



COVID-19 Vaccine Uptake, Unmet Need and Reported Side Effect in Nigeria: An Online Cross-sectional Study

Olanrewaju D. Eniade ^{a,b,c*}, Okedare Omowumi ^c, Abayomi T. Olarinmoye ^b,
Yusuff Olasunkanmi ^c, Agofure Otovwe ^d, Funke Akintunde ^e
and Adebukola Aniyeloye ^b

^a International Research Center of Excellence, Institute of Human Virology, Nigeria.

^b Department of Public Health, Faculty of Basic Medical Sciences, Adeleke University, Ede, Osun State, Nigeria.

^c Department of Epidemiology and Medical Statistics, University of Ibadan, Nigeria.

^d Department of Public Health and Community Health, Novena University, Delta State, Nigeria.

^e Department of Nursing, Faculty of Basic Medical Sciences, Adeleke University, Ede, Osun State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The COVID-19 pandemic continues to wreak havoc in Nigeria, with more cases and deaths reported every day. However, vaccine development and uptake are believed to aid the fight against this outbreak. We investigated vaccine uptake, unmet need for vaccine, and reported side effects among the populace.

An online cross-sectional study was conducted among 417 adults from the six geopolitical zones in Nigeria using the online data collection tool, Kobo-toolbox. We obtained information on socio-demographic characteristics, vaccine uptake, unmet need, and related side effects of COVID-19 vaccine. Descriptive analysis and binary logistic regression were done using Stata MP 16.

The mean age of the respondents was 32.1 ± 10.7 years. About half (49.9%) were below 30 years of age. Majority were females (63.1%), Christians (89.2%), and urban dwellers (74.6%). Majority

*Corresponding author: E-mail: eniadetreasure@gmail.com;

(89.2%) of respondents know that vaccines are beneficial to health, and 41.2% have received the COVID-19 vaccine. Unmet need for COVID-19 vaccine was 74.3% and herd immunity was estimated as 93.1%. Respondents working in the private sector (AOR=0.32, 95% CI=0.11-0.90), and who said COVID-19 vaccine is not beneficial to health (AOR=0.04, 95% CI=0.01-0.29) were less likely to receive COVID-19 vaccine, while those who have tested for COVID-19 (AOR=3.93, 95%CI=1.98-7.84) have a higher likelihood of receiving COVID-19 vaccine. Continuous awareness for COVID-19 vaccine is needed. The government needs to persistently assure citizens of the safety and efficacy of the vaccines. Also, this study recommends that the administration of a highly effective vaccine would result in achievable herd immunity and curb the transmission of COVID-19 virus.

Keywords: Herd immunity; unmet need; COVID-19; vaccine; side effects.

1. INTRODUCTION

There has been increase in morbidity and mortality worldwide since the COVID-19 pandemic started. As of August 8, 2021, there have been more than 202 million cases of COVID-19 worldwide and over 4 million mortality [1]. The trial for COVID-19 vaccine started as soon as COVID-19 was announced a pandemic. At the beginning of the pandemic, non-pharmaceutical interventions such as the use of face masks, hand washing, use of hand sanitizer, social distancing, and isolation were the recommended preventive measures. However, as the pandemic progressed there was a need for large-scale pharmaceutical intervention to achieve herd immunity.

Vaccines are biological products administered to healthy individuals that confer immunity against infection and disease. They could be inactivated organisms or live-attenuated viruses. Vaccines work in a way that prepares the immune system to respond to natural infection in the future. They are recommended for all humans and require safety and monitoring for potential side effects [2]. The benefits of vaccination are numerous and not to only those vaccinated, but to other members of their families and community. Adequate coverage of individuals vaccinated confers a "herd immunity" which reduces or terminates the continuous transmission of the disease within the population. Vaccination has socio-economic, physical development, educational, social, and health advantages [3]. Several brands of COVID-19 vaccines are available, they include; Johnson & Johnson, Oxford/AstraZeneca, Pfizer/BioNTech, Sinovac, Sputnik V, Sinopharm/Beijing, Moderna, Covaxin, Abdala, Soberana02, CanSino, EpiVacCorona [4].

One key step in stopping the COVID-19 pandemic is to ensure that a large proportion of

the world population is vaccinated. Vaccines have proved effective and efficient in reducing mortality due to infectious disease globally [2,3]. Governments all over the world have been urged to ensure large-scale, equitable access and distribution of COVID-19 vaccines [5]. As of August 8, 2021, less than one-third of the world population has received at least a dose of any type of COVID-19 vaccine, with 15.4% receiving the complete dose. Globally, an estimated 4.43 billion doses of COVID-19 vaccines have been administered. However, the population of people in low-income countries that have been vaccinated is only one-tenth [3,4]. COVID-19 vaccination rate in Nigeria stands at 1.91 per 100, one of the lowest globally [3]. Vaccine hesitancy and misinformation impede uptake and achieving the herd immunity desired in the case of COVID-19 [5].

Vaccine hesitancy, a major impediment to vaccine uptake has been documented globally, but especially in Africa. A major concern towards the COVID-19 vaccine was the accelerated pace of the development of the vaccine, mistrust of the government's response, and safety [6-8]. It was reported by WHO that several African countries have paused COVID-19 vaccine rollouts because of safety concerns, due to fears of side effects reported in developed countries [4]. Social media contributed greatly to the spread of myths and misconceptions on COVID-19 vaccines, as well as the safety and efficacy of the vaccine. Unfortunately, many African countries cannot track and provide up-to-date information on the side effects of the COVID-19 vaccine and share empirical information on the benefits [4] to assure and demystify the widespread misconceptions.

To achieve herd immunity for COVID-19, about 55% to 82% of the population must be vaccinated, depending on the genetic, environmental, and socio-cultural factors of the people [9]. Despite the obvious benefits of

vaccines and vaccination, there is still widespread delay or refusal to get vaccinated [10,2].

In our previous study, we documented the willingness of Nigerians to receive the COVID-19 vaccines when it is made available, which shows that less than half of the population surveyed were willing to take the vaccine [11]. This brings concern and the need to further investigate the uptake of the vaccine, now that they are available. Also, an unmet need for the vaccine and reported side effects.

2. MATERIALS AND METHODS

This was a cross-sectional study carried out in Nigeria; the most populous nation in Africa with an estimated population of about 200 million. Nigeria has 36 States divided into six geopolitical zones (South-west, South-east, South-south, North-west, North-east, and North-central). The study participants were adults aged 18 years and above who consented to participate in the study. Using the lesile kish formula for cross-sectional study $n = \frac{Z_{\alpha}^2 x pq}{d^2}$ where $P=0.405$ [7]. we calculated a sample size of 407 after adjusting for 10% non-response rate. But due to the online mode of questionnaire administration we got 417 completed questionnaires for this study.

A total of 417 people responded to the questionnaire within the time frame of the study, August to October 2021. The study was an online survey, and information was obtained using a well-structured questionnaire designed using the Kobo toolbox application, an online data collection tool. The questionnaire was adapted from several published literature and comprised of two sections A and B namely, socio-demographic characteristics of respondents and the uptake, unmet and related side effects on COVID-19 vaccine. The link generated for the questionnaire was sent to various social media platforms, and privately to individuals. The questionnaire took respondents about three minutes to complete.

The outcome variable in this study was COVID-19 vaccine uptake (Yes/No). Respondents were said to have an unmet need for the vaccine if he/she was willing to take the vaccine but had no access to take the vaccine. The independent variables were the socio-demographic characteristics of the respondents (Age, Gender, Level of education, Religion, Marital status, Type of residence, and Occupation), Knowledge of

Vaccines, Exposure to COVID-19 virus, Access to COVID-19 vaccine.

2.1 The Herd Immunity Estimation

R_0 is the estimated/expected number of infected individuals when an infected person enters a population that is immunologically naïve to the infectious agent. Effective reproduction number (R) is the expected/estimated number of infected individuals when an infected (and infectious) individual enters a population that is not immunologically naïve to the infectious agent in question and the population is indeed a mix of immunologically naïve and immunologically experienced individuals.

Formula:

$$\text{Herd immunity} = \frac{1 - \frac{1}{R_0}}{V}$$

Where R_0 ranges between 0.18 and 2.3 according to the estimate reported in a study conducted in Nigeria [12] and V is the vaccine efficacy.

The dataset was exported from the Kobo toolbox to an excel sheet and then exported into Stata Version 16 for analysis. Descriptive statistics (frequencies, percentages and charts) were presented for the outcome variable and explanatory variables. The herd immunity in Nigeria was calculated using the existing formula and estimated reproductive number R_0 . The assessment of factors associated with COVID-19 vaccine uptake was carried out using binary logistic regression analysis, after which factors that were significant at the crude level were adjusted to control for confounding variables.

3. RESULTS

3.1 Socio-demographic Characteristics of the Respondents

The socio-demographic characteristics of respondents are presented in table 1. The mean age of the respondents was 32.1 ± 10.7 years. About half (49.9%) were aged below 30 years, and 6.2% were aged above 49 years. Majority of the respondents were females (63.1%), had tertiary education (97.8%), and were Christians (89.2%). About 46% were currently married, and 0.7% was widow/widower. There were more urban dwellers (74.6%) than peri-urban (14.6%), and rural dwellers (10.8%). The distribution of the respondents' occupations was: Health worker

(18.0%), Civil servants (19.7%), private sector (12.0%), unemployed (7.7%), self-employed (15.1%), and students (27.6%). Median family size was 5 (4, 6), and median income was #71,000 (#31,500, 125,000).

3.2 Knowledge of Vaccination and COVID-19 Vaccine

As shown in Table 2, although majority (89.2%) of the respondents agreed that vaccine is beneficial to health, 23% reported that they have never received any form of vaccine in their lifetime. Knowledge of COVID -19 vaccine was high (98.8%) among the respondents. Also, 67.9% of them reported that their work exposed them to COVID-19 infection. More than one-third

(37%) have tested for COVID-19 (Fig. 1), and 3.4% tested positive. On vaccination, three-quarters (75.1%) reported that they had no access to COVID-19 vaccine, and 74.3% were not willing to take the vaccine. Reasons given for not willing to take the vaccine (figure 3) were: COVID-19 is a propaganda (7.5%); fear of adverse effect (21.7%); pregnancy (4.7%); safety of vaccine (43.4%); because I don't have COVID-19 (0.9%); Parents warning not to take the vaccine (1.9%); I have no interest (19.8%). Most (54.9%) of the respondents preferred the intravenous mode of vaccine administration, and a quarter (25.2%) preferred any of the modes of administration. As shown in Fig. 2, among those who have taken the vaccine (41.2%), 38.2% said it was mandated by their employer.

Table 1. Socio-demographic Characteristics of the respondents

Variables	Frequency (n=417)	Percentage (%)
Age mean(SD)	32.1 (10.7)	
Age group (years)		
<30	208	49.9
30 – 39	111	26.6
40 – 49	72	17.3
>49	26	6.2
Gender		
Female	263	63.1
Male	154	36.9
Level of education		
Secondary	9	2.2
Tertiary	408	97.8
Religion		
Christian	372	89.2
Islam	45	10.8
Marital Status		
Currently Married	193	46.3
Single	221	53.0
Widow/Widower	3	0.7
Type of residence		
Urban	311	74.6
Peri-Urban	61	14.6
Rural	45	10.8
Occupation		
Health worker	75	18.0
Civil servant	82	19.7
Private sector	50	12.0
Unemployed	32	7.7
Self-employed	63	15.1
Students	115	27.6
Number of persons in your household	5 (4,6)	Range : 1 - 13
Median (IQR)		
Monthly Income in Naira Median (IQR)	71000 (31500,125000)	Range: 10,000- 400,000

Table 2. COVID-19 Vaccine

Variables	Frequency (n=417)	Percentage (%)
Is taking of vaccine beneficial to your health?		
Yes	372	89.2
No	45	10.8
Have you ever received any vaccine?		
Yes	321	77.0
No	96	23.0
Does your work expose you to COVID-19 infection?		
Yes	283	67.9
No	134	32.1
Was the result of your COVID19 test positive? (n=154)		
No	140	33.6
Yes	14	3.4
Do you have access to take the COVID-19 vaccine		
Yes	313	75.1
No	104	24.9
Are you willing to take COVID19 vaccine		
Yes	310	74.3
No	107	25.7
Which method of the vaccination do you prefer		
Any	105	25.2
Injection	229	54.9
Oral	83	19.9
If you have taken the vaccine, was the vaccine mandated by your employer (n=170)		
Yes	65	38.2
No	105	61.8

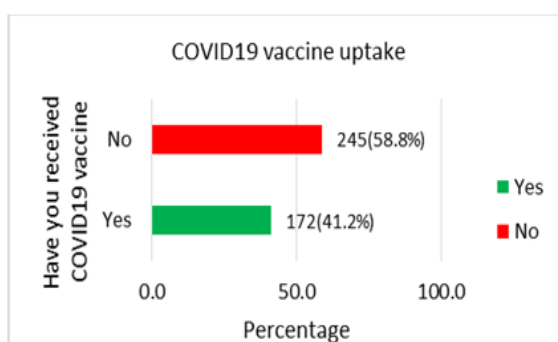


Fig. 1. COVID-19 testing

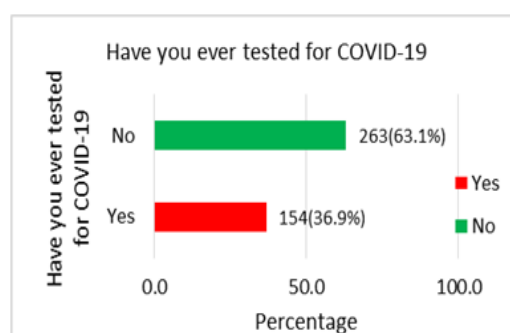


Fig. 2. COVID-19 Vaccine uptake

3.3 Features of COVID-19 Vaccine Received by the Respondents

Fig. 4 presents information on the type of COVID-19 vaccine received by respondents. Among 172 respondents that have received the vaccine, 114 (66.3%) received Oxford-AstraZeneca, 27(15.7%) received Moderna, while 17(9.9%) do not know the name of the vaccine they received.

As regards the dosage, figure 5 showed that more than one-third (39.0%) have received only first dose while majority (61.0%) have completed the dosage. Similarly in figure 7, those who didn't receive the vaccine reported some reasons for not doing so, the result was presented in Fig. 7. About 32(13.1%) said they don't know where to take the vaccine, 23(9.4%) said the venue was too distant to their area, 162(66.1%) doubted the effectiveness of the vaccine, 33(13.5%) said they

are just testing the vaccine on us, and 86(35.1%) said that the reported side-effect by those who have taken the vaccine was scaring them.

The reported side effects were shown in Fig. 6. These includes: pain, headache and fever (25%); arm soreness (2.3%); itching (2.3%); sudden stomach ulcer (0.6%); and 64.5% reported no side effect.

3.4 Unmet Need for COVID-19 Vaccine

The result in Table 3 showed that 74.3% were willing to take the vaccine in this population, but only 41.2% were able to take the vaccine. This revealed 33.1% unmet need for COVID 19 vaccine.

3.5 Estimate of Herds Immunity in Nigeria

Scholars have revealed that 60% to 72% herds' immunity is required to cut the chain of COVID-19 transmission with an assumption of 100% vaccine efficacy (Kadkhoda, 2021). But in the case of Nigeria where AstraZeneca/Oxford COVID-19 vaccine that was reported to have 63.09% efficacy [13] is the most administered. By estimation, at least 95% herd immunity is required to cut the chain of COVID-19 transmission in Nigeria.

Reproduction number (R_0) is 2.5 to 3.5

$$\text{Herd immunity} = \frac{1 - \frac{1}{R_0}}{V} = \frac{1 - \frac{1}{2.42}}{63.09} \times 0.95 = 93.1\%$$

Where R_0 is the reproduction number (2.42) with intervals ranging between 2.37 to 2.47 according to the estimate reported in a study carried out in Nigeria [14].

V is the Vaccine efficacy: V for AstraZeneca/Oxford COVID-19 vaccine=63.09%.

The herd immunity is estimated as 93.1% if Nigeria continued with the AstraZeneca/Oxford vaccine.

3.6 Gap from Herd Immunity

This study revealed COVID-19 vaccine uptake rate of 41.2%. Since this study was conducted online, meaning that the 41.2% rate represented the proportion of those who took COVID-19 vaccine and had access to the internet. A previous study revealed that only 48.0% of Nigerians have access to the internet [15]. By estimate 41.2% of the 48.0% Nigerian who had internet access took the COVID-19 vaccine, this implies that about 19.8% of Nigerian adults took the vaccine.

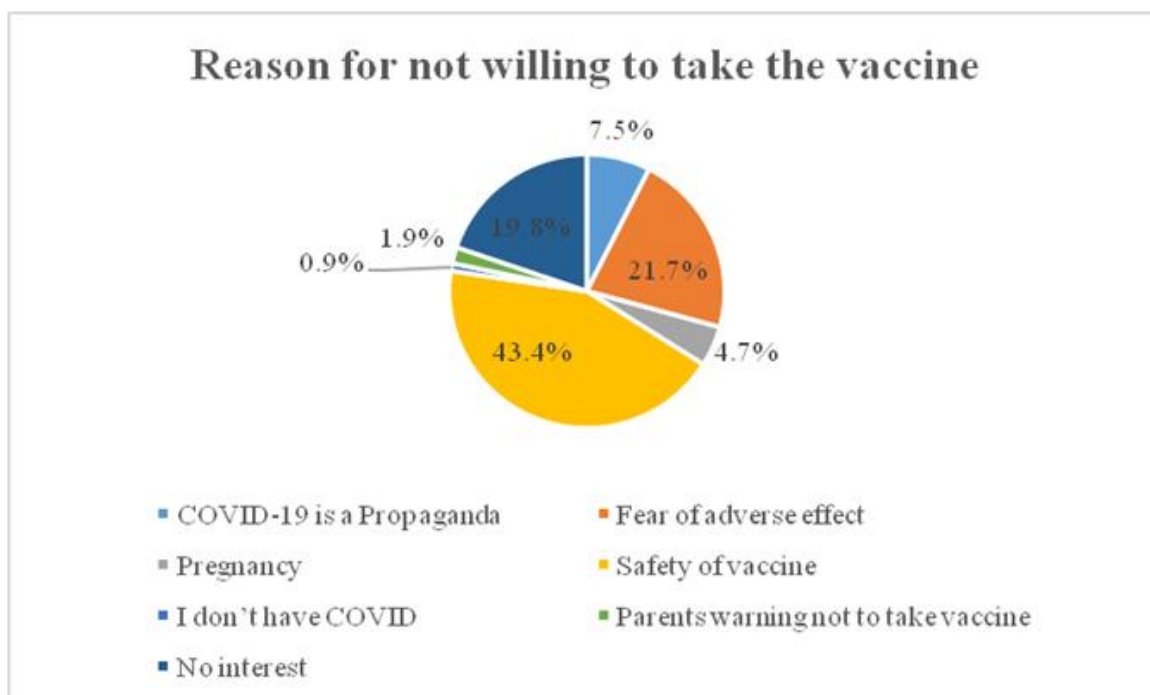


Fig. 3. Reason for not willing to take the vaccine

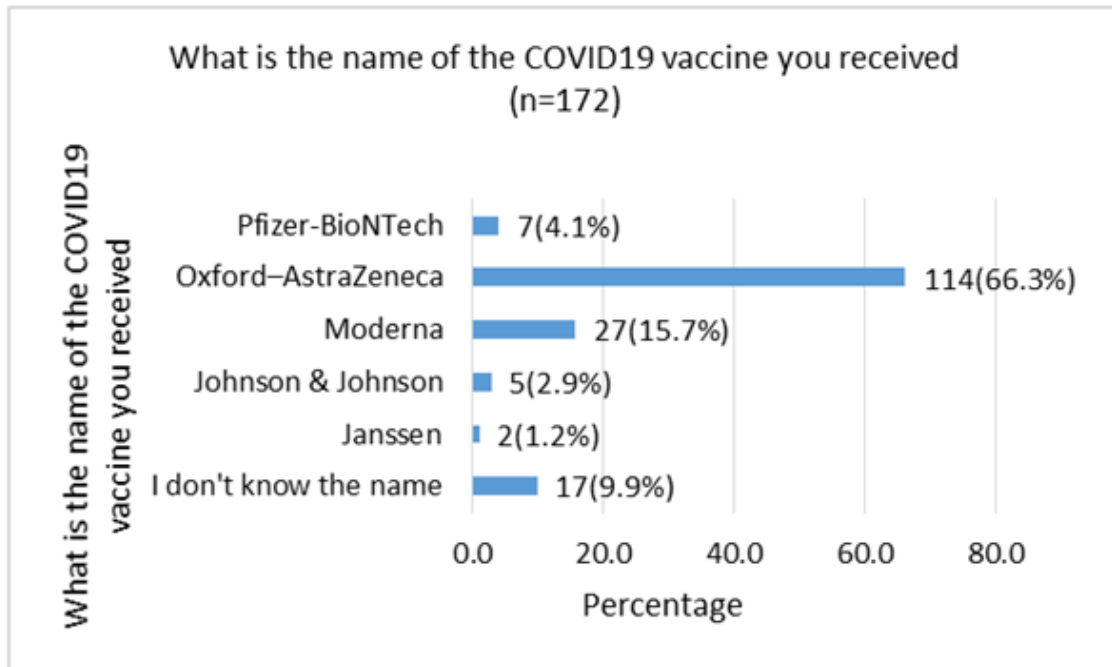


Fig. 4. Name of vaccines received

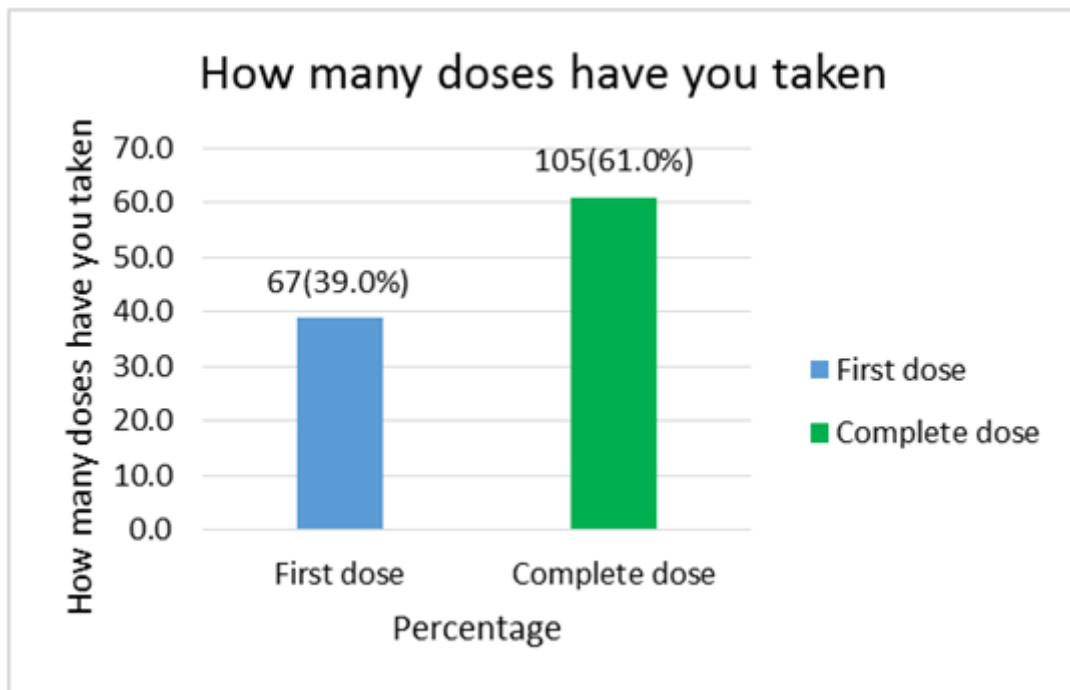


Fig. 5. Dosage taken

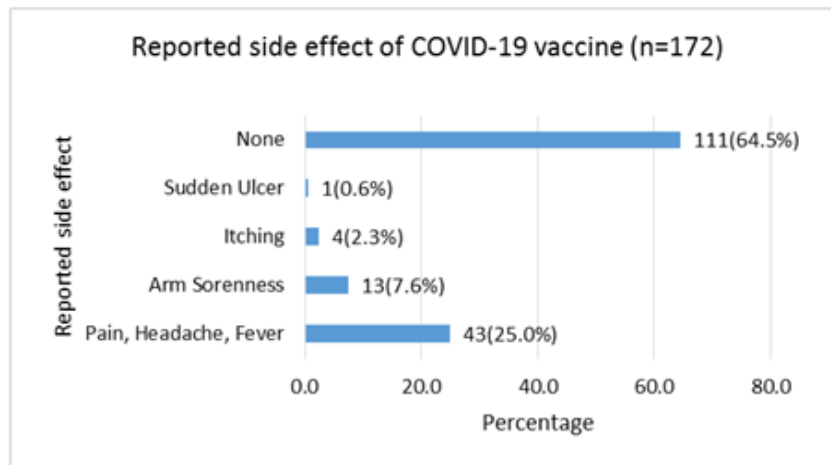


Fig. 6. Reported side effect of COVID-19 vaccine

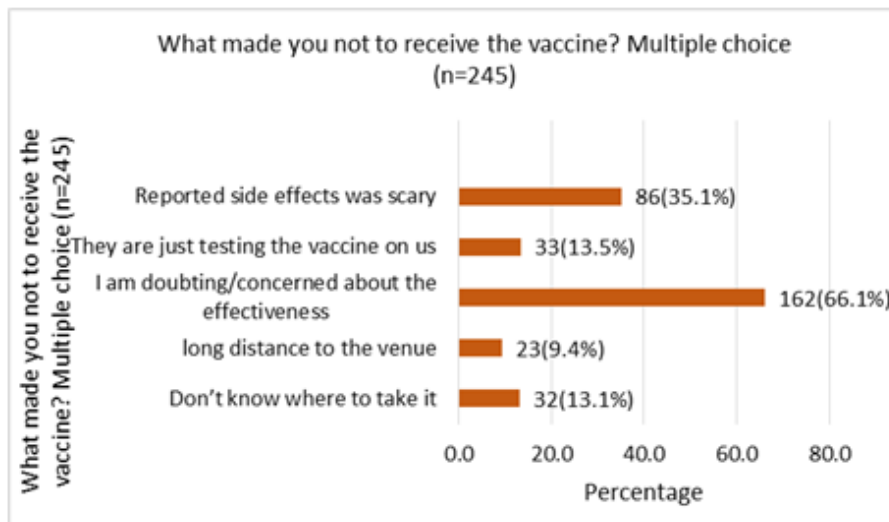


Fig. 7. Reasons for not receiving the vaccine

Table 3. Willingness to take COVID-19 vaccine and unmet need

Variables	Frequency (n)	Percentage (%)
Are you willing to take COVID19 vaccine		
Yes	310	74.3
No	107	25.7
Have you been able to take the vaccine		
Yes	172	41.2
No	245	58.8
Unmet need for COVID-19 Vaccine		
Unmet need	138	33.1
No Unmet need	279	66.9

3.7 Factors Associated with COVID-19 Vaccine Uptake

After adjusting for confounder, the factors associated with the likelihood of COVID-19

vaccine uptake were presented in table 4. Occupation was associated with COVID-19 uptake. For instance, respondents working in private sector (AOR=0.32, 95%CI=0.11 -0.90), unemployed (AOR=0.29, 95%CI= 0.05-1.78),

self-employed (AOR=0.48, 95%CI=0.16-1.46), and students (AOR=0.43, 95%CI= 0.15-1.24) were less likely to receive COVID-19 vaccine compared to health workers. Those who said COVID-19 vaccine is not beneficial to health (AOR=0.04, 95%CI=0.01-0.29) were less likely to receive the vaccine compared to respondents who said COVID-19 vaccine is beneficial to health. Also, COVID-19 testing was associated with the uptake of COVID-19 vaccine, as those

who have tested for COVID-19 (AOR=3.93, 95%CI=1.98-7.84) have a higher likelihood of receiving COVID-19 vaccine compared to those who have never tested for COVID-19. In the same vein, respondents who had access to COVID-19 (AOR=3.63, 95%CI= 8.04-16.41) were more likely to receive the COVID-19 vaccine compared to those who have no access to COVID-19 vaccine.

Table 4. Factors associated with COVID-19 Vaccine uptake

Variables	UOR	95% CI		AOR	95% CI	
		Lower	Upper		Lower	Upper
Age group (ref: ≤29)						
30 – 39	1.23	0.76	1.99	0.74	0.27	2.10
40 – 49	3.72*	2.12	6.53	2.12	0.54	8.25
≥50	4.74*	1.96	11.44	2.97	0.52	16.99
Gender (ref: Male)						
Female	1.11	0.74	1.67	-	-	-
Level of education (ref: ≤secondary)						
Tertiary	0.55	0.15	2.09	-	-	-
Religion (ref: Christian)						
Islam	0.99	0.52	1.87	-	-	-
Marital Status (ref: Single)						
Currently Married	2.27	1.52	3.39*	1.45	0.72	2.94
Widow/Widower	1.06	0.09	11.84	0.41	0.02	10.61
Type of residence (ref: Rural)						
Urban	1.63	0.91	2.93	-	-	-
Peri-Urban	1.93	0.87	4.30	-	-	-
Occupation (ref: Health worker)						
Non- health worker (Government sector)	1.21	0.63	2.33	1.39	0.56	3.42
Non-health worker (private sector)	0.22	0.10	0.49*	0.32**	0.11	0.90
Unemployed	0.49	0.21	1.13	0.29	0.05	1.78
Non-health worker (self-employed)	0.18	0.08	0.38*	0.48	0.16	1.46
Students	0.23	0.13	0.43*	0.43	0.15	1.24
Number of persons in your household	1.05	0.97	1.14	-	-	-
Monthly Income in Naira	1.00	1.00	1.01*	0.99	0.99	1.00
Is taking of vaccine beneficial to health (ref: Yes)						
No	0.03	0.01	0.20*	0.04**	0.01	0.29
Does your work expose you to COVID-19 infection (ref: No)						
Yes	2.95	1.87	4.47*	1.55	0.72	3.31
Have you ever tested for COVID-19? (ref: No)						
Yes	2.09	1.39	3.14*	3.93**	1.98	7.84
Do you have access to take the COVID-19 vaccine (ref: No)						
Yes	1.84	7.85	43.31*	3.63**	3.04**	8.41

UOR*: unadjusted Odds ratio significant at 5%; AOR**: adjusted Odds-ratio significant at 5%; ref: Reference category

4. DISCUSSION

The present survey covered all geo-political zones in Nigeria, with many of the respondents residing in urban areas. In the past few decades, due to migration and urbanization, there has been a surge in the population of urban dwellers. The large number of urban dwellers that participated in this study is not unexpected because it is a web-based study and requires access to a mobile phone, laptop, and internet services which are most readily available in the urban areas. While many respondents in this present study agreed that vaccine is beneficial, one in four persons has never taken any form of vaccine in their lifetime. This is similar to the NDHS report that vaccination coverage in Nigeria is low, one in five children did not receive any of the recommended childhood vaccines [16,17]. The country is among the list of ten countries in the world where 60% of all children did not receive the basic vaccine [2]. This is a pointer to vaccine education and general belief about the COVID-19 vaccine in Nigeria.

4.1 COVID-19 Vaccine Willingness, Uptake and Unmet Need

A quarter of our respondents expressed unwillingness to uptake the COVID-19 vaccine similar to the 24.3% reported by Qiao and colleagues [18]. Consistent with other studies in Nigeria, Ethiopia [19] and Jordan [20] fear of the safety of the vaccine, fear of adverse effects, the efficacy of vaccine, lack of trust in the government and knowledge about the vaccines were the major reasons for unwillingness to take the COVID-19 vaccine. A previous study among women in Northern Nigeria documented vaccine hesitancy as 13%. Reasons given for the non-uptake of the vaccine include general beliefs and lack of knowledge about the importance of vaccines [21].

This study revealed COVID-19 vaccine uptake rate of 41.2%, but because this study was conducted online, meaning that the 41.2% rate represented the proportion of those who took COVID-19 vaccine and had access to the internet. A study has revealed that only 48.0% of Nigerian have access to the internet (Ceci, 2021). By estimate 41.2% of the 48.0% Nigerian who had access to the internet took COVID-19 vaccine, this implied that about 19.8% of Nigeria have received the vaccine. We also identified that one in every three respondents in this study was willing to take the COVID-19 vaccine but

have not (unmet need), because of lack of knowledge about where to access COVID-19 vaccine, belief that the vaccine was being tested on Nigerians, and reported side effects by those who have taken the vaccine. This finding showed that knowledge about access to vaccines and misconceptions were major hindrances to vaccine uptake in Nigeria. The lack of effective and educative awareness about the COVID-19 vaccine could be a reason for the poor awareness. The lack of awareness about the COVID-19 vaccine and misconception about the vaccine has a link to politicization, a study has revealed that politicization is a major hindrance to COVID-19 vaccine coverage [22].

Vaccine completion rate was 61% in this study. Compared to another study that reported a slightly higher completion rate in the United State of America [20]. The variation in the completion rate across countries could be tied to people's beliefs about the vaccine as a lot of those who didn't take the vaccine provided reasons for not taking the vaccine. Provided reasons can be regarded as misconceptions about the vaccine. In the same vein, the majority in this study reported no side effects of the COVID-19 vaccine. The reported side effects of the COVID-19 vaccine included headache and fever, arm soreness, and itching, which are some of the signs reported. This finding is in agreement with the WHO publication on the side effects of the vaccine (World Health Organization, 2021). Further, the reported side effect in this study has been earlier reviewed and confirmed protective and effective to combat the transmission of COVID-19 (World Health Organization, 2021).

4.2 Herd Immunity

Regarding herd immunity, we incorporated the vaccine efficacy of the most administered vaccine in Nigeria to estimate a country-specific herd immunity. Based on the vaccine efficacy of 63.09% (AstraZeneca vaccine), we estimated the herd immunity to be 93.1% with an interval of 91.7% to 94.4%, this is a great task to achieve in a country where high vaccine hesitancy was found. Compared to other studies that estimated the threshold for COVID-19 herd immunity between 55% and 82%. Vaccine hesitancy impedes vaccine uptake and the achievement of herd immunity [21].

We proceeded to estimate the herd immunity for a highly effective vaccine such as Moderna, Moderna vaccine have been proven to have high (94.1%) efficacy [22]. Going by the vaccine

efficacy of Moderna, the country-specific herd immunity would be 62%, this implies that a highly effective vaccine would help achieve herd immunity and reduce the chances of COVID-19 transmission in Nigeria.

Furthermore, the result showed herd immunity in Nigeria is quite higher (93.1%) compared to other countries (75.2%). Also, going by the published proportion (1.71%) of fully vaccinated in Nigeria (World Health Organization, 2021), Nigeria is still very far from achieving herd immunity against COVID-19 transmission.

5. CONCLUSION AND RECOMMENDATION

There is a need for continuous awareness of service centers for COVID-19 vaccine in Nigeria. The government needs to persistently assure and encourage the citizens of the safety and efficacy of the vaccines, so that Nigeria can achieve the desired herd immunity to stop the spread of the COVID-19 infection. Also, this study recommends that administering a highly effective vaccine would result in achievable herd immunity and curb the transmission of the COVID-19 virus.

LIMITATION

This study was carried out online; therefore, as a result of inaccessibility to the internet among some Nigerians, the generalizability of some of the findings may not be appropriate. However, the limitation does not erode the findings from this study.

DISCLAIMER

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CONSENT AND ETHICS APPROVAL

The ethical approval for this study was gotten from Adeleke University Ethical Review Committee (AUERC/FBMS/IND/02). All participants provided informed consent to participate in the study by clicking the informed consent button after they were fully informed about their freedom to withdraw from the study at

any point. Every tenet of the Helsinki Declaration and other ethical requirements were strictly complied with throughout the study. No identifying information was captured from participants, and the study database was accessible to the only Data manager.

AVAILABILITY OF DATA AND MATERIALS

The de-identified data has been provided as a supplementary file in the submission platform.

COMPETING INTERESTS

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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