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COVID-19 vaccine hesitancy among people living with HIV in a low-resource setting: A multi-center study of prevalence, correlates and reasons

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ABSTRACT

Background: Hesitancy to COVID-19 vaccine may worsen the burden of COVID-19 among people living with HIV (PLHIV), who are at a higher risk of COVID-19-related hospitalization and death, compared to HIV non-infected individuals. Therefore, we evaluate the predictors and reasons for COVID-19 vaccine hesitancy among unvaccinated PLHIV in six antiretroviral therapy (ART) clinics across northern Nigeria.
Methodology: In this cross-sectional study, conducted between October 2021 and February 2022 in six hospitals across two geopolitical regions of Nigeria, we utilized interviewer-administered questionnaires to assess COVID-19 vaccine hesitancy among a convenience sample of 790 eligible adult PLHIV. Hesitancy was defined as answering 'no' or 'maybe' to a question asking participants their willingness to accept the COVID-19 vaccine. A multivariate logistic regression model was used to estimate the adjusted odds ratio (aOR) and 95% confidence interval (CI) of the factors associated with COVID-19 vaccine hesitancy among PLHIV.
Results: Of the total 660 unvaccinated participants included in the analysis (61.82% female, mean age [SD] of 39.76 [10.75]), 381 (57.72%) were hesitant to COVID-19 vaccine. Being 50 years and older (aOR: 0.43; 95% CI: 0.21–0.89), being unemployed (aOR: 0.57; 95% CI: 0.34–0.95), experiencing the adverse effects of ART (aOR: 0.36; 95% CI: 0.15–0.86), and perception of being at high risk of contracting COVID-19 (aOR: 0.22; 95% CI: 0.13–0.37) were associated with significantly lower odds of hesitancy. Conversely, being female (aOR: 1.64; 95% CI: 1.02–2.61) and attending ART clinics at state administrative capital cities (IIDH Kano [aOR: 2.40; 95% CI: 1.10–5.25], MMSH Kano [aOR: 5.59; 95% CI: 1.97–10.66],

Abbreviations: ART, Anti-retroviral therapy; aOR, Adjusted odds ratio; BMI, Body mass index; CI, Confidence interval; GH, General Hospital; IDH, Infectious Disease Hospital; LGA, Local Government Authority; MMSH, Murtala Muhammad Specialist Hospital; PLHIV, People living with HIV; SD, Standard deviation; SQuAD-HIV, Stigma, health-related Quality of life, antiretroviral Adherence, and Depression among people living with HIV; LMICs, Low- and middle-income countries.

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YSSH Damaturu [aOR: 9.88; 95% CI: 4.02–24.29] vs. GH Gashua) were associated with significantly higher odds of hesitancy. The most common reasons for hesitancy include fear of potential adverse effects, skepticism about vaccine efficacy, the rapid development of the COVID-19 vaccine, and the perceived lack of effort to develop a cure or vaccine for HIV/AIDS.

Conclusion: Interventions aimed at combating misperceptions and misinformation regarding the COVID-19 vaccination program may reduce the prevalence of COVID-19 vaccine hesitancy among unvaccinated PLHIV.

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1. Introduction

The coronavirus disease 2019 (COVID-19) has worsened the existing medical, psychological, and socio-cultural challenges faced by people living with HIV (PLHIV), particularly those in Africa[1]. Owing to their compromised immune function, PLHIV are at a higher risk of hospital admission and mortality following exposure to the severe acute respiratory coronavirus 2 (SARS-CoV-2) infection[2-6]. Several vaccines have been developed against SARS-CoV-2 and have generally been proven to be safe, effective, and immunogenic among HIV-infected people and non-HIV-infected individuals [7-9]. However, despite the proven effectiveness of these vaccines, hesitancy towards COVID-19 vaccine uptake is common in the highly vulnerable population of PLHIV, with rates of hesitancy reported to be as high as 50% [10-13].

Vaccine hesitancy is rising, especially in low and middle-income countries (LMICs), including Nigeria[14,15]. Rising prevalence of vaccine hesitancy may have been engendered by a massive overflow of vaccine-related disinformation and conspiracy theories (particularly in online media), as well as historical antecedents of ethical misconduct in drug trials (such as the scandal in the Trovan drug trial).[16,17] COVID-19 unvaccinated individuals are at heightened risk of contracting SARS-CoV-2, developing more severe COVID-19 infection, and experiencing in-hospital admission and death,[18,19] and these risks may likely be more profound among PLHIV.

COVID-19 vaccine "hesitancy" among PLHIV had been widely studied in various countries across Asia, Europe, North America, and Africa.[12,13,20-24] However, many of these studies were conducted via online[12,21,23,24] and telephone-based surveys,[22] rather than through face-to-face interviewer survey approach, which may be ridden with information and case ascertainment bias. Importantly, the literature available for COVID-19 hesitancy/acceptance among PLHIV in Africa is largely limited to single-center studies with limited generalizability.

Therefore, in this study, we aim to evaluate the prevalence of hesitancy to the COVID-19 vaccine, the rate of COVID-19 vaccine uptake, factors associated with hesitancy towards the COVID-19 vaccine, and the reasons for the hesitancy among a convenience sample of PLHIV attending antiretroviral treatment (ART) clinics in Kano State, the most populous state and center of commerce in Nigeria, and Yobe State, a state heavily affected by Boko Haram insurgency.

2. Methods

2.1. Study design, setting, and participants

This study used data from the Stigma, health-related Quality of life , antiretroviral Adherence, and Depression among people living with HIV (SQuAD-HIV) project, a multicenter cross-sectional study conducted in two conveniently selected states from northern Nigeria between 11th October 2021 to 24th February 2022. In Kano state, ART clinics of two large hospitals located in Kano State's capital city, Kano, were selected: (1.) Murtala Muhammad Specialist Hospital (MMSH), and (2.) Infectious Diseases Hospital (IDH). In Yobe, ART clinics of four large hospitals were selected: (1) Yobe State Specialist Hospital (YSSH) Damaturu, located in Damaturu, the capital city of Yobe (2) YSSH Potiskum, located in Potiskum local government authority (L.G.A); (3) General Hospital (GH) Gashua, located in Bade L.G.A; and (4) GH Geidam, located in Geidam L.G.A. Participants eligible for the study were PLHIV who are aged at least 18 years (verified using information from the patient's medical record folder) during the start of the study, attend one of the selected ART clinics for follow-up, are currently on ART, grant the consent to participate, are not on admission at the time of the study, and have not yet taken a single dose of the COVID-19 vaccine. No remuneration for participation in this study was given to participants.

2.2. Sample Size:

We used Fisher's formula for sample size determination in health studies to calculate the minimum sample size required for this study.[25].

$$N = Z^2 pq/d^2$$

Where N = Minimum sample size, Z = Standard Normal distribution, corresponding to a 95% confidence level, the value obtained from a normal distribution table is 1.96, p = 53.8% (proportion of unwillingness to accept COVID-19 vaccine obtained from a previous study).[10] q = 1 - p, and d = desired precision = 0.05. Thus, N = $(1.96)^2$ * 0.538 * 0.462 / $(0.05)^2$ = 382. However, given the multicenter coverage of our study, we obtained a much higher sample size of 790 at the end of the study.

2.3. Data collection

We employed the non-probabilistic convenience sampling approach to recruit participants due to the disruptions in clinic schedules brought about by the COVID-19 pandemic lockdown measures, which resulted in a highly variable availability of the study population at the ART centers during clinic days.[26,27] Data were collected using an interviewer-administered questionnaire designed in Google Forms (docs.google.com/forms). Data collection was conducted by trained doctors, pharmacists, nurses, and final-year medical students under the routine watch of a supervisor assigned to each center. Each eligible participant was interviewed in a private room for an average of 60 min, with the patient's record folder available for collecting required clinical information.

2.4. Variables

The primary outcome variable of interest in this study is COVID-19 vaccine hesitancy among PLHIV, defined based on the *SAGE Working Group on Vaccine Hesitancy 2012* definition of vaccine hesi-

tancy: ‘‘a delay in the acceptance or refusal of vaccination despite the availability of vaccination services.”[28] Therefore, participants who responded “NO” or ‘‘MAYBE” to the question ‘‘will you accept the COVID-19 vaccine for yourself?” were considered to be hesitant to COVID-19 vaccine.

The main independent variables are the initial source of information about the COVID-19 vaccine. Other covariates include age, sex, marital status, the highest level of education, employment status, average personal monthly income, place of residence, ART center, having HIV-infected kids, Time (in years) since initial diagnosis of HIV, history of HIV-related hospitalization, past co-infection with HIV and Tuberculosis (TB), the experience of ART adverse effects, latest viral load, body mass index (BMI),[29] WHO clinical stage at last visit, and perceived risk of contracting COVID-19. Participants who were hesitant to accept the COVID-19 vaccine were asked to indicate their level of agreement (on a five-point Likert scale (strongly disagree, disagree, neutral, agree, strongly agree) with a fifteen-item list of reasons for hesitancy. This list was compiled following an extensive literature review of review articles on the subject of vaccine hesitancy (details in appendix).[28,30-36].

2.5. Ethics approval and consent to participate

This research was conducted according to the guidelines of the Helsinki declaration.[37] The study was approved by the Health Research Ethics Committee of the Kano State Ministry of Health (approval number: SHREC/2021/2889), Yobe State Ministry of Health and Human Services (MOH/GEN/747/Vol. 1), and the Yobe State Specialist Hospital, Damaturu (YSS/DTR/GEN/013). Informed consent was obtained from all respondents and participation was voluntary.

2.6. Statistical analysis

We used means and proportions for descriptive statistics. Similar to previous studies,[20,23,24,38-41] our analysis only included the unvaccinated participants (660). A series of simple logistic regression models were used for bivariate comparisons to report the crude odds ratio (OR) and 95% confidence interval (CI) of the factors associated with COVID-19 vaccine hesitancy among unvaccinated PLHIV. We fit a multivariate logistic regression model to estimate the adjusted odds ratio (aOR) and 95% CI of the factors independently associated with vaccine hesitancy. Applying the backward selection approach to obtain a parsimonious model, we sequentially removed variables with a p-value > 0.20 and no known clinical significance from the full model (which comprises all variables), thereby comparing sequential models using the likelihood ratio test. The final model included age, sex, employment status, residence, ART center, the experience of ART adverse effects, VL, and perceived risk of contracting COVID-19. We used the Hosmer–Lemeshow and Pearson’s chi-squared statistics to evaluate the overall model fit (a p-value > 0.05 indicates a good fit).[42] All analyses were conducted using STATA version 15.0 (StataCorp LLC, College Station, TX, USA).

3. Results

A total of 790 PLHIV responded to the survey. However, we excluded participants who have taken one or more doses of a COVID-19 vaccine (n = 103) (Fig. 1). We further excluded 27 responses due to data entry (clerical) errors. Therefore, a total of 660 responses were used for our final analysis.

3.1. Characteristics of the participants

Our analyses included 660 participants with a mean age (SD) of 39.76 (10.75) years, of whom 381 (57.72%) were hesitant to accept the COVID-19 vaccine. Among included participants, 407 (62.33%) were females, 362 (57.66%) had no formal education, 473 (73.22%) were unemployed, 529 (84.10%) had an average monthly income below the national minimum wage (NGN30,000), and 264 (40.80%) were not married (Table 1). Additionally, 377 (57.82%) were residents of urban areas, 206 (31.26%) attended the ART clinic at MMSH Kano state, and 137 (20.79%) attended the ART clinic at GH Gashua in Yobe state. Furthermore, 73 (11.44%) had a history of HIV-related hospitalization, 133 (20.34%) had a history of concomitant intake of TB treatment and ART, 37 (6.19%) had experienced side effects of ART, 408 (67.11%) had a detectable viral load from their latest test, 341 (53.79%) had a normal baseline BMI (between 18.5 to 24.9 kg/m^2)[29], 608 (93.39%) were in the WHO clinical stage 1 during their last clinic visit, and 441 (67.85%) believed they were not at risk of contracting the COVID-19 (Table 1).

3.2. Factors associated with hesitancy toward the COVID-19 vaccine among the participants

Factors that independently associated with lower odds of being hesitant to COVID-19 vaccine included age $\geq$ 50 years (vs. 18 to 29 years) (aOR: 0.43; 95% CI: 0.21–0.89), being unemployed (aOR: 0.57; 95% CI: 0.34–0.95), and experience of ART side effects (aOR: 0.36; 95% CI: 0.15–0.86). Additionally, participants who believed they were at risk of contracting COVID-19 had significantly lower odds of being hesitant to the COVID-19 vaccine (aOR: 0.22; 95% CI: 0.13–0.37). However, we found that females had higher odds of COVID-19 vaccine hesitancy, compared to males (aOR, CI: 1.64, 1.02–2.61). Furthermore, compared to those receiving care at GH Gashua, participants attending ART centers at IDH Kano (aOR: 2.40; 95% CI: 1.10–5.25), MMSH Kano (aOR: 5.59; 95% CI: 1.97–10.66), YSSH Damaturu (aOR:9.88; 95% CI: 4.02–24.29) had significantly higher odds of being vaccine-hesitant. However, those attending the ART clinic at YSSH Potiskum have significantly lower odds of hesitancy (aOR: 0.25; 95% CI: 0.10–0.62) (Fig. 2).

3.3. Reasons for hesitancy towards the COVID-19 vaccine among the participants

Among 381 unvaccinated COVID-19 hesitant participants, 68% (n = 258) agreed or strongly agreed that the potential adverse effects of the vaccine were a reason for their hesitancy. Furthermore, 257 participants (67%) agreed or strongly agreed that they were hesitant about COVID-19 vaccination due to their skepticism about its effectiveness. Other reasons for hesitancy which participants agreed or strongly agreed with included: not witnessing the vaccine’s benefit or harm in other PLHIV (66%, n = 250), the rapid pace with which the COVID-19 vaccine was developed (64%, n = 242), and the fact that HIV has been present for decades without a cure or vaccine (63%, n = 227). Information regarding other reasons for hesitancy is given in Fig. 3.

4. Discussion

In this study, we observed a high COVID-19 vaccine hesitancy rate of 57.73% among COVID-19 unvaccinated PLHIV and identified factors independently associated with COVID-19 vaccine hesitancy, including age, sex, employment status, experiencing side

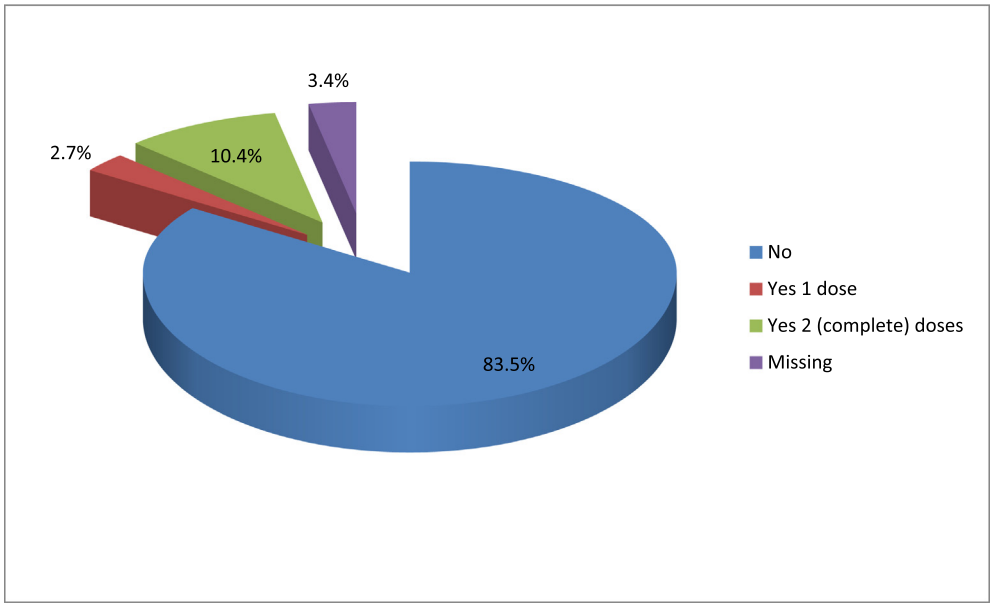

Fig. 1. Proportion of COVID-19 vaccine uptake, non-uptake, and missing data among the participants.

effects of ART, participants' belief regarding their risk of contracting COVID-19, and ART clinic.

The prevalence of hesitancy to the COVID-19 vaccine among COVID-19 unvaccinated PLHIV varies widely across previous studies;[12,13,20-24,39] however, the rate of hesitancy reported in our study lies towards the upper end of the spectrum of rates reported in previous reports conducted in low- and middle-income countries. This variation in the reported rates of hesitancy may be potentially be explained by differences in the burden of COVID-19 (morbidity and mortality) across the study settings, the timing of the studies relative to the onset of the pandemic, as well as differences in the socio-demographic composition of the studied populations, including participant's level of health literacy.[33,43,44] For example, one report indicated that 39% of initially hesitant PLHIV in a New York HIV clinic accepted the COVID-19 vaccine after receiving a health education intervention regarding the COVID-19 vaccine from their clinicians,[45] suggesting that differences in participants' level of knowledge about the vaccine may also explain the variations in the reported hesitancy rates. We would like to stress that our findings are only relevant to the population of PLHIV who have not yet received any dose of the COVID-19 vaccine, as they may be the population of primary interest for COVID-19 vaccination campaigns, particularly in the early days of the pandemic.

To date, vaccination remains the most effective way of providing lasting immunity against highly lethal viral diseases.[46] Vaccination is also essential in achieving the herd immunity needed to protect communities against epidemics. The WHO continues to support and advocate for achieving 70% COVID-19 vaccination coverage among the general population and 100% coverage among high-risk individuals, including PLHIV.[47](p19),[48] However, vaccine hesitancy, particularly in LMICs, remains a major factor impeding progress toward achieving these goals.[14,15] Thus, studies evaluating the factors associated with COVID-19 vaccine hesitancy will go a long way in guiding policymakers and relevant stakeholders in designing and developing tailored interventions to improve COVID-19 vaccine uptake, particularly among highly vulnerable populations like PLHIV.

Similar to a South African study,[49] we found that individuals aged 50 years and older had significantly lower odds of being vaccine-hesitant compared to those aged 18 to 29 years. Considering, the higher rate of COVID-19-related mortality among older individuals, our finding highlights the urgent need for interventions to address vaccine hesitancy, particularly among older PLHIV.[5,50] Also, similar to the findings of an Ethiopian study, [11] we found that females had significantly higher odds of COVID-19 vaccine hesitancy compared to males, underscoring the need for identification and evaluation of factors contributing to sex differences in COVID-19 vaccine hesitancy among PLHIV. Furthermore, our analysis demonstrated that unemployed PLHIV had significantly lower odds of hesitancy compared to the employed. On the contrary, a Chinese,[51] and a US study,[52] found that being unemployed is associated with significantly higher odds of hesitancy among PLHIV. Differences in vaccine policies between these countries and Nigeria may explain these conflicting results. For example, the COVID-19 vaccination policies in the US and China mandate or aggressively encourage employers to vaccinate their employees. Hence, employers in these countries may have greater incentive to aggressively educate their employees on the merits of the COVID-19 vaccination.

Furthermore, compared to those who attend ART clinic at GH Gashua, those who attend an ART clinic at GH Geidam had lower odds of being vaccine-hesitant, and those who attend ART clinics at MMSH, IDH, and YSSH Damaturu had a significantly higher odds of hesitancy. These differences in hesitancy among attendees of different ART clinics may in part be explained by differences in participants' level of exposure to COVID-19 vaccine-related misinformation, which may be higher among participants attending ART clinics in administrative capital cities because these participants likely have better access to the internet, which is one of the most common media through which such misinformation is massively spread. Also, given their relatively limited access to the internet, PLHIV in smaller towns may have to rely on the information they receive from legitimate sources (i.e. their healthcare providers), which may ultimately reduce their likelihood of being hesitant about receiving the vaccine.[13,40,51,53,54].

Also, our results indicate that participants who experienced the adverse effects of ART had significantly lower odds of being hesitant compared to those who had no prior experience of the side effects of ART. It is possible that having a history of adverse reac-

Table 1
Sociodemographic characteristics and crude odds ratios for factors associated with COVID-19 vaccine hesitancy among survey respondents.

Characteristic	Frequency (%)	Non-hesitant (%)	Hesitant (%)	Crude OR (95% CI)	P-value
Age group [mean (SD) = 39.76 (10.75) years]					
18 to 29	127 (16.06)	37 (13.26)	70 (18.37)	Ref.	
30 to 39	273 (34.51)	95 (34.05)	137 (35.96)	0.76 (0.47–1.23)	0.264
40 to 49	216 (27.31)	67 (24.01)	110 (28.87)	0.87 (0.53–1.43)	0.579
≥ 50	147 (18.58)	66 (23.66)	56 (14.70)	**0.45 (0.26–0.77)**	**0.003**
Sex					
Male	293 (37.04)	117 (41.94)	129 (33.86)	Ref.	
Female	489 (61.82)	157 (56.27)	250 (65.62)	**1.44 (1.05–1.99)**	**0.024**
Marital status					
Not married	311 (39.32)	103 (36.92)	161 (42.26)	Ref.	
Married	465 (58.79)	170 (60.93)	213 (55.91)	0.80 (0.58–1.10)	0.174
Highest level of education					
None	422 (53.35)	158 (56.63)	204 (53.54)	Ref.	
Primary	96 (12.14)	29 (10.39)	47 (12.34)	1.26 (0.76–2.08)	0.380
Secondary	156 (19.72)	53 (19.00)	80 (21.00)	1.67 (0.78–1.75)	0.449
Tertiary	105 (13.27)	34 (12.19)	47 (12.34)	1.07 (0.66–1.74)	0.784
Employment status					
Employed	208 (26.30)	62 (22.22)	111 (29.13)	Ref.	
Unemployed	565 (71.43)	210 (75.27)	263 (69.03)	0.70 (0.49–1.00)	0.052
Monthly income (NGN)					
30,000 and below	616 (77.88)	225 (80.65)	304 (79.79)	Ref.	
Above 30,000	138 (17.45)	40 (14.34)	60 (15.75)	1.11 (0.72–1.72)	0.638
Residence					
Rural	329 (41.59)	119 (42.65)	156 (40.94)	Ref.	
Urban	451 (57.02)	156 (55.91)	221 (58.01)	1.08 (0.79–1.48)	0.629
ART center					
GH Gashua	179 (22.63)	59 (21.15)	78 (20.47)	Ref.	
GH Geidam	66 (8.34)	47 (16.8%)	15 (3.94)	**0.24 (0.12–0.47)**	**<0.001**
IDH Kano	96 (12.14)	33 (11.83)	60 (15.75)	1.38 (0.80–2.37)	0.250
MMSH Kano	236 (29.84)	67 (24.01)	139 (36.48)	**1.57 (1.00–2.45)**	**0.048**
YSSH Damaturu	141 (17.83)	17 (6.09)	75 (19.69)	**3.34 (1.78–6.24)**	**<0.001**
YSSH Potiskum	70 (8.85)	56 (20.07)	13 (3.41)	**0.18 (0.09–0.35)**	**<0.001**
Year diagnosed HIV positive					
2015 and below	387 (38.93)	149 (53.41)	173 (45.41)	Ref.	
After 2015	389 (49.18)	126 (45.16)	201 (52.76)	**1.37 (1.00–1.88)**	**0.046**
Past HIV-related hospitalization					
Yes	84 (10.62)	32 (11.47)	41(10.76)	Ref.	
No	630 (79.65)	223 (79.93)	299 (78.48)	1.05 (0.64–1.71)	0.857
Not sure	51 (6.45)	16 (5.73)	27 (7.09)	1.32 (0.61–2.85)	0.484
Past TB-HIV treatment					
Yes	143 (18.08)	50 (17.92)	83 (21.78)	Ref.	
No	636 (80.04)	225 (80.65)	296 (77.69)	0.79 (0.54–1.17)	0.244
Experienced adverse effects to ART					
No	669 (84.58)	217 (77.78)	344 (90.29)	Ref.	
Yes	37 (6.19)	20 (7.17)	17 (4.46)	0.53 (0.27–1.04)	0.068
Last viral load					
Undetected	259 (32.74)	106 (37.99)	94 (24.67)	Ref.	
Detected	471 (59.54)	152 (54.48)	256 (67.19)	**1.90 (1.35–2.68)**	**<0.001**
BMI					
< 18.5	135 (17.07)	45 (16.13)	73 (19.16)	0.94 (0.58–1.52)	0.786
18.5–24.9	410 (51.83)	156 (55.91)	185 (48.56)	**0.68 (0.47–0.99)**	**0.046**
≥25	217 (27.43)	64 (22.94)	111 (29.13)	Ref.	
WHO clinical stage at last visit					
Stage 1	720 (91.02)	253 (90.68)	355 (93.18)	Ref.	
Stage 2	50 (6.32)	17 (6.09)	20 (5.25)	0.84 (0.43–1.63)	0.604
Stage 3	11 (1.39)	7 (2.51)	2 (0.52)	1.43 (0.26–7.84)	0.684
Perceived risk of contracting COVID-19					
No	493 (62.33)	173 (62.01)	268 (70.34)	Ref.	
Yes	274 (34.64)	104 (37.28)	105 (27.56)	**0.65 (0.47–0.91)**	**0.011**

Missing values: Age = 153; sex = 138; marital status = 144; highest level of education = 139; employment status = 145; monthly income = 162; residence = 139; ART center = 132; HIV-positive child = 159; year diagnosed HIV positive = 142; past HIV-related hospitalization = 153; past TB-HIV treatment = 137; experienced adverse effects of ART = 193; last viral load = 183; BMI = 157; WHO clinical stage at last visit = 140; perceived risk of contracting COVID-19 = 141. Bold font indicates statistical significance at alpha = 0.05.

tions to ART may have made this group have better health-seeking behavior. This may make them more likely to rely on healthcare professionals for obtaining health information/education (including information related to the COVID-19 vaccine), and therefore, less likely to be hesitant about the vaccine.

Of note, only about a quarter of the PLHIV in this study believed that they have a higher risk of contracting COVID-19, which may indicate that a majority of our participants have poor knowledge of the dangers associated with SARS-CoV-2 infection among PLHIV. Moreover, we found that those who perceived themselves as having a high risk of contracting SARS-CoV-2 infection had significantly lower odds of hesitancy, further indicating that the high rate of vaccine hesitancy observed in this study may have been occasioned by poor knowledge of the consequences of COVID-19 infection among our study participants. Therefore, interventions aimed at combating COVID-19 vaccine hesitancy among PLHIV

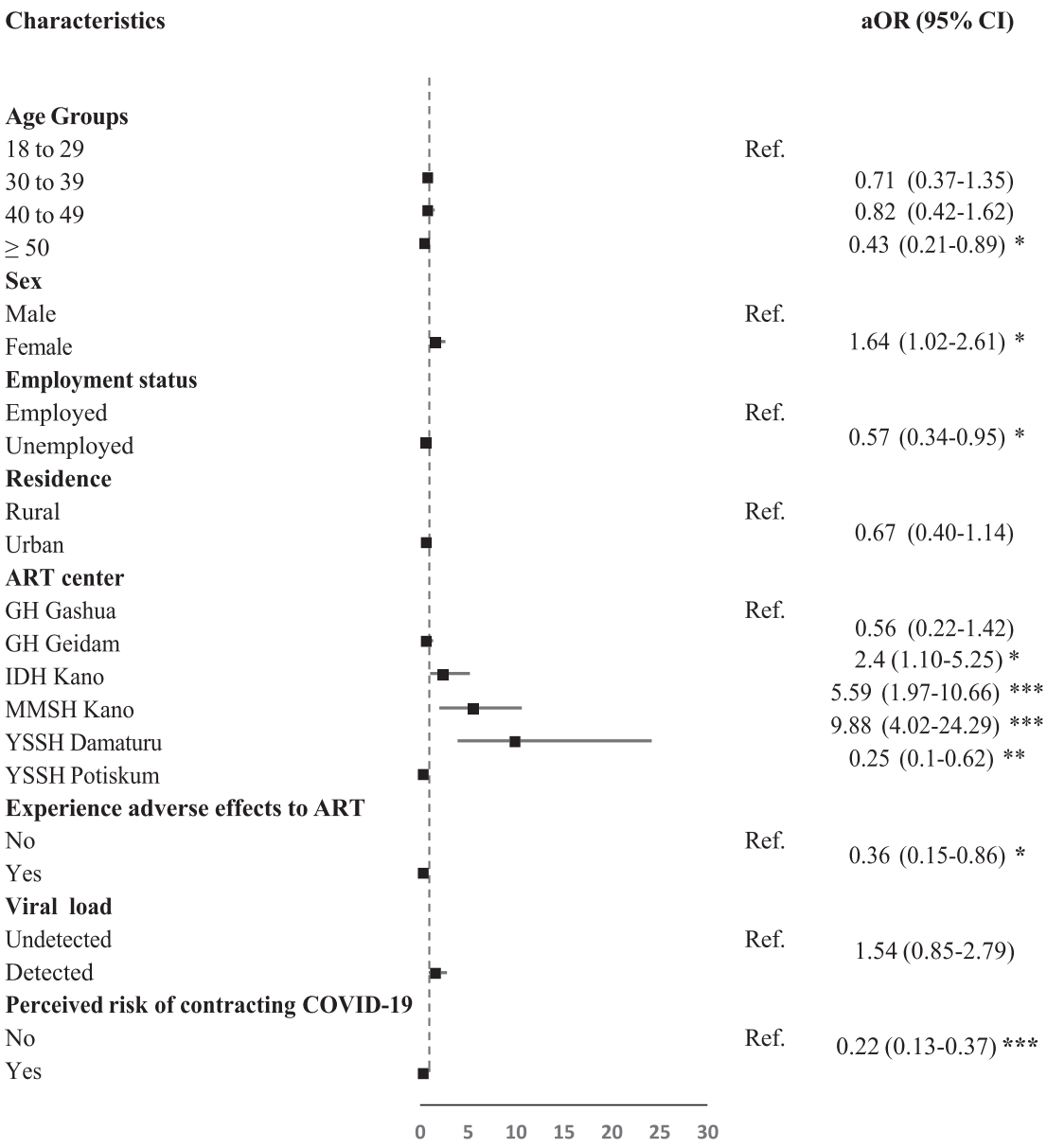

Fig. 2. Multivariable logistic regression model for factors independently associated with hesitancy to COVID-19 vaccine. AUC = 0.785, Hosmer–Lemeshow chi squared (8) = 8.00, p-value = 0.433. Keys: *= p-value < 0.05, **= p-value < 0.01, ***= p-value < 0.001.

need to pay close attention to educating this high-risk population about the elevated risk of severe SARS-CoV-2 infection and death among PLHIV.

The present study has also explored the reasons for hesitancy toward the COVID-19 vaccine among PLHIV. The most common reasons for hesitancy included concerns about the potential side effects of the vaccine and skepticism about the efficacy profile of the vaccines. These reasons have also been reported as the major reasons for hesitancy among PLHIV in previous studies.[24,55,56] Multivariable analysis in other studies also showed these factors to be independently associated with higher odds of hesitancy towards the COVID-19 vaccine.[10,12,21,51,57,58] The fact that these concerns have been vastly reported across several studies indicates a lack of public awareness about the proven safety and efficacy profile of the COVID-19 vaccine,[59] not only among the general population but also among PLHIV, who may even have a greater degree of routine contact with healthcare professionals than the general population.

4.1. Strengths & limitations

One of the strengths of this study is the use of face-to-face interviews, which has been shown to result in improved data accuracy, compared to online survey. Moreover, face-to-face interviewer-administered interviews also allow for the inclusion of participants who could not read/write and lacked formal education, a group that accounted for a significant number of PLHIV attending the selected study sites. Also, because the study participants were conveniently recruited by research assistants, rather than by individual participants, the bias of having like-minded people (hesitant for example) recruiting one another (which may be more likely with snowball sampling) may have been mitigated.

The findings of this study should also be interpreted while considering its limitations. Firstly, we employed a cross-sectional study design, which means that both COVID-19 vaccine hesitancy and its determinants were evaluated simultaneously. Therefore, the findings of this study may not be used to infer a causal relation-

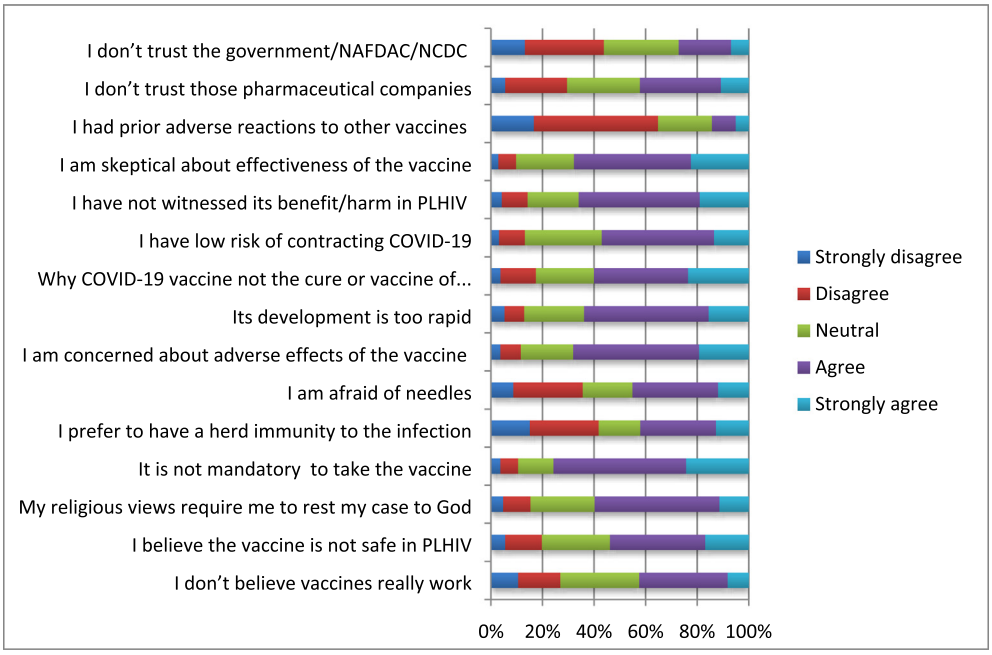

Fig. 3. Reasons for hesitancy towards accepting COVID-19 vaccine among the study participants.

ship between COVID-19 vaccine hesitancy and its associated factors. Also, we used the convenience sampling technique rather than the random sampling technique to recruit participants, thereby limiting the generalizability of our study. However, the present study's large sample size and our robust adjustment for potential sociodemographic confounders may help mitigate the bias that may be introduced by our chosen sampling technique.

5. Conclusion

In this multi-center study, we found a high rate of COVID-19 vaccine hesitancy among PLHIV, and the reported reasons for hesitancy indicate a poor level of knowledge of the COVID-19 vaccine and its benefit in this vulnerable population. Our findings, therefore, suggest the need for targeted educational interventions aimed at combating misperceptions and misinformation surrounding the COVID-19 vaccination program among PLHIV.

6. Declaration

Parts of the results of this study have been presented as poster abstract (number: P2.61) on 13th September 2022 at the 16th Vaccine Congress that was held at Riva del Garda Congress Centre, Lake Garda, Italy.

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Sahabi Kabir Sulaiman: Conceptualization, Investigation, Methodology, Formal analysis, Data curation, Supervision, Visualization, Resources, Validation, Project administration, Software, Writing - original draft, Writing - review & editing. **Muhammad Sale Musa.** Conceptualization, Investigation, Methodology, Data curation, Supervision, Visualization, Formal analysis, Validation, Writing - review & editing. **Fatimah Isma'il Tsiga-Ahmed:** Conceptualization, Supervision, Validation, Writing - review & editing. **Farouq Muhammad Dayyab:** Conceptualization, Supervision, Validation, Writing - review & editing. **Abdulwahab Kabir Sulaiman:** Conceptualization, Resources, Supervision, Validation, Writing - review & editing. **Bashir Dabo:** Conceptualization, Validation, Writing - review & editing. **Saidu Idris Ahmad:** Investigation, Investigation, Conceptualization, Validation, Writing - review & editing. **Salisu Abubakar Haruna:** Investigation, Conceptualization, Validation, Writing - review & editing. **Abdullahi Abdurrahman Zubair:** Investigation, Conceptualization, Validation, Writing - review & editing. **Aminu Hussein:** Investigation, Validation, Writing - review & editing. **Sadiya Usman:** Investigation, Validation. **Jummai Usman Wada:** Investigation, Validation. **Ayoola Yekeen Ayodele:** Writing – review & editing. **Muhammed Wulgo Ali:** Writing – review & editing. **Islam Umar Bello:** Investigation. **Alhaji Muhammad Isa.** Investigation. **Fatima Shettima Ali:** Investigation. **Abubakar Garba Ismail:** Investigation. **Bello Tijjani Makama:** Writing – review & editing. **Abdulkadir Dalhatu Abdulkadir:** Investigation. **Najib Jamal Abdulnasir:** Investigation. **Bashir Zakar Gambo:** Investigation. **Mukhtar Usman Mustapha:** Investigation. **Gambo Ibrahim:** Investigation. **Hadiza Adamu Dogo:** Investigation. **Fatima Ishaq Abubakar:** Investigation. **Yakubu kurugu:** Investigation. **Garba Auwal Yusufari:** Investigation. **Abubakar Yakubu:** Investigation. **Saeed Sulaiman:** Investigation. **Abdulaziz Tijjani Bako:** Conceptualization, Methodology, Supervision, Validation, Visualization, Data curation, Writing - review & editing.

Data availability

The authors do not have permission to share data.

Declaration of Competing 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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References

[1] Uwishema O, Taylor C, Lawal L, et al. The syndemic burden of HIV/AIDS in Africa amidst the COVID-19 pandemic. Immun Inflamm Dis 2022;10(1):26–32. https://doi.org/10.1002/iid3.544.
[2] Ssentongo P, Heilbrunn ES, Ssentongo AE, et al. Epidemiology and outcomes of COVID-19 in HIV-infected individuals: a systematic review and meta-analysis. Sci Rep 2021;11(1):6283. https://doi.org/10.1038/s41598-021-85359-3.
[3] Jakharia N, Subramanian AK, Shapiro AE. COVID-19 in the Immunocompromised Host, Including People with Human Immunodeficiency Virus. Infect Dis Clin 2022;36(2):397–421. https://doi.org/10.1016/j.idc.2022.01.006.
[4] Danwang C, Noubiap JJ, Robert A, Yombi JC. Outcomes of patients with HIV and COVID-19 co-infection: a systematic review and meta-analysis. AIDS Res Ther 2022;19(1):3. https://doi.org/10.1186/s12981-021-00427-y.
[5] Bertagnolio S, Thwin SS, Silva R, et al. Clinical features of, and risk factors for, severe or fatal COVID-19 among people living with HIV admitted to hospital: analysis of data from the WHO Global Clinical Platform of COVID-19. Lancet HIV 2022;9(7):e486–95. https://doi.org/10.1016/S2352-3018(22)00097-2.
[6] Oyelade T, Alqahtani JS, Hjazi AM, Li A, Kamila A, Raya RP. Global and Regional Prevalence and Outcomes of COVID-19 in People Living with HIV: A Systematic Review and Meta-Analysis. Trop Med Infect Dis 2022;7(2):22. https://doi.org/10.3390/tropicalmed7020022.
[7] Chen M, Yuan Y, Zhou Y, et al. Safety of SARS-CoV-2 vaccines: a systematic review and meta-analysis of randomized controlled trials. Infect Dis Poverty 2021;10(1):94. https://doi.org/10.1186/s40249-021-00878-5.
[8] Yuan P, Ai P, Liu Y, et al. Safety, Tolerability, and Immunogenicity of COVID-19 Vaccines: A Systematic Review and Meta-Analysis. *medRxiv*. Published online November 4, 2020:2020.11.03.202249910.1101/2020.11.03.20224998.
[9] Tamuzi JL, Muyaya LM, Mitra A, Nyasulu PS. Systematic review and meta-analysis of COVID-19 vaccines safety, tolerability, and efficacy among HIV-infected patients. Published online January 11, 2022:2022.01.11.222690410.1101/2022.01.11.22269049.
[10] Iliyasu Z, Kwaku AA, Umar AA, et al. Predictors of COVID-19 Vaccine Acceptability among Patients Living with HIV in Northern Nigeria: A Mixed Methods Study. Curr HIV Res 2022;20(1):82–90. https://doi.org/10.2174/1570162X19666211217093223.
[11] Mesfin Y, Argaw M, Geze S, Zewdu BT. Factors Associated with Intention to Receive COVID-19 Vaccine Among HIV Positive Patients Attending ART Clinic in Southwest Ethiopia. Patient Prefer Adherence 2021;15:2731–8. https://doi.org/10.2147/PPA.S342801.
[12] Shrestha R, Meyer JP, Shenoi S, et al. COVID-19 Vaccine Hesitancy and Associated Factors among People with HIV in the United States: Findings from a National Survey. Vaccines 2022;10:424. Published online 2022.
[13] Jones DL, Salazar AS, Rodriguez VJ, et al. Severe Acute Respiratory Syndrome Coronavirus 2: Vaccine Hesitancy Among Underrepresented Racial and Ethnic Groups With HIV in Miami, Florida. *Open Forum*. Infect Dis 2021;8(6):ofab154. https://doi.org/10.1093/ofid/ofab154.
[14] Pian W, Chi J, Ma F. The causes, impacts and countermeasures of COVID-19 "Infodemic": A systematic review using narrative synthesis. Inf Process Manag 2021;58(6):. https://doi.org/10.1016/j.ipm.2021.102713102713.
[15] Simas C, Larson HJ. Overcoming vaccine hesitancy in low-income and middle-income regions. Nat Rev Dis Primer 2021;7(1):1–2. https://doi.org/10.1038/s41572-021-00279-w.
[16] Wise J. Pfizer accused of testing new drug without ethical approval. BMJ 2001;322(7280):194. https://doi.org/10.1136/bmj.322.7280.194.
[17] Jegede AS. What Led to the Nigerian Boycott of the Polio Vaccination Campaign? PLOS Med 2007;4(3):e73.
[18] Rotshild V, Hirsh-Raccah B, Miskin I, Muszkat M, Matok I. Comparing the clinical efficacy of COVID-19 vaccines: a systematic review and network meta-analysis. Sci Rep 2021;11(1):22777. https://doi.org/10.1038/s41598-021-02321-z.
[19] Bernal JL, Andrews N, Gower C, et al. Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on covid-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. BMJ 2021;373:. https://doi.org/10.1136/bmj.n1088n1088.

[20] Chai R, Yang J, Zhang X, et al. Reasons for COVID-19 Vaccine Hesitancy Among Chinese People Living With HIV/AIDS: Structural Equation Modeling Analysis. JMIR Public Health Surveill 2022;8(6):e33995.
[21] Vallée A, Fourn E, Majerholc C, Touche P, Zucman D. COVID-19 Vaccine Hesitancy among French People Living with HIV. Vaccines 2021;9(4):302. https://doi.org/10.3390/vaccines9040302.
[22] Ekstrand ML, Heylen E, Gandhi M, Steward WT, Pereira M, Srinivasan K. COVID-19 Vaccine Hesitancy Among PLWH in South India: Implications for Vaccination Campaigns. J Acquir Immune Defic Syndr 1999. 2021,;88 (5):421–5. https://doi.org/10.1097/QAI.0000000000002803.
[23] Jaiswal J, Krause KD, Martino RJ, et al. SARS-CoV-2 Vaccination Hesitancy and Behaviors in a National Sample of People Living with HIV. AIDS Patient Care STDs 2022;36(1):34–44. https://doi.org/10.1089/apc.2021.0144.
[24] Zheng W, Sun Y, Li H, et al. COVID-19 vaccine uptake and hesitancy among HIV-infected men who have sex with men in mainland China: a cross-sectional survey. Hum Vaccines Immunother 2021;17(12):4971–81. https://doi.org/10.1080/21645515.2021.1996152.
[25] Lwanga SK, Lemeshow S, Organization WH. Sample size determination in health studies : a practical manual Accessed October 27, 2021. World Health Organization 1991. https://apps.who.int/iris/handle/10665/40062.
[26] Jager J, Putnick DL, Bornstein MH. More than Just Convenient: The Scientific Merits of Homogeneous Convenience Samples. Monogr Soc Res Child Dev 2017;82(2):13–30. https://doi.org/10.1111/mono.12296.
[27] Suen LJW, Huang HM, Lee HH. A comparison of convenience sampling and purposive sampling. Hu Li Za Zhi 2014;61(3):105–11. https://doi.org/10.6224/JN.61.3.105.
[28] MacDonald NE. Vaccine hesitancy: Definition, scope and determinants. Vaccine 2015;33(34):4161–4. https://doi.org/10.1016/j.vaccine.2015.04.036.
[29] Jan A, Weir CB. BMI Classification Percentile and Cut Off Points. StatPearls Treasure Isl FL USA: Published online; 2021.
[30] Lane S, MacDonald NE, Marti M, Dumolard L. Vaccine hesitancy around the globe: Analysis of three years of WHO/UNICEF Joint Reporting Form data-2015–2017. Vaccine 2018;36(26):3861–7. https://doi.org/10.1016/j.vaccine.2018.03.063.
[31] Dubé E, Gagnon D, Nickels E, Jeram S, Schuster M. Mapping vaccine hesitancy—Country-specific characteristics of a global phenomenon. Vaccine 2014;32 (49):6649–54. https://doi.org/10.1016/j.vaccine.2014.09.039.
[32] Dubé E, Vivion M, MacDonald NE. Vaccine hesitancy, vaccine refusal and the anti-vaccine movement: influence, impact and implications. Expert Rev Vaccines 2015;14(1):99–117. https://doi.org/10.1586/14760584.2015.964212.
[33] Larson HJ, Jarrett C, Eckersberger E, Smith DMD, Paterson P. Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007–2012. Vaccine 2014;32 (19):2150–9. https://doi.org/10.1016/j.vaccine.2014.01.081.
[34] Chataway J. Attitudes to vaccination: A critical review. Published online November 13, 2021. Accessed November 13, 2021. https://core.ac.uk/reader/82212690.
[35] Ackah BBB, Woo M, Stallwood L, et al. COVID-19 vaccine hesitancy in Africa: a scoping review. Glob Health Res Policy 2022;7(1):21. https://doi.org/10.1186/s41256-022-00255-1.
[36] Aborode AT, Fajemisin EA, Ekwebelem OC, et al. Vaccine hesitancy in Africa: causes and strategies to the rescue. *Ther Adv Vaccines Immunother*. 2021;9:25151355211047510. 10.1177/25151355211047514.
[37] Association (WMA) WM. Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects. *Jahrb Für Wiss Ethik*. 2009;14(1):233-238. 10.1515/9783110208856.233.
[38] Holt M, MacGibbon J, Bavinton B, et al. COVID-19 Vaccination Uptake and Hesitancy in a National Sample of Australian Gay and Bisexual Men. AIDS Behav 2022;26(8):2531–8. https://doi.org/10.1007/s10461-022-03603-x.
[39] Shallangwa MM, Musa SS, Iwenya HC, Manirambona E, Iii DELP, Tukur BM. Assessment of COVID-19 vaccine hesitancy among people living with HIV/AIDS: a single-centered study. PAMJ - One Health. 2023;10(2). 10.11604/pamj-oh.2023.10.2.37945.
[40] Huang X, Yu M, Fu G, et al. Willingness to Receive COVID-19 Vaccination Among People Living With HIV and AIDS in China: Nationwide Cross-sectional Online Survey. JMIR Public Health Surveill 2021;7(10):e31125.
[41] Muhindo R, Okoboi S, Kiragga A, King R, Arinaitwe WJ, Castelnuovo B. COVID-19 vaccine acceptability, and uptake among people living with HIV in Uganda. PLoS One 2022;17(12):e0278692.
[42] Hosmer D. Assessing the fit of the model. *Appl Logist Regres*. Published online 2000:143–202.
[43] Robinson E, Jones A, Lesser I, Daly M. International estimates of intended uptake and refusal of COVID-19 vaccines: A rapid systematic review and meta-analysis of large nationally representative samples. Vaccine 2021;39 (15):2024–34. https://doi.org/10.1016/j.vaccine.2021.02.005.
[44] Aboelsaad IAF, Hafez DM, Almaghraby A, et al. Systematic Review and Meta-analysis on COVID-19 Vaccine Hesitancy. Published online May 18, 2021:2021.05.15.21257261. 10.1101/2021.05.15.21257261.
[45] Buckley M, Shayani K, Spier D, Stefanov D, Ahmadi L. Attitudes Towards COVID-19 Vaccination in People Living with HIV (PLWHIV) at an Urban Primary Care Clinic. Published online May 23, 2022. Accessed June 16, 2022. https://papers.ssrn.com/abstract=4113173.
[46] Trovato M, Sartorius R, D'Apice L, Manco R, De Berardinis P. Viral Emerging Diseases: Challenges in Developing Vaccination Strategies. *Front Immunol*. 2020;11. Accessed July 21, 2022. https://www.frontiersin.org/articles/10.3389/fimmu.2020.02130.
[47] WHO COVID-19 vaccines. Accessed July 21, 2022. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines.
[48] Coronavirus disease (COVID-19): COVID-19 vaccines and people living with HIV. Accessed July 21, 2022. https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-(covid-19)-covid-19-vaccines-and-people-living-with-hiv.
[49] Govere-Hwenje S, Jarolimova J, Yan J, et al. Willingness to accept COVID-19 vaccination among people living with HIV in a high HIV prevalence community. *Res Sq*. Published online April 12, 2022:rs.3.rs-824083. 10.21203/rs.3.rs-824083/v1.
[50] Varshney K, Ghosh P, Stiles H, Iriowen R. Risk Factors for COVID-19 Mortality Among People Living with HIV: A Scoping Review. AIDS Behav 2022;26 (7):2256–65. https://doi.org/10.1007/s10461-022-03578-9.
[51] Yang J, Yu M, Fu G, et al. COVID-19 Vaccination Uptake Among a Nationwide Sample of People Living With HIV During the Early Phase of Vaccine Rollout in China. Front Med 2022;9:. https://doi.org/10.3389/fmed.2022.822680822680.
[52] Davtyan M, Frederick T, Taylor J, Christensen C, Brown BJ, Nguyen AL. Determinants of COVID-19 vaccine acceptability among older adults living with HIV. Medicine (Baltimore) 2022;101(31):e29907.
[53] Kaida A, Brotto LA, Murray MCM, et al. Intention to Receive a COVID-19 Vaccine by HIV Status Among a Population-Based Sample of Women and Gender Diverse Individuals in British Columbia. Canada *AIDS Behav* 2022;26 (7):2242–55. https://doi.org/10.1007/s10461-022-03577-w.
[54] Mohamed R, White TM, Lazarus JV, et al. COVID-19 vaccine acceptance and associated factors among people living with HIV in the Middle East and North Africa region. South Afr J HIV Med 2022;23(1):1391. https://doi.org/10.4102/sajhivmed.v23i1.1391.
[55] Ortiz-Martínez Y, López-López MÁ, Ruiz-González CE, et al. Willingness to receive COVID-19 vaccination in people living with HIV/AIDS from Latin America. Int J STD AIDS 2022;33(7):652–9. https://doi.org/10.1177/09564624221091752.
[56] Wu S, Ming F, Xing Z, et al. COVID-19 Vaccination Willingness Among People Living With HIV in Wuhan, China. Front Public Health 2022;10:. https://doi.org/10.3389/fpubh.2022.883453883453.
[57] Su J, Jia Z, Wang X, et al. Acceptance of COVID-19 vaccination and influencing factors among people living with HIV in Guangxi, China: a cross-sectional survey. BMC Infect Dis 2022;22(1):471. https://doi.org/10.1186/s12879-022-07452-w.
[58] Zhao H, Wang H, Li H, et al. Uptake and adverse reactions of COVID-19 vaccination among people living with HIV in China: a case–control study. Hum Vaccines Immunother 2021;17(12):4964–70. https://doi.org/10.1080/21645515.2021.1991183.
[59] Liu Y, Han J, Li X, et al. COVID-19 Vaccination in People Living with HIV (PLWH) in China: A Cross Sectional Study of Vaccine Hesitancy, Safety, and Immunogenicity. Vaccines 2021;9(12):1458. https://doi.org/10.3390/vaccines9121458.