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Original Research

Epidemiology of COVID-19 Control, Vaccine Development, and Public Health Communication: Insights from Post-Pandemic Africa

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Abstract

Background: COVID-19 is a major public health concern, and epidemiology remains central to vaccine development, priority-setting, product testing, marketing strategy, equitable distribution, post-vaccination surveillance, and the interpretation of vaccine uptake and hesitancy. This research examined COVID-19 knowledge, vaccine uptake, vaccine hesitancy, and preventive behaviours in post-pandemic African settings to identify lessons for future vaccine development and vaccination programs.

Methods: A questionnaire-based cross-sectional survey was conducted in Nigeria and South Africa from October 2023 to March 2024 following pilot validation. The final research included 2002 participants recruited through convenience sampling. Data were analysed using ANOVA, Chi-square test, Student's t-test, logistic regression, and Fisher's exact test to identify epidemiologically relevant patterns in knowledge, attitudes, and vaccination status.

Although the survey did not directly measure clinical trial performance, post-vaccination efficacy, or pharmacovigilance outcomes, it generated population-level evidence relevant to transparent and equitable testing, public communication, uptake, and post-marketing surveillance planning.

Results: Education, employment, living status, and occupation significantly shaped COVID-19 knowledge and vaccine attitudes. Most participants with secondary or college/university education demonstrated good knowledge, whereas most participants with vocational/technical education demonstrated poor knowledge. Full-time employment and living with a spouse or small family were associated with better knowledge. Most participants correctly identified COVID-19 as a virus and recognised cough as the main route of transmission. Vaccine awareness was high, yet uptake was low: 21% received a first dose and 5% a second. Negative attitudes toward vaccination remained common, and misinformation about vaccine-related harm persisted. These findings suggest that future vaccine development and marketing strategies must link scientific progress with transparent communication, equitable access, affordability, and stronger post-deployment monitoring.

Conclusions: This research shows that epidemiological understanding, vaccine uptake, and vaccine hesitancy are closely linked in post-pandemic Africa. High vaccine awareness did not translate into high vaccination coverage. Low uptake appears to reflect both access barriers and persistent mistrust, especially among younger and less-educated groups. The findings highlight the need for epidemiology-informed vaccine development, transparent and equitable testing, responsible marketing, equitable distribution and pricing, stronger post-vaccination efficacy assessment and surveillance, and targeted public health communication to support future vaccine acceptance.

Trial registration: The study was registered in the ClinicalTrials.gov (PRS) registry under the PRS number NCT05950243.

Keywords: *COVID-19 epidemiology; Vaccine development; Public health communication; Vaccine hesitancy; Vaccine pharmacovigilance; Post-marketing surveillance*

Introduction

The SARS-CoV-2 virus causes COVID-19 infection [1,2,3]. Although many infected patients recover without specialised treatment, some develop severe illness or die [1]. During the COVID-19 pandemic from March 2020 to May 2023, the disease strained health systems, increased mortality, and disrupted economies [2,3]. Epidemiology is fundamental to disease control because it clarifies transmission patterns, population risk, disease burden, and the efficacy of prevention strategies. These epidemiological functions also underpin vaccine development, as disease surveillance, burden estimation, transmission mapping, and risk stratification help define target populations, trial endpoints, and deployment strategies. The World Health Organisation (WHO) recommendations, including physical distancing, hand hygiene, personal protective equipment, and vaccination, are grounded in epidemiological evidence [3-5]. Vaccination remains especially important because it reduces severe disease and helps limit the emergence and impact of new COVID-19 variants [5,6].

COVID-19 vaccine uptake varies widely across countries, and vaccine hesitancy is a major public health challenge [6,7]. Epidemiological evidence suggests that vaccine uptake is influenced not only by supply and access, but also by trust, perceived risk, safety concerns, prior vaccination history, pricing, affordability, and the credibility of health information and marketing messages [6-8]. In Africa, studies have reported uneven knowledge of COVID-19, inconsistent adherence to preventive measures, and a persistent gap between awareness and actual vaccination behaviour [9-11]. Some sub-Saharan African data further suggest that educational level, gender, occupational status, attitudes toward control measures, and social media exposure shape vaccine hesitancy and uptake [12-14]. These patterns matter beyond the COVID-19 pandemic because they offer practical lessons for future vaccine development, including the need for transparent and equitable testing, culturally credible marketing, fair distribution, affordable pricing, and robust post-marketing surveillance.

COVID-19 remains a relevant public health issue, and post-pandemic epidemiological assessment is still needed to understand the social and behavioural drivers of vaccine uptake and hesitancy [6]. This research forms part of regional efforts to strengthen public health knowledge in sub-Saharan African countries. It examines public knowledge of COVID-19, attitudes toward preventive measures, and vaccination patterns in Nigeria and South Africa. This research aims to identify epidemiological trends that can guide policy and inform future vaccine development, marketing, communication, distribution, pricing, and surveillance strategies. The pilot survey was completed in 2021, and the final survey was conducted from October 2023 to March 2024.

Methods

This research used a non-probability cross-sectional survey design and was conducted in Port Elizabeth, South Africa, and Port Harcourt, Nigeria. The study protocol was registered in the ClinicalTrials.gov (PRS) registry under the PRS number NCT05950243. Cross-sectional epidemiological survey methods are appropriate because they allow the research to measure knowledge, vaccine uptake, hesitancy, and related sociodemographic patterns across a broad community population at a defined post-pandemic period. The design also provided population-level evidence relevant to downstream vaccine policy questions, including communication strategy, market acceptance, equitable access, and the practical conditions that shape vaccine performance after rollout.

The University of Ibadan in Nigeria and the Eastern Cape Department of Health in South Africa approved the research. The survey included participants from different age groups, literacy levels, socioeconomic classes, and professions. Survey participation was voluntary. Participants completed consent forms and questionnaires independently after receiving information about the research aims and rationale. Written informed consent was obtained from all adult participants and from guardians of participants younger than 18 years. The research followed the principles of the Declaration of Helsinki for research involving human participants.

The questionnaire-based survey was conducted in Port Elizabeth, South Africa, and Port Harcourt, Nigeria, from 1 October 2023 to 30 March 2024. The survey questionnaire was validated in a pilot study in 2021 and refined to align the questions better, the measured constructs, and the study objectives. The final questionnaire was administered both online and in person. In-person administration improved reach among participants who might otherwise have been excluded from digital surveys, while online distribution expanded access through social media networks, including Facebook, Instagram, WhatsApp, Twitter, and LinkedIn. This mixed approach was important because vaccine development and vaccine marketing ultimately succeed or fail in the real world across populations with unequal access to information, technology, services, and trusted health institutions.

The questionnaire collected sociodemographic data and assessed knowledge of COVID-19 epidemiology, preventive measures, vaccines, and therapies. Vaccine-related questions explored awareness of vaccine types, preference, safety, efficacy, benefits, ingredients, adverse effects, and vaccination status. Although the research did not directly evaluate laboratory development pathways, clinical trial conduct, biological efficacy, or formal pharmacovigilance records, the questionnaire addressed issues that strongly influence these later stages, including trust in vaccines, willingness to accept them, and beliefs about benefits and harms. Such variables are essential for interpreting how transparent testing, responsible marketing, equitable distribution and pricing, and post-vaccination surveillance may affect public uptake. Questions used multiple-choice formats with one or more correct responses. Correct responses were scored one point each, producing a total possible score of 22. Scores below 11 were classified as poor knowledge, and scores above 50% as good knowledge. See Supplementary Data

Of the 2017 participants recruited, 15 were excluded due to incomplete data, leaving 2002 for analysis. Data were analysed using IBM® SPSS® Statistics 28 (IBM Corp, Armonk, NY). The analytical approach included cross-tabulation, frequency analysis, respondent segmentation, clustering analysis, and logistic regression to identify predictors of poor knowledge and poor vaccine attitudes. Continuous variables, including age, knowledge score, and attitude score, were categorised where appropriate. A p-value below 0.05 was considered statistically significant. This approach enabled the research to identify epidemiologically relevant differences in vaccine uptake, hesitancy, and understanding of disease control across population groups, while also generating practical evidence for future vaccine marketing, equitable rollout, and post-deployment monitoring.

Results

Table 1 and Figure 1 present the sociodemographic profile of the participants, which is important for interpreting the epidemiology of vaccine uptake and hesitancy in this study population. The largest age group was early adults aged 20-49 years (68%), and females constituted 57% of participants. Most participants had completed secondary education (31%) or college/university education (49%). Nearly half lived with a spouse or small family, while more than half were unemployed. These characteristics provide important context because age, education, living arrangements, and employment often shape exposure to health information, trust in health systems, price sensitivity, access to care, and willingness to accept vaccines marketed through public health or mixed public-private channels.

Table 1. Socio-demographics of participants (single-choice answers)

Variables	Number	%
Age Group		
13-19, Youth	360	18
20-49, Early adult	1361	68
50-64, Middle-aged adult	220	11
65-99, Older adult	61	3
Gender		
Female	1141	57
Male	861	43
Education Status		
Primary school	200	10
Secondary school	620	31
College/University	980	49
Vocational/Technical	202	10
Living Status		
Congregation	422	21
Single/Alone	600	30
Spouse or Small family	980	49
Job Status		
Full-time work	620	31
Part-time work	340	17
Unemployed because or since COVID	360	18
Unemployed before COVID	682	34
Job Type		
Business owner or executive	200	10
Essential worker, not healthcare	160	8
Healthcare nurse worker	242	12
Labour worker	240	12
Market or store worker	160	8
Office worker	380	19
Student	620	31

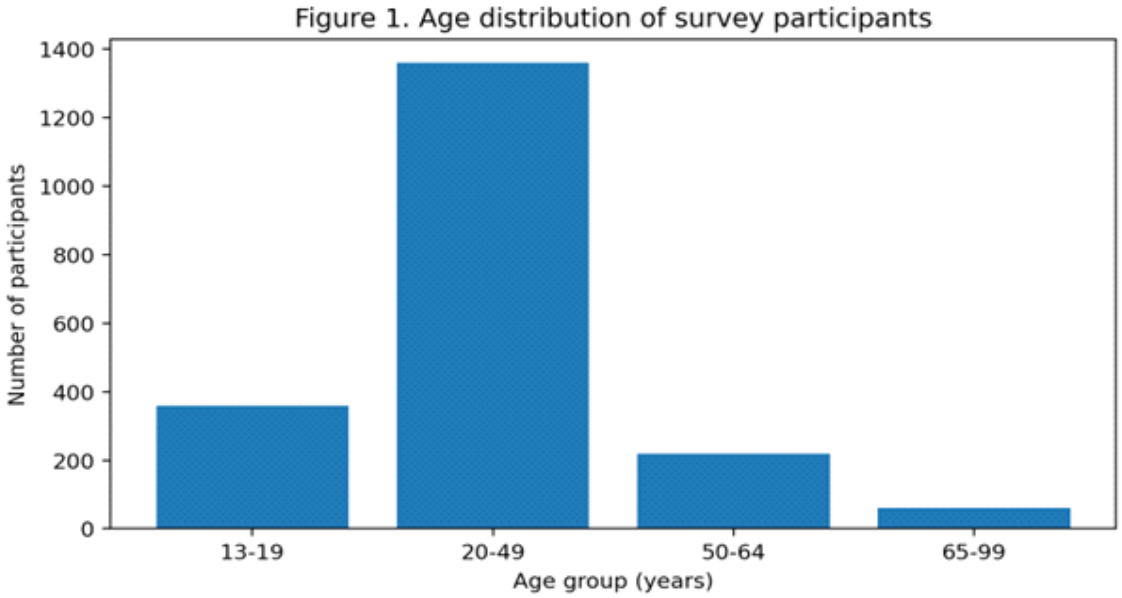

Table 2 and Figure 2 summarise participants' knowledge of COVID-19 epidemiology and control measures. Most participants correctly identified COVID-19 as a viral disease and recognised coughing and sneezing as the main routes of transmission. Many also identified facemasks, hand hygiene, physical distancing, and vaccination as preventive measures. These findings suggest broad awareness of core public health messages, although the persistence of incorrect responses indicates that epidemiological knowledge remained incomplete in a meaningful minority of participants. That gap matters because an incomplete understanding of disease can weaken confidence in vaccine development, reduce receptivity to evidence-based marketing, and undermine later uptake.

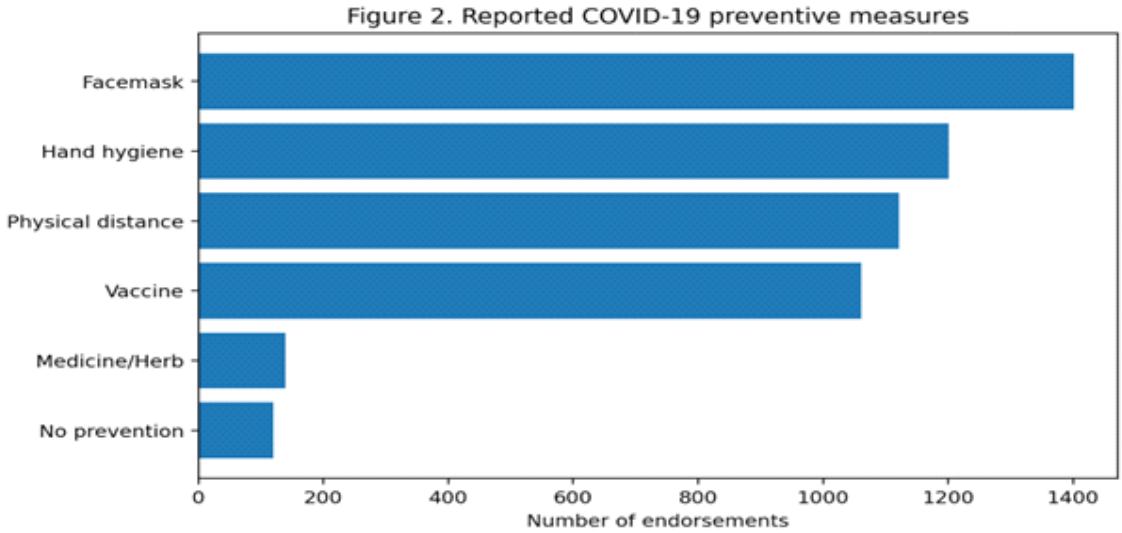

Table 2. Knowledge of COVID-19 transmission and control

Characteristics	Number	%
Cause of COVID-19 (single-choice answer)		
Bacteria	80	4
Virus	1922	96
Route of transmission (multiple-choice answers)		
Insects	60	3
Cough, sneeze	1881	94
Household items	540	27
Close physical contact	1001	50
Curse or bad luck	20	1
Treatment cure (multiple-choice answers)		
Herbalist or spiritual cure	80	4
Antibiotic	240	12
Vaccine cure	840	42
Home remedy or mixture	220	11
Dexamethasone	79	4
No Cure	700	35
COVID problem in any nation (single-choice answer)		
COVID is a problem	1621	81
COVID is not a problem	381	19
Population affected (multiple-choice answers)		
Affect poor people	200	10
Affect rich people	180	9
Affect rural people	140	7
Affect city people	120	6
Affect anyone	1741	87
Preventive measures (multiple-choice answers)		
Facemask	1401	70
Hand hygiene	1201	60
Physical distance	1121	56
Vaccine	1061	53
Medicine or Herb	140	7
No prevention	120	6
Responsibility for control (multiple-choice answers)		
Government control	1361	68
Private sector	640	32
Religious group	680	34
WHO control	1041	52
Other charities or donors	360	18

Table 3. Knowledge of COVID-19 vaccine types

Characteristics	Number	%
Awareness about vaccine types (multiple-choice answers)		
AstraZeneca	1501	75
Pfizer-Biontech	400	20
Sinovac	220	11
Covishield	260	13
Sputnik-Gamaleya	280	14
Moderna	180	9
Sinopharm	100	5
Janssen-Johnson	500	25
No vaccine awareness	240	12
Vaccine doses received (single-choice answer)		
Vaccine 1st dose received	420	21
Vaccine 2nd dose received	100	5
Vaccine type preferred (single-choice answer)		
AstraZeneca	902	45
Covishield	180	9
Janssen-Johnson	540	27
Moderna	240	12
Pfizer-Biontech	140	7
Reasons for vaccine preference (multiple-choice answers)		
Safety	800	40
Efficacy	1901	95
Recommended by doctor	220	11
Readily available	420	21
No choice	460	23
Recommend by government or employer	480	24
Characteristics of vaccines (multiple-choice answers)		
Vaccine safe	1121	56
Vaccine secret ingredient	300	15
Vaccine tested well	800	40
Vaccine cause Covid	340	17
Vaccine minor effect	820	41
Vaccine death	520	26
Vaccine benefit for people group (multiple-choice answers)		
Vaccines are suitable for old people	1261	63
Good for young people	720	36
Good for healthcare worker	1181	59
Good for chronic disease	880	44
Good for international travellers	840	42
Good for the rich	540	27

Table 3 and Figure 3 describe vaccine awareness and vaccine preference. AstraZeneca was the most recognised and preferred vaccine, likely reflecting patterns of availability, pricing, and public familiarity in the study settings. Although awareness of vaccine types was high and many participants viewed vaccines as safe or effective, actual uptake remained low. Figure 4 highlights the low vaccine uptake. Figure 5 shows the vaccine awareness-to-uptake cascade. This gap between awareness and vaccination behaviour is epidemiologically important because it signals that vaccine acceptance cannot be inferred from awareness alone. It also suggests that successful vaccine development must be linked to trusted marketing, equitable distribution, affordability, and credible post-vaccination follow-up.

Figure 3. Awareness of COVID-19 vaccine types

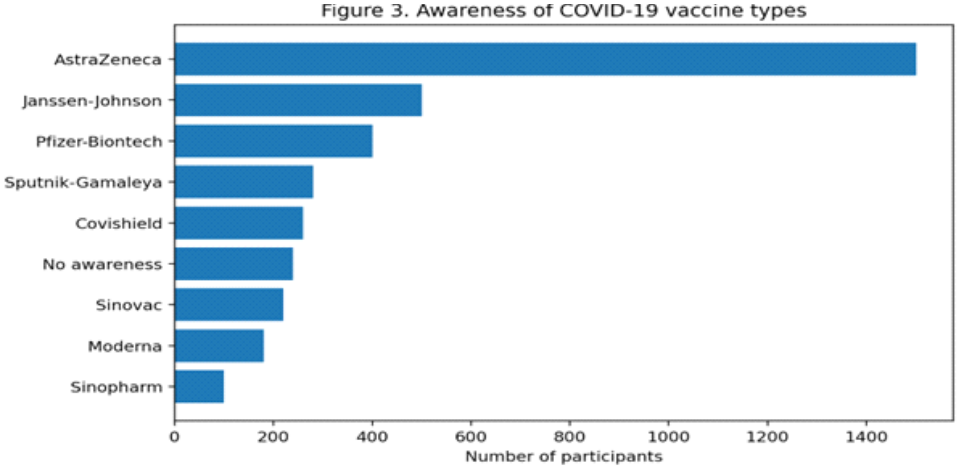

Figure 4. COVID-19 vaccine dose uptake

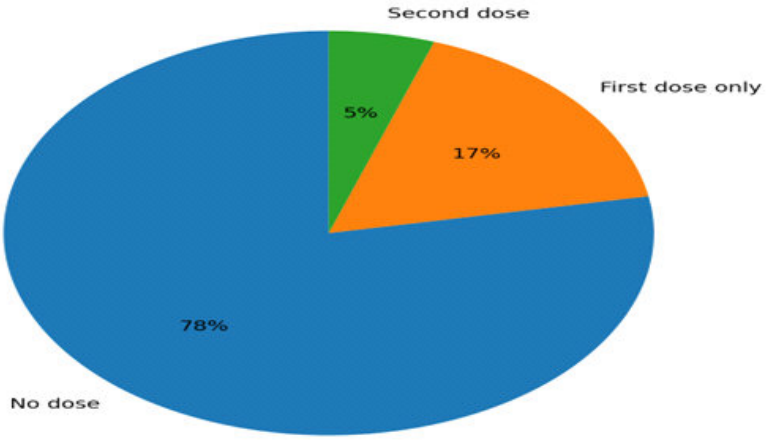

Figure 5. Vaccine awareness-to-uptake cascade

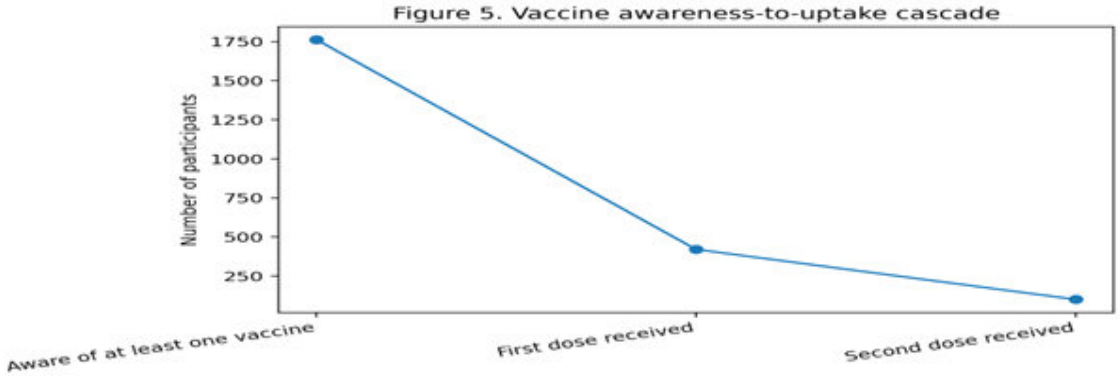

Table 4 shows that COVID-19 knowledge was associated with education, living status, employment, and occupation. Participants with secondary and college/university education were more likely to demonstrate good knowledge, while participants with vocational/technical education were more likely to demonstrate poor knowledge. Those living with a spouse or a small family, and those in full-time work, also showed better knowledge. These findings identify socially patterned differences in epidemiological understanding that may later influence vaccine uptake, response to vaccine marketing, and willingness to participate in equitable vaccination programs.

Table 4. Association between sociodemographic factors and COVID-19 knowledge level

Characteristics	Poor knowledge		Good knowledge		p-value
	Number	%	Number	%	
Age group					0.3
13-19, Youth	162	45	198	55	
20-49, Early adult	598	44	763	56	
50-64, Middle-aged	77	35	143	65	
65-99, Older adult	28	46	33	54	
Gender					0.7
Female	490	43	651	57	
Male	361	42	500	58	
Education Status					0.001
Primary school	90	45	110	55	
Secondary school	248	40	372	60	
College/University	401	41	579	59	
Vocational/Technical	127	63	75	37	
Living Status					0.001
Congregation	211	50	211	50	
Single/alone	282	47	318	53	
Spouse/small family	362	37	618	63	
Job Status					0.002
Full-time work	223	36	397	64	
Part-time work	139	41	201	59	
Unemployed because or since COVID	151	42	209	58	
Unemployed before COVID	347	51	335	49	
Job Type					<0.001
Business owner or executive	60	30	140	70	
Essential worker, not healthcare	57	36	103	64	
Healthcare nurse worker	147	61	95	39	
Labour work	93	39	147	61	
Market or store worker	67	42	93	58	
Office worker	159	42	221	58	
Student	279	45	341	55	

Table 5 presents the logistic regression analysis of factors associated with poor COVID-19 knowledge. Vocational/technical education, unemployment, and healthcare nurse work were significant predictors of inadequate knowledge. These findings highlight the need for more targeted public health education strategies, especially when designing vaccine communication and marketing campaigns for occupational or socially vulnerable groups. They also suggest that equitable vaccine development and rollout require better alignment between scientific evidence, frontline communication, and local trust.

Table 5. Logistic regression of factors associated with poor COVID-19 knowledge

Characteristics	OR[1]	95% CI[1]	p-value
Education Status			
Primary	—	—	
Secondary	0.80	0.49, 1.32	0.4
College/University	0.65	0.39, 1.08	0.093
Vocational/Technical	2.20	1.16, 4.23	0.017
Living Status			
Congregation	—	—	
Single/alone	1.22	0.84, 1.77	0.3
Spouse/small family	0.83	0.58, 1.18	0.3
Job Status			
Full-time work	—	—	
Part-time work	1.57	0.99, 2.49	0.057
Unemployed because or since COVID	2.03	1.30, 3.19	0.002
Unemployed before COVID	3.37	2.17, 5.29	<0.001
Job Type			
Business owner or Executive	—	—	
Essential worker, not healthcare	1.22	0.61, 2.43	0.6
Healthcare nurse worker	6.08	3.20, 11.8	<0.001
Labour work	1.02	0.57, 1.85	>0.9
Market or store worker	1.36	0.68, 2.71	0.4
Office worker	1.56	0.91, 2.71	0.11
Student	0.98	0.57, 1.70	>0.9

[1] OR = Odds Ratio, CI = Confidence Interval

Table 6 presents the association between sociodemographic characteristics and attitudes toward COVID-19 vaccines. Poor attitudes were especially common among younger participants, those with lower educational attainment, those living in congregation settings, and those who were unemployed or working part-time. These findings help define the epidemiology of vaccine hesitancy in the study population and identify groups that may require tailored engagement in future vaccination campaigns, especially when pricing, access, misinformation, and marketing credibility shape decision-making.

Table 6. Association between socio-demographics and attitude toward the COVID-19 vaccine

Characteristics	Poor Attitude		Good attitude		p-value
	Number	%	Number	%	
Age Group					<0.001
13-19, Youth	338	94	22	6	
20-49, Early adult	1102	81	259	19	
50-64, Middle-aged	165	75	55	25	
65-99, Older adult	41	68	20	32	
Gender					0.3
Female	947	83	194	17	
Male	689	80	172	20	
Education Status					<0.001
Primary	198	99	2	1	
Secondary	514	83	106	17	
College/University	754	77	226	23	
Vocational/Technical	185	92	17	8	
Living Status					<0.001
Congregation	405	96	17	4	
Single/alone	498	83	102	17	
Spouse/small family	725	74	255	26	
Job Status					<0.001
Full-time work	440	71	180	29	
Part-time work	289	85	51	15	
Unemployed because or since COVID	316	88	44	12	
Unemployed before COVID	593	87	89	13	
Job Type					0.1
Business owner or executive	160	80	40	20	
Essential worker, not healthcare	140	88	20	12	
Healthcare nurse worker	188	78	54	22	
Labour work	196	82	44	18	
Market or store worker	121	76	39	24	
Office worker	288	76	92	24	
Student	533	86	87	14	

Table 7 presents the multivariable analysis of factors associated with poor vaccine attitudes. Older age groups were relatively protected against poor attitudes, while unemployment remained a strong risk factor. Living alone, with a spouse, or with a small family also appeared protective compared with living in congregation housing. These patterns reinforce that vaccine hesitancy is socially distributed and should be addressed with targeted, evidence-based public health strategies rather than relying solely on uniform messaging. They also show why future vaccine development and marketing strategies must anticipate social vulnerability rather than treat uptake as a purely individual choice.

Table 7. Logistic regression of factors associated with a poor attitude toward COVID-19 disease

Characteristics	OR[1]	95% CI[1]	p-value
Age Group			
13-19, Youth	—	—	
20-49, Early adult	0.26	0.12, 0.56	<0.001
50-64, Middle-aged	0.22	0.08, 0.56	0.002
65-99, Older adult	0.12	0.04, 0.37	<0.001
Education Status			
Primary school	12,303	0.00, NA	>0.9
Secondary school	0.56	0.23, 1.23	0.2
College/University	0.48	0.20, 1.06	0.083
Vocational/Technical	1.23	0.40, 3.94	0.7
Living Status			
Congregation	—	—	
Single/alone	0.36	0.17, 0.72	0.006
Spouse/small family	0.17	0.08, 0.33	<0.001
Job Status			
Full-time work	—	—	
Part-time work	1.68	0.96, 3.00	0.075
Unemployed because or since COVID	2.89	1.61, 5.33	<0.001
Unemployed before COVID	2.04	1.18, 3.55	0.011
Job Type			
Business owner or executive	—	—	
Essential worker, not healthcare	2.02	0.81, 5.37	0.14
Healthcare worker	0.92	0.41, 2.07	0.8
Labour worker	0.70	0.33, 1.48	0.4
Market or store worker	0.56	0.24, 1.30	0.2
Office worker	0.68	0.35, 1.31	0.3
Student	0.47	0.22, 0.99	0.049

[1] OR = Odds Ratio, CI = Confidence Interval

Discussion

The present study provides a post-pandemic epidemiological view of COVID-19 knowledge, vaccine uptake, and vaccine hesitancy in two African urban settings. Many participants understood the basic epidemiology of COVID-19, including the viral cause of the disease and the dominant routes of transmission. This level of knowledge likely reflects both public health campaigns and the partly online mode of data collection, which may have favoured individuals with greater digital literacy and better access to health information. The finding aligns with evidence from other sub-Saharan African urban settings, which have generally shown high awareness of COVID-19 [6,12]. From a vaccine-development perspective, this matters because epidemiological literacy shapes whether communities understand why vaccines are developed, who should be prioritised, and how evidence should guide adoption.

Most participants identified facemasks, hand hygiene, physical distancing, and vaccination as preventive measures. This pattern suggests that core public health messages reached a large portion of the study population. However, awareness of preventive measures does not necessarily produce sustained adherence. Previous work from sub-Saharan Africa has shown that compliance may still be weakened by negative attitudes, limited access to protective resources, and structural barriers such as inadequate potable water [7-12]. From an epidemiological perspective, this gap between knowledge and behaviour is important because prevention depends not only on awareness but also on feasibility, trust, social context, and the credibility of public messaging and marketing.

The study also showed that education level, living arrangement, employment status, and occupation shaped knowledge of COVID-19. Participants with secondary and college education generally had better knowledge, whereas those with vocational or technical education were more likely to have poor knowledge. Similar associations between higher education and stronger COVID-19 knowledge have been reported elsewhere in sub-Saharan Africa [6,12,13]. These findings matter for public health because epidemiological literacy influences how people interpret risk, respond to vaccination campaigns, evaluate marketing claims, and engage with prevention guidance.

Participants living with a spouse or a small family, and those in full-time work, demonstrated better COVID-19 knowledge. These findings may reflect more stable social environments, stronger information networks, or greater exposure to formal health messaging. Business owners or executives also showed relatively good knowledge. Together, these results suggest that the social distribution of knowledge is not random. It follows recognisable demographic and occupational patterns that can help public health teams identify where to concentrate communication, equitable access planning, price protection, and community outreach efforts.

One notable finding was the poor knowledge observed among healthcare nurse workers. This contrasts with many studies from other sub-Saharan African settings, where healthcare workers are often reported to have stronger disease knowledge [6,12,14]. The odds ratio of 6.08 suggests a strong association, but this result should be interpreted cautiously because residual confounding, subgroup heterogeneity, or local contextual factors may contribute. Even so, the finding is epidemiologically and operationally important. Frontline workers influence patient trust, vaccine confidence, participation in equitable testing and rollout, and the credibility of public health messaging. If knowledge gaps exist in this group, they could weaken vaccination efforts, post-vaccination follow-up, and the implementation of future immunisation programs.

The study's vaccine-related findings were especially important. Most participants were aware of COVID-19 vaccines, and AstraZeneca was the most recognised and preferred option. Perceived efficacy strongly influenced preference, and many participants believed vaccines would benefit older adults and healthcare workers. Yet uptake remained low, with only 21% reporting a first dose and 5% reporting a second dose. This disconnect between vaccine awareness and uptake is one of the study's central epidemiological findings. It emphasises that awareness alone does not secure vaccination coverage [15]. It also indicates that public health success depends on converting awareness into trust, affordability, access, and action. It also suggests that vaccine development should be accompanied by early planning for transparent testing, equitable distribution, fair pricing, and credible public communication.

Poor attitudes toward vaccination were widespread across the study population. Many participants believed that vaccines could cause death or illness, despite a majority also describing vaccines as safe or tested. This apparent contradiction suggests that vaccine hesitancy is not merely a lack of knowledge. It may instead reflect ambivalence, exposure to conflicting information, distrust of institutions, concerns about product development and testing, price anxiety, or difficulty translating general awareness into personal acceptance.

These dynamics are well recognised in vaccine epidemiology and remain highly relevant for public health planning, marketing ethics, and future vaccine deployment [16-19].

Age, education, housing, and employment status were all associated with vaccine attitudes. Adolescents and younger participants showed particularly negative attitudes toward vaccination. This pattern is consistent with reports from other settings, where younger people often perceive themselves to be at lower risk while also being more exposed to rapidly circulating misinformation on social media [20-25]. For public health agencies, this means that future vaccine campaigns should not rely only on generic mass messaging. They should also use age-specific communication, trusted messengers, transparent marketing, and accessible digital strategies that can compete effectively with misinformation.

Negative vaccine attitudes were also common among participants with primary, vocational, or technical education, among those living in congregation housing, and among those who were unemployed or working part-time. Unemployment before or since COVID-19 was associated with poor attitudes in the regression analysis. These findings suggest that vaccine hesitancy is intertwined with broader social vulnerability, institutional mistrust, and unequal access to reliable health information. Public health interventions should therefore treat vaccine hesitancy not only as a communication problem but also as a social and structural issue involving affordability, equitable distribution, and trust in how vaccines are developed, tested, marketed, and monitored.

High awareness but low uptake suggests that future vaccine programs must address both supply and demand. On the supply side, people may face limited availability, inconsistent delivery, long travel distances, clinic congestion, or indirect costs such as transportation and time away from work. On the demand side, people may delay or refuse vaccination because of mistrust, fear of adverse effects, low perceived risk, cultural concerns, or misinformation. For future vaccine development, these findings offer several lessons. Scientific efficacy alone is not enough. Vaccine innovation must be paired with transparent and equitable testing, realistic market preparation, culturally credible marketing, fair pricing, equitable distribution, and systems for post-vaccination efficacy assessment and surveillance. Although this study did not directly measure biological effectiveness after vaccination, it shows that post-deployment success depends on whether communities trust the product, can access it, can afford it, and receive follow-up that is visible, responsive, and credible.

Public health systems in many African settings continue to face resource constraints [26-28]. These constraints affect both outbreak control and the equitable delivery of vaccines. Administrators and providers must therefore be resourceful in designing delivery systems that reach vulnerable groups without worsening cost pressures. For example, COVID-19 vaccine delivery in some sub-Saharan countries, such as Nigeria and South Africa, is estimated at approximately US$ 0.8 per dose, with major cost drivers including fieldwork, labour incentives, and travel [16,29]. Such evidence matters for future vaccine development and marketing because successful vaccination depends not only on the product itself, but also on affordability, logistics, distribution equity, price acceptability, and the sustainability of surveillance and follow-up systems in real-world settings.

Limitations

This study has several limitations. Convenience sampling may limit representativeness and reduce generalizability to the wider populations of Nigeria and South Africa. The cross-sectional design also limits causal inference. Although the sample size is larger than in some comparable studies, the findings should still be interpreted as a snapshot of post-pandemic epidemiology rather than a definitive account of all population groups. The survey examined knowledge, uptake, and attitudes, but it did not directly measure vaccine development pathways, trial conduct, pricing mechanisms, biological efficacy after vaccination, or formal pharmacovigilance outcomes. As a result, lessons for vaccine development, marketing, and surveillance should be understood as implications drawn from population attitudes and behaviours rather than direct evaluations of those systems.

The mixed online and in-person data collection strategy improved inclusivity, but online recruitment may have overrepresented participants with stronger digital access and higher baseline exposure to health information. Self-reported responses may also have introduced recall or social desirability bias. Nonetheless, the study used a validated questionnaire, prospective data collection, and robust statistical analyses. These strengths support the value of the findings while underscoring the need for future research using probability sampling, deeper behavioural measures, pricing and access indicators, and longitudinal approaches to better understand vaccine uptake, post-vaccination effectiveness perceptions, safety monitoring, and hesitancy over time.

Conclusions

Most participants demonstrated good basic knowledge of COVID-19 epidemiology, yet vaccine uptake remained low, and vaccine hesitancy remained common. Education, living status, employment, and occupation shaped both knowledge and attitudes. The study, therefore, highlights a key public health lesson from post-pandemic Africa: awareness alone is insufficient. Effective vaccination requires epidemiology-informed vaccine development, transparent and equitable testing, responsible marketing, equitable distribution and pricing, trusted delivery systems, and sustained efforts to counter misinformation. Future vaccine programs should also include visible post-vaccination efficacy assessment, safety surveillance, and community feedback mechanisms so that scientific progress is matched by public confidence and real-world uptake.

Declarations

Ethics Approval and Informed Consent: The South African Eastern Cape Department of Health and the University of Ibadan, Nigeria, approved the study. Each participant signed a written informed consent form. Also, written informed consent was obtained from the guardian of each participant under 18 years of age. This study adheres to the principles of the Declaration of Helsinki for medical research involving human participants.

Availability of Data and Materials: The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing Interests: The authors declare that they have no competing interests. All the authors declare no conflict of interest.

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Authors' Contributions: OAB conceived and supervised the study. OAB, VOO, and NET were involved in the methodology, data analysis, and interpretation. All the authors were involved in writing initial and final drafts, proofreading, critical review, and approval of the final article draft.

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References

1. M. Cao, Bridges K, Vemulapalli P, Sexton J, Gilchrist B. Case Report: Survival in Newly Created Hospital Units in Response to COVID-19 Pandemic Crisis. *SVOA Medical Research* 2023, 1(1), 24-29.

2. Bamgbade OA, Magboh VO, Otegbeye AU, King MB, Oluwole OJ, Olatunji BT. Difficult tracheal extubation due to endotracheal tube malfunction: A challenge during the COVID-19 pandemic. *J Taibah Univ Med Sci* 2021, 16, 935.

3. Godspower AJ, Robertson SF. Genetic Variability in Taste Receptors and Its Influence on COVID-19 Symptom Severity. *SVOA Medical Research* 2025, 3(4), 141-158.

4. Bamgbade OA, Richards RN, Mwaba M, Ajirenike RN, Metekia LM, Olatunji BT. Facial topical cream promotes facemask tolerability and compliance during COVID-19 pandemic. *J Taibah Univ Med Sci* 2022, 17: 441.

5. Noel ER, Mizuo B, Yamamoto LG, Ishikawa KM, Chen JJ, Len KA. Effect of the COVID-19 Pandemic on Medical Student Performance and Evaluation Scores. *SVOA Medical Research* 2024, 2(1), 10-18.

6. Wiysonge CS, Alobwede SM, de Marie C Katoto P, Kidzeru EB, Lumngwena EN, Cooper S, Goliath R, Jackson A, Shey MS. COVID-19 vaccine acceptance and hesitancy among healthcare workers in South Africa. *Expert Rev Vaccines* 2022, 21(4):549-559.

7. Sato R. Vaccine hesitancy against COVID-19 vaccine over time in Nigeria. *Vaccine* 2023, 41(17):2749-2753.

8. Ilboudo DP, Simpore A, Sawadogo J, Ouattara AK, Ouedraogo AR, Zongo L, Yonli AT, Zouré AA, Zohoncon TM, Djigma FW, Obiri-Yeboah D, Ouedraogo CM, Simpore J. Acceptance, hesitancy, and ethical challenges of the COVID-19 vaccine in sub-Saharan Africa: a systematic review and meta-analysis. *Vaccine* 2026, 69:127966.

9. Prall S, Lopes A. "Better to die trying": Vaccine perceptions and COVID-19 experiences in rural Namibian pastoralists. *Vaccine* 2025, 55:127061.

10. Iliyasu Z, Umar AA, Abdullahi HM, Kwaku AA, Amole TG, Tsiga-Ahmed FI, Garba RM, Salihu HM, Aliyu MH. "They have produced a vaccine, but we doubt if COVID-19 exists": correlates of COVID-19 vaccine acceptability among adults in Kano, Nigeria. *Hum Vaccin Immunother* 2021, 17(11): 4057-4064.

11. Tibbels NJ, Dosso A, Fordham C, Benie W, Brou JA, Kamara D, Hendrickson ZM, Naugle DA. "On the last day of the last month, I will go": A qualitative exploration of COVID-19 vaccine confidence among Ivoirian adults. *Vaccine* 2022, 40(13):2028-2035.

12. George G, Strauss M, Lansdell E, Nota P, Peters RPH, Brysiewicz P, Nadesan-Reddy N, Wassenaar D. Factors associated with COVID-19 vaccine uptake among South African health care workers. *Vaccine* 2024, 42(21):126181.

13. Ackah BBB, Woo M, Stallwood L, Fazal ZA, Okpani A, Ukah UV, Adu PA. COVID-19 vaccine hesitancy in Africa: a scoping review. *Glob Health Res Policy* 2022, 7(1):21.

14. Osaigbovo II, Ogboghodo EO, Obarisiagbon OE, Obaseki DE. An assessment of COVID-19 vaccine knowledge and acceptability among healthcare workers in a Nigerian tertiary hospital. *Ghana Med J* 2023, 57(4):284-292.

15. de Figueiredo A, Temfack E, Tajudeen R, Larson HJ. Declining trends in vaccine confidence across sub-Saharan Africa: A large-scale cross-sectional modeling study. *Hum Vaccin Immunother* 2023, 19(1): 2213117. doi: 10.1080/21645515.2023.2213117.

16. Edoka I, Silal S, Jamieson L, Meyer-Rath G. A cost-effectiveness analysis of South Africa's COVID-19 vaccination programme. *Vaccine* 2024, 42(20):125988.

17. Carcelen AC, Prosperi C, Mutembo S, Chongwe G, Mwansa FD, Ndubani P, Simulundu E, Chilumba I, Musukwa G, Thuma P, Kapungu K, Hamahuwa M, Mutale I, Winter A, Moss WJ, Truelove SA. COVID-19 vaccine hesitancy in Zambia: a glimpse at the possible challenges ahead for COVID-19 vaccination rollout in sub-Saharan Africa. *Hum Vaccin Immunother* 2022, 18(1):1-6.

18. Sankar C, Meyer JC, Schönfeldt M, Gunter H, Dawood H, Sekiti V, Pickard N, Mubaiwa L, Mawela D, Dlamini S, Peter J, Spencer D, Gray C, Patel V, Bamford L, Sehloho T, McCarthy K. Vaccine safety surveillance in South Africa through COVID-19: A journey to systems strengthening. *Vaccine* 2025, 46:126535.

19. Massinga Loembé M, Nkengasong JN. COVID-19 vaccine access in Africa: Global distribution, vaccine platforms, and challenges ahead. *Immunity* 2021, 54(7):1353-1362.

20. Whitehead HS, Songo J, Phiri K, Kalande P, Lungu E, Phiri S, van Oosterhout JJ, Hoffman RM, Moucheraud C. Correlates of uptake of COVID-19 vaccines and motivation to vaccinate among Malawian adults. *Hum Vaccin Immunother* 2023, 19(2):2228168.

21. Sharma A, Kerkhoff AD, Haambokoma M, Shamoya B, Sikombe K, Simbeza SS, Zulu N, Geng EH, Eshun-Wilsonova I, Le Tourneau N, Pry JM. Intention to receive new vaccines post-COVID-19 pandemic among adults and health workers in Lusaka, Zambia. *Vaccine* 2025, 50:126846.

22. Marinda E, Mathentamo Q, Coulson N, Parker S, Dmc Katoto P, Houston G, Magampa M, Pillay N, Ngungu M, Wiysonge CS, van Rooyen H. Impact evaluation of a youth led intervention to increase COVID-19 vaccine uptake in Kwazulu-Natal, South Africa. *Vaccine* 2024, 42(8):2089-2098.

23. Lockman A, Callaghan T, Blackburn CC, Colwell B. Vaccine spillover effects in Africa: A cross-national study of vaccine spillover and confidence in Kenya, Nigeria, and South Africa. *Vaccine* 2025, 43(2):126528.

24. Liga AD, Jabir YN, Bacha RH. COVID-19 vaccine acceptance and adherence to non-pharmaceutical interventions among employees of public transportations company in Addis Ababa, Ethiopia. *Hum Vaccin Immunother* 2023, 19(1):2184759.

25. Morgan AK, Aziire MA, Cobbold J, Agbobada AA, Kudzawu SK. Hesitant or not: A cross-sectional study of socio-demographics, conspiracy theories, trust in public health information, social capital and vaccine hesitancy among older adults in Ghana. *Hum Vaccin Immunother* 2023, 19(1):2211495.

26. Bamgbade OA, Adebayo SA, Otegbeye AU, Alawa FB, Lawal OO, Okpeki JR, Hoggar SK, Ossai OS, Samuel-Ogunnoiki PM, Mulenga JM, Atcham Amougou LM, Gitonga GG. Acute Lethal Hepato-Bronchial Fistula: Emergency Perioperative Management Using Two Single-Lumen Endotracheal Tubes for Lung Isolation. *SVOA Medical Research* 2024, 2:56.

27. Eyawo O, Ugoji UC, Pan S, Oyibo P, Rehman A, Mahboob M, Esimai OA. Predictors of the willingness to accept a free COVID-19 vaccine among households in Nigeria. *Vaccine* 2024, 42(23):126225.

28. Nonvignon J, Owusu R, Asare B, Adjagba A, Aun YW, Yeung KHT, Azeez JNK, Gyansa-Lutterodt M, Gulbi G, Amponsa-Achiano K, Dadzie F, Armah GE, Brenzel L, Hutubessy R, Resch SC; Ghana Health Technology Assessment Technical Working Group. Estimating the cost of COVID-19 vaccine deployment and introduction in Ghana using the CVIC tool. *Vaccine* 2022, 40(12):1879-1887.

29. Noh DH, Darwar R, Uba BV, Gab-Deedam S, Yani S, Jimoh A, Waziri N, David J, Amoo B, Atobatele S, Dimas J, Fadahunsi R, Sampson S, Simple E, Ugbenyo G, Wisdom M, Asekun A, Pallas SW, Ikwe H. Cost of COVID-19 vaccine delivery in nine States in Nigeria via the U.S. Government Initiative for Global Vaccine Access. *BMC Health Serv Res* 2024, 24:1232.

Supplementary Data

COVID-19 Survey Questionnaire **Page 1**

Read questions carefully; select your best answers; mark with X or √. Thanks for your contribution.

Section I – Demographic Data

1. Country: South Africa ☐ Nigeria ☐

2. Age: 13-19 yrs ☐ 20-49 yrs ☐ 50-64 yrs ☐ 65-99 yrs ☐

3. Gender: Male ☐ Female ☐ Other ☐

4. Highest level of education completed: (choose one)
None ☐ Primary ☐ Secondary ☐ Vocational/Technical ☐ College/University ☐

5. Current living situation/status: (choose one)
Living alone, Single ☐ With spouse or small/nuclear family ☐ Congregation, Group living ☐

6. Current job status: (choose one)
Unemployed because or since COVID ☐ Unemployed before COVID ☐

Full-time work ☐ Part-time work ☐

7. Current job type: (choose one)
Office work ☐ Business owner or executive ☐ Essential worker, not healthcare ☐

Labour work ☐ Market or store worker ☐ Healthcare worker ☐ Student ☐

Section II – Knowledge about COVID-19 disease

1. COVID-19 disease is caused by: (choose one)
Virus ☐ Bacteria ☐ Fungus ☐ Not sure ☐

2. COVID-19 can be transmitted by: (choose one or more)
Insects ☐ Cough, sneeze ☐ Sharing household items ☐

Curse, Bad luck ☐ Close physical contact ☐

3. COVID-19 can be cured by: (choose one or more)
Herbalist or spiritual cure ☐ Antibiotic ☐ COVID Vaccine ☐

Home remedy or mixture ☐ Dexamethasone ☐ No cure ☐

4. COVID-19 is a problem in our country: (choose one)
Yes ☐ No ☐ Not sure ☐

5. COVID-19 affects: (choose one or more)
Poor people ☐ Rich people ☐ Village/Rural people ☐ City/Urban people ☐ Anyone ☐

6. COVID-19 can be prevented by: (choose one or more)
Face mask ☐ Hand hygiene ☐ Physical distancing ☐ Vaccine ☐ Medicine/Herb ☐ None ☐

7. COVID-19 control & management needs to be improved by: (choose one or more)
Government ☐ Private sector ☐ Religious groups ☐ The WHO ☐ Other donors/charity ☐

Section III: Knowledge of COVID-19 vaccine **Survey Page 2**

1. Which of these vaccines are you aware of? (choose one or more)
Astra-Zeneca ☐ Pfizer-Biontech ☐ Sinovac ☐ Covishield ☐ Sputnik-Gamaleya ☐

Moderna ☐ Sinopharm-BIBP ☐ Janssen-Johnson&Johnson ☐ None ☐

2. Have you received your 1st dose of any vaccine? (choose one)
Astra-Zeneca ☐ Pfizer-Biontech ☐ Sinovac ☐ Covishield ☐ Sputnik-Gamaleya ☐

Moderna ☐ Sinopharm-BIBP ☐ Janssen-Johnson&Johnson ☐ None ☐

3. Have you received your 2nd dose of any vaccine? (choose one)

Astra-Zeneca ☐ Pfizer-Biontech ☐ Sinovac ☐ Covishield ☐ Sputnik-Gamaleya ☐

Moderna ☐ Sinopharm-BIBP ☐ Janssen-Johnson&Johnson ☐ None ☐

4. Which one of these vaccines do you prefer? (choose one)

Astra-Zeneca ☐ Pfizer-Biontech ☐ Sinovac ☐ Covishield ☐ Sputnik-Gamaleya ☐

Moderna ☐ Sinopharm-BIBP ☐ Janssen-Johnson&Johnson ☐ None ☐

5. Why do you prefer your choice of vaccine? (choose one or more)

Safety ☐ Efficacy ☐ Recommended by doctor ☐ Ready available ☐

No choice ☐ Recommended by government/employer ☐

6. COVID vaccine is safe for our people or citizens. (choose one)

Yes ☐ No ☐ Not sure ☐

7. COVID vaccine contains unknown or secret ingredients. (choose one)
Yes ☐ No ☐ Not sure ☐

8. COVID vaccine was tested properly & adequately, with enough time & research. (choose one)

Yes ☐ No ☐ Not sure ☐

9. COVID vaccine may cause COVID-19 disease. (choose one)

Yes ☐ No ☐ Not sure ☐

10. COVID vaccine may cause minor side-effects. (choose one)
Yes ☐ No ☐ Not sure ☐

11. COVID vaccine may cause severe problems or death. (choose one)

Yes ☐ No ☐ Not sure ☐

12. COVID-19 vaccine is only beneficial for: (choose one or more)

Old people ☐ Young people ☐ Healthcare workers ☐ People with chronic disease ☐

International travellers ☐ Rich people ☐

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