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Original Research

Assessment of COVID-19 Vaccine Knowledge, Uptake, and Factors Influencing its Uptake Among Medical Students at the University of Jos

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Abstract

Background: COVID-19 vaccination is crucial to containing the pandemic. COVID-19 vaccine knowledge, attitudes, and uptake among medical students are vital, as they are future healthcare professionals expected to promote vaccination. This study assessed the knowledge of the COVID-19 vaccine, its uptake, and associated factors among medical students.

Methodology: A cross-sectional study was conducted among 245 medical students at the University of Jos, Nigeria. Participants were selected using stratified random sampling. Data was collected via a self-administered questionnaire and analysed using descriptive and inferential statistics.

Results: The median knowledge score was 8, with an interquartile range (IQR) of 3. Most participants had low knowledge of the COVID-19 vaccine (65.7%), while a minority had high knowledge (34.3%). The overall vaccine coverage was 20%. Gender and tribe were significantly associated with vaccine uptake. Males were more likely to receive the vaccine than females (24.3% vs. 12.9%, $p = 0.039$), and participants from the Igbo tribe were less likely to receive the vaccine than those from the Yoruba tribe (0% vs. 29.4%, $p = 0.002$). Additionally, being tested for COVID-19 was significantly associated with vaccine uptake ($p < 0.001$). Factors influencing COVID-19 vaccination decisions were access to accurate information (68.9%, $p < 0.001$), healthcare professionals' recommendations (31.1%, $p < 0.001$), concerns about safety and side effects (26.6%, $p < 0.006$), self-protection (19.5%, $p = 0.011$), government guidelines (39.6%, $p < 0.001$), vaccine availability (38.0%, $p = 0.005$), and the availability and convenience of vaccination centres (33.7%, $p < 0.001$).

Conclusions: There was low COVID-19 vaccine knowledge and uptake among medical students. Gender, tribe, access to information, healthcare guidance, and practical barriers influenced vaccination decisions. Targeted education and provider involvement are needed to address hesitancy in this critical population.

Keywords: *COVID-19 Vaccine; Medical Students; Knowledge; Uptake; Factors.*

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Quick Response Code:

Introduction:

COVID-19, also known as the coronavirus disease, is a viral illness caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] It was declared a global pandemic by the World Health Organization (WHO) in March 2020.[2] COVID-19 primarily spreads through respiratory droplets when an infected person coughs, sneezes, or talks. The disease can range from mild to severe, with symptoms including fever, cough, shortness of breath, fatigue, loss of taste or smell, and in severe cases, it can lead to respiratory failure, organ damage, and even death.[1]The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has profoundly impacted global health, social structures, and economies.

Vaccines were developed to combat the spread of COVID-19 and mitigate its impact.[1] COVID-19 vaccines work by stimulating the immune system to recognize and fight the SARS-CoV-2 virus. Different types of vaccines have been authorized for emergency use or approved by regulatory agencies worldwide. These include mRNA vaccines (such as Pfizer-BioNTech and Moderna), viral vector vaccines (such as AstraZeneca and Johnson & Johnson), inactivated vaccines (such as Sinovac and Bharat Biotech), and protein subunit vaccines (such as Novavax).[3, 4] Vaccination has emerged as a crucial tool in containing the spread of the virus and mitigating the burden of the disease.[5] It is vital to understand the knowledge, attitudes, and behaviours of specific populations, such as medical students, regarding COVID-19 vaccination. This understanding is essential for effective public health interventions and vaccine promotion.[6]

COVID-19 vaccine knowledge, uptake, and associated factors among medical students have become a significant concern in the context of the COVID-19 pandemic. As future healthcare professionals, medical students play a crucial role in public health and are expected to be well-informed and supportive of vaccination efforts. However, understanding their knowledge level, attitudes, and behaviour regarding COVID-19 vaccination is essential for developing effective strategies to ensure high vaccine acceptance and uptake among this population.

In one study at Southern US University, COVID-19 vaccine acceptance among university students is influenced by various factors, including vaccine efficacy, safety concerns, trust in healthcare providers, and peer influence.[6] A study conducted among medical students from a Caribbean medical school revealed that a significant proportion of students have not yet been vaccinated, with 61.89% of the participants reporting that they had not received the COVID-19 vaccine.[7] Among the unvaccinated students, 19.65% were unsure or did not intend to accept the vaccine, while 80.35% expressed the intention to be vaccinated within the next 6 months.[7]

Acceptance and hesitancy toward COVID-19 vaccination among university students have been studied, emphasizing the significance of addressing vaccine acceptability behaviour in this population.[8, 9] Factors such as vaccine efficacy, safety concerns, trust in healthcare systems, and knowledge gaps have been identified as key determinants of COVID-19 vaccine acceptance among university students.[8, 9] Additionally, in Northwest Nigeria among 440 university health sciences students, vaccine acceptance was 40%, with acceptance higher among those aged ≥25 years (aOR 2.72), if instructed by school heads (aOR 11.71), with trust in government (aOR 20.52), and willingness to pay (aOR 7.92). In Kenya across urban, peri-urban, and rural areas, among 665 youth aged 18-35 years, only 42% were ready for vaccination, while 52% adopted a “wait and see” approach, and 6% were unwilling; females, Protestants, and the post-secondary educated showed higher hesitancy. The major causes of hesitancy included concerns about safety and effectiveness, inadequate and conflicting information on vaccines, perceived low infection risk, and distrust in the health ministry.[10, 11]

Medical students play a crucial role in the healthcare system and are future healthcare professionals. Their knowledge, attitudes, and behaviours regarding COVID-19 vaccination can influence public health outcomes and the overall success of vaccination efforts. If the problem persists, it may result in

suboptimal vaccination rates among medical students, leading to increased risks of COVID-19 transmission within healthcare settings and the wider community. Additionally, the lack of vaccine acceptance and knowledge among medical students may contribute to vaccine hesitancy among the general population, further hindering efforts to control the COVID-19 pandemic.

Despite the growing body of literature on COVID-19 vaccine knowledge, uptake, and associated factors, medical students still lack a comprehensive understanding of these issues. Medical students, as a vital subset of the healthcare community, have not been sufficiently studied regarding their vaccine acceptability behaviour.[6] This gap in research calls for a more comprehensive examination of their knowledge, the underlying reasons for vaccine hesitancy, and the factors that influence their acceptance of vaccines. By delving deeper into these aspects, we can gain valuable insights that will inform targeted strategies to enhance vaccine uptake among these future healthcare professionals, contributing to better public health outcomes.

Methodology

Study Area

The study was conducted at the University of Jos, a federal tertiary institution in Nigeria with over 40,000 students.[12] The College of Medical Sciences at the University of Jos offers programs in medicine and surgery, among others. Medical students at the University of Jos undertake a rigorous curriculum to prepare them to make meaningful contributions to society as engaged citizens and leaders in the healthcare field.

Study Design

The research has employed a cross-sectional study design, providing a snapshot of the knowledge and vaccine uptake among medical students at the University of Jos, Nigeria.

Study Population

The study population comprised medical students enrolled at the University of Jos, irrespective of their academic year.

Inclusion Criteria: Participants were eligible for inclusion in the study if they met the following criteria: Current enrollment as a medical student at the University of Jos and willingness to participate in the study, as demonstrated by providing informed consent. Exclusion Criteria: Individuals who were sick during the period of the study were excluded

Sample Size and Technique

The calculated sample size was approximately 245, stratified random sampling technique was employed to ensure a representative and diverse sample. The total population of medical students at the University of Jos was divided into distinct strata based on the year of study. Each student was assigned to a specific stratum, ensuring they belonged to only one group. A random sampling technique using balloting was employed within each stratum to select a proportionate number of students, considering the size of each stratum relative to the total population.

Data Collection Instrument and Technique

A structured questionnaire was developed based on a thorough review of existing literature.[4-5, 7-8, 11-15, 17, 21]

It was pre-tested on 10% of the sample to ensure clarity, validity, and reliability. The data for this study was collected using the Kobo Collect application version v2022.4.4. The questionnaire covered socio-demographic characteristics, knowledge of the COVID-19 vaccine, vaccine uptake, reasons for non-vaccination, and factors influencing vaccine uptake.

Data Analysis

The data was analysed using SPSS Statistics version v27.0. Descriptive analysis summarised socio-demographic information, knowledge, vaccine uptake, and associated factors. The study population's characteristics were summarised using means, standard deviations, ranges, and frequencies as needed.

The analysis of knowledge involved assigning one mark for each correct answer and zero marks for incorrect responses. The questionnaire assessed various aspects of COVID-19 vaccine knowledge, including awareness, types of vaccines, recommended dosages, and safety perceptions. Total scores were calculated by summing the marks for all correct answers, resulting in a maximum score indicative of comprehensive knowledge of the COVID-19 vaccine.

The median knowledge score was used to dichotomise knowledge levels into low and high. Participants with knowledge scores below the median were categorised as having low knowledge, while those with scores equal to or above the median were categorised as having high knowledge.

To examine the relationship between COVID-19 vaccine knowledge and socio-demographic factors, we employed a two-pronged analytical approach. Initially, univariate regression analysis was conducted to assess unadjusted associations, yielding odds ratios (ORs) with 95% confidence intervals (CIs). This was followed by multivariate logistic regression modelling to obtain adjusted ORs, controlling for potential confounders selected based on existing literature and theoretical considerations. These confounding variables included age, gender, marital status, tribe/ethnicity, religion, academic year, and course of study. For both analyses, statistical significance was determined at a P-value threshold of 0.05, enabling a comprehensive evaluation of both individual and adjusted associations between vaccine knowledge and the various sociodemographic factors under study.

Ethical Consideration

The study protocol was approved by the Jos University Teaching Hospital (JUTH) Ethics Committee (NHREC/JUTH/05/10/22). Participants provided written informed consent prior to enrollment. To safeguard confidentiality, we anonymized data, used coded identifiers on questionnaires, and limited data access to authorized researchers. Electronic data was secured through encryption and password protection. Participants were assured of their right to withdraw without consequences. This research involving human subjects complied with the Declaration of Helsinki and local ethical guidelines, with a strong emphasis on safeguarding participant privacy and ensuring data security throughout the study.

Results

Socio-demographic Characteristics of Participants

The sample consisted of predominantly young adult medical students with a mean age of 24.7 years. Gender distribution shows a slight male predominance (62.9%). Most participants were single (96.7%). Regarding ethnicity, other tribes are the most common category (60.0%), followed by Igbo (13.1%) and Yoruba (8.6%).

The majority identify as Christian (93.5%), with a smaller proportion as Muslim (6.5%). In terms of the year of study, participants are distributed across different academic years, with the highest proportion in the second year (24.9%). MBBS (76.3%) is the most common course pursued, followed by BDS (23.7%). (Table1)

Table 1: Socio-demographic Characteristics of the Participants

Socio-demographic Characteristics		**n**	**(%)**
Age in years, Mean (SD)=	24.7 (2.6)		
Gender	Male	154	(62.9)
	Female	91	(37.1)
Marital Status	Single	237	(96.7)
	Married	8	(3.3)
Tribe	Hausa	13	(5.3)
	Igbo	32	(13.1)
	Yoruba	21	(8.6)
	Berom	20	(8.2)
	Ngas	12	(4.9)
	Other	147	(60.0)
Religion	Christian	229	(93.5)
	Islam	16	(6.5)
Year of Study	First Year	38	(15.5)
	Second Year	61	(24.9)
	Third Year	47	(19.2)
	Fourth Year	41	(16.7)
	Fifth Year	33	(13.5)
	Sixth Year	25	(10.2)
Course	MBBS	187	(76.3)
	BDS	58	(23.7)

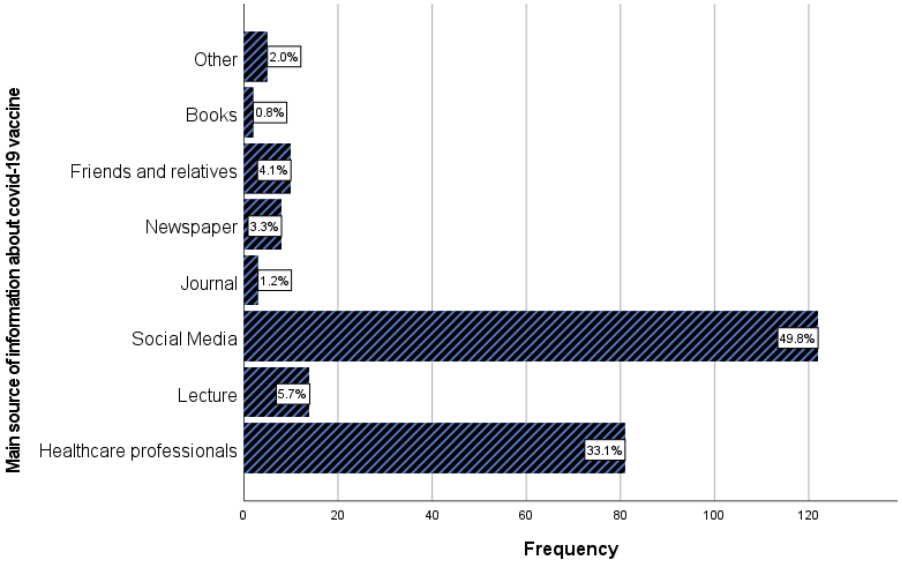

Figure 1: Distribution of the Main Source of Information about COVID-19 Vaccine among Medical Students of the University of Jos

Figure 1 displays the main sources from which 245 respondents obtained information about the COVID-19 vaccine. The result revealed that social media was the most frequently mentioned source of information about the COVID-19 vaccine, with 49.8% of respondents stating that they rely on social media platforms for information. Healthcare professionals were also a main source of information, with 33.1% of respondents citing them as their main source.

Knowledge of COVID-19 Vaccine

All 245 respondents were aware of COVID-19. Knowledge about available vaccine types varied, with 55.5% identifying mRNA, viral vector, protein subunit, and inactivated vaccines, while 19.2% mentioned antibody-based, antiviral, and antipyretic vaccines. Understanding of recommended dosages varied by vaccine type, with many respondents correctly identifying the recommended dosage for Pfizer-BioNTech (49.8%), Oxford/AstraZeneca (46.9%), Moderna (35.9%), and Johnson & Johnson (38.7%). Many recognised the need for booster doses for various vaccines. Most respondents correctly identified that all COVID-19 vaccines are administered via injections (77.6%), while opinions on vaccine safety were diverse. Less than half of the respondents (44.1%) acknowledged the reporting of rare and severe side effects (Table 2).

Table 2: Knowledge of COVID-19 Vaccine Among University of Jos Medical Students

Variables		n	(%)
Aware of Covid-19	No	0	(0.0)
	Yes	245	(100.0)
Types of COVID-19 vaccines available	mRNA vaccines, viral vector vaccines, protein subunit vaccines, and inactivated vaccines	136	(55.5)
	Antibody-based vaccines, antiviral vaccines, and antipyretic vaccines	47	(19.2)
	Oral vaccines, nasal spray vaccines, and injectable vaccines	9	(3.7)
	Live attenuated vaccines, inactivated vaccines, and DNA vaccines	53	(21.6)
Recommended dosage of Pfizer-BioNTech vaccine for individuals aged 12 years and above	One-Dose	16	(6.5)
	Two doses	122	(49.8)
	Three doses	64	(26.1)
	The dosage recommendation depends on individual health conditions	43	(17.6)
Recommended dosage of Oxford/AstraZeneca COVID-19 vaccine	One-Dose	20	(8.2)
	Two doses	115	(46.9)
	Three doses	61	(24.9)
	The dosage recommendation depends on individual health conditions	49	(20.0)
Recommended dosage of Moderna COVID-19 vaccine	One-Dose	35	(14.3)
	Two doses	88	(35.9)
	Three doses	61	(24.9)
	The dosage recommendation depends on individual health conditions	61	(24.9)
Recommended dosage of Johnson & Johnson COVID-19 vaccine	One-Dose	29	(12.9)
	Two doses	87	(38.7)
	Three doses	50	(22.2)
	The dosage recommendation depends on individual health conditions	59	(26.2)
A booster dose is required for the Pfizer-BioNTech vaccine	No	62	(25.3)
	Yes	183	(74.7)
A booster dose is required for the Moderna vaccine	No	101	(41.2)
	Yes	144	(58.8)
A booster dose is required for the AstraZeneca vaccine	No	97	(39.6)
	Yes	148	(60.4)
A booster dose is required for the Johnson & Johnson vaccine	No	91	(37.1)
	Yes	154	(62.9)
A booster dose is required for the Novavax vaccine	No	86	(35.1)
	Yes	159	(64.9)
All COVID-19 vaccines are given through injections	No	55	(22.4)
	Yes	190	(77.6)

In general, COVID-19 vaccines are safe	Strongly disagree	7	(2.9)
	Disagree	25	(10.2)
	Neutral	94	(38.4)
	Agree	102	(41.6)
	Strongly agree	17	(6.9)
Rare or severe side effects were reported	No, all side effects are mild and temporary	96	(39.2)
	Yes, rare and severe side effects have been reported	108	(44.1)
	Side effects are only reported in individuals with pre-existing conditions	28	(11.4)
	Side effects are only reported in individuals who receive multiple vaccines simultaneously	13	(5.3)

The median knowledge score was 8, with an interquartile range (IQR) of 3. Regarding the level of knowledge of the COVID-19 vaccine, 161 respondents (65.7%) had a low level of knowledge, while 84 respondents (34.3%) had a high level of knowledge (Table 3).

Table 3: Knowledge of COVID-19 Vaccine Scores among Medical Students at the University of Jos

Knowledge score, median (IQR)		8 (3)	
Level of knowledge of COVID-19 vaccine, n (%)	Low knowledge	161	(65.7)
	High knowledge	84	(34.3)

In the univariate analysis, students in their second year exhibited a significantly lower likelihood of high knowledge scores (OR = 0.330, p = 0.041, 95% CI [0.114, 0.958]) compared to those in the first year. Moreover, the Ngas tribe had significantly higher odds of achieving high knowledge scores (OR = 2.910, p = 0.029, 95% CI [1.117, 7.581]) compared to the reference group (Hausa tribe). After adjustment in multivariate logistic regression, there was no statistically significant difference in knowledge scores between students in their second year (adjusted OR = 0.350, p = 0.117, 95% CI [0.094, 1.298]) and those in the first year. However, the Ngas tribe exhibited an increase in the likelihood of achieving high knowledge scores (adjusted OR = 3.104, p = 0.024, 95% CI [1.163, 8.285]) relative to the reference group, the Hausa tribe (Table 4).

Table 4: Bivariate and Multivariate Logistic Regression of Predictors of Higher Knowledge Score of COVID-19 Vaccine

Variable	Unadjusted OR	p-value	95% CI (Unadjusted)	Adjusted OR	p-value	95% CI (Adjusted)
Age	1.061	0.256	(0.958, 1.176)	1.035	0.633	(0.898, 1.194)
Gender						
Male	Referent			Referent		
Female	1.016	0.956	(0.588, 1.754)	0.979	0.943	(0.547, 1.752)
Marital Status						
Single						
Married	0.865	0.846	(0.202, 3.713)	0.597	0.554	(0.108, 3.295)
Tribe						
Hausa	Referent			Referent		
Igbo	0.353	0.186	(0.075, 1.653)	0.164	0.054	(0.026, 1.028)
Yoruba	1.164	0.707	(0.527, 2.572)	1.176	0.703	(0.511, 2.710)
Berom	0.456	0.178	(0.146, 1.429)	0.452	0.185	(0.140, 1.462)
Ngas	2.910	**0.029**	(1.117, 7.581)	3.104	**0.024**	(1.163, 8.285)
Other	0.970	0.962	(0.279, 3.378)	1.010	0.988	(0.277, 3.686)
Religion						
Christian	Referent			Referent		
Islam	0.863	0.791	(0.290, 2.571)	0.499	0.342	(0.119, 2.092)

Academic Year						
First Year	Referent			Referent		
Second Year	0.330	**0.041**	(0.114, 0.958)	0.350	0.117	(0.094, 1.298)
Third Year	0.485	0.133	(0.188, 1.248)	0.550	0.313	(0.172, 1.756)
Fourth Year	0.476	0.142	(0.177, 1.282)	0.559	0.322	(0.177, 1.767)
Fifth Year	0.382	0.068	(0.136, 1.074)	0.341	0.054	(0.114, 1.020)
Sixth Year	0.527	0.236	(0.183, 1.519)	0.463	0.189	(0.147, 1.462)
Course						
MBBS	Referent			Referent		
BDS	1.500	0.220	(0.784, 2.869)	1.327	0.419	(0.667, 2.640)

Uptake of COVID-19 Vaccine

24.9% of the participants had been tested for COVID-19, with 87.9% testing negative. Only 20% of the participants had received the COVID-19 vaccine, with AstraZeneca being the most common type of vaccine received. The most common reason for not receiving the vaccine was concerns about vaccine safety (41.2%). Most participants (86.1%) did not think the COVID-19 vaccine should be mandated for all Nigerian citizens (Table 5).

Table 5: Distribution of COVID-19 Vaccination Uptake among Medical Students of University of Jos

Variables	Category	n	(%)
Tested for the COVID-19 virus	No	184	(75.1)
	Yes	61	(24.9)
Outcome of the COVID-19 Test	Negative	51	(87.9)
	Positive	7	(12.1)
Received COVID-19 vaccine	No	180	(80.0)
	Yes	45	(20.0)
Number of doses of COVID-19 received	1	12	(24.0)
	2	28	(56.0)
	3	10	(20.0)
Type of COVID-19 vaccine received	Pfizer-BioNTech	7	(15.6)
	Moderna	3	(6.7)
	AstraZeneca	23	(51.1)
	Johnson & Johnson	12	(26.7)
	Other	0	(.0)
Reason for not receiving the COVID-19 vaccine	Concerns about vaccine safety	82	(41.2)
	Lack of information about vaccines	26	(13.1)
	Personal or religious beliefs	37	(18.6)
	Medical contraindications	16	(8.0)
	Other	38	(19.1)
Do you think the COVID-19 vaccine should be mandated on all Nigerian citizens?	No	210	(86.1)
	Yes	34	(13.9)

Gender and tribe were significantly associated with vaccine uptake. Males were more likely to receive the vaccine than females (24.3% vs. 12.9%, $p = 0.039$), and participants from the Igbo tribe were less likely to receive the vaccine than those from the Yoruba tribe (0% vs. 29.4%, $p = 0.002$). Additionally, being tested for COVID-19 was significantly associated with vaccine uptake ($p < 0.001$). However, age, marital status, religion, year of study, course, and knowledge of the COVID-19 vaccine were not significantly associated with vaccine uptake (Table 6).

Table 6: Association between sociodemographic factors, testing for COVID-19, knowledge of COVID-19 vaccine and uptake of COVID-19 vaccine

Independent variables		Received COVID-19 vaccine				p-value
		No		Yes		
	Category	n	(%)	n	(%)	
Age						0.777[b]
Gender	Male	106	(75.7)	34	(24.3)	
	Female	74	(87.1)	11	(12.9)	**0.039**
Marital Status	Single	172	(79.3)	45	(20.7)	
	Married	8	(100.0)	0	(0.0)	0.363[a]
Tribe	Hausa	10	(76.9)	3	(23.1)	
	Igbo	27	(100.0)	0	(0.0)	
	Yoruba	12	(70.6)	5	(29.4)	
	Berom	18	(100.0)	0	(0.0)	**0.002[a]**
	Ngas	7	(77.8)	2	(22.2)	
	Other	106	(75.2)	35	(24.8)	
Religion	Christian	168	(80.0)	42	(20.0)	
	Islam	12	(80.0)	3	(20.0)	1.000[a]
Year of Study	First Year	30	(78.9)	8	(21.1)	
	Second Year	39	(72.2)	15	(27.8)	
	Third Year	35	(85.4)	6	(14.6)	
	Fourth Year	30	(83.3)	6	(16.7)	
	Fifth Year	27	(87.1)	4	(12.9)	0.510
	Sixth Year	19	(76.0)	6	(24.0)	
Course	MBBS	148	(81.8)	33	(18.2)	
	BDS	32	(72.7)	12	(27.3)	0.179
Tested for the COVID-19 virus	No	145	(86.8)	22	(13.2)	
	Yes	35	(60.3)	23	(39.7)	**<0.001**
Outcome of the Covid-19 Test	Negative	33	(64.7)	18	(35.3)	
	Positive	2	(28.6)	5	(71.4)	0.102[a]
Knowledge of COVID-19 Vaccine	Low Knowledge	116	(78.9)	31	(21.1)	
	High Knowledge	64	(82.1)	14	(17.9)	0.575

a = Fisher's Exact Test, b = t-test

Factors Associated with COVID-19 Vaccine Uptake

Table 7 presents factors influencing COVID-19 vaccination decisions. Access to accurate information (68.9%, $p < 0.001$) and healthcare professionals' recommendations (31.1%, $p < 0.001$) strongly influence vaccination. Concerns about safety and side effects (26.6%, $p < 0.006$) are significant barriers, while trust in vaccine effectiveness shows no strong association (21.3%, $p = 0.262$). Reasons like self-protection (19.5%, $p = 0.011$) and government guidelines (39.6%, $p < 0.001$) impact decisions. Barriers to access, such as vaccine availability (38.0%, $p = 0.005$), play a role. The availability and convenience of vaccination centres (33.7%, $p < 0.001$) also influence uptake.

Table 7: Distribution of Factors Associated with COVID-19 Vaccine Uptake

Variables	Category	No Vaccine, n (%)	Yes Vaccine, n (%)	p-value
Access to accurate information	Not influential	17 (100.0)	0 (0.0)	**<0.001c**
	Neutral	43 (100.0)	0 (0.0)	
	Somewhat influential	47 (79.7)	12 (20.3)	
	Very Influential	73 (68.9)	33 (31.1)	
Healthcare professionals' advice	Not influential	17 (100.0)	0 (0.0)	**<0.001c**
	Neutral	39 (90.7)	4 (9.3)	
	Somewhat influential	64 (90.1)	7 (9.9)	
	Very Influential	60 (63.8)	34 (36.2)	

Safety and side effects concerns	Not influential	7 (100.0)	0 (0.0)	**<0.006c**
	Neutral	32 (88.9)	4 (11.1)	
	Somewhat influential	47 (87.0)	7 (13.0)	
	Very Influential	94 (73.4)	34 (26.6)	
Trust in vaccine effectiveness	Not influential	14 (87.5)	2 (12.5)	<0.262c
	Neutral	44 (86.3)	7 (13.7)	
	Somewhat influential	48 (75.0)	16 (25.0)	
	Very Influential	74 (78.7)	20 (21.3)	
Main reasons for vaccination	Protection for myself	95 (80.5)	23 (19.5)	**0.011a**
	Protection for loved ones	9 (90.0)	1 (10.0)	
	Public health responsibility	28 (68.3)	13 (31.7)	
	Trust in scientific research	24 (96.0)	1 (4.0)	
	Convenience and accessibility	3 (42.9)	4 (57.1)	
	Other	21 (87.5)	3 (12.5)	
Barriers to access	No barriers	106 (84.8)	19 (15.2)	**0.005a**
	Lack of availability	31 (62.0)	19 (38.0)	
	Scheduling difficulties	22 (81.5)	5 (18.5)	
	Lack of transportation	8 (80.0)	2 (20.0)	
	Other	13 (100.0)	0 (0.0)	
Influence of family and friends	Not influential	21 (75.0)	7 (25.0)	0.349c
	Neutral	50 (82.0)	11 (18.0)	
	Somewhat influential	71 (89.9)	8 (10.1)	
	Very Influential	38 (66.7)	19 (33.3)	
Government guidelines	Not influential	32 (88.9)	4 (11.1)	**<0.001c**
	Neutral	63 (86.3)	10 (13.7)	
	Somewhat influential	56 (82.4)	12 (17.6)	
	Very Influential	29 (60.4)	19 (39.6)	
Availability of vaccination centres	Not influential	39 (100.0)	0 (0.0)	**<0.001c**
	Neutral	39 (84.8)	7 (15.2)	
	Somewhat influential	45 (83.3)	9 (16.7)	
	Very Influential	57 (66.3)	29 (33.7)	

a = Fishers Exact Test, c = Linear-by-Linear Association

Discussion

COVID-19 vaccination protects individuals from serious illness, hospitalization, and death. However, vaccine hesitancy remains challenging, particularly among certain populations such as young adults. Understanding the factors associated with vaccine knowledge and hesitancy among medical students is essential for developing targeted interventions to increase vaccine uptake in this population. This study has provided valuable insights into the COVID-19 vaccination status and associated factors among medical students at the University of Jos, Nigeria. The findings can be used to inform the development of effective strategies to promote vaccination and protect this critical population from COVID-19.

This present study showed that social media was the main source of information about the COVID-19 vaccine, with 49.8% of respondents relying on social media platforms for information. Healthcare professionals were also a main source of information, with 33.1% of respondents citing them as their main source. The prevalence of social media as a source of COVID-19 vaccine information observed in our study is consistent with findings from other research in this area. For instance, a study highlighted the proliferation of anti-vaccination on social media accounts during the pandemic, emphasizing the role of these platforms in escalating vaccine hesitancy.[13] Moreover, a study among medical and health science students found that those who received information about the COVID-19 vaccine from social media were more likely to exhibit vaccine hesitancy, underscoring the potential influence of these platforms on attitudes towards vaccination.[14] However, while social media can be a significant source of vaccine information, it is important to acknowledge the role of healthcare professionals as another key source, as

this study indicates. Healthcare professionals' guidance remains a trusted and influential factor in vaccination decisions. Addressing vaccine hesitancy should involve targeted strategies on social media platforms and effective communication from healthcare professionals to provide accurate and reliable information and counteract misinformation.

Regarding knowledge of the COVID-19 vaccine, our findings showed that 84 (34.3%) of participants had good knowledge about the COVID-19 vaccine. This is lower than the proportion of medical and health science students with good knowledge of the vaccine in other studies, such as those conducted in Ethiopia (78.6%),[15] Ghana (45%),[16] Bangladesh (57%),[17] and Egypt (70.2%).[18] However, it is higher than the proportion of undergraduate students with good knowledge of the vaccine in a study conducted at the University of Uyo (20.6%).[19]

The lower proportion of participants with good COVID-19 vaccine knowledge in our study compared to others can be attributed to several factors. These include regional differences in healthcare infrastructure and educational resources, variations in study timing as vaccine knowledge evolves, differences in study populations' characteristics, and the effectiveness of local public health communication strategies. Despite these variations, our study showed higher knowledge levels than a similar study at the University of Uyo, suggesting regional consistency in vaccine knowledge disparities within certain countries.

These findings emphasize the importance of targeted education and communication efforts to improve vaccine knowledge and effectively address regional disparities.

This study also found that only 20% of the respondents had received the COVID-19 vaccine, with the most common reason for not receiving the vaccine being concerns about vaccine safety. The low COVID-19 vaccine uptake of only 20% among medical students, primarily due to safety concerns, is consistent with findings from other studies that reported vaccine hesitancy rates ranging from 17% to 31% in this population.[23] However, these rates contrast with higher vaccine acceptance observed in some regions, such as Sudan, where a substantial proportion of medical students were vaccine-hesitant.[20] Similarly, a study in Enugu, Nigeria, found a lower acceptance rate, with only 36.1% of respondents willing to take the COVID-19 vaccine.[21] These discrepancies highlight the variability in vaccine attitudes among medical students across different contexts and the need for tailored interventions. Nevertheless, vaccine safety concerns are commonly cited as a primary reason for hesitancy among medical students, emphasizing the importance of targeted educational efforts to address misconceptions and build confidence in vaccine safety.[15]

Meanwhile, a strikingly high 93.1% of medical students in Romania expressed a strong intention to vaccinate.[22] Also, in the United States, a study found hesitancy rates of 45% among dental students and 23% among medical students.[23]Dental students were more likely to have had COVID-19 and personally know individuals with COVID-19, suggesting that prior experiences might influence vaccine hesitancy. This increased exposure could affect hesitancy through various mechanisms, including perceptions of natural immunity, varied experiences with disease severity, altered risk perception, and exposure to diverse anecdotal information.[23] Notably, after controlling for these experiences and personal vaccination behaviours, the type of healthcare education (dental vs. medical) was no longer predictive of vaccine willingness, underscoring the significant role of personal experiences in shaping vaccine attitudes.[23]

Furthermore, our findings are consistent with broader research on COVID-19 vaccine hesitancy, which has identified various determinants influencing vaccine uptake. For example, the study found an average vaccine hesitancy rate of 29.72%, emphasizing the prevalence of hesitancy across populations.[24] Concerns about vaccine safety, identified as the primary reason in this study, are a recurring theme in the literature on vaccine hesitancy.[25] However, the relatively low vaccination rate among medical students, who are typically well-informed about healthcare, highlights the need for targeted interventions to

address specific concerns and enhance vaccine confidence within this critical group. These studies collectively illustrate the complex interplay of factors influencing medical students' COVID-19 vaccination decisions, including regional disparities, field of study, socioeconomic factors, and prior experiences.

Our study found that students in their second year (24.9%) and those from the Ngas tribe (60%) were more likely to have high knowledge scores. Also, male medical students were more likely to receive the COVID-19 vaccine than female medical students (24.3% vs. 12.9%, p = 0.039). The finding that male medical students were more likely to receive the COVID-19 vaccine than female medical students is consistent with some studies that have reported a gender gap in vaccine hesitancy, with females being more hesitant towards COVID-19 vaccines.[26-27] However, other research suggests the opposite trend, with women being less hesitant towards COVID-19 vaccines compared to men.[28] These contrasting findings highlight the complex nature of vaccine hesitancy and the potential influence of various factors, such as socioeconomic status, cultural norms, and risk perceptions.[27] A possible explanation for the higher vaccine hesitancy among female medical students could be related to their perception of risks and benefits associated with the COVID-19 vaccines, influenced by factors such as risk aversion, concerns about fertility and pregnancy, trust in authorities, and social and cultural norms.[27, 29] However, these explanations are not universally applicable, as the contrasting findings from other studies suggest that gender differences in vaccine hesitancy may vary across different populations and contexts, highlighting the need for an intersectional approach that considers the interplay of gender with other social determinants.[26, 28-29]

Our findings on factors influencing COVID-19 vaccine uptake align with several other studies examining determinants of vaccine acceptance and hesitancy. Access to accurate information (68.9%) resonates with research highlighting the importance of reliable information sources in shaping vaccination attitudes and behaviours.[30] Similarly, healthcare professionals' recommendations (31.1%) and government guidelines (39.6%) mirror the influence of expert guidance in promoting vaccination and align with the expanding evidence of vaccine safety and effectiveness.[31] Concerns about safety and side effects (26.6%) echo broader discussions on addressing safety-related anxieties to boost vaccine confidence.[32] Barriers to access (38.0%) align with pre-pandemic research on substantial barriers to vaccination, especially among underserved populations, emphasizing the need to improve vaccine accessibility.[33] Lastly, the availability and convenience of vaccination centres (33.7%) highlight the importance of ensuring convenient access to vaccination, consistent with efforts to tailor vaccine rollouts for diverse communities.[33]

Our study has limitations that should be considered when interpreting the results. Firstly, the cross-sectional design limits our ability to establish causal relationships between the factors investigated and vaccine hesitancy. This means we can only identify associations, not determine cause and effect. Secondly, our reliance on self-reported data introduces the potential for response bias. Participants' reported intentions and behaviours may differ from their actual actions, which could affect the accuracy of our findings. Additionally, our study did not explore preferences for specific vaccine types or brands, which could provide valuable insights into vaccine hesitancy factors. Lastly, the lack of longitudinal data prevents us from understanding how attitudes toward COVID-19 vaccination, particularly regarding booster doses, may change over time. Future research addressing these limitations could provide more comprehensive insights into vaccine hesitancy among healthcare students and inform targeted strategies to promote vaccine uptake.

Conclusions

The study reveals low COVID-19 vaccine uptake (20%) and limited knowledge (34.3%) among University of Jos medical students. Key influencing factors include access to accurate information, safety concerns, and gender disparities. These findings underscore the need for targeted educational interventions and strategies to address specific barriers. By leveraging these insights, health authorities

can develop effective approaches to enhance vaccine knowledge and increase uptake among these crucial future healthcare providers.

Recommendations

It is recommended that the University of Jos management enhance accessibility to vaccination centres and streamline the vaccination process, integrate comprehensive vaccine education into academic curricula, initiate targeted educational campaigns on social media platforms, and, for future research, consider qualitative research to explore specific concerns and barriers related to vaccine safety and side effects.

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