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COVID-19 VACCINE ACCEPTANCE AND RISK PERCEPTION IN GHANA: INSIGHTS FROM A STUDY ON TERTIARY-LEVEL STUDENTS AND SURROUNDING RESIDENTS IN KUMASI

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ABSTRACT

The introduction of COVID-19 vaccines in sub-Saharan Africa has been met with mixed feelings. In Ghana, several concerns were raised about the potency and side effects of the COVID-19 vaccine. We investigated the acceptance and risk perception of students on the KNUST campus and the residents of the surrounding communities on the risk factors that will influence their willingness or unwillingness to be vaccinated in the Government's quest to get its citizens vaccinated. A well-structured questionnaire was administered online and through face-to-face interviews to survey 3332 respondents between the periods of March 15 and May 28, 2021. Chi-square analysis was used to show the association between the sociodemographic characteristics and, the acceptance and risk perception of the COVID-19 vaccine. Logistic regression analysis was used to explain the relationship between the acceptance and risk perception of the COVID-19 vaccine and the various socio-demographic characteristics. Out of 3323 respondents, 1,703 (45.23%) were hesitant whiles 64.39% of 3311 indicated they would accept being vaccinated. In a multivariate analysis, the age range of 31 to 40 years, being male, having secondary level education, and having a previous vaccination post-childhood immunization increased the likelihood of vaccine acceptance. More than half of the students of KNUST and inhabitants around the campus are likely to accept the COVID-19 vaccine. However, adequate and timely information is needed to educate prospective vaccine recipients with tertiary level education to better the level of acceptance and address misinformation about vaccines and promote individual and population-level benefits of vaccination.

Keywords: Vaccine Acceptance, vaccine risk perception, vaccine safety, COVID-19 vaccine, preventive method, KNUST, Ghana

INTRODUCTION

Vaccination is often cited as the greatest contributor to public health aside the introduction of sanitation and clean water. At the end of the 19th century, child mortality reduced extremely as a result of vaccination (Greenwood and Greenwood 2014). However, these successes attained with the aid of vaccines are progressively under threat due to the recent decline in acceptance of this mode of disease prevention (MacDonald 2015). According to Kanyanda and co., acceptance of vaccines varies; in Ethiopia, it is almost universal (97.9%, 95% CI 97.2% to 98.6%), whereas in Mali, it is less than what is probably needed for herd immunity (64.5%, 95% CI 61.3% to 67.8%) (Kanyanda *et al*., 2021). In Ghana, 74.5% of the youth population are optimistic of the Covid-19 vaccine (Arko, 2023).**.** The refusal to partake in community vaccination programs is currently a major composite of vaccine hesitancy which poses a risk for an increase in preventable infectious diseases. As such vaccine hesitancy has been classified among the top threats to maintaining global health (WHO 2019).

A more efficient and lasting means of controlling the spread of COVID-19 is likely to be pivoted on a preventive method with stringent policy to ensure compliance. It is, therefore, reasonable to suggest that vaccination is the best option which has received much attention by way of vaccine development and their assessment through clinical trials (Callaway 2020a, 2020b). This venture has been productive with the availability of several COVID-19 vaccines currently being used in national rolled-out vaccinations in several regions around the globe including sub-Saharan Africa (Dhimal *et al*. 2021; Teerawattananon and Dabak 2020)

However, there have been concerns raised about these global vaccinations rolled out by various governments in stemming a possible new wave of COVID-19 infections. Studies conducted in the United States and European countries have shown significant levels of hesitancy towards the taking of COVID-19 vaccines (Palamenghi *et al*. 2020; Peretti-Watel *et al*. 2020). These apprehensions have been fueled by political undertones, misinformation, and conspiracy theories that are widespread on the internet and social media platforms (Romer and Jamieson 2020) the widespread use of preventive measures such as masking, physical distancing, and eventually vaccination is needed to bring it under control. We hypothesized that accepting conspiracy theories that were circulating in mainstream and social media early in the COVID-19 pandemic in the US would be negatively related to the uptake of preventive behaviors and also of vaccination when a vaccine becomes available. Moreover, perceptions of an unusually fast-tracked approval and deployment of these vaccines have given sceptics some hold on discrediting the safety of using these medical products (Graham 2020). There have been several conspiracy theories feeding into the risk of populations, particularly those in Africa, being rather infected and or eliminated through the use of these vaccines (Romer and Jamieson 2020; Verger *et al*. 2015)and 2. These perceptions may probably be the trigger of the indifference by some populations in employing and adhering to protocols for fighting the prevailing pandemic.

Studies among low- and middle-income countries about vaccine acceptance have shown health workers to be an important group in positively influencing society to accept and even advocate for vaccination programmes (MacDonald and Dubé 2015). However, the recent trend indicates a decline in health workers accepting and recommending vaccines largely due to historical, religious, and political factors and this is likely to influence acceptance levels of the ongoing mass vaccinations against

COVID-19 (Karafillakis *et al*. 2016; Verger *et al*. 2015)

Being the first African country to receive 600,000 doses of AstraZeneca COVID-19 vaccines through the COVAX initiative, Ghana started a staggered mass vaccination in March 2021 albeit with few educational promotions (Burki 2021; Quakyi *et al*. 2021). Social appeals were however made with key personalities including the president, and traditional and religious leaders serving as the first group of vaccine recipients in a bid to increase the coverage that would stem the tide of increasing infection cases and associated mortalities. It is therefore important to continually assess the acceptance levels and probable factors that can hinder achieving vaccine coverage that will be protective for sub-Saharan populations with different social and demographic characteristics. This study determined the acceptance and risk perception of the COVID-19 vaccine within the premier science and technology university in Ghana and its environs to help researchers and policymakers to design appropriate interventions to reduce vaccine hesitancy among the general population of Ghana. We define risk perception as the belief, attitude and feelings about the potential harm whereas acceptance is the willingness to take the COVID-19 vaccine.

METHOD

Study area

The Kwame Nkrumah University of Science and Technology (KNUST) is located in Kumasi, in the Ashanti region of Ghana covering a land area of 2512.96 acres with a total student population of around 74,000. It has 6 colleges including College of Engineering (COE), College of Health Sciences (COHS), College of Science (COS), College of Agriculture and Natural Resources (CANR), College of Humanities and Social Sciences (COHSS), and College of Art and Built Environment (CABE) with 4497, 5036, 4056, 3926, 6259 and 4194 students respectively. The digital or satellite location of the KNUST campus is $6^0 36' 09'' N\ 1^0 34' 17'' W$ (9.86km) with the main campus (7 square miles in area) about 13 km to the east of Kumasi. The study was carried out at KNUST campus as well as Ayeduase, Kotei, and Bomso (off-campus), which are all part of the Oforikrom Municipal Assembly in Kumasi, Ashanti. These communities are inhabited by both indigenes and students of the Kwame Nkrumah University of Science and Technology (KNUST). Kotei, Ayeduase and Bomso are surrounding communities of KNUST, and as such, located outside campus. Kotei is located at latitude $6^o 39.523'N$ and longitude $1^o 33.435'W$ and an elevation of 254 m. Ayeduase lies between latitude 6.67 and longitude -1.54. Bomso is found between latitude $6^o 40'60''$ N and longitude $1^o 34'60''$ W in DMS (Degrees Minutes Second). The total population of people living in the various selected study area are; Kotei with a population of 15,637 (Solís Arce *et al*. 2021a), Bomso, 20.053 (Al-Mohaithef and Padhi 2020) and Ayeduase: 29,748 (Lamptey, Serwaa, and Appiah 2021).

Study design

A cross-sectional study design using a random sampling technique was employed for selecting participants from the two study sites i.e., on-campus (drawn from various KNUSTcolleges) and off-campus (Kotei, Bomso and Ayeduase).

Study population

Local indigenes of ages 18 and above living at Kotei, Bomso and Ayeduase were eligible for this study and formed the off-campus sub-population. Students and staff of KNUST consisted of participants of the on-campus sub-population. The diverse student population of KNUST makes it well suited for this study as it

will provide a valuable insight on the varied factors that will influence risk perception and risk acceptance of the COVID-19 vaccine. Also the accessibility to large potential participants allows for a representative study sample ensuring generalization of study results. Kotei, Ayeduase and Bomso were included in the study to assess the risk perception and acceptance of local residence of the surrounding communities of KNUST to complement the knowledge level of the tertiary students on the KNUST campus and to aid in establishing association between the risk factors associated with our study.

Inclusive criteria

Formally consenting to the study

A resident of the study site for the past two years

Sample size determination and sampling techniques

The sample size was estimated using infinite population formula by considering the following assumptions: 95% confidence level with a Z score of 1.96, 5% margin of error and 0.5 population proportion which gives 384.16. Finally, to account for non-response an adjusted sample size formula was employed and the final sample sizes for the off-campus were approximately 375, 377, and 380 for Kotei Bomso and Ayeduase respectively. Likewise, on-campus sample sizes were 351, 354, 357, 362, 350 and 352 for COS, COE, COHS, COHSS, CANR and CABE accordingly. A total of 3354 individuals were recruited for the study, with 1148 coming from off-campus due to high participation. All individuals who lived in the study catchment area and fulfilled the inclusion criteria were enrolled conveniently.

Ethical Considerations

All participants were required to formally consent to be part of the study by either signing electronically or in print. This study was approved by the Committee on Human Research, Publication and Ethics, School of Medicine and Dentistry, KNUST (Ref: CHRPE/AP/421/21).

Data collection methods and variables

A well-structured questionnaire was drafted in English and administered both online through Google forms on https://forms.gle/Y5p8NSjcKEqLXgYy5 for students on KNUST campus and https://forms.gle/3JbephtUYrXFp25r7 for the residents of Kotei, Ayeduase and Bomso and face-to-face interviews. The questionnaires were interpreted for the local residents who were not able to understand the language with which the questionnaires were drafted and their responses were entered without any alteration. Sampling at Kotei, Ayeduase and Bomso were completed by taking responses directly from the participants. COVID-19 protocols such as the 1m social distancing, wearing of nose mask, use of alcohol-based hand sanitizer, frequent washing of hands were strictly adhered to prevent the transmission of the disease**.** Data collection started on 15th March and was completed on 28th May, 2021. The questionnaire included socio-demographic data on participant's age, gender (male or female), educational level, occupation, marital status, religion and whether participants reside on/off the KNUST campus. Regarding vaccine acceptance, study participants were asked if they would take the vaccine without any pressure, with "yes" and "no" responses to select just one. Similarly, to assess risk perception of the COVID-19 vaccine, participants were asked, "Have you heard of any theories or you have conceived ideas on your own that will prevent you from taking the vaccine shot?" with single select options "yes" and "no". Socio-demographic characteristics and the variable: Ever taken a vaccination after childhood immunization

were included as independent variables. The dependent variables were vaccine acceptance and risk perception for the vaccine, both of which were dichotomized as yes=1 and no=0

Statistical Analysis

Face-to-face interview data were entered into MS Excel 2016, and then merged with online interview data exported into MS Excel 2016. The dataset was cleaned by data entry staff before importing it into STATA ver. 14.0 (StataCorp., 4905 Lakeway Dr, College Station, TX 77845, USA) for statistical analysis. All missing data points were dropped in their respective variables before analyzed. Continuous variables were categorized and labelled. Categorical variables were reported as frequencies and percentages with associations determined using a chi-square test set at a 5% significance level. The statistical associations between the dependent and independent variables were determined using univariate and multivariate logistic regression analyses and their crude and adjusted odds ratios were reported with a 95% confidence interval. For best fit model all variables in the univariate models (crude) were included in the multivariate model (adjusted odds) in a forward step-wise manner

RESULTS

A total of 3354 participants were enrolled out of which 47.79% had ages 21 to 30, 40.22% were aged 18 to 20 with 3.82% were above 40 years (Table 1). There were more male respondents (56.11%) compared to females. On educational status, 1.67% had no formal education, whiles 6.02%, 10.52% and 81.78% had primary, secondary and tertiary education respectively. The majority of the study population were students (71.79%) followed by those working in the private (22.89%) and public sector (5.20%) and retirees (0.12%). Most of the respondents were single (87.65%) with some married (10.35%) and a few divorced (1,53%) or widowed (0.48%). When categorized by religion, less than a per cent (0.99%) of the respondents were traditionalists with 90.56% and 8.01% being Christians and Muslims respectively. More of the respondents were residents on campus (64.94%).

When asked about their reaction if a vaccine was brought to them, 45.23% reported they will be hesitant whiles 37.01% stated they will take it (Table 2). However, when asked categorically "Will you take the vaccine", 64.39% responded "Yes". Using the Likert scale, a higher proportion (48.61%) of the respondents with a mean score of 3.0 indicated they were "not quite sure" the vaccine will be effective whiles 5.81% strongly agreed to its effectiveness with 10.15% stating the opposite. The majority of the respondents (69.7%) were "not at all" pressured with lower proportions responding to feeling little (15.92%) or significant pressure to take the vaccine. More than half of the respondents (59.46%) had not taken a vaccine after childhood immunization. When asked about their risk perception for the vaccine, only a quarter (25.38%) responded "Yes". The major reason why respondents will not take the vaccine was the fear of adverse side effects.

The odds for intent to take a vaccine were statistically significant (p=0.040) for the age range of 31 to 40 (1.54 OR; 95% CI 1.02 – 2.34) compared to those of 18 to 20 years as a reference in a multivariate model (Table 3). Similarly, respondents above 40 years had six-fold odds of taking the vaccine compared to the reference age range. Males were more likely to accept the vaccine (1.17 OR; 95% CI 1.01 – 1.37) compared to females. With respect to the level of education, respondents with secondary education had about twice the odds for vaccine acceptance for both the univariate (2.44 OR; 95% CI 1.37 – 4.34) and multivariate (1.99 OR; 95% CI 1.07 – 3.69) models compared to those with none.

Respondents who were married (0.59 OR; 95% CI 0.41 – 0.85), divorced (0.33 OR; 0.16 – 0.68) or widowed were less (0.18 OR; 95% CI 0.06 – 0.59) likely to accept the vaccine with those who were single as a reference in a multivariate model. In both the univariate and multivariate models, traditionalists were less likely to accept the vaccine with odds of 0.35 and 0.39 respectively regarding Christians. In addition, respondents on campus and in the various colleges reported significantly lower odds of accepting the vaccine with the College of Science [(0.80 OR; 95% CI 0.59 – 1.08), p= 0.141] being an exception. Respondents who had ever taken a vaccine post-childhood immunization were more likely to accept the vaccine with odds of 1.61 ($p < 0.001$) and 1.46 ($p < 0.001$) in univariate and multivariate models respectively.

Odds for risk perception for the COVID-19 vaccine were statistically significant (p = 0.025) in a univariate model for the age range of 31 to 40 (Table 4). On the other hand, the likelihood of risk perception for the vaccine in respondents above 40 was lower compared to the reference in both univariate (0.57 OR; 95% CI 0.35 – 0.93) and multivariate (0.36 OR; 95% CI 0.19 – 0.69) models. Risk perception on the level of education was twofold within respondents having basic education compared with those with none in univariate analysis. Similarly, a univariate analysis reported significant odds for Muslims (0.73 OR; 95% CI 0.53 – 0.99) as against Christians. With respect to college/residence, respondents from the Agriculture and Natural Resources were less likely to express risk perceptions for the COVID-19 vaccine (0.72 OR; 95% CI 0.54 – 0.97) although this relationship was lost in multivariate logistic regression. Respondents who had ever taken a vaccine had increased odds (1.66 OR; 95% CI 1.40 – 1.96) of risk perception for the vaccine compared to those who had not in multivariate logistic regression.

Table 1: Demographics of study participants

Variable	Respondents (N= 3354)	%
Age group		
18-20	1,349	40.22
21-30	1,603	47.79
31-40	274	8.17
Above 40	128	3.82
Gender		
Male	1,882	56.11
Female	1,472	43.89
Level of education		
None	56	1.67
Basic	202	6.02
Secondary	353	10.52
Tertiary	2,743	81.78
Occupation (n=3346)		
Student	2,402	71.79

Public sector worker	166	4.96
Private sector worker	766	22.89
National Service Personnel	8	0.24
Retired	4	0.12
Marital status (n=3344)		
Single	2,931	87.65
Married	346	10.35
Divorced	51	1.53
Widow(er)	16	0.48
Religion (n=3347)		
Christian	3,031	90.56
Muslim	268	8.01
Traditionalist	33	0.99
Others	4	0.12
None (Atheist)	11	0.33
College/ Residence (n=3274)		
On-campus	2126	64.94
Off-campus	1148	35.06

**Variables that do not add up to 3354 are due to missing data.*

Table 2: Acceptance of COVID vaccine

Items	Respondents (N=3353)	N%
How will you react if the vaccine was brought right to you? (n=3323)		
Hesitate/ ask questions	1,503	45.23
Take it	1,230	37.01
Not take it	566	17.03
Not decided/ Unspecified	24	0.72
On a scale of 1-5, how effective do you think the vaccine will be? (n=3339)		
1- Very ineffective	339	10.15
2- Ineffective	416	12.46
3- Not quite sure	1,623	48.61
4- Effective	767	22.97

5- Very effective	194	5.81
Mean Scale Score	3.0	
Do you feel pressured to take the vaccine? (n=3323)		
Maybe a little	529	15.92
Not at all	2,316	69.70
Yes	478	14.38
Ever taken a vaccine after childhood immunization?		
Yes	1355	40.54
No	1987	59.46
Will you take the vaccine? (n=3311)		
Yes	2,132	64.39
No	1,179	35.61
Why won't you take the vaccine? (n=1179)		
Family influence	110	9.33
Fear	350	29.69
Ineffectiveness of vaccine	37	3.14
Religion	42	3.56
Side effects	482	40.88
Others	158	13.40
Do you perceive any risk for the COVID-19 vaccine? (n=3317)		
Yes	842	25.38
No	2,475	74.62

Mean scale score: 1.0=strongly disagree; 2.0=somehow disagree; 3.0=not quite sure; 4.0= do agree; 5=strongly agree.

Variables that do not add up to 3354 are due to missing data.

Table 3: Univariate and Multivariate analysis of demographic characteristics of study participants by Intent to take the COVID-19 vaccine

Variable	Intent to take the vaccine						
	No (n=1179)	*Yes (n=2132)*	*Chi (P-value)*	Univariate COR (95% CI)	P-Value	Multivariate AOR (95% CI)	P-Value
Age group	***n(%)***	***n(%)***					
18-20	520 (44.11)	813 (38.13)		Ref			
21-30	544 (46.14)	1034 (48.5)	31.69 (**<0.001***)	1.22 (1.04-1.41)	**0.011***	1.13 (0.95-1.33)	0.158
31-40	96 (8.14)	176 (8.26)		1.17 (0.89-1.54)	0.251	1.54 (1.02-2.34)	**0.040***
Above 40	19 (1.61)	109 (5.11)		3.67 (2.23-6.05)	**<0.001***	6.21 (3.24-12.00)	**<0.001***
Gender							
Male	640 (54.28)	1219 (57.18)	2.58 (0.108)	1.12 (0.97-1.30)	0.108	1.17 (1.01-1.37)	**0.042***
Female	539 (45.72)	913 (42.82)		Ref			
Level of education							
None	27 (2.29)	29 (1.36)		Ref			
Basic	73 (6.19)	128 (6.0)	14.09 (**0.003**)	1.63 (0.89-2.97)	0.108	1.05 (0.55-2.01)	0.890
Secondary	95 (8.06)	249 (11.68)		2.44 (1.37-4.34)	**0.002***	1.99 (1.07-3.69)	**0.030***
Tertiary	984 (83.46)	1726 (80.96)		1.63 (0.96-2.77)	0.070	1.57 (0.87-2.81)	0.131
Occupation (n=3303)							

Table 3 Continued

Student/ Retired	855 (72.91)	1516 (71.21)		Ref			
Public sector worker/ NSS personnel	45 (3.83)	125 (5.87)	6.45 (**0.040***)	1.57 (1.10-2.23)	**0.012***	1.14 (0.76-1.71)	0.520
Private sector worker	273 (23.25)	488 (22.92)		1.01 (0.85-1.20)	0.915	0.82 (0.65-1.02)	0.079
Marital status (n=3301)							
Single	1027 (87.55)	1865 (87.64)		Ref			
Married	119 (10.14)	224 (10.53)	1.05 (0.790)	1.04 (0.82-1.31)	0.765	0.59 (0.41-0.85)	**0.004***
Divorced	21 (1.79)	29 (1.36)		0.76 (0.43-1.34)	0.344	0.33 (0.16-0.68)	**0.003***
Widow(er)	6 (0.51)	10 (0.47)		0.92 (0.33-2.53)	0.868	0.18 (0.06-0.59)	**0.005***
Religion (n=3304)							
Christian	1050 (89.36)	1939 (91.08)		Ref			
Muslim	98 (8.34)	170 (7.98)		0.94 (0.72-1.22)	0.637	1.00 (0.76-1.32)	0.988
Traditionalist	20 (1.7)	13 (0.61)	10.67 (**0.031***)	0.35 (0.17-0.71)	**0.004***	0.39 (0.17-0.88)	**0.024***
Others	2 (0.17)	2 (0.09)		0.54 (0.07-3.85)	0.540	0.10(0.01-1.32)	0.080
None (Atheist)	5 (0.43)	5 (0.23)		0.54 (0.15-1.87)	0.333	0.45 (0.13-1.65)	0.231
College/ Residence (n=3233)							

Table 3 Continued

COS	109 (9.46)	238 (11.44)		0.88 (0.68-1.14)	0.334	0.80 (0.59-1.08)	0.141
COE	146 (12.67)	206 (9.9)		0.57 (0.44-0.73)	**<0.001***	0.53 (0.39-0.70)	**<0.001***
COHS	115 (9.98)	241 (11.58)		0.84 (0.65-1.09)	0.196	0.73 (0.55-0.98)	**0.038***
COHSS	139 (12.07)	220 (10.57)	73.87 (**<0.001***)	0.64 (0.49-0.82)	**<0.001***	0.64 (0.48-0.86)	**0.003***
CANR	175 (15.19)	171 (8.22)		0.39 (0.31-0.50)	**<0.001***	0.39 (0.29-0.52)	**<0.001***
CABE	145 (12.59)	203 (9.75)		0.56 (0.44-0.72)	**<0.001***	0.56 (0.42-0.75)	**<0.001***
Off-Campus	323 (28.04)	802 (38.54)		Ref			
Ever taken a vaccine after childhood immunization?							
Yes	394 (33.47)	949 (44.70)	39.54 (**<0.001***)	1.61 (1.39-1.86)	**<0.001***	1.46 (1.25-1.71)	**<0.001***
No	783 (66.53)	1174 (55.30)		Ref			

* Statistical Significance based on logistic regression analysis set at p≤0.05; Ref~; two/more variables combined in logistic regression analysis; COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio. Variables that do not add up to 3354 are due to missing data.

Table 4: Univariate and Multivariate analysis of demographic characteristics of study participants by risk perception for COVID-19 vaccine

Variable	Risk perception for COVID-19 vaccine						
	No (n=2475)	*Yes (n=842)*	*Chi (P-value)*	Univariate COR (95% CI)	P-Value	Multivariate AOR (95% CI)	P-Value
Age group	***n(%)***	***n(%)***					
18-20	1007 (40.69)	333 (39.55)		Ref			
21-30	1174 (47.43)	403 (47.86)	11.46	1.034 (0.88-1.23)	0.663	0.96 (0.80-1.16)	0.7
31-40	188 (7.6)	86 (10.21)	(**0.009***)	1.38 (1.04-1.84)	**0.025***	1.18 (0.77-1.81)	0.462
Above 40	106 (4.28)	20 (2.38)		0.57 (0.35-0.93)	**0.026***	0.36 (0.19-0.69)	**0.002***
Gender							
Male	1380 (55.76)	477 (56.65)	0.20 (0.652)	1.04 (0.88-1.21)	0.652	1.11 (0.94-1.32)	0.212
Female	1095 (44.24)	365 (43.35)		Ref			
Level of education							
None	43 (1.74)	13 (1.54)		Ref			
Basic	124 (5.01)	76 (9.03)	17.99	2.03 (1.02-4.01)	**0.043***	1.99 (0.97-4.05)	0.059
Secondary	260 (10.51)	87 (10.33)	(**<0.001***)	1.11 (0.56-2.15)	0.765	0.98 (0.50-1.95)	0.961
Tertiary	2048 (82.75)	666 (79.1)		1.08 (0.57-2.01)	0.820	0.85 (0.44-1.64)	0.628
Occupation (n=3310)							
Student/ Retired	1789 (72.4)	589 (70.2)		Ref~			
Public sector worker/ NSS personnel~	129 (5.22)	44 (5.24)	1.71 (0.425)	1.04 (0.73-1.48)	0.845	1.16 (0.79-1.76)	0.427
Private sector worker	553 (22.38)	206 (24.55)		1.13 (0.94-1.36)	0.191	1.02 (0.80-1.31)	0.846

Variable	Risk perception for COVID-19 vaccine						
	No (n=2475)	*Yes (n=842)*	*Chi (P-value)*	Univariate COR (95% CI)	P-Value	Multivariate AOR (95% CI)	P-Value
Marital status (n=3308)							
Single	2170 (87.85)	726 (86.63)	6.58 (0.087)	Ref			
Married	244 (9.88)	101 (12.05)		1.24 (0.97-1.58)	0.091	1.08(0.74-1.58)	0.688
Divorced	44 (1.78)	7 (0.84)		0.48 (0.21-1.06)	0.069	0.52 (0.20-1.31)	0.166
Widow(er)	12 (0.49)	4 (0.48)		0.99 (0.32-3.10)	0.995	1.39 (0.39-4.96)	0.609
Religion (n=3310)							
Christian	2224 (89.97)	771 (92.0)	4.89 (0.180)	Ref			
Muslim	214 (8.66)	54 (6.44)		0.73 (0.53-0.99)	**0.044***	0.74 (0.53-1.02)	0.074
Traditionalist	25 (1.01)	8 (0.95)		0.92 (0.41-2.06)	0.845	0.85 (0.33-2.12)	0.722
Others (including Atheist)	9 (0.36)	5 (0.60)		1.60 (0.53-4.80)	0.399	1.47 (0.44-4.88)	0.532
College/ Residence (n=3240)							
COS	264 (10.87)	84 (10.36)	6.26 (0.395)	0.90 (0.97-1.19)	0.452	1.01 (0.74-1.39)	0.942
COE	260 (10.7)	94 (11.59)		1.02 (0.78-1.34)	0.881	1.19 (0.87-1.63)	0.266
COHS	259 (10.66)	95 (11.71)		1.04 (0.79-1.36)	0.799	1.12 (0.82-1.53)	0.463
COHSS	269 (11.07)	95 (10.97)		0.93 (0.71-1.23)	0.627	1.17 (0.86-1.61)	0.32
CANR	277 (11.4)	71 (8.75)		0.72 (0.54-0.97)	**0.030***	0.90 (0.65-1.26)	0.553
CABE	267 (10.99)	83 (10.23)		0.88 (0.66-1.16)	0.361	1.11 (0.81-1.52)	0.532
Off Campus	833 (34.29)	295 (36.37)		Ref~			

Table 4 Continued

Variable	Risk perception for COVID-19 vaccine						
	No (n=2475)	*Yes (n=842)*	*Chi (P-value)*	Univariate COR (95% CI)	P-Value	Multivariate AOR (95% CI)	P-Value
Ever taken a vaccine after childhood immunization?							
Yes	925 (37.51)	419 (49.88)	39.74	1.66 (1.42-1.94)	**<0.001***	1.66 (1.40-1.96)	**<0.001***
No	1541 (62.49)	421 (50.12)	**(<0.001*)**	Ref			

* Statistical Significance based on logistic regression analysis set at p≤0.05; Ref~; two/more variables combined in logistic regression analysis; COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio. Variables that do not add up to 3354 are due to missing data.

DISCUSSION

This study found the proportion of vaccine acceptance to be 63.4% with another 45.2% indicating hesitance in taking the vaccine. Moreover, multivariate analysis showed that the age range of 31 to 40 years, being male, having secondary level education and having a previous vaccination post-childhood immunization increases the likelihood of vaccine acceptance.

A vaccine acceptance of 63.4% is relatively high considering a suggested average threshold of 80.3% among low-middle-income countries (Solís Arce *et al*. 2021a). This finding is comparable to the 64.7% of the respondents intending to take the vaccine in Saudi Arabia (Al-Mohaithef and Padhi 2020). A similar study conducted before vaccination campaigns and only web-based within the Ghanaian population found that 54.1% of participants were willing to take the vaccine (Lamptey, Serwaa, and Appiah 2021). Probably, the drive by countries and the global health industry to make vaccines available and heighten advocacy for vaccine uptake is fueling the steady rise in acceptance. Moreover, as there have been reports of mainly mild and quick resolving vaccine adverse effects, the population may feel now more emboldened to go for COVID-19 vaccination (Klugar *et al*. 2021; Riad, Pokorná, *et al*. 2021; Riad, Schünemann, *et al*. 2021)medical and COVID-19-related anamneses, and local, systemic, oral, and skin-related side effects following COVID-19 vaccination; Results: out of the 599 participating healthcare workers, 72.3% were females, and 79.1% received mRNA-based vaccines, while 20.9% received a viral vector-based vaccine. 88.1% of the participants reported at least one side effect. Injection site pain (75.6%. Participants aged more than

30 years, were more likely to take a vaccine as compared to their younger counterparts. This is consistent with an earlier study which showed that older people are willing to be vaccinated against COVID-19 (Lazarus *et al*. 2021). This could be attributed to the fact that the older population are more conscious of their health and declining immunity against infections. Additionally, these age groups may be well aware of the effect of comorbidities such as diabetes and cardiovascular diseases on the severity of the COVID-19 disease. It is therefore essential that local health authorities prioritize increasing acceptance among younger populations. This should focus on sensitizing them on how vulnerable they might be due to a lack of information on individual health statuses such as undiagnosed diseases and immunocompromised states.

Contrary to conclusions from previous studies, males were more likely to take the vaccines compared to their female counterparts (Travis *et al*. 2021; Yoda and Katsuyama 2021). This gender preference for the COVID-19 vaccine could plausibly be a result of cultural dynamics were in Africa, the male is taught to be "tough" and easily embrace risks such as vaccinations and not to be seen as afraid and weak. Again, this can be attributed to the female respondents being more likely to harbour risk perceptions for the vaccine as reported in the results though not significant and are therefore hesitant in getting vaccinated. Perhaps, this may be an indication of the narrowing gender gap with respect to health-seeking behaviour.

Our study also found respondents with Secondary school education were twice as likely to take the vaccine compared to those with no education whiles a similar significant association was not reported for those having tertiary education. This finding is inconsistent with prior studies stating the significance of higher education in the acceptance of a vaccine (Malik *et al*. 2020). It is probable that even though higher education enhances populations with skills to seek information and make informed choices, the prevailing era of "fake news" particularly surrounding the outbreak of the infection and vaccine development makes this population category hesitant about the genuineness of the vaccine. Moreover, some of these conspiracy theories are targeted at this population class with access to social media outlets. The feeding of credible, adequate and timely information on the vaccine is important in increasing acceptance levels in such populations (Kelekar *et al*. 2021). We further found participants who have had previous vaccinations to be more susceptible to taking the COVID-19 vaccine compared to those who have not. This suggests the positive role of vaccination history in populations accepting the COVID-19 vaccine as indicated in previous studies (Echoru, Ajambo, and Bukenya 2020a; Solís Arce *et al*. 2021b). Individuals who have ever undertaken a vaccination post-childhood immunization are privy to the benefits of these preventive methods albeit some predominantly mild adverse effects which are short-lived and are confident and likely to volunteer in taking another vaccine. It is also possible that this finding may be because participants were surveyed after vaccination campaigns had already started in the sub-region without reports of serious adverse effects from the administration of the vaccines.

Although the vaccine acceptance rate is comparatively high, over the third quarter (79%) of the respondents are either in doubt or unsure as to whether the vaccine is effective. This could be an indication that a large number of individuals lack the necessary information concerning the vaccine's efficacy but are still willing to take it anyway. Prospective vaccine communication strategies should therefore take into account the general and scientific literacy of communities, identify the information sources they trust, and go beyond just claiming the safety and effectiveness of the vaccine (Lazarus *et al*. 2021). This study further found the most commonly stated

reason for vaccine refusal was concerns about safety (side effects) suggesting reluctance or delay in opting for a vaccine (Solís Arce *et al*. 2021b). The concern about safety mainly stems from the perceived rapid rate of the COVID-19 vaccine development and limited information about the safety of the vaccine. It is inferred that more effort should be channelled towards educating the populace about vaccine safety, the stages of its development and possibly why it seems the process has been faster for COVID-19 than usual.

LIMITATIONS OF THE STUDY

It is fair to state that this study presents some limitations based on the cross-sectional design and that data collection was by self-reporting from participants. The effect of these limitations was however attenuated with adequate sampling and the blend of both face-to-face and online questionnaire administration.

CONCLUSION

More than half of the students of KNUST and inhabitants around the campus are likely to accept the COVID-19 vaccine even though a significant proportion are hesitant in being vaccinated. On the other hand, our findings revealed, only age and education had association with risk perception of COVID-19 vaccine. The respondents aged between 31-40years had the highest risk perception compared to the other age categories and those with basic education also had the highest risk perception. To ensure that herd immunity is attained, it is important that the risk perception of the people is addressed to enhance the uptake of COVID-vaccine**.** Therefore, adequate and timely information is needed to educate prospective vaccine recipients with tertiary level education to better the level of acceptance.

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