Scientific Research Publishing

World Journal of Vaccines, 2025, 15(3), 39-50
https://www.scirp.org/journal/wjv
ISSN Online: 2160-5823
ISSN Print: 2160-5815

Predictors of COVID-19 Vaccine Uptake among Adults in Kiambu, Kenya

Said Mohamed Abdulla[1*], Halima A. Mohamed[2], Reagan Chweya[3], Charles Wafula[4], Simon Karanja[1]

[1]Department of Environmental Health and Disease Control, School of Public Health, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya
[2]Department of Food and Nutrition, Faculty of Science, Technology, and Environmental Studies, Open University of Tanzania, Dar es Salaam, Tanzania
[3]Independent Researcher, Nairobi, Kenya
[4]Great Lakes University of Kisumu (GLUK), Kisumu, Kenya
Email: *hanjir02@yahoo.com

How to cite this paper: Abdulla, S.M., Mohamed, H.A., Chweya, R., Wafula, C. and Karanja, S. (2025) Predictors of COVID-19 Vaccine Uptake among Adults in Kiambu, Kenya. *World Journal of Vaccines*, **15**, 39-50.
https://doi.org/10.4236/wjv.2025.153003

Received: June 3, 2025
Accepted: July 21, 2025
Published: July 24, 2025

Abstract

Introduction: COVID-19 continues to pose a major public health challenge, contributing to a significant global disease burden and economic disruption, particularly in low- and middle-income countries. The widespread rollout of COVID-19 vaccines remains a crucial strategy for controlling the pandemic. However, vaccine uptake has remained low in many regions despite efforts of the World Health Organization (WHO), pharmaceutical companies, and other stakeholders. In Kenya, there has been limited research identifying predictors of the COVID-19 vaccine uptake among adults. This study aimed to determine the level of vaccine uptake and identify the predictors associated with COVID-19 vaccine uptake in Central Kenya. **Methods:** This study adopted a community-based cross-sectional design. A total of 537 adult participants residing in Kiambu County were recruited from selected sub-counties using a multi-stage sampling technique. Participants were identified and enrolled at their households. We conducted an ordinal logistic regression analysis to identify the predictors associated with COVID-19 vaccine uptake. **Results:** Of the 537 participants, 421 (78%) had received at least one dose of the COVID-19 vaccine, with 366 (68%) completing the vaccination series. Participants aged 18 - 30 years (adjusted odds ratio [aOR] = 0.50; 95% confidence interval [CI]: 0.30 - 0.83; $p < 0.001$) and those aged 31 - 45 years (aOR = 0.46; 95% CI: 0.28 - 0.74; $p = 0.002$) had significantly lower odds of the COVID-19 vaccine uptake by 50% and 54% respectively. Believing the COVID-19 vaccine would not protect from infection was associated with a 76% reduction in vaccine uptake (aOR = 0.24; 95% CI: 0.16 - 0.35; $p < 0.001$). Additionally, concern about vaccine side effects was associated with a 41% reduction in vaccine uptake (aOR = 0.59; 95%

CI: 0.40 - 0.87; p = 0.008). **Conclusion:** COVID-19 vaccine uptake remains suboptimal, particularly among younger adults. The vaccine uptake was positively associated with increasing age and negatively associated with the belief that the COVID-19 vaccine will not protect from infection and concerns about vaccine side effects. Targeted interventions addressing these concerns, particularly among younger populations, are crucial to improving vaccine coverage and enhancing community-level protection.

Keywords

Vaccine-Uptake, COVID-19, Individual-Level Predictor, Adults, Prevalence, Kenya

1. Introduction

The novel coronavirus SARS-CoV-2, which causes COVID-19, has led to significant global morbidity and mortality, claiming millions of lives worldwide [1]. By 2022, COVID-19 had affected over 600 million people, resulting in approximately 6.5 million deaths [2]. In response, the World Health Organization (WHO), in collaboration with pharmaceutical companies, developed and rolled out COVID-19 vaccines by the end of 2020 [3]. Despite these efforts, global vaccine uptake—defined as the proportion of individuals receiving at least one dose within a specific time frame—remained low [4] [5]. A 2022 report indicated that only 49% of adults globally and 14% in Africa were fully vaccinated against COVID-19, while in Kenya, just 34% had received the complete vaccine regimen by mid-2022 [5] [6]. The WHO set a global target of achieving at least 70% complete COVID-19 vaccination coverage by mid-2022 [7]. Low vaccine uptake contributes to higher transmission rates, increased severity of infections, greater hospitalization, and elevated COVID-19-related mortality [8]. Several individual-level factors, such as age, gender, education, occupation, attitudes, perceptions, health-seeking behaviors, and various vaccine concerns, are among the common factors contributing to the low uptake of the COVID-19 vaccine [9] [10]. However, research on these factors at the sub-national level in Kenya remains limited despite clear evidence of low vaccine uptake [11]. Kiambu County has reported high numbers of COVID-19 cases alongside low uptake of COVID-19 vaccine [11]. Identifying the predictors of COVID-19 vaccine uptake at the sub-national level is essential for formulating targeted strategies to improve vaccination rates. Increasing vaccine uptake is critical, as it has the potential to reduce disease transmission, severity, hospitalization, and mortality by up to 90% [12] [13]. This study aims to determine the predictors of COVID-19 vaccine uptake in Kiambu County, Kenya.

2. Materials and Methods

2.1. Study Site

Kiambu County, located in central Kenya, covers an area of 2,538.6 square kilo-

meters and has a population of 2,417,735, with 59.3% of residents being adults [14]. The county consists of twelve sub-counties: Gatundu North, Gatundu South, Githunguri, Juja, Lari, Limuru, Kabete, Kiambaa, Kiambu, Kikuyu, Thika, and Ruiru. In 2022, Kiambu had recorded 19,778 COVID-19 cases, the highest among Kenya's counties [16].

2.2. Sampling Technique

This study adopted a cross-sectional design. Adults aged 18 years and above were selected from sub-counties within Kiambu County. A sample size of 536 participants was calculated using the formula:

$$n = [DEFF \times N \times p\,(1 - p)]/\{[d^2/Z^2_{(1-\alpha/2)}] \times (N - 1) + p\,(1 - p)\}$$

where p was 36.7% (COVID-19 vaccine uptake prevalence), DEFF was 1.5 (design effect for cluster survey), z-value of 1.96 (95% confidence interval), d was 0.05 (precision level), and N was considered greater than 1,000,000 [11] [14].

The sample was distributed equally between two clusters: urban and rural. The rural cluster comprised Gatundu South, Gatundu North, Githunguri, Juja, Kabete, and Kiambaa sub-counties, while the urban cluster included Karuri, Kiambu, Kikuyu, Limuru, Ruiru, and Thika Town sub-counties.

We selected one sub-county from each cluster using random sampling: Ruiru from the urban cluster and Githunguri from the rural cluster. A ward was randomly selected from each sub-county, followed by a village from each ward. Community Health Volunteers (CHVs) from each selected village provided lists of sub-villages, and participants were then proportionally selected from these sub-villages. The total number of households in each sub-village was divided by the required sample size to determine the sampling interval, which typically resulted in an interval of four. The first household was selected based on proximity to the CHV, and thereafter, every fourth household was approached. The first adult contacted in each household was invited to participate.

In cases where a household declined participation or did not meet eligibility criteria, the data collector proceeded to the next adjacent household to maintain the sampling continuity. A total of 573 households were approached (281 in Ruiru and 292 in Githunguri) to reach the target sample size. Non-participation included 21 individuals who declined the interview, 11 who were ineligible (no adult present), and four who declined due to time constraints. All 537 consenting adults completed the face-to-face questionnaire, with no partial completions.

2.3. Data Collection and Analysis

Data collection was conducted by the researcher and four trained research assistants. The research assistants were trained on the study protocol and data collection methods to minimize bias. Informed consent was obtained from all participants prior to the interview. The interviews were administered using an electronic questionnaire through the Open Data Kit (ODK) application. The questionnaire was adapted and modified from previous studies [16]-[20] and consisted of two

sections: one focused on sociodemographic factors and the other on individual predictors such as awareness, health-seeking behaviors, believing COVID-19 vaccine will not protect from infection, I do not need vaccine because I am healthy, worrying about vaccine side effects and perceptions of the COVID-19 vaccine. Data were synced daily to maintain quality control.

In Kenya, five types of COVID-19 vaccines were available: Johnson & Johnson, Moderna, Pfizer, AstraZeneca, and Sinopharm. Vaccine uptake was self-reported and categorized into three levels: no doses (not vaccinated), one dose (partial), and two or more doses (complete). For Johnson & Johnson, receiving one dose was considered complete vaccination [21].

Series of statements such as: "I believe the COVID-19 vaccine will not protect me from infection," "I am worried about potential side effects," and "I do not need the vaccine because I am healthy and at low risk." These items were rated on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). For analysis, responses were dichotomized as "Disagree" or "Agree" based on their individual mean score from a maximum obtainable score, which serves as cut-off marks. Scores below the mean score obtained for these variables were classified as "Disagree" and vice versa [16].

Data were manually entered into Excel 2019 for cleaning and imported into R (version 4.3.1) for analysis. Descriptive statistics (frequencies and percentages) were computed and presented in tables. Vaccine uptake was treated as an ordinal dependent variable with three levels. All predictor variables were initially tested in a univariate ordinal logistic regression model. Predictors with a p-value < 0.05 were included in a multivariate ordinal logistic regression to identify independent associations.

2.4. Ethical Considerations

Ethical approval for this study was granted by the Ethics Review Board at Jomo Kenyatta University of Agriculture and Technology (Ref: JKU/ISERC/02316/0843) and the National Commission for Science, Technology, and Innovation (NACOSTI) (Ref: NACOSTI/P/23/25646). Permission was also obtained from the Kiambu County government. All participants provided informed consent, and their personal identifiers were omitted to ensure privacy and confidentiality. Data were stored on password-protected devices and will be kept for five years after study completion.

3. Results

Of the 537 recruited participants, the majority were female, 313 (58%). The participants were almost equally distributed across age categories. The majority of the participants were married, 304 (57%). Additionally, most of the participants had attained post-secondary education, 392 (73%). Largely, more than 365 (68%) of the participants earned more than 5,000 Kenya shillings (KES), with the majority working in informal sectors (n = 317, 59%). As shown in **Table 1**.

Table 1. Demographic characteristics of study participants.

Variable	Frequency (N = 537)	Percent %
Age (years)		
18 - 30	167	31.1
31 - 45	187	34.8
>45	183	34.1
Mean age—41 years (SD = 14.9 years)		
Gender		
Female	313	58.3
Male	224	41.7
Marital status		
Single	218	40.6
Married	304	56.6
Cohabiting	15	2.8
Education Level		
None	28	5.2
Primary	117	21.8
Secondary	277	51.6
Tertiary	115	21.4
Source of income		
Formal	137	25.5
Informal	317	59.0
Supported[1]	83	15.5
Religion		
Christians	531	98.9
Muslim	6	1.1
Income (KSH)		
<5000	172	32
5000 - 10,000	205	38.2
>10,000	160	29.8

[1]Students and retirees.

3.1. Level of COVID-19 Vaccine Uptake

Of the 537 participants, 421 (78%) received at least one dose of the COVID-19 vaccine, with 366 (68%) receiving the complete vaccination. Among these, 162 (89%) participants were aged >45 years received at least one dose of COVID-19 vaccine. Additionally, 334 (81%) of female participants received at least one dose of COVID-19 vaccine. Among those with secondary school education, 224 (81%) received at least one vaccine dose. Furthermore, 69 (83%) of financially supported (Students and retirees) participants received at least one dose of COVID-19 vaccine. Finally, 144 (90%) of participants earning more than 10,000 KSH received at least one dose of COVID-19 vaccine. As shown in Figure 1.

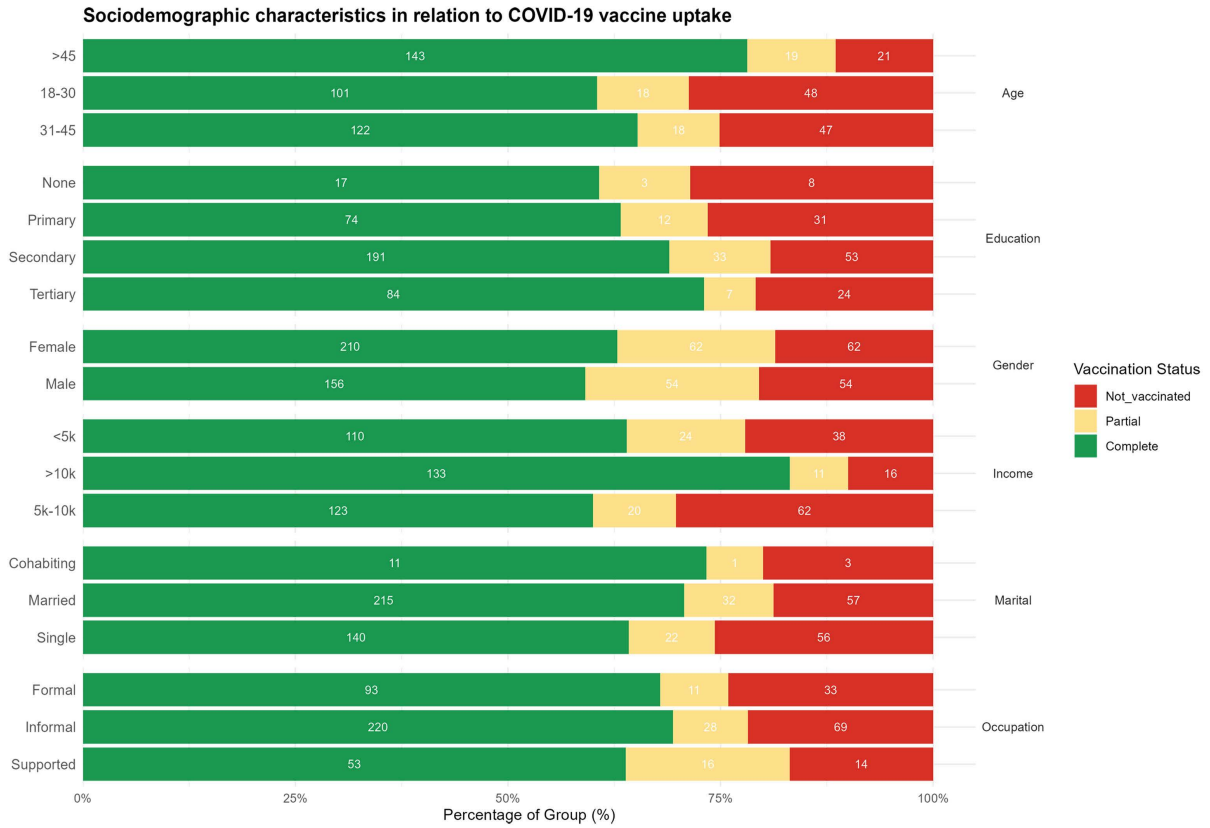

Figure 1. Sociodemographic characteristics in relation to COVID-19 vaccine uptake.

3.2. Univariate Analysis

Univariate analysis revealed that participants aged >45 years had 2.46 times higher odds of COVID-19 vaccine uptake (OR = 2.46; 95% CI: 1.56 - 3.92; $p < 0.001$). Those earning more than 10,000 KSH had 2.69 times higher odds of vaccine uptake (OR = 2.69; 95% CI: 1.63 - 4.55; $p < 0.001$). Consulting a physician when feeling unwell was also significantly associated with increased odds of vaccine uptake, with a 91% higher likelihood (OR = 1.91; 95% CI: 1.33 - 2.74; $p < 0.001$). In contrast, participants who believed that the COVID-19 vaccine would not protect them from infection had 77% lower odds of taking the vaccine (OR = 0.23; 95% CI: 0.15 - 0.33; $p < 0.001$). Similarly, those who felt the vaccine was unnecessary had 74% reduced odds of uptake (OR = 0.26; 95% CI: 0.18 - 0.38; $p < 0.001$). Finally, concerns about potential side effects significantly reduced the odds of vaccine uptake by 48% (OR = 0.52; 95% CI: 0.36 - 0.75; $p < 0.001$). These findings are summarized in Table 2.

Table 2. Univariate analysis.

Variable	OR (95% Confidence Interval (CI))	p
Age (years)		
18 - 30	Ref	
31 - 45	1.23 (0.8 - 1.87)	0.352
>45	2.46 (1.56 - 3.92)	<0.001

Continued

Gender		
Female	Ref	
Male	1.03 (0.72 - 1.49)	0.878
Marital status		
Cohabiting	Ref	
Married	0.92 (0.25 - 2.73)	0.885
Single	0.66 (0.18 - 1.99)	0.492
Education Level		
No formal education	Ref	
Primary	1.11 (0.47 - 2.51)	0.799
Secondary	1.50 (0.66 - 3.22)	0.312
Tertiary	1.70 (0.72 - 3.94)	0.215
Occupation status		
Supported	Ref	
Informal	1.13 (0.68 - 1.83)	0.638
Formal	1.03 (0.59 - 1.8)	0.915
Religion		
Christians	Ref	
Muslim	2.18 (0.35 - 42.05)	0.479
Income (KSH)		
<5000	Ref	
5000 - 10,000	0.78 (0.52 - 1.18)	0.243
>10,000	2.69 (1.63 - 4.55)	<0.001
Corona reinfection is possible		
Disagree	Ref	
Agree	1.28 (0.89 - 1.84)	0.183
Vaccinated individuals can still get COVID-19		
Disagree	Ref	
Agree	1.34 (0.93 - 1.92)	0.111
Consulting physician		
Unlikely	Ref	
Likely	1.91 (1.33 - 2.74)	<0.001
Consulting traditional practitioner		
Unlikely	Ref	
Likely	0.92 (0.61 - 1.40)	0.691
I believe COVID-19 vaccine will not protect me from infection		
Disagree	Ref	
Agree	0.23 (0.15 - 0.33)	<0.001

Continued

COVID-19 vaccine is unnecessary		
Disagree	Ref	
Agree	0.26 (0.18 - 0.38)	<0.001
I am concerned that I will die from COVID-19		
Disagree	Ref	
Agree	1.20 (0.81 - 1.80)	0.366
Vaccination lowers COVID-19 infection risk		
Disagree	Ref	
Agree	1.29 (0.87 - 1.93)	0.213
I am concerned about potential side effects of the COVID-19 vaccine		
Disagree	Ref	
Agree	0.52 (0.36 - 0.75)	<0.001

3.3. Multivariate Analysis

The multivariate analysis revealed that participants aged between 18 and 45 years were significantly less likely to receive the COVID-19 vaccine compared to those aged 45 years and above, with the odds reduced by 50% (aOR = 0.50; 95% CI: 0.30 - 0.83; p = 0.001) and 54% (aOR= 0.46; 95% CI: 0.28 - 0.74; p < 0.002), respectively. Additionally, participants who agreed that the COVID-19 vaccine would not protect them from infection had 76% lower odds of COVID-19 vaccine uptake (aOR = 0.24; 95% CI: 0.16 - 0.35; p < 0.001) compared to those who disagreed. Similarly, participants who reported being concerned about COVID-19 vaccine side effects had a 49% reduction in vaccine uptake (aOR = 0.51; 95% CI: 0.40 - 0.87; p = 0.008). As shown in Table 3.

Table 3. Multivariate analysis.

Variable	Adjusted OR (95% CI)	p
Age (years)		
>45	Ref	
31 - 45	0.46 (0.28 - 0.74)	<0.002
18 - 30	0.50 (0.30 - 0.83)	0.001
I believe COVID-19 vaccine will not protect me from infection		
Disagree	Ref	
Agree	0.24 (0.16 - 0.35)	<0.001
I am concerned about potential side effects of the COVID-19 vaccine		
Disagree	Ref	
Agree	0.59 (0.40 - 0.87)	<0.008

4. Discussion

The study found that COVID-19 vaccine uptake remains below the national target of complete adult vaccination by December 2022 [20]. Our study is consistent with previous findings on vaccine uptake, which reported a 71.1% uptake across five informal settlements in Nairobi, Kenya [20]. Their longitudinal cohort study also indicated that vaccine willingness prior to availability closely matched the uptake once vaccines became accessible. Nevertheless, the remaining gap in coverage highlights the need for sustained and targeted interventions. Similarly, another study conducted in Tanzania found that only 18% of the general population had received the COVID-19 vaccine by April 2022 [18]. Factors contributing to the low uptake included vaccine hesitancy, lack of trust, and limited access to reliable information. In the Tanzanian context, early mixed messages from national leadership may have contributed to slow public acceptance of the vaccine. The findings suggest that, despite the widespread availability of vaccines, achieving full population coverage remains a challenge. Although vaccines were available and provided free of charge, uptake may have been limited by hesitation, misinformation, or distrust in health authorities.

Age was found to be a significant predictor of COVID-19 vaccine uptake. Participants under the age of 45 were less likely to take the vaccine compared to those aged 45 and above. These findings are consistent with those of a study conducted in Tanzania, which reported that older adults (30 years and above) were more likely to receive the vaccine, with uptake increasing by 3% with each additional year of age [18]. Similarly, another study found that vaccine acceptance was lower among individuals under 35 years, attributing this to differences in risk perception, particularly during the early phase of the pandemic when COVID-19 was primarily associated with severe illness in older adults [17]. In addition, a separate study reported that younger, well-educated participants were among the least likely to be vaccinated [20]. These findings suggest that lower perceived vulnerability among younger populations may contribute to their reduced motivation to seek vaccination. Addressing this perception through targeted messaging may be crucial in enhancing vaccine uptake among this age group.

This study found that the belief that the COVID-19 vaccine does not protect against infection was significantly associated with reduced vaccine uptake. These findings are consistent with prior research emphasizing the role of perceived vaccine effectiveness in shaping vaccination behavior. Participants who believed the vaccine could protect from COVID-19 infection were more likely to receive the vaccine, with a 12-percentage-point increase in uptake observed among those confident in vaccine efficacy [22]. Similarly, another study identified perceived effectiveness as one of the strongest predictors of vaccination intentions [23]. Additionally, research has found that belief in the vaccine's protective effect—both for oneself and others—is strongly linked to higher uptake [24]. These findings underscore the central role of vaccine confidence in influencing individual decisions to take the vaccine. Misinformation, myths, and disinformation continue to con-

tribute to negative perceptions about vaccine efficacy, thereby fueling low uptake of the vaccine. To address this barrier, public health efforts should prioritize clear, evidence-based messaging delivered through trusted sources to reinforce vaccine effectiveness and build public trust.

This study found that concern about side effects was significantly associated with reduced COVID-19 vaccine uptake, with individuals expressing such concerns being 49% less likely to receive the vaccine. These findings are consistent with previous studies that identified fear of side effects as a primary reason for low vaccine uptake [25]. Similarly, a scoping review of twelve studies reported that concerns about side effects or adverse events were among the most common barriers to vaccine acceptance [26]. These concerns underscore the critical role of public perception in shaping vaccine decision-making. Misinformation and misconceptions regarding side effects can contribute to low uptake and undermine efforts to achieve adequate vaccine coverage. Targeted communication through mass media and community health volunteers may help strengthen public trust and improve vaccine uptake.

5. Limitations and Strengths of the Study

The study used a cross-sectional study and collected data using questionnaires. The findings are based on data obtained from the participants' personal perceptions and judgments. However, it collected data from both rural and urban county representatives, which allowed for generalization to the entire county.

6. Conclusion

We conclude that COVID-19 vaccine uptake in Kiambu County remained below national targets. Uptake was higher among older adults and lower among those with concerns about vaccine efficacy and side effects. Addressing these concerns through targeted communication is essential to improve the vaccine uptake. Further research employing more rigorous study designs is recommended to strengthen the evidence base and inform future public health strategies.

Acknowledgements

Special thanks for my supervisors, JKUAT Department of Environmental Health and Disease Control staff, study participants, and EDCTP2 for funding.

Availability of Data Statement

Data is publicly available and can be requested.

Source of Financial Support

This research was funded by the Second European and Developing Countries Clinical Trials Partnership (EDCTP2), supported by the European Union (EU).

Conflicts of Interest

No conflicts of interest exist.

References

[1] Thanh Le, T., Andreadakis, Z., Kumar, A., Gómez Román, R., Tollefsen, S., Saville, M., *et al.* (2020) The COVID-19 Vaccine Development Landscape. *Nature Reviews Drug Discovery*, **19**, 305-306. https://doi.org/10.1038/d41573-020-00073-5

[2] León, T.M., Dorabawila, V., Nelson, L., Lutterloh, E., Bauer, U.E., Backenson, B., *et al.* (2022) COVID-19 Cases and Hospitalizations by COVID-19 Vaccination Status and Previous COVID-19 Diagnosis—California and New York, May-November 2021. *MMWR. Morbidity and Mortality Weekly Report*, **71**, 125-131. https://doi.org/10.15585/mmwr.mm7104e1

[3] Ocholla, B.A., Nyangena, O., Murayi, H.K., Mwangi, J.W., Belle, S.K., Ondeko, P., *et al.* (2021) Association of Demographic and Occupational Factors with SARS-CoV-2 Vaccine Uptake in Kenya. *Open Access Library Journal*, **8**, e7424. https://doi.org/10.4236/oalib.1107424

[4] Ioannidis, J.P.A. (2022) Factors Influencing Estimated Effectiveness of COVID-19 Vaccines in Non-Randomised Studies. *BMJ Evidence-Based Medicine*, **27**, 324-329. https://doi.org/10.1136/bmjebm-2021-111901

[5] World Health Organization (2021) Monitoring COVID-19 Vaccination: Considerations for the Collection and Use of Vaccination Data: Interim Guidance, 3 March 2021.

[6] Zavala, E., Fesshaye, B., Lee, C., Mutwiwa, S., Njagi, W., Munyao, P., *et al.* (2022) Lack of Clear National Policy Guidance on COVID-19 Vaccines Influences Behaviors in Pregnant and Lactating Women in Kenya. *Human Vaccines & Immunotherapeutics*, **18**, Article ID: 2127561. https://doi.org/10.1080/21645515.2022.2127561

[7] WHO Advisory Group Recommends Extra COVID-19 Vaccine Dose for Immunocompromised. UN News. https://news.un.org/en/story/2021/10/1102732

[8] El-Shabasy, R.M., Nayel, M.A., Taher, M.M., Abdelmonem, R., Shoueir, K.R. and Kenawy, E.R. (2022) Three Waves Changes, New Variant Strains, and Vaccination Effect against COVID-19 Pandemic. *International Journal of Biological Macromolecules*, **204**, 161-168. https://doi.org/10.1016/j.ijbiomac.2022.01.118

[9] Troiano, G. and Nardi, A. (2021) Vaccine Hesitancy in the Era of COVID-19. *Public Health*, **194**, 245-251. https://doi.org/10.1016/j.puhe.2021.02.025

[10] Schaffer DeRoo, S., Pudalov, N.J. and Fu, L.Y. (2020) Planning for a COVID-19 Vaccination Program. *JAMA*, **323**, 2458-2459. https://doi.org/10.1001/jama.2020.8711

[11] Ministry of Health (2022) Ministry of Health—Republic of Kenya 2022. https://www.health.go.ke/sites/default/files/2023-05/MINISTRY-OF-HEALTH-KENYA-COVID-19-IMMUNIZATION-STATUS-REPORT-16TH-MAY-2022.pdf

[12] Mohammed, I., Nauman, A., Paul, P., Ganesan, S., Chen, K., Jalil, S.M.S., *et al.* (2022) The Efficacy and Effectiveness of the COVID-19 Vaccines in Reducing Infection, Severity, Hospitalization, and Mortality: A Systematic Review. *Human Vaccines & Immunotherapeutics*, **18**, Article ID: 2027160. https://doi.org/10.1080/21645515.2022.2027160

[13] Rahmani, K., Shavaleh, R., Forouhi, M., Disfani, H.F., Kamandi, M., Oskooi, R.K., *et al.* (2022) The Effectiveness of COVID-19 Vaccines in Reducing the Incidence, Hospitalization, and Mortality from COVID-19: A Systematic Review and Meta-Analysis. *Frontiers in Public Health*, **10**, Article ID: 873596. https://doi.org/10.3389/fpubh.2022.873596

[14] KNBS (2019) 2019 Kenya Population and Housing Census: Volume II. http://knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-

ii-distribution-of-population-by-administrative-units

[15] Lars, K. (2022) Kenya: Coronavirus Cases by County 2022. Statista. https://www.statista.com/statistics/1136519/cumulative-coronavirus-cases-in-kenya-by-county/

[16] Adedeji-Adenola, H., Olugbake, O.A. and Adeosun, S.A. (2022) Factors Influencing COVID-19 Vaccine Uptake among Adults in Nigeria. *PLOS ONE*, **17**, e0264371. https://doi.org/10.1371/journal.pone.0264371

[17] Kilima, J.I., Morema, E.N. and Ochieng, E.O. (2023) Uptake of COVID-19 Vaccination among Healthcare Providers in Busia County in Kenya. *Evidence-Based Nursing Research*, **5**, 46-57. https://doi.org/10.47104/ebnrojs3.v5i4.312

[18] Msuya, S.E., Manongi, R.N., Jonas, N., Mtei, M., Amour, C., Mgongo, M.B., *et al.* (2023) COVID-19 Vaccine Uptake and Associated Factors in Sub-Saharan Africa: Evidence from a Community-Based Survey in Tanzania. *Vaccines*, **11**, Article No. 465. https://doi.org/10.3390/vaccines11020465

[19] Nasimiyu, C., Ngere, I., Dawa, J., Amoth, P., Oluga, O., Ngunu, C., *et al.* (2022) Near-complete SARS-CoV-2 Seroprevalence among Rural and Urban Kenyans Despite Significant Vaccine Hesitancy and Refusal. *Vaccines*, **11**, Article No. 68. https://doi.org/10.3390/vaccines11010068

[20] Rajshekhar, N., Pinchoff, J., Boyer, C.B., Barasa, E., Abuya, T., Muluve, E., *et al.* (2023) Exploring COVID-19 Vaccine Hesitancy and Uptake in Nairobi's Urban Informal Settlements: An Unsupervised Machine Learning Analysis of a Longitudinal Prospective Cohort Study from 2021 to 2022. *BMJ Open*, **13**, e071032. https://doi.org/10.1136/bmjopen-2022-071032

[21] Muchiri, S.K., Muthee, R., Kiarie, H., Sitienei, J., Agweyu, A., Atkinson, P.M., *et al.* (2022) Unmet Need for COVID-19 Vaccination Coverage in Kenya. *Vaccine*, **40**, 2011-2019. https://doi.org/10.1016/j.vaccine.2022.02.035

[22] Maughan-Brown, B., Eyal, K.C., Njozela, L. and Buttenheim, A.M. (2023) Predictors of COVID-19 Vaccine Uptake among Adults in South Africa: Multimethod Evidence from a Population-Based Longitudinal Study. *BMJ Global Health*, **8**, e012433. https://doi.org/10.1136/bmjgh-2023-012433

[23] Burke, P.F., Masters, D. and Massey, G. (2021) Enablers and Barriers to COVID-19 Vaccine Uptake: An International Study of Perceptions and Intentions. *Vaccine*, **39**, 5116-5128. https://doi.org/10.1016/j.vaccine.2021.07.056

[24] Kikut, A., Clark, D., Jesch, E. and Hornik, R. (2022) Strengthened Belief in Vaccine Effectiveness Predicted Increased COVID-19 Vaccination Intention and Behaviour: Results from a Nationally Representative Longitudinal Survey of U.S. Adults from July 2020 to April/May 2021. *Vaccine*, **40**, 6035-6041. https://doi.org/10.1016/j.vaccine.2022.08.046

[25] Nzaji, M.K., Kamenga, J.d.D., Lungayo, C.L., Bene, A.C.M., Meyou, S.F., Kapit, A.M., *et al.* (2024) Factors Associated with COVID-19 Vaccine Uptake and Hesitancy among Healthcare Workers in the Democratic Republic of the Congo. *PLOS Global Public Health*, **4**, e0002772. https://doi.org/10.1371/journal.pgph.0002772

[26] Ackah, M., Ameyaw, L., Gazali Salifu, M., Afi Asubonteng, D.P., Osei Yeboah, C., Narkotey Annor, E., *et al.* (2022) COVID-19 Vaccine Acceptance among Health Care Workers in Africa: A Systematic Review and Meta-Analysis. *PLOS ONE*, **17**, e0268711. https://doi.org/10.1371/journal.pone.0268711