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Determinants of COVID-19 Vaccine Acceptance Among Adults in Kogi State, Nigeria: A Study Applying the Health Belief Model and Theory of Planned Behaviour

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Abstract

The COVID-19 pandemic has significantly impacted global public health, with effective vaccine distribution being crucial to mitigating virus spread and reducing healthcare burdens. This study investigates determinants of COVID-19 vaccine uptake among adults in Kogi State, Nigeria, using the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB). A cross-sectional survey of 484 participants selected through multistage sampling involved a structured questionnaire covering demographic information and HBM and TPB constructs. Results show that the age category (35-44) and senatorial zone (Kogi East) significantly predict vaccine uptake, with individuals aged 35-44 years being 2.5 times more likely to get vaccinated (OR = 2.5, $p < 0.05$). Perceived behavioral control significantly influences vaccine uptake ($B = -0.112$, $p = 0.018$), while perceived subjective norm ($\beta = 0.038$, $p = 0.41$) and behavioral intention ($B = 0.039$, $p = 0.423$) have minimal impact. The HBM constructs, including perceived severity ($B = 0.062$, $p = 0.027$), susceptibility ($B = 0.08$, $p < 0.001$), barriers, and cues to action, provided a significant fit. However, the combined TPB model did not significantly explain the variability in vaccine uptake ($F\text{-}_{statistic} = 2.025$, $p = 0.109$). The study underscores the necessity for targeted public health interventions and longitudinal research to enhance vaccine uptake and provides insights for effective public health strategies and educational campaigns in Kogi State and similar contexts.

Keywords: *COVID-19, Health Belief Model, Theory of Planned Behavior, Vaccine Uptake.*

Introduction

The COVID-19 pandemic, caused by SARS-CoV-2, has significantly impacted Nigeria's health and economic systems [1]. The virus primarily spreads through droplet infections and contact with mucous membranes [2]. While public health measures like social distancing were initially implemented, vaccine development was deemed crucial for controlling the pandemic [3, 4]. Unprecedented collaborative efforts led to the rapid development and approval of multiple vaccines within a year of identifying

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the viral sequence [4]. As of 2021, thirteen vaccines had been approved, with over 90 candidates in clinical trials [3]. Vaccination plays a crucial role in disease prevention at both the individual and community levels. It is widely recognized as one of the most cost-effective and efficient methods of improving health outcomes, saving numerous lives, and promoting global health and well-being [5]. The COVID-19 vaccine serves as a vital tool in containing the ongoing pandemic by limiting the number of individuals susceptible to illness and reducing the transmission of the virus to others. Additionally, it significantly contributes to the prevention of COVID-19 hospitalizations and fatalities. By vaccinating individuals, the strain on healthcare systems can be alleviated, making hospital beds and resources available for other medical needs [5]. The country initiated its vaccination program in March 2021 after less effective interventions [6]. Despite initial challenges, including low acceptance rates and infrastructure issues, Nigeria's vaccination efforts improved, with over 54% of the target population vaccinated by December 2022 [6]. As of May 31, 2022, the NPHCDA reported that 30,327,550 people had received the first dose, 14,629,451 had received the second dose, and 1,229,909 had received booster doses [7]. By December 14, 2022, over 54% of the target population, equivalent to more than 60 million people, had been fully vaccinated [8]. Recent data as of June 20, 2023, indicated further progress, with 75.1% of eligible individuals having received at least one dose and 65.9% having completed the primary series of COVID-19 vaccines in Nigeria. However, disparities persist across regions; for instance, in Kogi State, as of June 20, 2023, according to unpublished data obtained from National Primary Health Care Development Agency, June 2023, showed only 18% and 6% of the eligible population had received the first dose and completed the primary series, respectively [9]. The vaccination campaign has reduced COVID-19 mortality and case rates [6]. Health behavior models and theories provide guidance in understanding and explaining health-related behaviors. This study draws upon the Health Belief Model and Theory of Planned Behavior, which provide a framework for understanding the personal beliefs and intentions that shape health-related behaviors. Despite the benefits of COVID-19 vaccination in terms of individual and community protection, a significant proportion of the population remains hesitant to receive the vaccine. Therefore, it is crucial to examine the behavioral factors influencing COVID-19 vaccine hesitancy [10]. The low COVID-19 vaccine uptake is a significant concern and poses a challenge in curbing the spread of COVID-19 infection. Hence, this study aims to examine the current vaccination rate in Kogi State and identify potential underlying factors contributing to its low uptake.

Previous studies conducted in Nigeria regarding COVID-19 vaccine acceptance or hesitancy-related behavior have either not incorporated any theoretical framework [13], [14], [15] or have solely relied on the health belief model [16]. Therefore, the present study seeks to investigate determinants of COVID-19 uptake among the adult population by drawing concept from the Health Belief Model [11] and Theory of planned Behaviour [12].

Additionally, it is important to highlight that there has been no corresponding research conducted in Kogi State, underscoring its significant contribution to the existing body of knowledge. These findings will provide valuable insights for the Government of Kogi State to design effective campaigns aimed at reducing vaccine hesitancy and increasing COVID-19 vaccine uptake. Furthermore, this information can guide decision-makers in developing strategies to enhance vaccine uptake throughout Nigeria, such as establishing additional vaccination centers or implementing educational campaigns targeting increased vaccine uptake in Kogi State and

potentially extending beyond its borders. The lesson learnt from understanding the determinant of uptake of COVID-19 vaccination can be used to design interventions for future emergency/outbreak.

The aim of this cross-sectional study is to examine the determinants of COVID-19 vaccine uptake among adults in Kogi State, Nigeria, using the Health Belief Model and Theory of Planned Behavior frameworks. The specific objectives are to investigate the associations between demographic factors, perceived susceptibility and severity, perceived barriers and cues to action, and perceived behavioral control, behavioral intention, and subjective norms and COVID-19 vaccine uptake. The lesson learnt from understanding the determinant of uptake of COVID-19 vaccination can be used to design interventions for future emergency/outbreak.

Research Methodology

Study Design and Sampling Techniques

This community-based cross-sectional study investigated factors associated with COVID-19 vaccine uptake among adults in Kogi State, Nigeria.

Sample Size Estimation

The minimum sample size of households for the survey was calculated using the Cochrane formula [25].

$$n = \frac{Z^2\, p(1-p)}{d^2}$$

The calculation was based on the following parameters: (n) represented the minimum sample size, (Z) was the standard normal deviate corresponding to a 5% significance level, (p) was the COVID-19 vaccine uptake prevalence rate in Nigeria, which stood at 58% proportion [15]. It was suggested that in cases of uncertainty regarding the value of (p), it would be prudent to default to 50% as this would yield a larger sample size [25]. The term (q) equaled (1 - p), and (d) was the precision set at 0.05. With (Z = 1.96), (p = 0.5), and (q = 1 - 0.5), the application of the formula yielded a calculated minimum sample size of 384.

Using 95% confidence level on the standard normal distribution (Z), 0.5 standard deviation, and a margin of error of +/- 5%.

((1.96)2 x .5(.5)) / (.05)2

(3.8416 x .25) / .0025

.9604 / .0025

384.16

Rounding up, it was determined that 385 respondents were needed.

Therefore, a sample size of approximately 450 households was utilized in this study, taking into consideration an attrition rate of 15%.

Sampling Techniques: A multistage cluster sampling method, as recommended by WHO, was used. Kogi State was divided into three senatorial zones (West, East, Central), from which six LGAs were selected. In each LGA, one political ward was randomly selected, followed by the random selection of five communities per ward, totaling 30 communities. Sixteen households from each community were chosen, and within each household, one adult participant was randomly selected. Data collection involved face-to-face interviews using a structured questionnaire administered via Kobo toolbox. The questionnaire, developed from a comprehensive literature review, was divided into six sections: demographic characteristics; knowledge about COVID-19 and vaccination; attitudes towards vaccination; perceptions based on the Health Belief Model; motivation using the Theory of Planned Behaviour; and assessment of vaccination uptake.

Hypotheses:

1. Demographic factors are positively associated with COVID-19 vaccine uptake.
2. Perceived susceptibility, perceived severity, perceived barriers, and cues to

action are positively associated with and predict COVID-19 vaccine uptake.

3. Perceived behavioral control, behavioral intention, and subjective norms predict COVID-19 vaccine uptake.

Instrumentation, Data Collection, and Analysis

To ensure data quality, data collectors received one-day training, and the questionnaire's validity was ensured through a pilot study, content validation, and expert reviews. Internal consistency was confirmed with a Cronbach's Alpha of 0.6, and data accuracy was maintained through double entry and cross-validation. Ethical approval was obtained from the Kogi State Ministry of Health. Participation was voluntary, with informed verbal consent, and confidentiality was maintained throughout the study. Data were analyzed using IBM SPSS version 23, employing summary statistics and multiple logistic regression analyses to determine associations between variables at a significance level of 0.05. Descriptive statistics, ANOVA, correlation, and multiple regression analyses were conducted to validate hypotheses. The study included Nigerian adults aged 18 and above who had resided in Kogi for more than six months, excluding individuals under 18, non-Nigerians, and those who had resided in Kogi for less than six months.

Results

Tables 1A & B presents the demographic characteristics of the 484 study participants. The gender distribution was evenly split with 50% identifying as male and 50% as female, ensuring equitable gender-related insights.

Table 1A. Frequency Distribution of Demographic Characteristics of Study Participants

Variables	Frequency N = 484	Percent (%)
Gender		
Male	242	50
Female	242	50
Total	484	100
Age Category		
18 - 24	25	5.2
25 - 34	118	24.4
35 - 44	150	31
45 - 54	103	21.3
55 - 64	55	11.4
65 and above	33	6.8
Total	484	100
Ethnicity		
Yoruba	163	33.7
Igala	153	31.6
Ebira	99	20.5
Hausa	28	5.8
Igbo	11	2.3
Gwari	23	4.8
Othe Minority tribe	7	1.4
Total	484	100
Occupational Status		
Student	63	13

Employed	161	33.3
Unemployed	216	44.6
Health Worker	21	4.3
Retired	23	4.8
Total	484	100

Table 1B. Frequency Distribution of Demographic Characteristics of Study Participants

Variables	Frequency N = 484	Percent (%)
Educational Attainment		
Non-Formal	68	14
Primary School	29	6
Secondary school	154	31.8
Post-Secondary	233	48.1
Total	484	100
Nature of Occupation		
Civil Servant	77	15.9
Businessperson	155	32
Self-Employed	151	31.2
Professional	58	12
Housewife	26	5.4
Retired	17	3.5
Total	484	100
Senatorial Zone		
Kogi Central	183	37.8
Kogi East	157	32.4
Kogi west	144	29.8
Total	484	100
Religious Affiliation		
Christianity	226	46.7
Islam	247	51
Traditional	6	1.2
Others	5	1
Total	484	100

Age-wise, most participants (31%) were aged 35-44 years, followed by those 25-34 years (24.4%), and 45-54 years (21.3%). Smaller age groups included 18-24 years (5.2%), 55-64 years (11.4%), and those 65 years and above (6.8%), highlighting a predominantly middle-aged sample with diverse age representation.

Ethnic diversity was notable, with Yoruba participants the largest group at 33.7%, followed by the Igala at 31.6%, and Ebira at 20.5%. Other ethnic groups included Hausa (5.8%), Igbo (2.3%), Gwari (4.8%), and other minorities (1.4%). This broad ethnic representation allows comprehensive ethnic-related insights.

Occupational status varied, with 44.6% unemployed constitute the largest group, 33.3% employed, 13% students, 4.3% health workers, and 4.8% retired.

Educational background showed that 48.1% had post-secondary education, 31.8% had secondary education, 14% had non-formal education, and 6% had primary education,

indicating relatively high educational attainment. This distribution indicates a significant portion of the sample is currently unemployed or high level of education.

Occupational roles included businesspersons (32%), self-employed individuals (31.2%), civil servants (15.9%), professionals (12%), housewives (5.4%), and retired individuals (3.5%).

Geographically, participants were distributed across senatorial zones with Kogi Central having the highest representation at 37.8% (183). Kogi East followed with 32.4% (157), and Kogi West comprised 29.8% (144). ensuring regional coverage. Participants' religious affiliations were predominantly Muslim (51%), followed by Christianity (46.7%). A small number practiced traditional religion (1.2%) or other religions (1%), reflecting the group's religious diversity.

Table 2 shows the relationships between demographic characteristics and COVID-19 vaccine uptake. While gender shows no significant association (p = 0.675), age category reveals a notable correlation (p = 0.019), with the 35-44 group having a higher vaccination rate. No significant associations are found between occupational status, educational attainment, and vaccine uptake (p=0.239 and p=0.861). However, a significant relationship exists between senatorial zone and vaccine uptake (p=0.003), with Kogi East having a higher rate. No association is found between religion and vaccine uptake (p = 0.889).

Table 2. Association Between Participants Demographics Status and Covid-19 Vaccine-Uptake

Variables	**COVID-19 Vaccine Uptake**			**Statistic**		
	Vaccinated	**Not Vaccinated**	**Total**	**χ^2**	**df**	**P-value**
Gender						
Male	229(94.6)	13(5.4)	242(100.0)			
Female	231(95.5)	11(4.5)	242(100.0)	0.175	1	0.675
Total	460(95.0)	24(5.0)	484(100.0)			
Age category						
18 – 24	21(84.0)	4(16.0)	25(100.0)			
25 – 34	111(94.1)	7(5.9)	118(100.0)			
35 – 44	147(98.0)	3(2.0)	150(100.0)	13.539	5	0.019*
45 – 54	99(96.1)	4(3.9)	103(100.0)			
55 – 64	53(96.4)	2(3.6)	55(100.0)			
≥ 65	29(87.9)	4(12.1)	33(100.0)			
Total	460(95.0)	24(5.0)	484(100.0)			
Occupational Status						
Student	57(90.5)	6(9.5)	63(100.0)			
Employed	152(94.4)	9(5.6)	161(100.0)			
Unemployed	207(95.8)	9(4.2)	216(100.0)	5.505	4	0.239
Health	21(100.0)	0(0.0)	21(100.0)			
Retired	23(100.0)	0(0.0)	23(100.0)			
Total	460(95.0)	24(5.0)	484(100.0)			

Educational attainment						
Non-Formal	65(95.6)	3(4.4)	68(100.0)			
Primary	27(93.1)	2(6.9)	29(100.0)			
Secondary	145(94.2)	9(5.8)	154(100.0)	0.75	3	0.861
Post-	223(95.7)	10(4.3)	233(100.0)			
Total	460(95.0)	24(5.0)	484(100.0)			
Senatorial Zone						
Kogi Central	173(94.5)	10(5.5)	183(100.0)			
Kogi East	156(99.4)	1(0.6)	157(100.0)	11.381	2	0.003*
Kogi West	131(91.0)	13(9.0)	144(100.0)			
Total	460(95.0)	24(5.0)	484(100.0)			
Religion						
Christianity	214(94.7)	12(5.3)	226(100.0)			
Islam	233(95.1)	12(4.9)	246(100.0)			
Traditional	6(100.0)	0(0.0)	6(100.0)	0.632	3	0.889
Others	7(100.0)	0(0.0)	7(100.0)			
Total	460(95.0)	24(5.0)	484(100.0)			

*Statistically Significant at $p<0.05$

Table 3 shows the correlation analysis between COVID-19 vaccine uptake and various factors revealed diverse relationships. Knowledge average showed a weak negative correlation (r = -0.063), while attitude average exhibited a slight positive correlation (r = 0.09). Perceived susceptibility (r = 0.187) and perceived severity (r = 0.148) had moderate positive correlations with vaccine uptake. Similarly, perceived benefit also demonstrated a positive correlation (r = 0.115). On the other hand, perceived barrier had a negligible positive correlation (r = 0.006), and cue to action showed a minor negative correlation (r = -0.036). Perceived subjective norm was slightly positively correlated (r = 0.03), whereas perceived behavioral control had a slight negative correlation (r = -0.096). Lastly, perceived behavioral intention was weakly positively correlated with vaccine uptake (r = 0.016). These findings highlight the varying degrees of association between COVID-19 vaccine uptake and different psychological and behavioral factors.

Table 3. Correlations Between COVID-19 Vaccine Uptake and Other Variables

Pearson Correlation													
Variables	**(x̄)**	**± SD**	**COVID-19 Vaccine Uptake**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
COVID-19 Vaccine Uptake	0.95	0.22	1										
Knowledge Average	15.01	3.11	-0.063	1									
Attitude Average	8.53	1.55	0.09	0.312	1								
Perceived	5.73	1.47	0.187	0.039	0.252	1							

Susceptibility													
Perceived Severity	5.52	1.09	0.148	0.234	0.411	0.224	1						
Perceived Benefit	8.11	1.47	0.115	0.261	0.516	0.28	0.442	1					
Perceived Barrier	7.26	1.66	0.006	-0.012	0.147	-0.3	0.062	-0.001	1				
Cue To Action	6.03	1.21	-0.036	-0.083	-0.129	-0.063	-0.14	-0.19	-0.02	1			
Perceived Subjective Norm	4.02	0.82	0.03	-0.041	-0.149	-0.118	-0.01	-0.165	0.109	0.242	1		
Perceived Behavioural Control	7.45	1.78	-0.096	-0.089	-0.067	0.024	-0.04	-0.141	-0.02	0.271	0.148	1	
Perceived Behavioural Intention	5.96	1.31	0.016	-0.055	-0.12	-0.08	-0.09	-0.171	-0.07	0.208	0.217	0.276	1

The regression analysis on COVID-19 Vaccine Uptake reveals several important findings (Table 4). The results of the regression analysis show that perceived susceptibility (B = 0.08, p < 0.001) and perceived severity (B = 0.062, p = 0.027) are positively associated with COVID-19 vaccine uptake. However, perceived barrier (B = 0.029, p = 0.261) and cue to action (B = 0.001, p = 0.839) are not significantly associated with vaccine uptake. The standardized coefficients (B) indicate that perceived susceptibility has the strongest relationship with vaccine uptake (B = 0.18), followed by perceived severity (B = 0.103).

Table 4. Regression Analysis of Relationship Between HBM Constructs and COVID-19 Vaccination Uptake

			Coefficients(a)			
		Unstandardized Coefficients		**Standardized Coefficients**		
Model		**B**	**Std. Error**	**B**	**t**	**Sig.**
1	(Constant)	0.484	0.13		3.718	0
	Perceived Susceptibility	0.08	0.021	0.18	3.715	0.000
	Perceived Severity	0.062	0.028	0.103	2.217	0.027
	Perceived Barrier	0.029	0.025	0.053	1.126	0.261
	Cue To Action	-0.001	0.007	-0.009	-0.203	0.839

a. Dependent Variable: COVID-19 Vaccine Uptake

The ANOVA table evaluates the overall significance of a regression model predicting COVID-19 Vaccine Uptake using Cue to Action, Perceived Barrier, Perceived Severity, and Perceived Susceptibility as predictors (Table 5). The regression model is statistically significant with an F-statistic of 6.237 and a p-value of 0.000, indicating that at least one of the predictors is significantly associated with the dependent variable. The model explains a portion of the total variation in vaccine uptake, with the residual variation not accounted for by the predictors. Overall, the results suggest the model provides a good fit to the data.

Table 5. Analysis of Variance (Anova) Predictors of Covid-19 Vaccine Uptake Using the Health Belief Model

			ANOVA			
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	1.129	4	0.282	6.237	.000a
	Residual	21.681	479	0.045		
	Total	22.81	483			

a. Predictors: (Constant), Cue to Action, Perceived Barrier, Perceived Severity, Perceived Susceptibility.

b. Dependent Variable: COVID-19 Vaccine Uptake.

The regression analysis revealed that among the three predictors, only Perceived Behavioural Control (PBC) has a significant impact on COVID-19 vaccine uptake (p = 0.018), indicating that individuals with higher perceived control are less likely to get vaccinated, with a moderate effect size (B = 0.112) (Table 6). In contrast, Perceived Subjective Norm (PSN) and Perceived Behavioural Intention (PBI) do not significantly influence vaccine uptake (p = 0.41 and p = 0.423, respectively), with small and negligible effect sizes (B = 0.038 and B = 0.039, respectively). These findings suggest that perceived behavioural control is the dominant factor influencing vaccine uptake, while the other two factors have minimal impact.

Table 6. Regression Analysis of Relationship Between TPB Constructs and COVID-19 Vaccination Uptake

		Coefficients(a)				
		Unstandardized Coefficients		**Standardized Coefficients**		
Model		**B**	**Std. Error**	B	**t**	**Sig.**
1	(Constant)	1.031	0.081		12.702	0
	Perceived Subjective Norm	0.015	0.018	0.038	0.824	0.41
	Perceived Behavioural Control	-0.06	0.025	-0.112	-2.364	0.018
	Perceived Behavioural Intention	0.016	0.02	0.039	0.802	0.423

a. Dependent Variable: COVID-19 Vaccine Uptake

The ANOVA results indicate that the regression model, which includes Perceived Behavioural Intention, Perceived Subjective Norm, and Perceived Behavioural Control as predictors, does not significantly explain the variability in COVID-19 Vaccine Uptake (Table 7). This is evidenced by the F-statistic of 2.025 and a p-value of 0.109, which is above the common significance threshold of 0.05. Therefore, we fail to reject the null hypothesis and conclude that the predictors, as a whole, do not have a statistically significant effect on COVID-19 Vaccine Uptake.

Table 7. Analysis of Variance (ANOVA) Predictors of COVID-19 Vaccine Uptake using the Theory of Planned Behaviour

ANOVA						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
1	Regression	0.285	3	0.095	2.025	0.109
	Residual	22.525	480	0.047		

	Total	22.809	483			

Discussion

Hypothesis 1: Demographic Factors are Positively Associated with Covid-19 Vaccine Uptake

The study found that COVID-19 vaccine uptake in Nigeria was nearly equal between genders, with around 95% of both males and females receiving at least one dose ($\chi^2 = 0.175$, df = 1, p = 0.675). This contrasts with existing literature indicating that males typically exhibit higher vaccine acceptance rates than females [26] [40] [41]. For example, Yakasai *et al.* (2024) reported greater vaccine willingness among males [40], and Adebowale *et al.* (2022) found male veterinarians 2.3 times more likely to accept the vaccine than females [42].

Globally, studies show that women often have higher vaccine hesitancy [27]. The current study's findings suggest that addressing barriers to vaccine access can reduce gender disparities, reflecting successful public health initiatives promoting equitable vaccination. While existing literature emphasizes gender's role in vaccine acceptance, this study indicates a potential shift in attitudes in Nigeria. Future research should investigate the factors driving these changes, including community engagement and public health messaging.

Age, however, played a significant role, with the 35-44 age group exhibiting a higher vaccination rate compared to other age categories ($\chi^2 = 13.539$, p = 0.019). This aligns with previous research that identified age as a crucial factor in COVID-19 vaccine uptake [43] [44] [28]. Unlike previous studies [29], no significant associations were found between occupational status, educational attainment, and vaccine uptake (p>0.05). However, significant disparities in vaccination rates were observed across different senatorial zones (p = 0.003), with Kogi East having the highest vaccination rate and Kogi West having the lowest. These findings highlight the complex interplay of demographic factors in shaping COVID-19 vaccination behavior, emphasizing the need for targeted interventions to improve vaccine acceptance and coverage across diverse populations. In summary, Age and senatorial zones were statistically significant in predicting COVID-19 vaccine uptake, with the 35-44 age group showing a higher vaccination rate ($\chi^2 = 13.539$, p = 0.019) and significant disparities observed across different senatorial zones (p = 0.003). This is contrary to other studies that found that older age consistently predicts higher vaccination rates across studies [45] [46].

Hypothesis 2: Perceived Susceptibility, Perceived Severity, Perceived Barriers and Cues to Action are Positively Associated with and Predict Covid-19 Vaccine Uptake

The regression analysis reveals that perceived susceptibility (B = 0.08, p < 0.001) and perceived severity (B = 0.062, p = 0.027) are significant positive predictors of COVID-19 vaccine uptake, aligning with previous research utilizing the Health Belief Model (HBM) [17] [20] [21] [28]. These findings suggest that individuals who perceive a higher risk of contracting COVID-19 and believe it to be a severe illness are more likely to get vaccinated.

Consistent with previous studies [22] [30] [31], perceived susceptibility is positively related to vaccine uptake. However, Apuke & Tunca (2023) found no predictive effect of perceived susceptibility, severity, and COVID-19 vaccine benefits on vaccination intention in Nigeria [32].

Perceived severity also shows a positive relationship with vaccine uptake, supported by previous research [33][35]. A study in South Khorasan Province found that perceived susceptibility and severity, along with attitude and perceived behavioral control, collectively explained 33% of the variance in vaccination intention [34].

In contrast, perceived barriers (B = 0.029, p = 0.261) and cue to action (B = -0.001, p = 0.839) do not significantly predict vaccine uptake, inconsistent with some studies [17] [33] [36]. However, other studies have found similar results, suggesting that perceived barriers may not be a significant determinant of vaccine uptake [37] [38]. The non-significant effect of cue to action on vaccine uptake is consistent with some studies [44], but inconsistent with others [39]. Furthermore, the ANOVA table (Table 5) evaluates the overall significance of the regression model predicting COVID-19 vaccine uptake using the four predictors. The model is statistically significant (F-statistic = 6.237, p-value = 0.000), indicating that at least one of the predictors is significantly associated with vaccine uptake. The model explains a portion of the total variation in vaccine uptake, with the residual variation not accounted for by the predictors. Overall, the results suggest that the model provides a good fit to the data.

This study's findings contribute to the body of knowledge by highlighting the significance of perceived susceptibility and severity in predicting COVID-19 vaccine uptake, consistent with previous research utilizing the HBM. The non-significant effects of perceived barriers and cue to action suggest that these factors may not be as important in predicting vaccine uptake. The overall significance of the regression model and its good fit to the data further support the importance of these predictors in understanding COVID-19 vaccine uptake. These results have implications for targeted health communications aimed at enhancing perceived susceptibility and severity to increase vaccine uptake.

Hypothesis 3: Perceived Behavioral Control, Behavioral Intention, and Subjective Norms Predict Covid-19 Vaccine Uptake.

The correlation analysis between COVID-19 vaccine uptake and various factors revealed diverse relationships. Perceived susceptibility (r = 0.187), perceived severity (r = 0.148), and perceived benefit (r = 0.115) had moderate positive correlations with vaccine uptake (table 3). These findings align with previous research, including a systematic review by Limbu *et al.* (2022), which highlighted that individual who perceived a higher risk of contracting the virus and experiencing severe consequences were more likely to get vaccinated. Similarly [30], Short *et al.* (2022) found that perceived severity and perceived benefits were significantly associated with the intent to receive the COVID-19 vaccine in the United States [33]. Steffens *et al.* (2022) also emphasized that perceived susceptibility and severity were key factors influencing vaccine acceptance in high-income countries, reinforcing the importance of public health campaigns that communicate the severity of COVID-19 and the benefits of vaccination [36].

In Nigeria, Rasaq et al. (2023) found that perceived susceptibility and perceived benefits were significantly associated with vaccine acceptance among household heads in a rural community, consistent with global trends [22]. Perceived barriers, such as concerns about side effects and access to vaccines, had a minimal impact on vaccine uptake (r = 0.006), similar to findings by Steffens *et al.* (2022) in high-income countries [36]. The slight positive correlation for perceived subjective norm (r = 0.03) also aligns with Rasaq *et al.*'s findings, highlighting the role of social influence in vaccination decisions [22]. However, perceived behavioral control had a slight negative correlation (r = -0.096), consistent with Limbu *et al.* (2022), who noted that perceived control over vaccination behavior often had a limited direct impact on vaccination decisions [30].

Perceived behavioral intention showed a weak positive correlation with vaccine uptake

(r = 0.016), consistent with Short *et al.* (2022), who found that intention to vaccinate was often not a strong predictor unless accompanied by other facilitating factors like ease of access and strong public health advocacy [33]. Overall, the current study's findings align well with existing literature, suggesting that perceived susceptibility, perceived severity, and perceived benefits are crucial determinants of COVID-19 vaccine uptake. Public health interventions should leverage these insights to design effective communication strategies that address these perceptions and encourage higher vaccination rates.

The regression analysis indicates that among the predictors derived from the Theory of Planned Behavior (TPB), only Perceived Behavioral Control (PBC) significantly impacts COVID-19 vaccine uptake (p = 0.018, B = -0.112), suggesting that individuals with higher PBC are less likely to get vaccinated (table 6). In contrast, Perceived Subjective Norm (PSN) and Perceived Behavioral Intention (PBI) do not significantly influence vaccine uptake, with p-values of 0.41 and 0.423, and minimal effect sizes (B = 0.038 and B = 0.039, respectively). These results emphasize PBC as the dominant factor influencing vaccination behavior, while PSN and PBI have negligible effects.

However, the ANOVA results indicate that the overall regression model (table 7), which includes Perceived Behavioral Intention, Perceived Subjective Norm, and Perceived Behavioral Control as predictors, does not significantly explain the variability in COVID-19 vaccine uptake (F-statistic = 2.025, p = 0.109). This suggests that while PBC may have a significant individual effect, the combined predictors from the TPB model are not sufficient to explain the variability in vaccine uptake.

Comparative studies highlight varying influences of TPB constructs on vaccination intentions. Alshagrawi (2023) found that both perceived behavioral control and attitude were strong predictors of vaccination intentions among Saudi health science students, explaining a significant portion (78.2%) of the variance, but subjective norms were not significant [18]. This finding aligns with Fan *et al.* (2021), who reported that subjective norms and perceived behavioral control did not significantly predict anti-vaccination attitudes among Chinese university [47]. However, Lau *et al.* (2023) found that attitudes, perceived behavioral control, and intention significantly predicted children's vaccination uptake, with intention mediating the effects of attitudes and subjective norms [19].

Shmueli (2021) integrated both HBM and TPB to study vaccination intentions in Israeli adults and found significant predictors included perceived benefit, severity, cue to act, subjective norms, and self-efficacy, indicating a broader range of influential factors beyond just PBC [23]. Similarly, Chu and Liu (2021) observed that perceived community benefits, positive attitudes, and vaccination history positively related to vaccination uptake in Americans, while safety concerns and underestimation of personal risks negatively impacted intentions [24].

The findings from this study and comparative research underscore the multifaceted nature of vaccine uptake behavior. While Perceived Behavioral Control (PBC) is a crucial factor, a combination of attitudes, perceived benefits, and other health belief constructs significantly influence vaccination behavior. However, the overall regression model incorporating PBI, PSN, and PBC did not significantly explain the variability in vaccine uptake, indicating the need for more comprehensive models or additional predictors.

Conclusion

This study examined the Determinants of COVID-19 Vaccine Uptake among Adults in

Kogi State, Nigeria, using the Health Belief Model (HBM) and Theory of Planned Behavior (TPB). A cross-sectional survey of 484 adults found that age category (35-44) and senatorial zone (Kogi East) significantly predicted vaccine uptake, while gender, occupation, education, and religion had no significant relationship. In line with the HBM, perceived susceptibility and severity significantly predicted vaccine uptake, whereas perceived barriers and cue to action did not. Additionally, TPB's perceived behavioural (PBC) control was a significant individual predictor, but the combined regression model (PBI, PSN, and PBC) did not fully explain vaccine uptake variability. It is recommended that interventions aimed at improving the uptake of the COVID-19 vaccine should put a high priority on enhancing perceived behavioral control through the removal of logistical obstacles and the provision of easily understood information. Furthermore, by busting myths and guaranteeing simple access to immunization sites, efforts should be directed toward lowering perceived barriers. Reminders, public support, and community leaders can all serve as cues to take action to further promote vaccination. Targeted education campaigns that highlight the dangers and vulnerability of COVID-19 as well as the advantages of immunization are also essential. Furthermore, longitudinal designs should be used in future studies in order to produce more reliable causal inferences and a deeper understanding of the dynamic relationships between constructs over time.

Contribution to the Body of Knowledge

This study contributes to the existing literature by combining the Health Belief Model (HBM) and Theory of Planned Behavior (TPB) to comprehensively understand COVID-19 vaccine uptake determinants, providing context-specific insights into Kogi State, Nigeria, a previously under-researched area. The study identifies perceived behavioral control, perceived severity, susceptibility and barriers as key predictors, and compares results with similar studies from other regions, highlighting the need for context-specific interventions and emphasizing the importance of perceived behavioral control as a dominant factor.

Ethical Consideration

Ethical approval was obtained from the Kogi State Ministry of Health, ensuring compliance with ethical standards. Participation was voluntary, and informed consent was obtained from all respondents prior to data collection. Confidentiality of responses was strictly maintained throughout the study.

Study Limitation

This study has four main limitations. Firstly, its generalizability is limited to Kogi State, and may not be applicable to the entire country. Secondly, the reliance on self-reported data makes it susceptible to biases like social desirability bias and recall bias. Thirdly, the cross-sectional design prevents the inference of causality and the observation of changes over time, highlighting the need for longitudinal studies. Lastly, the study's narrow scope of variables related to COVID-19 vaccine uptake overlooks potential influences like cultural, socio-economic, and political factors, which could provide a more comprehensive understanding of vaccine hesitancy and acceptance.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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