related attitudes of the respondents associated with the willingness to get the vaccine. Akai information criteria(AIC) and Log likelihood value(-2LL) were used to choose the best model.

**Results:** About 77% of the respondents were willing to be vaccinated within six months. The logistic regression model results suggested that, the respondents' socio-demographic factors: gender, education level and religion were significantly associated with the willingness to get Covid-19 vaccine, whereas age, marital status, family size and income were not significantly associated. The respondents' Covid-19 vaccine-related attitudes also were significantly associated with the willingness to be receive Covid-19 vaccine. In conclusion, accounting the effect of those significant factors can improve the confidence and attitude of societies to take vaccine earlier. Thus, it is important to increase the knowledge regarding the safety, effectiveness and importance of vaccination and source of information about it for the future.

**Keywords:** *Akai information criteria, Covid-19, Ordinal logistic regression, Vaccine.*

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## List of abbreviations

ACM	Adjacent Category Model
AIC	Akai Information Criteria
BCM	Baseline Category Model
CI	Confidence Interval
EDA	Exploratory Data Analysis
LL	Log Likelihood
OR	Odds Ratio
PO	Proportional Odds
POM	Proportional Odds Model
PPOM	Partial Proportional Odds Model
SD	Standard Deviation



# 1 Background of the study

## 1.1 Introduction

Covid-19 is an infectious disease caused by the SARS-CoV-2 virus and the first occurrences of Covid-19 -related disease-inducing pneumonia and mortality was reported in Wuhan, China, in 2019[14]. The number of cases and deaths quickly grew over the world. By the first week of June 2022, 531.4 million cases and 6.3 million deaths have been reported since the start of the pandemic[14]. The majority of people infected by Covid-19 have mild to moderate respiratory symptoms and recover without therapy. However, some people can become critically ill and require medical assistance[2]. People who are elder and those with underlying medical disorders such as cardiovascular diseases, diabetes, chronic respiratory disease, and/or cancer have high probability of becoming severely sick.

Vietnam has a 1200 km border with China, several direct flights from Wuhan, and long-standing cultural and business ties with China. Therefore, there was a high possibility that people with the disease traveled to the country. In Vietnam, the first case of Covid-19 was detected in January 22, 2020, in Ho Chi Minh City. After a week following the first case occurrence, Vietnam imposed a number of control measures, including closing its borders to tourists, prohibiting large gatherings, and requiring all foreign visitors to undergo quarantine[21]. However, those ways of controlling the spread of the disease had different indirect influences such as on the economic growth of a country, financial troubles, health services, food services and access to education. During the start of the study there were 255 cases with more than 125 recoveries and no deaths in April 2020[21]. As of 15 Jun 2022, Vietnam reported a total of 10.7 million cases and 43 thousand deaths since the start of the pandemic showed us quickly grew[14].

One of the most effective methods for the long-term management of the Covid-19 pandemic is vaccination[4, 9]. Covid-19 vaccines are one of the best response to protect people from infection, sever disease by creating antibody response.

In addition, they are more effective in minimizing the transmission of the disease from infected to uninfected people[4, 14]. Therefore to enhance protection for the Covid-19, the supply and uptake of vaccines need to accelerate. Since March 5, 2021, more than 200 vaccines were developed and more than 60 were in different trial stages, and seven of them have been rolled out[4]. Most countries

decided to vaccinate their people to control the spread of the disease. Vietnam is one of those that decided to apply the vaccine and is among the most highly vaccinated countries in the world[13, 14].

Vaccine confidence, which is the attitude in vaccines, healthcare professionals who administer them, procedures, and regulations that support them, is an important indicator of vaccine uptake[9]. Many studies suggested that some of the reasons for Covid-19 vaccine hesitancy are negative perceptions and attitudes towards pharmaceutical industries, concerns about vaccine safety, source of information about the vaccine, lack of confidence to Covid-19 vaccine , and vaccine costs[10].

Healthcare professionals are on the front lines of the Covid-19 pandemic, so it is crucial that they be willing to receive the vaccine. However, the majority of the studies under review had mixed findings. Studies conducted in Greece[32] and the Democratic Republic of the Congo[33] found that only a small proportion of healthcare professionals were willing to receive the Covid-19 vaccine. Surveys in China[34] also shown that nurses were hesitate to get the Covid-19 vaccine. In contrast, a sizable proportion of nurses in Hong Kong and healthcare workers in France[35] expressed a willingness to receive vaccinations. Different factors could influence the willingness to get Covid-19 vaccine. Understanding the vaccine confidence level and identifying the determinants of vaccine hesitancy is crucial to enhancing the impact of vaccination in the future.

The report is structured as follows: Sections 1 and 2 provide an introduction and a description of the data, respectively. Section 3 provides a detailed explanation of the ordinal and nominal logistic regression models with model diagnostics. The important findings are addressed in Section 4, and Section 5 discussion and conclusion.

## 1.2 Objectives

The aim of this study was to describe the level of vaccine confidence and attitudes towards Covid-19 vaccination in Vietnam and explore factors associated with the willingness to receive Covid-19 vaccine.

## 2 Data description

### 2.1 Study design and Data collection

A cross-sectional study was conducted in Vietnam to administer knowledge, attitudes, and confidence towards the Covid-19 vaccine. The study involved 1201 health care workers from across the country who volunteered to take part and had access to the internet. The data were collected before the vaccine was rolled out, from December 23, 2020, to January 11, 2021 online by kobo toolbox and google forms. The outcome variable for the study was willingness to receive a Covid-19 vaccine measured in time by the respondent's response regarding how long they would wait to receive the Covid-19 vaccination when it became available. It was categorized as immediately, after three months, after six months and after a year. Socio-demographic information about the respondents, such as age, gender, religion, education level, marital status, ethnic group, and family size were assessed. Respondents were informed about the Covid-19 vaccination program in Vietnam and surveyed about whether they had information about the Covid-19 vaccine previously or not. The demands, intention to recommend the vaccine to relatives, worry about possible complications, and Covid-19 vaccine-related attitudes of the respondents were also addressed. The attitudes of the respondents on the Covid-19 vaccination in particular were analyzed using three concepts Covid-19 vaccine is safe, Covid-19 vaccine is effective, and Covid-19 vaccine is important. All the covariates were categorical except age, which was later reformulated as categorical variables according to [10]. The study variables are described in Table 1.

**Table 1:** Description of the study variables

Variables	Levels	description
outcome variable		
Willingness to vaccine	1:After a year 2:After 6 months 3:After 3 months 4:Immediately	Willingness to receive Covid-19 vaccine measured in time
Respondents' Socio-demographic factors		
Age	1:18-29 2:>29	Age of respondents
Gender	1:Male 2:Female	Gender of respondents
Number of babies	1:zero 2:One 3:Two 4:>Two	Family size of respondents
Relationship	1:Single 2:Married 3:Divorced	Marital status of respondents
Religion	None 2:Budhism 3:Catholic	Religion of respondents
Income	1:< 2.5 2:2.5-6 3:6-10 4:10-20 5:>20	Economic status of respondents
Education	1:Graduated from university 2:Not graduated from university	Education level of respondents
Ethnic group	1:Kinh 2:Other	Ethnicity of respondents

Covid-19 vaccine-related attitudes	Levels	
Witnessing other people suffering complications when vaccinated	1:Yes 2:No	
Payment for Covid-19 vaccine	1:100000-200000 2:300000-500000 3:600000-900000 4:1-2million 5:>2million	
Searching information about Covid-19 vaccine	1:None 2:Rarely 3:Sometimes 4:Usually 5:Always	
	Variables categorized as: 1:Highly disagree 2:Disagree 3:Undecided 4:Agree 5:Highly agree	
Having a need for Covid-19 vaccine injection		
Worrying about complications that may occur after injection		
Recommend Covid-19 vaccine injection to relatives or family		
Worrying about complications that may occur after relatives get Covid-19 vaccine		
Trusting the recommendations of government about Covid-19 vaccine		Individuals' attitude
Trusting medical staff workers when consulting advice on Covid-19 vaccine		
Trusting traditional healers when consulting advice on Covid-19 vaccine		
Thinking Covid-19 vaccine is safe Thinking Covid-19 vaccine is important Thinking Covid-19 vaccine is effective		vaccine confidence index

## 3 Methodology

### 3.1 Exploratory Data Analysis

Exploratory Data Analysis (EDA) is a way of evaluating data sets in order to summarize their essential characteristics. It frequently involves the use of statistical graphs, tables, and other data visualization techniques. For this study, frequency, percentages, and bar charts were used to emphasize the descriptive results.

### 3.2 Ordinal and Multinomial variables

A variable is called ordinal if it has ordered categories, but no known absolute distance among the levels[8]. Different statistical methods for categorical variables treat the outcome variable as nominal without considering the ordinality. Although different methods are designed for ordinal variables, they can not be used for nominal variables. However, the statistical methods intended for nominal variables can be used with nominal and/or ordinal variables without taking into account the ordinality[15, 8]. Taking the ordinality of the outcome variable to account has the following different advantages: More significant variety of the models, greater power for detecting the relevant trend, more parsimonious, more rational, and more understandable interpretations than the statistical models for nominal variables.

### 3.3 Statistical Models

Statistical modeling aims to fit a model with a minimized number of variables which gives a better description of the data. Logistic Regression is an approach to studying relationships among variables when the outcome variable is categorical (dichotomous, polytomous, or ordinal). Different ordinal logistic regression models exist to account for the ordinal nature of the outcome. The most commonly used ordinal logistic regression models are the Adjacent category logit, continuation logit, and proportional odds models[12, 15]. The models differ in different ways, for example, the Proportional Odds Model (POM) compares cumulative higher categories versus remaining cumulative lower categories or cumulative lower categories versus the remaining higher category. The Continuation Category Logit Model compares cumulative higher categories versus lower categories only, and the Adjacent Category Logit Model (ACM) compares between any of two consecutive categories. Each form of the models have advantages and disadvantages. Continuation ratio logit

model is appropriate when the ordered categories of the outcome variable represent a progression through stages, in a sense an observation must potentially occur in category  $j$  before it occurs in the higher category. So continuation ratio logit model is no appropriate to fit this data.

The primary assumption in ordinal logistic regression model is that any covariate's effects is constant or proportional across the cutoff points(logit models)[15]. This presupposes that regardless of the cutoff point, the covariate have the same effect on the chances. Thus would be a common odds ratio across all regressions for each outcome variable. At each cutoff point in ordinal regression, there will be separate and ordered intercept terms. However, each covariate's effect is given a single Odds Ratio (OR). Suppose that at each cutoff point in ordinal regression, the assumption of common slope is not satisfied, in that case, the model of partial proportional odds model and multinomial logistic regression could be preferable options.

### 3.3.1 Univariate analysis

Before further going to fit the models with covariates, a univariate analysis for each covariate has been tested with 0.1 level of significance. This used us to identify the effect of each covariate, where the effect of other covariates are assumed to be constant. Following the variable selection in univariate analysis, significant covariates were kept in the multivariable ordinal logistic regression models.

### 3.3.2 Adjacent-Category Logit Model

Adjacent-Category Logit Model (ACM) contrasts two successive neighboring outcome categories and uses maximum likelihood estimation. It accept different parameter vectors for each logit (unequal slopes model) or be constrained (equal slopes model)[15]. One of the disadvantages of the adjacent category logit model is, that it is not based on the full response scale. In this study, the outcome variable  $y_{ij}$  is ordered according to the length of time that respondents were willing to receive the Covid-19 vaccination. The model compares each category of willingness to receive Covid-19 vaccine with the neighboring category, taking into account the order. For  $J$  outcome categories with probabilities  $\pi_1, \dots, \pi_J$  and  $p$  covariates, the model is defined as:

$$\log \left( \frac{\pi_j(x)}{\pi_{j+1}(x)} \right) = \beta_0^{(j)} + \beta_1^{(j)} x_1 + \dots + \beta_p^{(j)} x_p, \quad j = 1, 2, 3$$

Where  $j = 1, \dots, J - 1$ ,  $\beta$  of parameters represent the effects of the covariates.

### 3.3.3 Proportional Odds Model

The proportional odds cumulative model was first introduced by walker and Duncan and later renamed as Proportional Odds Model (POM) by McCullagh. It uses cumulative probabilities up to a cutoff point and simultaneously uses all the  $J-1$  cumulative logits[15]. It is based on the entire response scale and is cumulative in both directions. For this study, the outcome variable has four categories, so there would be three cutoff points (logit models). The first is similar to a binary logistic regression model where the outcome variable is recorded as the lower categories of the outcome (willingness to receive the Covid-19 vaccine after a year) versus others. The second cutoff point is with the outcome variable recorded as the first two lower categories of the outcome variable (willing to receive the vaccine after a year plus after six months) versus others. The third cutoff point is that the outcome variable is recorded as the first three lower categories of the outcome (willing to receive the vaccine after a year plus after six months plus after three months) versus the higher category(willing to receive the vaccine immediately when available). The model is applicable when a common slope is used for those three cutoff points[15]. The score test was used for testing the null hypothesis that all covariates have a common slope across the cutoff points against at least one covariates has a different slope.

For the subject  $i$  and  $p$  covariates suppose  $y_i$  represents the outcome category for the response variable then, the proportional odds model has the form:

$$\text{logit}[P(Y_i \leq j)] = \beta_{0j} + \beta x = \beta_{0j} + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p$$

Where  $j = 1, \dots, J - 1$ ,  $\beta$  of parameters represent the effects of the explanatory variables and  $[P(Y_i \leq j)]$  is the probability that an observation is being in  $j$  and lower category of the outcome. Since the  $p(Y \leq j)$  increases in  $j$  for each fixed value of  $x$ ,  $\beta_0$  is also increasing in  $j$ .

### 3.3.4 Partial proportional odds model

The Partial Proportional Odds model(PPOM) employed if the assumption of common slope under POM is not met. It treats the outcome variable as ordinal and allows a common slope for some covariates while not for others[15]. To identify the covariates that fail the proportionality assumption, a score test was fitted for each. The model contains different parameter estimates across the



cutoff points for the covariates that fail the common slope assumption. A single parameter estimate is used for the variables where the assumption is held.

For the subject  $i$  and  $p$  covariates suppose  $y_i$  represents the outcome category for the response variable then, the model has the following form:

$$\text{logit}[P(Y_i \leq j/x)] = \beta_0 j + \beta_1 x_1 + \alpha_m x_{3..} + \beta_{1p} x_{1p}, m = 1, 2..3.$$

Where:  $\beta$  represents the effects of the covariates with common slope variable,  $\alpha$  represents the effects of the covariates with no common slope,  $P(Y \leq j)$  is the probability that an observation is being in  $j$  and lower category of the outcome.

### 3.3.5 Multinomial Logistic Regression

Multinomial logistic regression is a statistical method that extends binary logistic regression and is used to analyze more than two categories of outcome variables. Multiple or single covariates are used to predict the likelihood of a outcome variable's membership in a specific category. As binary logistic regression, multinomial logistic regression uses Maximum Likelihood Estimation for parameter estimate[8]. Each category is paired with a reference in the nominal response variables model. For  $J = 4$ , the model uses  $\log(\pi_1/\pi_4)$ ,  $\log(\pi_2/\pi_4)$ , and  $\log(\pi_3/\pi_4)$ . The model with a predictor  $x$  and  $J$  outcome category as a reference is represented as:

$$\log \left( \frac{\pi_j(x)}{\pi_J(x)} \right) = \beta_0^{(j)} + \beta_1^{(j)} x_1 \dots + \dots \beta_p^{(j)} x_p, \quad j = 1, 2, \dots J - 1.$$

## 3.4 Multicollinearity

In a regression model, a multicollinearity problem exists when two or more covariates are highly correlated[11]. If two covariates are correlated, one of them can be predicted from the other. This can result in inaccurate coefficient estimates and a loss of power. It also widens confidence intervals, raises the estimate of the standard error of regression coefficients, and raises the likelihood that the significant test statistic will be rejected. So it is essential to check the multicollinearity before the fitting a model. The covariates in the study are all categorical, hence the chi-square test was first fitted to determine whether there is a relationship between the variables. However, the chi square test does not measure the strength of the link. Because of this, the Cramer's v test, which is based on the chi-square test result, is used to determine whether there is multicollinearity

between the covariates. The Cramer's v statistic measures the degree to which two covariates are related. Its value ranges from 0 to 1, and a value of at least 0.7 indicates the presence of strong multicollinearity.[\[12\]](#). To select one of correlated variables, we included them in the model one at a time and select the one with the smallest AIC. It is calculated as:

$$\phi_c = \sqrt{\left(\frac{\chi^2}{N(M-1)}\right)}$$

Where  $\phi_c$  denotes Cramer's v,  $\chi^2$  is Pearson chi-square, N represents sample size and M is the smaller number of categories of either variable.

## 4 Results

### 4.1 Exploratory Data Analysis

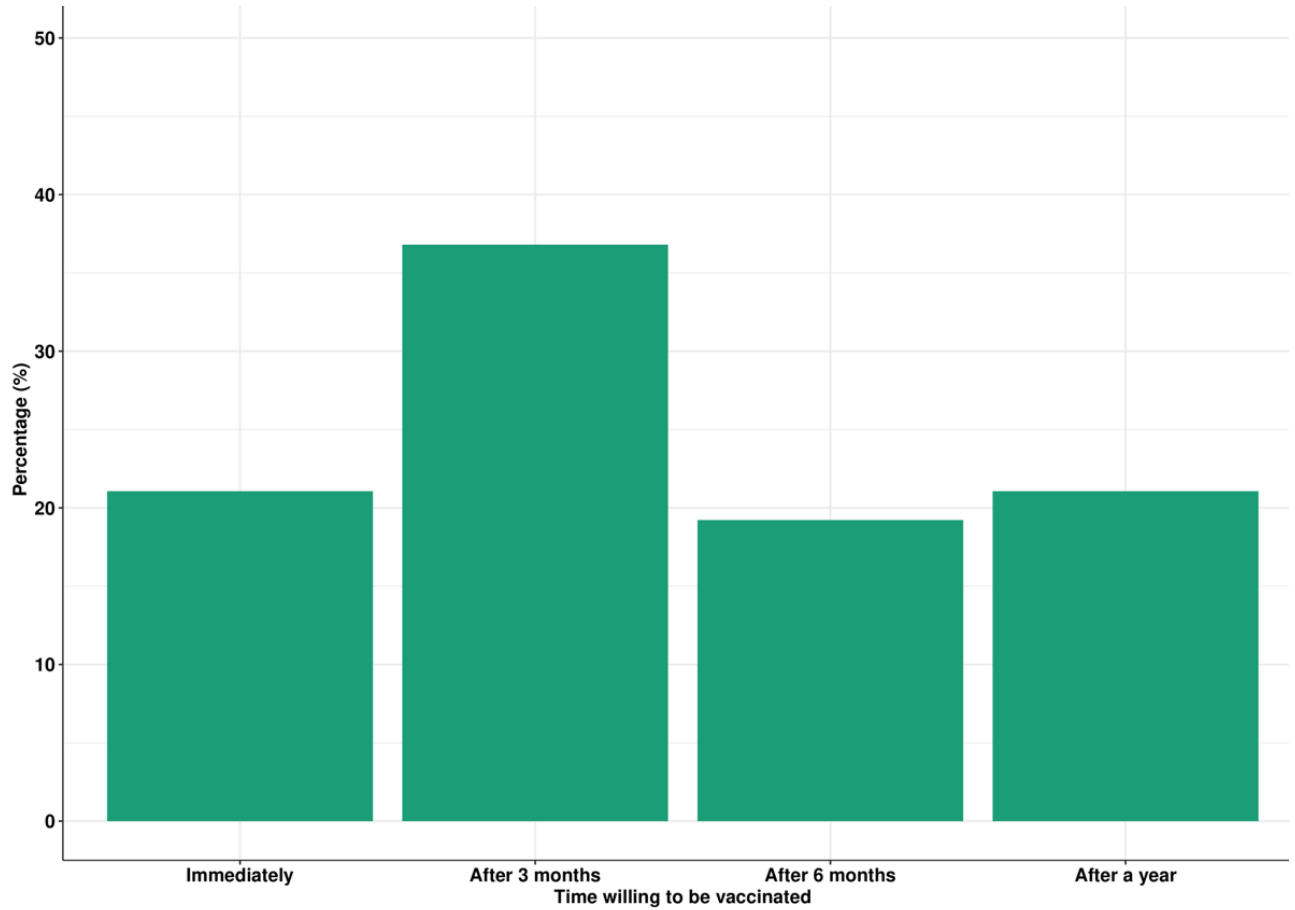
#### 4.1.1 Respondents' socio-demographic Characteristics

The socio-demographic characteristics of the respondents are summarized in Table 2. The mean age of the respondents was 26.4(SD=4.89) and 933(77%) of the them were aged from 18-29 years. Among the total 1201 respondents, 750(62%) were females, 1166 (97%) were from ethnic groups of kinh, 879(73%) graduated from university and 776 (64%) were single. Seven hundred fifty one(62%) lives with family, 596 (49%) were from the lowest wealth-income and 95%(1152) of the study respondents had no religious belief.

**Table 2:** Socio-demographic characteristics

Variable	Frequency	%	Cumulative Frequency	Cumulative %
Gender				
Male	451	37.5	451	37.55
Female	750	62.45	1201	100.00
Age				
18-29	933	77.68	933	77.68
>29	268	22.31	1201	100
Ethnic				
Kinh	1166	97.09	1166	97.09
Other	35	2.91	1201	100.00
Religion				
None	1153	96	1153	96
Budhism	24	2.00	1176	98
Christian	24	2.00	1200	100
Education				
Not.University	277	23.06	277	23.06
Gratuated from Unversity	879	73.19	1156	96.25
Other	45	3.75	1201	100.00
Marital status				
Single	776	64.61	776	64.61
Married	416	34.64	1192	99.25
Divorced	9	0.75	1201	100.00
Living with who				
Alone	207	17.24	207	17.24
With Family	751	62.53	958	79.77
Friends	243	20.23	1201	100.00
Income(VND)				
< 2.5million	596	49.63	596	49.63
2.5-6million	170	14.15	766	63.78
6-10million	207	17.24	973	81.02
10-20million	185	15.40	1158	96.42
>20million	43	3.58	1201	100.00

Figure 1 represents the bar chart of willingness to receive the Covid-19 vaccine. Among the total 1201 respondents, 253(21%) were willing to be vaccinated immediately when available, 442(36%) after three months, 241(20%) after six months and 265(22%) after a year.



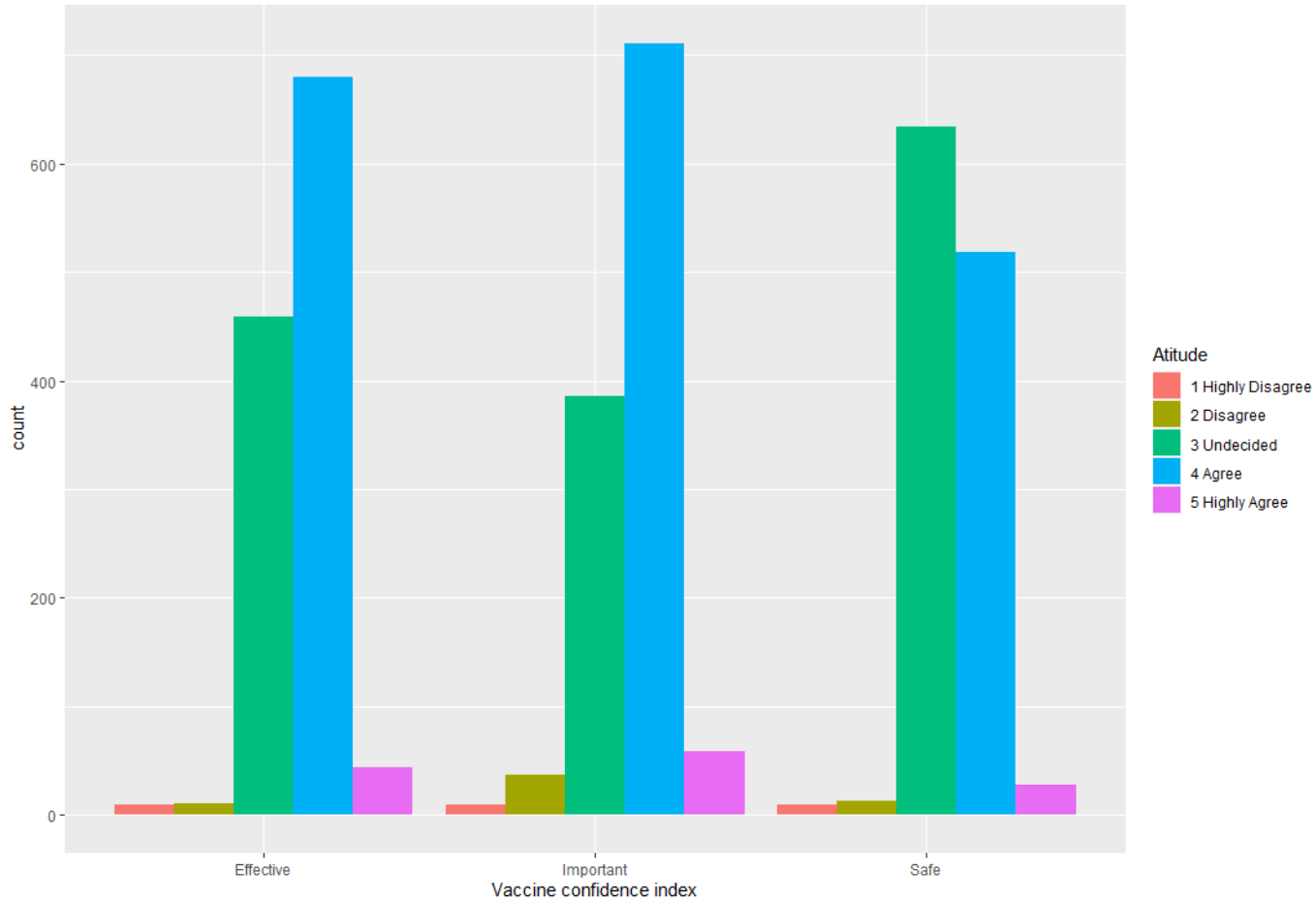
**Figure 1:** Willingness to receive Covid-19 vaccine

Table 3 represents the distribution of Covid-19 vaccine-related attitudes of the respondents by willingness to receive the vaccine . Among the respondents who witnessed other people suffering complications of Covid-19 vaccine, 130(10%) were willing to be vaccinated immediately. Of the respondents who never searched for information about Covid-19 vaccine, only 60(5%) were willing to be vaccinated immediately. Among 906 respondents who trust the recommendations of the government about the vaccine, 233(19%) were willing to be vaccinated immediately, 363(30%) after three months.

**Table 3:** Distribution of Covid-19 vaccine related attitudes by willingness to receive Covid-19 vaccine

Variable	Immediately Frequency(%)	After 3months Frequency(%)	After 6months Frequency(%)	After a year Frequency(%)
Witnessing other people suffered complications when vaccinated				
Yes	130(10.82)	314(26.14)	156(12.14)	170(14.15)
No	123(10.24)	128(10.66)	85(7.08)	95(7.91)
Searching information about Covid-19 vaccine				
Never	60(5)	101(8.41)	92(7.66)	92(7.66)
Rarely	29(2.41)	81(6.74)	52(4.33)	54(4.5)
Sometimes	105(8.74)	208(17.32)	88(7.33)	92(7.66)
Usually	59(5)	52(4.3)	9(0.75)	27(2.24)
Having a need for Covid-19 vaccine injection				
Disagree	11(0.92)	13(1.08)	21(1.75)	44(3.66)
Undecided	57(4.75)	216(17.99)	155(12.91)	183(15.24)
Agree	185(15.4)	213(17.74)	65(5.41)	38(3.16)
Worry about complications that may occur after injection				
Highly disagree	11(0.92)	2(0.17)	2(0.17)	3(0.25)
Disagree	34(2.83)	39(3.25)	14(1.17)	9(0.75)
Undecided	80(6.66)	216(17.99)	106(8.83)	102(8.49)
Agree	107(8.91)	173(14.40)	103(8.58)	129(10.74)
Highly agree	21(1.75)	12(1)	16(1.33)	22(1.83)
Worry about complications that may occur after relatives get vaccine				
Highly disagree	9(0.75)	1(0.08)	2(0.17)	3(0.25)
Disagree	21(1.75)	26(2.16)	11(0.92)	8(0.67)
Undecided	83(6.91)	180(14.99)	103(8.58)	85(7.08)
Agree	115(9.58)	211(17.57)	103(8.58)	143(11.91)
Highly agree	25(2.08)	24(2)	22(1.83)	26(2.16)
Trusting the recommendations of government about Covid-19 vaccine				
Disagree	6(0.5)	4(0.33)	10(0.83)	8(0.67)
Undecided	14(1.17)	75(6.24)	63(5.25)	115(9.58)
Agree	233(19.40)	363(30)	168(13.99)	142(11.82)
Trusting traditional healers when consulting advice on Covid-19 vaccine				
Highly disagree	61(5.08)	88(7.33)	42(3.5)	70(5.83)
Disagree	77(6.41)	136(11.32)	102(8.49)	84(6.99)
Undecided	46(3.83)	119(9.91)	66(5.5)	86(7.16)
Agree	69(5.75)	99(8.25)	31(2.5)	25(2.08)

The Covid-19 vaccine-specific attitudes of the respondents that Covid-19 vaccination is important, safe, and effective are shown in Figure 2. The graph demonstrated that more than 65% of respondents agreed that the Covid-19 vaccination is effective, almost 70% agreed on its importance, and the majority of them were unsure of the vaccine's safety.



**Figure 2:** Covid'19 vaccine confidence index

## 4.2 Chisquare association of socio-demographic characteristics with willingness to receive Covid-19 vaccine

Table 4 represents the Chi-square association between the socio-demographic characteristics of the respondents with the willingness to receive Covid-19 vaccine. All the socio-demographic characteristics were statistically associated with willingness to receive Covid-19 vaccine ( $p - value < 0.05$ ).

**Table 4:** Chisquare association of socio demographic factors with willingness to receive Covid-19 vaccine

Variable	Willingness to receive Covid-19 vaccine				P value
	Immediately Frequency(%)	After 3months Frequency(%)	After 6months Frequency(%)	After a year Frequency(%)	
Age					
18-29	215(17.9)	351(29.3)	188(15.65)	178(14.82)	< 0.0001
>29	38(3.16)	91(7.58)	53(4.4)	87(7.24)	
Gender					
Male	110(9.16)	179(14.9)	65(5.41)	97(8.08)	0.0007
Female	143(11.91)	263(21.9)	176(14.65)	168(13.99)	
Education level					
Not graduated	74(6.16)	118(9.83)	51(4.25)	34(2.83)	0.0001
Graduated	173(14.4)	309(25.73)	181(15.07)	216(17.99)	
Others	6(0.5)	15(1.25)	9(0.75)	15(1.25)	
Martial status					
Single	193(16.07)	296(24.65)	140(11.66)	147(12.24)	<.0001
Married	60(5)	146(12.16)	101(8.41)	118(9.83)	
Family size					
Zero	206(17.15)	323(26.89)	158(13.16)	163(13.57)	<0.0001
One	26(2.16)	65(5.41)	49(4.08)	61(5.08)	
>Two	21(1.75)	54(4.5)	34(2.83)	41(3.41)	
Income(VND)					
<2.5million	156(12.99)	200(16.65)	116(9.66)	124(10.32)	0.0007
2.5-6million	31(2.58)	72(6)	30(2.5)	37(3.08)	
6-10million	34(2.83)	82(6.83)	40(3.33)	51(4.25)	
10-20million	27(2.25)	76(6.33)	47(3.91)	35(2.91)	
>20million	5(0.42)	12(1)	8(0.67)	18(1.5)	
Living with who					
Alone	40(3.33)	94(7.83)	33(2.75)	40(3.33)	0.044
Family	149(12.41)	270(22.48)	160(13.32)	172(14.32)	
Friends	64(5.33)	78(6.49)	48(4)	53(4.41)	

### 4.3 Ordinal logistic regression analysis

A proportional odds model was first fitted. As mentioned in the methodology section, the proportional odds model is valid if the effect of each of the covariates are constant across the cutoff points. The result from the score test is presented in Table 5. The result suggested that the assumption for the common slope (proportional odds model) is not hold ( $p - value < 0.05$ ). Therefore, the popular ordinal logistic regression model which is proportional odds model is not valid to fit the data for this study.

**Table 5:** Score test

Chi-Square	DF	P value
180.0406	76	<.0001

As a result, alternative models including partial proportional dds model, adjacent category model and multinomial logistic regression (baseline category logit model) were fitted. However, the common slope assumption for the adjacent category model was also not hold. The summary results of the model comparison based on AIC and LL is presented in Table 6. Hence, the results revealed that the AIC and LL for the partial proportional odds model are smaller, meaning that it outperformed the data than the other candidate model. Therefore, the subsequent interpretation of the covariates and discussion will be based on PPOM model.

**Table 6:** Model comparison

Fitted Model	AIC	-2LL
PPOM	<b>2851.428</b>	<b>2617.428</b>
BCM(Multinomial)	2855.894	2685.894

#### 4.3.1 Partial proportional odds model

Table 7 represents the overall test of effects for the partial proportional odds model and the p-value for the score test of each covariates. Covariates which are in bold represents the common slope across the cutoff points. The overall test suggests that, gender, religion and education level of the respondents' socio-demographic characteristics had a significant association with the willingness to receive the Covid-19 vaccine, Whereas age, relationship, income, and family size were not significantly associated. In addition, the Covid-19 vaccine related attitudes, such as the demand for



Covid-19 vaccine injection, the recommendation of Covid-19 vaccine injection to family or friends, the concern over potential side effects after a relative receives the Covid-19 vaccine, the confidence in the government's advice regarding the Covid-19 vaccine, the importance of the Covid-19 vaccine, the search for information about the Covid-19 vaccine, and the cost of the Covid-19 vaccine, were also significantly associated with the willingness to receive the Covid-19 vaccine.

**Table 7:** Overall test of PPOM

Effect	Df	Wald Chi-Square	Pr > ChiSq	P.score test
Age	1	1.4559	0.2276	<b>0.0882</b>
Gender	3	13.7298	<b>0.0013</b>	0.0046
Religion	6	38.7122	<b>&lt;.0001</b>	0.0002
Income	12	20.9711	0.0508	0.0311
Education	2	6.1547	<b>0.0461</b>	<b>0.3680</b>
Relationship	1	1.0551	0.3043	<b>0.6757</b>
Family size	2	1.4824	0.4765	<b>0.91</b>
Witnessing other people suffered complications when vaccinated	3	14.0022	<b>0.0029</b>	< 0.0001
Searching information about Covid-19 vaccine	12	31.6292	<b>0.0016</b>	< 0.0001
Having a need for Covid-19 vaccine injection	6	35.4527	<b>&lt;.0001</b>	0.031
Recommend Covid-19 vaccine injection to relatives or family	2	23.3813	<b>&lt;.0001</b>	<b>0.1355</b>
Worry about complications that may occur after relatives get Covid-19 vaccine	6	26.0739	<b>0.0002</b>	<0.0001
Payment for Covid-19 vaccine	4	11.3780	<b>0.0226</b>	<b>0.1044</b>
Trusting the recommendations of government about Covid-19 vaccine	6	19.5395	<b>0.0033</b>	0.0044
Trusting traditional healers when consulting advice on Covid-19 vaccine	6	4.8520	0.5629	0.0243
Thinking Covid-19 vaccine is safe	2	0.0065	0.9967	<b>0.3140</b>
Thinking Covid-19 vaccine is important	2	14.0862	<b>0.0009</b>	<b>0.6501</b>
Thinking Covid-19 vaccine is effective	6	3.7054	0.7165	<0.0001

Table 8 represents the partial proportional odds model parameter estimates for the covarites that satisfy the assumption of common slope. Negative parameter estimates indicates that, as the value of a covariate increase the probability of the observation being in a lower category level increase, controlling for all other covariates. In contrast, a positive parameter estimate indicates that as the value of a given covariate increases the probability that the observation likely to be in the lower category level decrease. The odds ratio is computed from the parameter estimate by exponentiating the parameter estimate( $\exp(\beta)$ ).

Respondents who are not graduated from university were 0.713 times less likely to fall into the lower categories of willingness to receive the vaccine than those who graduated. Regarding the respondents' attitudes about the Covid-19 vaccine, those who do not advise friends or family to have the injection were 3.243 (95% CI: 1.793–5.864) times more likely to fall into the lower group of willingness to receive the Covid-19 vaccine than those who do. This indicates that responders who suggested Covid-19 vaccination to family members or the family were more likely to get vaccinated. When compared to respondents who agreed with the importance of the Covid-19 vaccine, the likelihood of a respondent falling into the lower category of vaccine willingness was 3.755 times higher for those who do not. In comparison to those who can spend more than 20 million dong for Covid-19 vaccine, those who can pay between 1-2 million dong were 0.378 (95% CI: 0.153 0.936) times less likely to fall into the lower category of willingness to receive the vaccine. This demonstrated that those who were willing to spend over 20 million dong were less confident than those who can spend 1-2 million dong.

**Table 8:** PPOM parameter estimates for covariates with common slope

Variables	Estimate	S.Error	Adjusted OR	95% CI for OR
Intercept	-0.3098	0.4886	-	-
Intercept	-0.0586	0.4283	-	-
Intercept	2.3053	0.4799	-	-
Education level				
Graduated	ref			
Not Graduated	-0.3376	0.1558	0.713	<b>0.526 0.968</b>
Other	0.3864	0.3356	1.472	0.762 2.841
Recommend Covid-19 vaccine injection to relatives or family				
Disagree	1.1764	0.3023	<b>3.243</b>	<b>1.793 -5.864</b>
Undecided	0.7639	0.1733	<b>2.147</b>	<b>1.528- 3.015</b>
Agree	ref			
Payment for Covid-19 vaccine				
1-2 million	-0.9719	0.4621	<b>0.378</b>	<b>0.153- 0.936</b>
3-5 million	-0.6085	0.4605	0.544	0.221 -1.342
6-10 million	-0.7155	0.4669	0.489	0.196 -1.221
10-20million	-0.4317	0.5157	0.649	0.236 -1.785
>20 million	ref			
Thinking Covid-19 vaccine is important				
Disagree	1.3231	0.4379	<b>3.755</b>	<b>1.592 -8.858</b>
Undecided	0.4480	0.1586	<b>1.565</b>	<b>1.147 -2.136</b>
Agree	ref			

Table 9 represents the parameter estimates of partial proportional odds model for covariates with no common slope. Each covariate had different estimates for the three different logit models(cutoff points). The symbols L1, L2, and L3 represents the three cutoff points(logit models). The odds of male respondents being willing to receive a vaccination after six months were 0.695 times lower than those of female respondents. The odds of a Christian respondent willing to be vaccinated after a year was 6.108 (95%CI: 2.212- 16.865) times higher compared to those who had no religious attitudes. The odds of the respondent who was unwilling to have a Covid-19 vaccine injection was 4.613 (95%CI: 2.300- 9.252) times more likely than who was willing to take to be in the lower category (after a year) of the willingness to receive the Covid-19 vaccine. The odds of the respondent who witnessed that other people suffering from complications when vaccinated was 1.504 (95%CI: 1.085- 2.086) times higher willing to be vaccinated after three months as compared to those who are not. For the respondent who sometimes searched for information about the Covid-19 vaccine, the odds of willing to be vaccinated after six months was 0.614 (95%CI:0.440 -0.855) times lower compared to those who never searched.

**Table 9:** PPOM parameter Estimates for covariates with no common slope

Variables	Estimate	S.Error	Adjusted OR	95% CI for OR
Male-L1	0.0966	0.1689	1.101	0.791 -1.534
Male-L2	-0.3644	0.1450	<b>0.695</b>	<b>0.523- 0.923</b>
Male-L3	-0.3351	0.1681	<b>0.715</b>	<b>0.514- 0.994</b>
Female	ref			
Religion				
Buddhism-L1	1.0064	0.5668	2.736	0.901- 8.309
Buddhism-L2	0.1783	0.5172	1.195	0.434 -3.294
Buddhism-L3	1.0815	0.7145	2.949	0.727- 11.964
Christian-L1	1.8096	0.5182	<b>6.108</b>	<b>2.212 16.865</b>
Christian-L2	-0.0831	0.5381	0.920	0.321- 2.642
Christian-L3	-0.0280	0.6828	0.972	0.255- 3.708
None	ref			
Witnessing other people suffered complications when vaccinated				
Yes-L1	-0.2598	0.1750	0.771	0.547- 1.087
Yes-L2	-0.2404	0.1492	0.786	0.587- 1.054
Yes-L3	0.4083	0.1668	<b>1.504</b>	<b>1.085- 2.086</b>
No	ref			
Searching information about Covid-19 vaccine				
Rarely-L1	0.1085	0.2297	1.115	0.711- 1.748
Rarely-L2	-0.0281	0.1998	0.972	0.657- 1.438
Rarely-L3	0.3402	0.2727	1.405	0.823- 2.398
Sometimes-L1	-0.0807	0.2018	0.923	0.621- 1.370
Sometimes-L2	-0.4886	0.1693	<b>0.614</b>	<b>0.440 0.855</b>
Sometimes-L3	-0.0924	0.2095	0.912	0.605- 1.375
Usually-L1	0.4593	0.2981	1.583	0.882- 2.839
Usually-L2	-0.5189	0.2658	0.595	0.353- 1.002
Usually-L3	-0.4418	0.2722	0.643	0.377- 1.096
Always-L1	0.00705	1.0182	1.007	0.137- 7.409
Always-L2	-0.5443	0.7483	0.580	0.134- 2.515
Always-L3	-0.6855	0.5607	0.504	0.168 -1.512
Never	ref			
Having a need for Covid-19 vaccine injection				
Disagree-L1	1.5290	0.3550	<b>4.613</b>	<b>2.300- 9.252</b>
Disagree-L2	1.0204	0.3435	<b>2.774</b>	<b>1.415- 5.439</b>
Disagree-L3	0.4014	0.4506	1.494	0.618- 3.613
Undecided-L1	0.8817	0.2322	<b>2.415</b>	<b>1.532- 3.807</b>
Undecided-L2	0.7824	0.1861	<b>2.187</b>	<b>1.518- 3.149</b>
Undecided-L3	0.9181	0.2199	<b>2.505</b>	<b>1.628 -3.854</b>
Agree	ref			

Variables	Estimate	S.Error	Adjusted OR	95% CI for OR
Worrying about complications that may occur after my relatives get Covid-19 vaccine				
Disagree-L1	-1.1596	0.4211	<b>0.314</b>	<b>0.137- 0.716</b>
Disagree-L2	-0.7319	0.3121	<b>0.481</b>	<b>0.261- 0.887</b>
Disagree-L3	-0.8139	0.2938	<b>0.443</b>	<b>0.249- 0.788</b>
Undecided-L1	-0.6815	0.1762	<b>0.506</b>	<b>0.358- 0.715</b>
Undecided-L2	-0.4438	0.1497	<b>0.642</b>	<b>0.478 -0.860</b>
Undecided-L3	-0.2396	0.1818	0.787	0.551- 1.124
Agree	ref			
Trusting the recommendations of government about Covid-19 vaccine				
Disagree-L1	-0.5366	0.7815	0.585	0.126- 2.705
Disagree-L2	-0.00893	0.7170	0.991	0.243- 4.041
Disagree-L3	-0.4030	1.2959	0.668	0.053- 8.474
Undecided-L1	0.8119	0.1977	<b>2.252</b>	<b>1.529- 3.318</b>
Undecided-L2	0.4047	0.1900	<b>1.499</b>	<b>1.033- 2.175</b>
Undecided-L3	0.5313	0.3403	1.701	0.873- 3.315
Agree	ref			

## 5 Discussion and Conclusion

This study is conducted to evaluate the level of Covid-19 vaccine confidence and determinants that associated with willingness to receive the Covid-19 vaccine in Vietnam.

We investigated the socio-demographic traits and Covid-19 vaccination-related attitudes that affect desire to accept Covid-19 vaccination. There was consequently a statistically significant association between education level and willingness to receive the vaccine. Higher education was linked to a lower risk of hesitation toward the Covid-19 vaccination and this finding coincide with previous study conducted in Kenya[10]. Religion was statistically associated with willingness to receive Covid-19 vaccine, indicating that respondents without a religious background were less likely to fall into the lower category. This was also mentioned in research that was done in Kenya[10]. Gender was also found to be significantly associated with the willingness to receive Covid-19 vaccine in present findings, the result indicating that male respondents were more likely than female respondents to fall into the higher category of willingness to receive Covid-19 vaccine. In other words, males were more willing to be immunized right away, which is also supported by the study conducted in Australia[28]. However, studies from South Asian nations like Bangladesh, Pakistan, India, and Nepal as well as from African nations like Kenya found no statistically significant link between gender and willingness to receive the Covid-19 vaccine. This variation may result from the different nature of the outcome variable.

The following vaccine-related attitudes of the respondents were statistically associated with willingness to receive Covid-19 vaccine and they could be utilized to inform public health policies and communications to increase vaccination willingness. The willingness to immunize was positively associated with understanding the importance of the Covid-19 vaccine, having knowledge of the Covid-19 vaccine prior to vaccination, and desire for obtaining a Covid-19 vaccination injection, whereas the willingness to immunize was negatively associated with witnessing others experience complications following vaccination and worrying about potential side effects. and advising Covid-19 vaccine injection to family or friends were significantly associated with willingness to receive Covid-19 vaccine. In comparison to those who did not hear about the Covid-19 vaccination, those who did were more likely to fall into the higher group of willingness to receive the vaccine. A significant attitude in the value of the Covid-19 immunization was held by the majority of re-

spondents (more than 65%), and this positive outlook may help to explain why respondents who heard previously about the vaccination were more ready to accept it. People who were particularly interested in the injection and those who pushed family members and/or relatives to acquire the vaccine were more likely to feel confident about accepting the Covid-19 vaccination. This could be because they want to prevent their family and friends from catching Covid-19, which is similar to what a research from China reported.[30]. Respondents who believed the government's advice on the Covid-19 vaccine were more likely to fall into the higher group of vaccine willingness. The majority of studies revealed a connection between vaccination-related views of vaccine safety and effectiveness and a willingness to get the Covid-19 vaccine[10, 28]. However, the results showed that these were statistically not significant at the multivariable level even though they were significant at the univariate level. According to the finding, 77% of the respondents were open to becoming immunized within six months. An email-based online survey of 398 students in Ho Chi Minh City, Vietnam, found that 83.4 percent of them approved of the Covid-19 vaccine. Also 599 Vietnamese volunteers participated in a global survey from October to December 2020 by De Figueiredo and Larson, which indicated that 96.8% of respondents were in favor of the Covid-19 vaccine. Therefore, compared to the results of the previous study, the healthcare professionals' acceptability of the Covid-19 vaccination was lower.

**In conclusion**, the Vietnamese healthcare workers who had a positive attitude toward the vaccine related attitudes and heard information about the vaccine previously appeared to have relatively high confidence to accept the Covid-19 vaccine. So it is important to increase the knowledge regarding the safeness, effectiveness and importance of vaccination and source of information about it for the future.

## Limitations of the methods

The partial proportional odds model which was the best model for this study has the drawback of numerous parameters as compared to the proportional odds model with common slope. As the number of parameters in the model increased, the complexity for the interpretation of the estimates are also become very vague. The method used for checking the assumption of common slope(proportional odds) is sensitive to sample size, such that large samples may be produce statistically significant p- value. The cramers'v for checking multicollinearity only used to check between

two variables. For the future it is better to use a method that checks collinearity for more than two variables at the same time.

## **Ethical considerations**

Ethical approval for this study was obtained from Hanoi medical university. The purpose of the study was fully explained to respondents prior to the data collection, and they volunteered to take part. No information about the study subjects was disclosed. On the other hand, there is no information provided about who is in the data, so it is impossible to identify individuals and the study had no effect on the study subjects' rights, health, or finances.

## **Societal relevance**

A greater impact of vaccination can be achieved by identifying the factors that influence vaccine hesitancy. This is because the finding of this study suggest that there were various factors for the society to hesitate to take the vaccine. Hence, accounting the effect of those factors can improve the confidence and attitude of societies to take vaccine earlier. Considering the fact that vaccine is one of the most pertinent methods that protect individuals from Covid-19, the earlier being vaccinated will enable the society to be more safer.

## **Stakeholders' awareness**

As this study mainly includes the health workers, they are also among our stakeholders where the final finding provides them important implication for their routine work. Since every progress and finding of this study is also reported to higher health sector officials of Vietnam by the medical university of Hanoi, they are also in the loop as stakeholders.



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## 6 Appendix

**Table 10:** Over all test of effects for Proportional odds model(POM)

Effect	DF	Wald Chi-Square	Pr > ChiSq
Age	1	2.2308	0.1353
Gender	1	4.8271	<b>0.0280</b>
Religion	2	13.9986	<b>0.0009</b>
Income	4	8.3333	0.0801
Education level	2	9.1072	<b>0.0105</b>
Relationship	1	1.2289	0.2676
Family size	2	1.6278	0.4431
Witnessing other people suffered complications when vaccinated	1	0.0783	0.7796
Searching information about Covid-19 vaccine	4	10.1033	<b>0.0387</b>
Having a need for Covid-19 vaccine injection	2	33.6782	<b>&lt;.0001</b>
Recommend Covid-19 vaccine injection to relatives or family	2	23.2787	<b>&lt;.0001</b>
Worry about complications that may occur after my relatives get Covid-19 vaccine	2	14.8201	<b>0.0006</b>
Payment for Covid-19 vaccine	4	17.7921	<b>0.0014</b>
Trusting the recommendations of government about Covid-19 vaccine	2	12.0611	<b>0.0024</b>
Trusting traditional healers when consulting advice on Covid-19 vaccine	2	0.8106	0.6668
Thinking Covid-19 vaccine is safe	2	0.1882	0.9102
Thinking Covid-19 vaccine is important	2	13.9528	<b>0.0009</b>
Thinking Covid-19 vaccine is effective	2	4.7209	0.0944

**Table 11:** Parameter estimates For Proportional odds model

Variables	Estimate	S.Error	Adjusted OR	95% CI for AOR
Male	-0.2600	0.1183	<b>0.771</b>	<b>0.611- 0.972</b>
Religion				
Budhism	1.0334	0.4067	<b>2.811</b>	<b>1.266- 6.238</b>
Christian	1.1776	0.4254	<b>3.247</b>	<b>1.410- 7.474</b>
None	Ref			
Education level				
not Gra.Uni	-0.4331	0.1527	<b>0.648</b>	<b>0.481- 0.875</b>
Other	0.3057	0.3193	1.358	0.726 -2.538
Gra.from uni	Ref			
Searching information about Covid-19 vaccine				
Rarely	0.0761	0.1687	1.079	0.775- 1.502
Sometimes	-0.2845	0.1418	<b>0.752</b>	<b>0.570- 0.993</b>
Usually	-0.4024	0.2072	0.669	0.446 -1.004
Always	-0.7353	0.5215	0.479	0.172- 1.332
Never	Ref			
Having a need for Covid-19 vaccine injection				
Disagree	1.3942	0.2979	<b>4.032</b>	<b>2.248 -7.229</b>
Undecided	0.8600	0.1640	<b>2.363</b>	<b>1.714 -3.259</b>
Agree	Ref			
Recommend Covid-19 vaccine injection to relatives or family				
Disagree	1.2066	0.2946	<b>3.342</b>	<b>1.876- 5.954</b>
Undecided	0.7260	0.1704	<b>2.067</b>	<b>1.480- 2.886</b>
Agree	Ref			
Worrying complications that may occur after relatives get vaccine				
Disagree	-0.6679	0.2394	<b>0.513</b>	<b>0.321- 0.820</b>
Undecided	-0.3871	0.1239	<b>0.679</b>	<b>0.533- 0.866</b>
Agree	Ref			
Payment for Covid-19 vaccine				
1-2million	-1.5314	0.4513	<b>0.216</b>	<b>0.089- 0.524</b>
3-5million	-1.1779	0.4495	<b>0.308</b>	<b>0.128- 0.743</b>
6-10million	-1.2403	0.4556	<b>0.289</b>	<b>0.118- 0.707</b>
10-20million	-0.9580	0.5046	0.384	0.143- 1.032
>20million	ref			
Trusting the recommendations of gov.t about Covid-19 vaccine				
Disagree	-0.1501	0.6493	0.861	0.241- 3.073
Undecided	0.5566	0.1628	<b>1.745</b>	<b>1.268- 2.401</b>
Agree	Ref			
Thinking Covid-19 vaccine is important				
Disagree	1.3802	0.4264	<b>3.976</b>	<b>1.724 -9.169</b>
Undecided	0.3946	0.1552	<b>1.484</b>	<b>1.095- 2.011</b>
Agree	Ref			

**Table 12:** Over all test of effects for Adjacent category model

Effect	DF	Wald Chi-Square	Pr > ChiSq
Age	1	3.0645	0.0800
Gender	1	4.7049	<b>0.0301</b>
Religion	2	16.4977	<b>0.0003</b>
Income	4	12.5161	<b>0.0139</b>
Education level	2	12.1243	<b>0.0023</b>
Relationship	1	1.1006	0.2941
Family size	2	1.5720	0.4557
Witnessing other people suffered complications when vaccinated	1	0.0685	0.7935
Searching information about Covid-19 vaccine	4	8.9990	0.0611
Having a need for Covid-19 vaccine injection	2	30.9100	<b>&lt;0.0001</b>
Recommend Covid-19 vaccine injection to relatives or family	2	22.1108	<b>&lt;0.0001</b>
Worry about complications that may occur after my relatives get Covid-19 vaccine	2	17.3353	<b>0.0002</b>
Payment for Covid-19 vaccine	4	12.6648	<b>0.0130</b>
Trusting the recommendations of government about Covid-19 vaccine	2	11.1298	<b>0.0038</b>
Trusting traditional healers when consulting advice on Covid-19 vaccine	2	0.8772	0.6449
Thinking Covid-19 vaccine is safe	2	0.1074	0.9477
Thinking Covid-19 vaccine is important	2	13.7324	<b>0.0010</b>
Thinking Covid-19 vaccine is effective	2	2.7146	0.2574

**Table 13:** Parameter estimates For Adjacent category model

Variables	Estimate	S.Error	Adjusted OR	95% CI for AOR
Male	-0.1587	0.0732	0.853	<b>0.739- 0.985</b>
Religion				
Budhism	0.7776	0.2443	2.176	<b>1.348- 3.513</b>
Christian	0.6824	0.2650	1.979	<b>1.177- 3.326</b>
None	Ref			
Income(VND)				
<2.5million	Ref			
2.5-6million	-0.3222	0.1154	0.725	<b>0.578- 0.909</b>
6-10million	-0.1548	0.1171	0.857	0.681 -1.078
10-20million	-0.4160	0.1392	0.660	<b>0.502- 0.867</b>
>20million	-0.3410	0.2145	0.711	<b>0.467 -1.083</b>
Education level				
Gra.from uni	Ref			
not Gra.Uni	-0.2983	0.0949	0.742	<b>0.616- 0.894</b>
Other	0.2723	0.1918	1.313	0.902 -1.912
Having a need for Covid-19 vaccine injection				
Disagree	0.7571	0.1799	2.132	<b>1.499- 3.033</b>
Undecided	0.5199	0.0997	1.682	<b>1.383- 2.045</b>
Agree	Ref			
Recommend Covid-19 vaccine injection to relatives or family				
Disagree	0.7544	0.1812	2.126	<b>1.491- 3.033</b>
Undecided	0.4200	0.1051	1.522	<b>1.239- 1.870</b>
Agree	Ref			
Worrying complications that may occur after relatives get vaccine				
Disagree	-0.4739	0.1574	0.623	<b>0.457- 0.847</b>
Undecided	-0.2565	0.0765	0.774	<b>0.666- 0.899</b>
Agree	Ref			
Payment for Covid-19 vaccine				
1-2million	-0.6409	0.2710	0.527	<b>0.310- 0.896</b>
3-5million	-0.4601	0.2696	0.631	0.372 -1.071
6-10million	-0.4998	0.2736	0.607	0.355- 1.037
10-20million	-0.2110	0.3031	0.810	0.447 -1.467
>20million	ref			
Trusting the recommendations of gov.t about Covid-19 vaccine				
Disagree	-0.2595	0.3987	0.771	0.353- 1.685
Undecided	0.3093	0.0973	1.362	<b>1.126 -1.649</b>
Agree	Ref			
Thinking Covid-19 vaccine is important				
Disagree	0.9023	0.2759	2.465	<b>1.436- 4.234</b>
Undecided	0.2191	0.0922	1.245	<b>1.039- 1.491</b>
Agree	Ref			



**Table 14:** Over all test of effects for multinomial logistic regression

Effect	DF	Wald Chi-Square	Pr > ChiSq
Age	3	7.5777	0.0556
Gender	3	12.5199	<b>0.0058</b>
Religion	6	23.1198	<b>0.0008</b>
Income	12	37.9453	<b>0.0002</b>
Education	6	23.2248	<b>0.0007</b>
Relationship	3	3.5791	0.3106
Family size	6	2.3400	0.8859
Witnessing other people suffered complications when vaccinated	3	19.3112	<b>0.0002</b>
Searching information about Covid-19 vaccine	12	27.7100	<b>0.0061</b>
Having a need for Covid-19 vaccine injection	6	38.1421	<b>&lt;.0001</b>
Recommend Covid-19 vaccine injection to relatives or family	6	20.6718	<b>0.0021</b>
Worrying about complications that may occur after my relatives get Covid-19 vaccine	6	25.8195	0.0002
Payment for Covid-19 vaccine	12	27.0861	<b>0.0075</b>
Trusting the recommendations of government about Covid-19 vaccine	6	18.6337	<b>0.0048</b>
Trusting traditional healers when consulting advice on Covid-19 vaccine	6	4.2557	0.6421
Thinking Covid-19 vaccine is safe	6	7.8663	0.2481
Thinking Covid-19 vaccine is important	6	12.6435	<b>0.0491</b>
Thinking Covid-19 vaccine is effective	6	11.7100	0.0688

**Table 15:** Parameter estimates for Baseline category logit model

Variables	Estimate	S.Error	Adjusted OR	95% CI for OR
Gender				
Male1	-0.0459	0.1832	0.955	0.667- 1.368
Male2	-0.6831	0.2289	0.505	0.322 -0.791
Male3	-0.3624	0.2327	0.696	0.441- 1.098
Female	Ref			
Religion				
Buddhism1	1.6326	0.8298	<b>5.117</b>	<b>1.006 -26.025</b>
Buddhism2	0.8195	1.1081	2.269	0.259- 19.914
Buddhism3	3.0034	0.9341	<b>20.154</b>	<b>3.231- 125.731</b>
Christian1	-0.3533	0.7868	0.702	0.150- 3.283
Christian2	-1.3338	1.2237	0.263	0.024 - 2.900
Christian3	1.3361	0.8110	3.804	0.776- 18.648
None	Ref			
Income				
<2.5	Ref			
2.5-6	0.5258	0.2902	1.692	0.958 -2.988
2.5-6	-0.2315	0.3640	0.793	0.389- 1.619
2.5-6	-0.8574	0.3863	<b>0.424</b>	<b>0.199- 0.905</b>
6-10	0.8016	0.3012	<b>2.229</b>	<b>1.235 -4.022</b>
6-10	0.1290	0.3708	1.138	0.550- 2.353
6-10	-0.2011	0.3831	0.818	0.386- 1.733
10-20	0.9032	0.3677	<b>2.468</b>	<b>1.200- 5.073</b>
10-20	0.2011	0.4426	1.223	0.514- 2.911
10-20	-1.0769	0.4837	<b>0.341</b>	<b>0.132- 0.879</b>
>20	0.4242	0.6341	1.528	0.441- 5.296
>20	-0.7318	0.7373	0.481	0.113- 2.041
>20	-0.9944	0.7159	0.370	0.091- 1.505
Education level				
Not Gra.Uni1	0.3933	0.2267	1.482	0.950 -2.311
Not Gra.Uni2	-0.1432	0.2784	0.867	0.502 -1.495
Not Gra.Uni3	-0.7939	0.3063	<b>0.452</b>	<b>0.248- 0.824</b>
Other1	-0.2027	0.5778	0.816	0.263 -2.534
Other2	-0.0490	0.6556	0.952	0.263- 3.442
Other3	0.6521	0.6361	1.920	0.552- 6.679
Gra.from uni	Ref			
Witnessing other people suffered complications when vaccinated				
Yes1	0.7428	0.1872	<b>2.102</b>	<b>1.456 -3.033</b>
Yes2	0.3104	0.2257	1.364	0.876- 2.123
Yes3	0.1435	0.2370	1.154	0.725- 1.837
No	Ref			

Variables	Estimate	S.Error	Adjusted OR	95% CI for OR
Searching information about Covid-19 vaccine before 30 days				
None1	Ref			
Rarely1	0.4321	0.2968	1.541	0.861- 2.756
Rarely2	0.1962	0.3254	1.217	0.643- 2.302
Rarely3	0.3513	0.3454	1.421	0.722- 2.796
Sometimes1	0.1133	0.2313	1.120	0.712 -1.762
Sometimes2	-0.5084	0.2635	0.601	0.359- 1.008
Sometimes3	-0.2886	0.2847	0.749	0.429 -1.309
Usually1	-0.3229	0.3002	0.724	0.402- 1.304
Usually2	-1.5734	0.4589	<b>0.207</b>	<b>0.084- 0.510</b>
Usually3	-0.1329	0.3903	0.876	0.407- 1.882
Always1	-0.7970	0.6228	0.451	0.133 -1.527
Always2	-1.5126	1.1316	0.220	0.024- 2.024
Always3	-0.9754	1.2800	0.377	0.031- 4.634
Having a need for Covid-19 vaccine injection				
Disagree1	-0.4814	0.5662	0.618	0.204- 1.875
Disagree2	0.5549	0.5738	1.742	0.566- 5.363
Disagree3	1.5589	0.5755	<b>4.754</b>	<b>1.539-14.685</b>
Undecided1	0.7411	0.2520	<b>2.098</b>	<b>1.280- 3.439</b>
Undecided2	1.2362	0.3010	<b>3.442</b>	<b>1.908- 6.209</b>
Undecided3	1.6231	0.3275	<b>5.069</b>	<b>2.668 -9.632</b>
Agree	Ref			
Recommend Covid-19 vaccine injection to relatives or family				
Disagree1	0.9029	0.6482	2.467	0.692 -8.787
Disagree2	1.2660	0.6789	3.546	0.937 -13.418
Disagree3	2.3796	0.6851	<b>10.800</b>	<b>2.820- 41.359</b>
Undecided1	0.2955	0.2434	1.344	0.834 -2.165
Undecided2	0.6578	0.3026	<b>1.930</b>	<b>1.067 -3.493</b>
Undecided3	1.2950	0.3491	<b>3.651</b>	<b>1.842- 7.237</b>
Agree	Ref			
Worrying about complications that may occur after my relatives get Covid-19 vaccine				
Disagree1	-0.4121	0.3224	0.662	0.352- 1.246
Disagree2	-0.7496	0.4312	0.473	0.203- 1.100
Disagree3	-1.4543	0.5158	<b>0.234</b>	<b>0.085- 0.642</b>
Undecided1	-0.0101	0.1974	0.990	0.672 -1.458
Undecided2	-0.0807	0.2339	0.922	0.583- 1.459
Undecided3	-0.8903	0.2529	<b>0.411</b>	<b>0.250- 0.674</b>
Agree	Ref			

Variables	Estimate	S.Error	Adjusted OR	95% CI for OR
Payment for Covid-19 vaccine				
1-2 million1	-0.5576	0.7650	0.573	0.128 -2.565
1-2 million2	-1.8274	0.8738	<b>0.161</b>	<b>0.029- 0.892</b>
1-2 million3	-2.3064	0.8410	<b>0.100</b>	<b>0.019- 0.518</b>
3-5 million1	0.0856	0.7648	1.089	0.243- 4.877
3-5 million2	-1.0019	0.8705	0.367	0.067- 2.022
3-5 million3	-1.6953	0.8374	<b>0.184</b>	<b>0.036- 0.947</b>
6-10 million1	-0.1553	0.7696	0.856	0.189- 3.869
6-10 million2	-1.4754	0.8811	0.229	0.041- 1.286
6-10 million3	-1.7525	0.8485	<b>0.173</b>	<b>0.033- 0.914</b>
10-20 million1	-0.1767	0.8647	0.838	0.154- 4.564
10-20 million2	-0.8582	0.9724	0.424	0.063- 2.851
10-20 million3	-1.1691	0.9517	0.311	0.048 -2.006
>20 million	Ref			
Trusting the recommendations of government about Covid-19 vaccine				
Disagree1	-1.5899	1.2887	0.204	0.016- 2.549
Disagree2	0.2994	1.0323	1.349	0.178- 10.204
Disagree3	-1.2888	1.3949	0.276	0.018- 4.243
Undecided1	0.5742	0.3548	1.776	0.886 -3.559
Undecided2	0.5128	0.3725	1.670	0.805 -3.466
Undecided3	1.2015	0.3717	<b>3.325</b>	<b>1.605- 6.889</b>
Agree	Ref			
Thinking Covid-19 vaccine is important				
Disagree1	3.8019	2.0741	44.785	0.768 -99.564
Disagree2	3.9591	2.0724	52.411	0.902 -123.786
Disagree3	4.8761	2.0815	<b>131.116</b>	<b>2.217 -152.091</b>
Undecided1	0.0980	0.2873	1.103	0.628 -1.937
Undecided2	0.4531	0.3097	1.573	0.857- 2.887
Undecided3	0.6129	0.3163	1.846	0.993 -3.431
Agree	Ref			

## SAS codes

```
/*frequency */
proc freq data=c.dataazeb;
tables age A1_Gender A4_Religion A9_Income A5_Education A7_Relationship ;
run;

proc freq data=c.dataazeb;
tables ;
run;

/*bivariate analysis of the sociodemographic characteristics*/
ods graphics on;
proc freq data=c.dataazeb;
tables c5*d5/ chisq
plots=(freqplot(twoway=grouphorizontal
scale=percent));
run;
ods graphics off;

/*univariable Analysis*/
proc logistic data=c.dataazeb descending;
class C4 ;
model C5=C4/ scale=none;
run;

/* if age is catagorical */
data c.dataazeb;
set c.dataxxxx;
if age <= 29 then age = "1";
if age >= 30 then age = "2";
run;

proc sort data=c.dataazeb;
by c5;run;

/* Pom*/
proc logistic data=c.dataazeb descending;
```

```

class age(ref="1") A1_Gender A4_Religion(ref="1")
A9_Income(ref="1") A5_Education(ref="2")
A7_Relationship(ref="1") A8_Baby(ref="1") A11 B1(ref="1")
C1 C3 C4 C6 D1 D3 D4 D5 D6/param=ref;
model C5= age A1_Gender A4_Religion A9_Income A5_Education
A7_Relationship A8_Baby A11 B1 C1 C3 C4 C6 D1 D3 D4 D5 D6 / scale=none;
run;

```

```

/*ppom best model*/
proc logistic data=c.dataazeb descending;
class age(ref="1") A1_Gender A4_Religion(ref="1")
A9_Income(ref="1") A5_Education(ref="2") A7_Relationship(ref="1")
A8_Baby(ref="1") A11 B1(ref="1") C1 C3 C4 C6 D1 D3 D4 D5
D6/param=ref;
model c5= age A1_Gender A4_Religion A9_Income A5_Education
A7_Relationship A8_Baby A11 B1 C1 C3 C4 C6 D1 D3 D4
D5 D6/ unequalslopes=(A4_Religion A1_Gender A9_Income A11 B1 C1
C4 D1 D3 D6);run;

```

```

/* Fitting baseline category logit model */
proc logistic data=c.dataazeb;
class age(ref="1") A1_Gender A4_Religion(ref="1")
A9_Income(ref="1") A5_Education(ref="2") A7_Relationship(ref="1")
A8_Baby(ref="1") A11 B1(ref="1") C1 C3 C4 C6 D1 D3 D4 D5
D6/param=ref;
model c5(ref="1") = age A1_Gender A4_Religion A9_Income
A5_Education A7_Relationship A8_Baby A11 B1 C1 C3 C4 C6 D1 D3
D4 D5 D6/ link=glogit aggregate=(age A1_Gender A4_Religion
A9_Income A5_Education A7_Relationship A8_Baby A11 B1 C1 C3 C4
C6 D1 D3 D4 D5 D6) scale=none;
run;
/* Adjacent catagory logit model*/

```

```

proc logistic data=c.dataazeb descending;
class age(ref="1") A1_Gender A4_Religion(ref="1")
A9_Income(ref="1") A5_Education(ref="2") A7_Relationship(ref="1")
A8_Baby(ref="1") A11 B1(ref="1") C1 C3 C4 C6 D1 D3 D4 D5
D6/param=ref;
model c5 = age A1_Gender A4_Religion A9_Income A5_Education
A7_Relationship A8_Baby A11 B1 C1 C3 C4 C6 D1 D3 D4 D5 D6 / link=logit
aggregate=(age A1_Gender A4_Religion A9_Income A5_Education
A7_Relationship A8_Baby A11 B1 C1 C3 C4 C6 D1 D3 D4 D5 D6 ) scale=none;
run;

```