




BMJ Open Variations in COVID-19 vaccine hesitancy over time: a serial cross-sectional study in five West African countries

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ABSTRACT

Objectives This study aims to identify the factors influencing vaccine hesitancy, willingness and its variation over time in order to inform more responsive strategies for increasing vaccination uptake. The specific objectives are: (1) to describe and compare levels of COVID-19 vaccine hesitancy among the general population in rural and urban settings in West Africa over time and (2) to identify factors associated with COVID-19 vaccination willingness and hesitancy among the general population across five West African countries over time.

Design Following a baseline survey (Wave I), three serial cross-sectional surveys (Waves II-IV) were implemented.

Setting The study was conducted in Burkina Faso, Guinea, Mali, Senegal and Sierra Leone from November 2021 to July 2022.

Participants A total of 13 571 study participants were included in the study (n=4373, n=4593 and n=4605 for survey Waves II, III and IV, respectively). Inclusion criteria were being 18 years or older, living in the study area and willing to provide informed consent. A two-stage sampling strategy was used to select the sample from among the general population.

Primary and secondary outcomes Primary outcomes were the variability of vaccine hesitancy over time and across the five West African countries. Secondary outcomes were factors associated with vaccine willingness.

Results A small but steady increase in hesitancy to COVID-19-vaccination can be observed across countries, with an upward trend of vaccine hesitancy reported by 952 participants (33.9%) in Wave II, 1055 (37.3%) in Wave III and 1089 (38.1%) in Wave IV. Among the countries included, Senegal shows the highest level of vaccine hesitancy ('Definitely no' and 'Probably no' ranging from 50.2% to 56.0% and 26.2 to 28.3%, respectively). At the same time, Senegal has the lowest vaccination coverage overall. Across all five countries and survey waves, the primary factor associated with vaccination willingness is fear of experiencing severe COVID-19 disease (Wave II: OR 0.42, 95% CI 0.34 to 0.51, Wave III: OR 0.48, 95% CI 0.40 to 0.59 and Wave IV: OR 0.54, 95% CI 0.44 to 0.66).

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The sample of the study was selected at different time points in five West African countries.
- ⇒ Data were collected during different phases of the COVID-19 pandemic.
- ⇒ The rural communities addressed in the study have been selected from among the surroundings of the capital cities of the five countries included, which limits the generalisability of the findings to the entire countries.
- ⇒ The study relied on self-reported data, which can be susceptible to social desirability bias; however, the influence of this bias is likely to have had a minimal impact on this study's main findings.

Perceived improved financial status seems to influence willingness to get vaccinated negatively (OR 0.57, 95% CI 0.40 to 0.81) and unlike in Western, Educated, Industrialised, Rich and Democratic countries, men seem more reluctant to get vaccinated than women (OR 0.77, 95%, CI 0.65 to 0.93).

Conclusions Our findings suggest that vaccine hesitancy should be monitored over time to inform communication strategies, which are responsive to changes in vaccination-related public sentiments. Additionally, a focus on social solidarity and the importance of women in vaccination advocacy can help improve COVID-19 vaccination coverage in West Africa.

Trial registration number The general protocol is registered on clinicaltrials.gov (protocol number: [NCT04912284](https://clinicaltrials.gov/ct2/show/study/NCT04912284)).

INTRODUCTION

Following the approval of vaccines against COVID-19 in late 2020, most sub-Saharan African (SSA) countries rolled out their vaccination campaigns throughout 2021 although at different speeds.¹ While in the beginning, insufficient vaccine supply and access were

the primary limiting factors for the success of vaccination efforts, high rates of vaccine hesitancy in countries, such as Burkina Faso, Guinea, Mali, Senegal and Sierra Leone, emerged as an additional important barrier.²

While vaccination willingness can be defined as the intent or motivation to be vaccinated, vaccine hesitancy refers to a 'delay in acceptance or refusal of vaccination despite availability of vaccination services'³ and is recognised as one major global health threat.⁴ The phenomenon of vaccine hesitancy has received renewed impetus in the wake of the COVID-19 pandemic. Vaccine hesitancy refers to 'the psychological state of being undecided',⁵ and is therefore dynamic by nature.⁶ Vaccine hesitancy can vary depending on the type of vaccine and is subject to the influence of a wide range of factors. In the case of hesitancy against COVID-19 vaccines, the dynamics of the communication and information environment have played a critical role in the variation of sentiments around the vaccines, sometimes prompting acceptance/willingness and at other times hesitancy, delays or refusal of vaccination.⁶ Several studies have described spikes of vaccine hesitancy in different countries against the backdrop of multiple coinciding factors, such as new information, new policies or newly reported vaccine risks. This, in addition to differences in vaccine availability and accessibility, has contributed to a delay in the global uptake of COVID-19 vaccination. As a result, the circulation of SARS-CoV-2 has continued, leading to the emergence of new variants of interest. These variants have contributed to a decrease in the effectiveness of COVID-19 vaccines.

Since March 2021, countries in SSA have implemented diverse COVID-19 vaccination strategies, taking into account factors such as local epidemiology, availability and accessibility of vaccines.⁷ These strategies have yielded varying degrees of success in terms of vaccine coverage. Considering this context of changing vaccination coverage between 2021 and 2022, the present study used a serial cross-sectional survey with three time points to describe the dynamic nature of COVID-19 vaccine hesitancy and its variations in five West African countries (Burkina Faso, Guinea, Mali, Senegal and Sierra Leone).

The overall aim of the study was to describe and examine variations in COVID-19 vaccine hesitancy over time among the general rural and urban population in five West African countries (Burkina Faso, Guinea, Mali, Senegal and Sierra Leone) between the start of the vaccine roll out in 2021 and the more advanced phase in 2022. The specific objectives were (1) to describe and compare levels of COVID-19 vaccine hesitancy among the general population in rural and urban settings in West Africa over time and (2) to identify factors associated with COVID-19 vaccination willingness and hesitancy among the general population, across five West African countries over time. The findings of the baseline cross-sectional survey (Wave I) have already been published.² This paper reports the results of Waves II, III and IV of our serial cross-sectional surveys performed in the general population.

MATERIALS AND METHODS

Study design and settings

This study conducted serial cross-sectional surveys at three different time points between November 2021 and July 2022 in five West African countries: Burkina Faso, Guinea, Mali, Senegal and Sierra Leone. For all countries, study sites were selected in consultation with the local principal investigators from among communities in the capital cities and their rural surroundings. The partners for each country were *Institut de Recherche en Sciences de la Santé* (IRSS/CNRST, Ouagadougou, Burkina Faso), *Santé Plus* Guinea (Conakry, Guinea), University of Sciences, Techniques and Technologies of Bamako (USTTB, Bamako, Mali), University Cheikh Anta Diop—Dakar (Dakar, Senegal) and University of Sierra Leone (Freetown, Sierra Leone).

Sample and sampling strategy

Study participants were selected from among the general population aged older than 18 years. Participation was voluntary and based on written informed consent. Participants were randomly selected from among the general population within predefined rural and urban study areas using a two-stage sampling strategy as described in detail elsewhere.² Briefly, an adjusted random walk procedure was applied. Within each cluster, between eight and 12 random walks were conducted and an equal number of interviews were conducted per random walk. Each random walk started on a randomly assigned location mark predefined through Global Positioning System (GPS) coordinates validated by the field teams before starting recruitment. Coordinates were selected in consecutive order from these valid location marks in order to start the random walks.

Sample size

The study sample size was calculated to estimate the proportion of the population willing to be vaccinated against COVID-19. Assuming a proportion of 0.5 (a conservative estimate, leading to the highest sample size) with a 95% confidence level that the true value is within $\pm 5\%$ of the survey value, considering an average population of 1 million inhabitants per region. The calculated sample size has been corrected considering a response rate of 80.0%. It was estimated that 432 people needed to be interviewed (385 uncorrected), in both urban and rural areas per survey wave.

Data collection

Survey data were collected between 18 November and 9 December 2021 for Wave II, 21 March and 6 April 2022 for Wave III and 20 June and 20 July 2022 for Wave IV. Participants were invited to take part in face-to-face structured interviews using a 45-item questionnaire. The questionnaire as described previously² was adapted in light of the findings of the baseline survey and adapted to include additional validated survey questions designed to measure COVID-19 vaccine hesitancy.⁸ At the time of

data collection, COVID-19 vaccination roll out was about to start in the study countries, and part of our study population had already been offered a vaccine. In Senegal, this part of the population, on specific request of the country's ethical commission, was excluded from the analysis.

Data analysis

We performed a descriptive analysis of sociodemographic characteristics, history of COVID-19 infection, concerns about having COVID-19 and the risk of having severe COVID-19, COVID-19 vaccination history and vaccination willingness and hesitancy among the non-vaccinated participants by country and by survey wave. Categorical variables were described in terms of numbers and percentages. The participants not yet vaccinated against COVID-19 were defined as respondents who answered 'No', 'I don't know' or 'I don't want to answer' to the question 'Have you ever received COVID-19 vaccination?' An indirect comparison with external data from WHO and state data of the percentage of people who received at least one dose of COVID-19 vaccine per country at the time of each wave was performed.⁹

Vaccination willingness was defined as responding 'Definitely Yes' or 'probably Yes', while vaccination hesitancy as responding 'Definitely no' or 'Probably no' or 'I don't know', to the question 'If you had access to a vaccine against COVID-19 infection, would you want to get vaccinated?' Multivariable logistic regression analyses were performed for each wave respectively (three regression models in total) to determine the association between willingness to be vaccinated (explanatory variable) and the following variables: age (reference: age 18–30), sex (reference: female), country (reference: Mali), ever had formal education (reference: no), living area (reference: rural), perceived financial situation (reference: worsened), history of COVID-19 (reference: no), worried to get COVID-19 (reference: worried) and perceived risk of severe COVID-19 (reference: no). Other variables were not included in the model because of the limited number of available observations (online supplemental tables 1 and 2). The analyses were conducted using the available data, with no imputation performed, as the missing data were assumed to be missing at random.

A p value of <0.05 was considered statistically significant. All the analyses were conducted using R software (V.4.2.3).

Patient and public involvement

The patients and public were not involved in the design of the study and the research instrument mainly due to time constraints since the first survey wave was meant to be conducted in the early phases of vaccine roll out in the partner countries. However, the public has been engaged in the dissemination of the results. Two webinars (one in French and one in English) were organised on 30 June 2021 in order to make the findings available to local stakeholders in order to inform vaccination strategies in a timely manner. Additionally, individual reports

have been submitted to the ethical commissions of those countries, which have requested them so far (ie, Guinea and Mali). On publication, the manuscript will be disseminated through social media and non-peer communication channels in order to reach a wide spectrum of the population.

Institutional review board and ethical considerations

Alongside a general study protocol, which defined the general rules for sampling strategy, sample size, selection of the recruitment areas and the ethical principles on which the survey is based, country-specific protocols were developed. The general protocol was submitted and approved by the Hamburg Ethical Commission (protocol number: 2021–10550-BO-ff). The country-specific protocols were submitted and approved by the ethical commissions of Burkina Faso (protocol number: 2021-05-115), Guinea (protocol number: 97/CNERS/21), Mali (protocol number: 2021/118/CE/USTTB), Senegal (protocol number: 00000065/MSAS/CNERS/SP) and Sierra Leone (protocol number: SLERSC deliberated 11.05.21 no official code). Data were collected according to a standard Good Clinical Practices (GCP) procedure. The general protocol is registered on clinicaltrials.gov (protocol number: NCT04912284).

RESULTS

Study population characteristics

A total of 13 571 study participants were included in the study, that is, 4373 for Wave II, 4593 for Wave III and 4605 for Wave IV (figure 1). The distribution of respondents across countries was balanced for each wave, with Burkina Faso, Guinea, Mali, Senegal and Sierra Leone all evenly represented. Specifically, Wave II had 884 (20.2%) participants from Burkina Faso, 859 (19.6%) from Guinea, 880 (20.1%) from Mali, 890 (20.4%) from Senegal and 860 (19.7%) from Sierra Leone. In Wave III, Burkina Faso had 940 (20.5%) participants, Guinea had 846 (18.4%), Mali had 867 (18.9%), Senegal had 893 (19.4%) and Sierra Leone had 1047 (22.8%). Finally, Wave IV had 999 (21.7%) participants from Burkina Faso, 810 (17.6%) from Guinea, (18.8%) 865 from Mali, 903 (19.6%) from Senegal and 1028 (22.3%) from Sierra Leone.

Participants' background characteristics stratified by country and wave are described in table 1. Sex and urbanicity ratios were well distributed across survey waves and countries. The percentage of respondents who ever had received formal education was in between 71.0% and 75.0%. Apart from Senegal, the majority of respondents reported that their financial situation had grown worse during the last 3 months of the period under review. In Senegal, only 160 (18.0%) of respondents in Wave II, 386 (43.2%) in Wave III and 224 (24.8%) in Wave IV reported a deterioration in their financial situation. A downward trend across all three waves can be seen in terms of ever being infected with SARS-CoV-2. The number of participants who reported to have tested positive for COVID-19

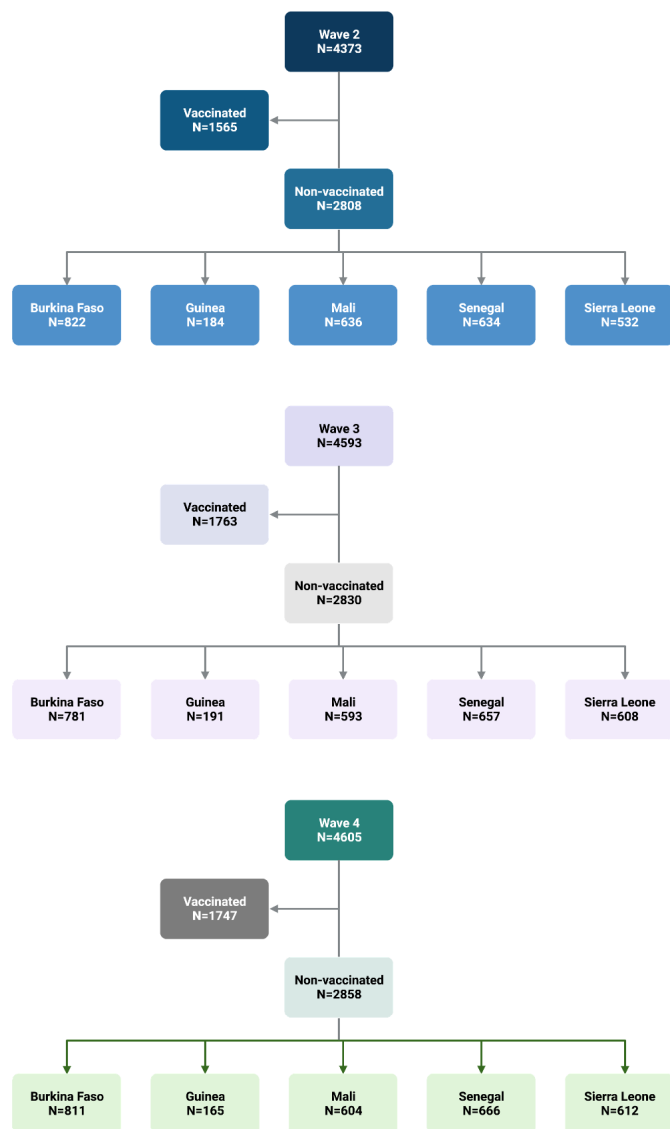


Figure 1 Flow chart depicting the distribution of participants per study wave and country.

at least once was very low, with a continuous decrease in numbers from 5.0% in Wave II to merely 2.9% in Wave IV.

Vaccine willingness, hesitancy and refusal in five West African countries

The COVID-19 infection status, COVID-19 vaccination status and willingness to get vaccinated against COVID-19 are described by survey waves in Supplementry Table 1. The percentage of participants who reported to have had a previous COVID-19 disease was low, from 5.0% for Wave II to 2.9% for Wave IV.

Non-vaccinated participants included in the analysis were 2765 (63.2%) from Wave II, 2801 (61.0%) from Wave III and 768 (60.1%) from Wave IV. Figure 2 shows the raw number of hesitant respondents for each wave compared with the total population with at least one dose administered. Contrary to the increasing number of people who have started the vaccination cycle, there is a uniform slight increase in hesitancy too. It is important

to know that Senegal stopped sharing the data about the public vaccination campaign before the end of our survey in July 2022.

Trends about COVID-19 vaccination based on background variables (sex, area, minimal level of education and age groups) are graphically represented in online supplemental figures 1–4. Males in Mali and Senegal had a higher proportion of vaccinated individuals compared with females. Furthermore, participants who had attended school had a higher COVID-19 vaccination rate in all countries, except Guinea.

Among non-vaccinated participants, the willingness to receive a COVID-19 vaccination is described by country and waves in figure 3. The majority of participants had a clear choice as to their attitude towards COVID-19 vaccination, with either a ‘definitively Yes’ or ‘definitively No’ response. A slow but steady increase in absolute hesitancy to vaccination is seen by the ‘definitely no’ response given by the respondents, with a trend of 952 (33.9%) in Wave II, 1055 (37.3%) in Wave III and 1089 (38.1%) in Wave IV. Senegal seemed to have a different pattern from other countries with a strong hesitancy of vaccination, ‘Definitely no’ and ‘Probably no’ ranging from 50.2 to 56.0% and 26.2 to 28.3%, respectively. A stable decline in respondents willing to get vaccinated can be seen over time.

COVID-19 risk perceptions

In terms of the perceived risk of getting COVID-19 and concerns about developing a severe form of the disease, overall, less than half of the respondents reported not being worried at all about getting infected (around 35.0%). However, in Senegal, 71.0% of the respondents were concerned about getting COVID-19 in Wave II, 57.4% in Wave III and 65.3% in Wave IV. By contrast, a greater proportion of the population surveyed were aware of the risk of developing a severe form of COVID-19, starting from 58.2% in Wave II to 50.1% in Wave IV. However, differences can be seen between countries. In fact, during Wave III, the proportion of individuals in Burkina Faso, Guinea and Sierra Leone who reported being aware of the risk of severe illness from the COVID-19 infection peaked, with estimates ranging from approximately 55.0% to 70.0%. They then proceed to decline during Wave IV, with Guinea registering the lowest point at 31.0%, Sierra Leone around 35.0% and Burkina Faso at 58.0%. On the other hand, Mali dropped from 68.0% in Wave II to 47.0% and then to 49.0% for the two subsequent Waves. For Senegal, the proportion of those who reported to be aware of the potential of getting severe form of COVID-19 increased from 45.1% (n=286) in Wave II to 47.8% (n=314) in Wave III and to 59.2% (n=394) in Wave IV.

Factors associated with COVID-19 vaccination willingness

Figure 3 summarises the results of the multiple regression analysis of factors associated with willingness to get vaccinated against COVID-19, segregated by survey waves II, III and IV.

Table 1 Description of the sociodemographic characteristics, by survey waves, among the general study population

Wave II		Burkina Faso (n=884)	Guinea (n=859)	Mali (n=880)	Senegal (n=890)	Sierra Leone (n=860)	Total (n=4373)
Age	(18–30)	362 (41.0%)	324 (37.7%)	246 (28.0%)	441 (49.6%)	390 (45.3%)	1763 (40.3%)
	(31–40)	258 (29.2%)	212 (24.7%)	203 (23.1%)	251 (28.2%)	297 (34.5%)	1221 (27.9%)
	40+	264 (29.9%)	323 (37.6%)	431 (49%)	198 (22.2%)	173 (20.1%)	1389 (31.8%)
Sex	Female	533 (60.3%)	392 (45.6%)	388 (44.1%)	319 (35.8%)	427 (49.7%)	2059 (47.1%)
	Male	351 (39.7%)	467 (54.4%)	492 (55.9%)	571 (64.2%)	433 (50.3%)	2314 (52.9%)
Area	Rural	451 (51.0%)	431 (50.2%)	436 (49.5%)	446 (50.1%)	467 (54.3%)	2231 (51.0%)
	Urban	433 (49.0%)	428 (49.8%)	444 (50.5%)	444 (49.9%)	393 (45.7%)	2142 (49.0%)
Ever had formal education	No	335 (37.9%)	283 (32.9%)	267 (30.3%)	184 (20.7%)	172 (20.0%)	1241 (28.4%)
	Yes	549 (62.1%)	576 (67.1%)	613 (69.7%)	706 (79.3%)	688 (80.0%)	3132 (71.6%)
Perceived financial status	Worsened	670 (75.8%)	523 (60.9%)	568 (64.5%)	192 (21.6%)	637 (74.1%)	2590 (59.2%)
	Improved	30 (3.4%)	52 (6.1%)	12 (1.4%)	323 (36.3%)	58 (6.7%)	475 (10.9%)
	Unaltered	184 (20.8%)	284 (33.1%)	300 (34.1%)	375 (42.1%)	165 (19.2%)	1308 (29.9%)
Wave III		Burkina Faso (n=940)	Guinea (n=846)	Mali (n=867)	Senegal (n=893)	Sierra Leone (n=1047)	Total (n=4593)
Age	(18–30)	378 (40.2%)	336 (39.7%)	190 (21.9%)	387 (43.3%)	475 (45.4%)	1766 (38.4%)
	(31–40)	284 (30.2%)	231 (27.3%)	249 (28.7%)	287 (32.1%)	334 (31.9%)	1385 (30.2%)
	40+	278 (29.6%)	279 (33%)	428 (49.4%)	219 (24.5%)	238 (22.7%)	1442 (31.4%)
Sex	Female	522 (55.5%)	485 (57.3%)	364 (42.0%)	237 (26.5%)	454 (43.4%)	2062 (44.9%)
	Male	418 (44.5%)	361 (42.7%)	503 (58.0%)	656 (73.5%)	593 (56.6%)	2531 (55.1%)
Area	Rural	453 (48.2%)	423 (50.0%)	439 (50.6%)	449 (50.3%)	517 (49.4%)	2281 (49.7%)
	Urban	487 (51.8%)	423 (50.0%)	428 (49.4%)	444 (49.7%)	530 (50.6%)	2312 (50.3%)
Ever had formal education	No	326 (34.7%)	272 (32.2%)	313 (36.1%)	88 (9.9%)	132 (12.6%)	1131 (24.6%)
	Yes	614 (65.3%)	574 (67.8%)	554 (63.9%)	805 (90.1%)	915 (87.4%)	3462 (75.4%)
Perceived financial status	Worsened	533 (56.7%)	577 (68.2%)	491 (56.6%)	417 (46.7%)	568 (54.3%)	2586 (56.3%)
	Improved	10 (1.1%)	33 (3.9%)	11 (1.3%)	229 (25.6%)	144 (13.8%)	427 (9.3%)
	Unaltered	397 (42.2%)	236 (27.9%)	365 (42.1%)	247 (27.7%)	335 (32.0%)	1580 (34.4%)
Wave IV		Burkina Faso (n=999)	Guinea (n=810)	Mali (n=865)	Senegal (n=903)	Sierra Leone (n=1028)	Total (n=4605)
Age	(18–30)	400 (40.0%)	313 (38.6%)	214 (24.7%)	354 (39.2%)	507 (49.3%)	1788 (38.8%)
	(31–40)	276 (27.6%)	214 (26.4%)	242 (28.0%)	284 (31.5%)	290 (28.2%)	1306 (28.4%)
	40+	323 (32.3%)	283 (34.9%)	409 (47.3%)	265 (29.3%)	231 (22.5%)	1511 (32.8%)
Sex	Female	548 (54.9%)	408 (50.4%)	392 (45.3%)	319 (35.3%)	489 (47.6%)	2156 (46.8%)
	Male	451 (45.1%)	402 (49.6%)	473 (54.7%)	584 (64.7%)	539 (52.4%)	2449 (53.2%)
Area	Rural	495 (49.5%)	425 (52.5%)	433 (50.1%)	459 (50.8%)	523 (50.9%)	2335 (50.7%)
	Urban	504 (50.5%)	385 (47.5%)	432 (49.9%)	444 (49.2%)	505 (49.1%)	2270 (49.3%)
Ever had formal education	No	347 (34.7%)	239 (29.5%)	307 (35.5%)	239 (26.5%)	195 (19.0%)	1327 (28.8%)
	Yes	652 (65.3%)	571 (70.5%)	558 (64.5%)	664 (73.5%)	833 (81.0%)	3278 (71.2%)
Perceived financial status	Worsened	589 (59%)	474 (58.5%)	443 (51.2%)	244 (27%)	666 (64.8%)	2416 (52.5%)
	Improved	9 (0.9%)	53 (6.5%)	15 (1.7%)	469 (51.9%)	118 (11.5%)	664 (14.4%)
	Unaltered	401 (40.1%)	283 (34.9%)	407 (47.1%)	190 (21%)	244 (23.7%)	1525 (33.1%)

Throughout the three waves, the concern about contracting COVID-19 and the perceived risk of experiencing severe COVID-19 were both significantly associated with willingness to get vaccinated against COVID-19.

We found that the ORs for the association between being worried about getting infected with COVID-19 and vaccination willingness highlighted a negative attitude towards vaccination from the respondents that are less

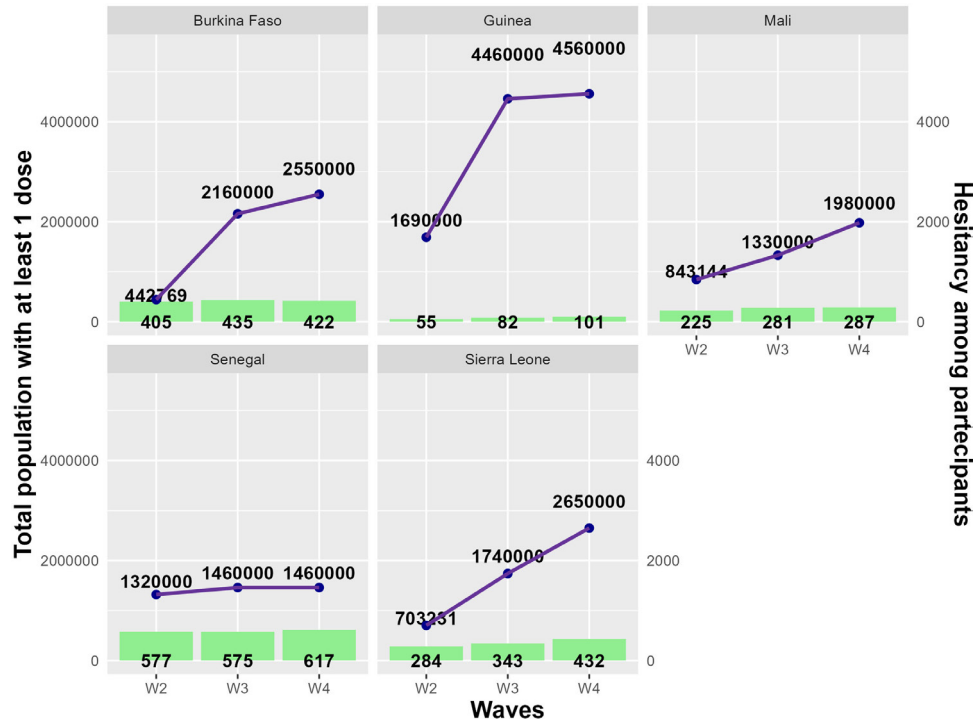


Figure 2 Representation of hesitancy among the surveyed population by country and waves (green bars) and the amount of general public who have received at least one dose of COVID-19 vaccine at the end of each (violet line).



Figure 3 COVID-19 vaccination willingness among non-vaccinated participants of the general study population by country and survey wave. W2, Wave II; W3, Wave III; W4, Wave IV.

preoccupied about getting infected (Wave II: OR 0.42, 95% CI 0.34 to 0.51, Wave III: OR 0.48, 95% CI 0.40 to 0.59 and Wave IV: OR 0.54, 95% CI 0.44 to 0.66). Further, those who reported to be aware of the potential severity of COVID-19 were three to four times more likely willing to be vaccinated as compared with those who are not across the survey waves (Wave II: OR 3.24; 95% CI 2.69 to 3.91; Wave III: OR 3.48; 95% CI 2.90 to 4.19 and Wave IV: OR 4.04; 95% CI 3.35 to 4.89). Furthermore, the acceptance of vaccines was significantly associated with the countries included in the study.

The only country in which the level of willingness to get vaccinated against COVID-19 is positively associated was Guinea in Wave II (OR 1.68, 95% CI 1.15 to 2.49) but with a steady decrease in willingness in Wave IV (OR 0.66, 95% CI 0.44 to 0.97), despite the positive trend in the country for total doses administered. The trend for Senegal was strongly negative across all three waves showing a persistent hesitation to vaccination (OR 0.09, 95% CI 0.06 to 0.13 Wave II; OR 0.15, 95% CI 0.11 to 0.20 Wave III and OR 0.6, 95% CI 0.04 to 0.09 Wave IV). During roughly the same time period, the WHO had reported a plateau in total doses administered. Weaker negative associations can be observed for the other countries, respectively, for Burkina Faso (OR 0.58, 95% CI 0.46 to 0.73 Wave II; OR 0.57, 95% CI 0.45 to 0.73 Wave III and OR 0.69, 95% CI 0.55 to 0.87 Wave IV) and Sierra Leone (OR 0.60, 95% CI 0.46 to 0.78 Wave II; OR 0.66, 95% CI 0.51 to 0.86 Wave III and OR 0.40, 95% CI 0.30 to 0.52 Wave IV). A slight negative association can be observed for urban populations starting from Wave III (OR 0.77, 95% CI 0.65 to 0.91) and Wave IV (OR 0.80, 95% CI 0.67 to 0.97). An association between sex and the willingness to get vaccinated against COVID-19 can be seen only for the fourth wave, in which the men are less likely willing to accept the vaccine (OR 0.77, 95% CI 0.65 to 0.93). Only in Wave III, a decrease in willingness to get vaccinated was shown by people who had perceived their financial situation as having improved (OR 0.57, 95% CI 0.40 to 0.81). No statistical association were found with other sociodemographic parameters such as age, education or diagnosis of relatives with COVID-19.

DISCUSSION

This study presents findings from a serial cross-sectional multicountry survey of factors influencing willingness and hesitancy to get vaccinated against COVID-19 in West Africa. The study was implemented in five Western African countries, some of which were involved in recent Ebola epidemics, where several vaccine studies have been implemented. Main findings from the survey, which was conducted in three waves in five West African countries (Burkina Faso, Guinea, Mali, Senegal and Sierra Leone) include, first, that over time vaccine hesitancy varies across and within countries, with a general trend towards an increase in COVID-19 hesitancy over time (figures 2 and 3). Overall, Senegal has the highest level

of COVID-19 vaccine hesitancy across all survey waves (91.0% in Wave II, 87.5% in Wave III and 92.6% in Wave IV) and Guinea started as the one with the lowest vaccine hesitancy with a crescent trend (29.9% Wave II, 42.9% Wave III and 61.2% Wave IV) (figure 2). Notably, among the countries included in the study, Senegal is the one with the lowest number of people vaccinated against COVID-19 (figure 2). In contrast, those countries primarily affected by the 2014–2016 Ebola epidemic are the countries with the lowest levels of COVID-19 vaccine hesitancy.¹⁰ These observations align with our previous findings, which describe the factors influencing the decision-making processes behind vaccination willingness.² In our current study, awareness of the risk of developing a severe form of COVID-19 showed the strongest association with COVID-19 vaccine hesitancy across all countries included in this study and across survey waves (figure 4). Several studies^{11–17} conducted since the beginning of the COVID-19 pandemic in different countries have clearly demonstrated that the fear of the disease or the perception that the disease cannot be fatal are key factors influencing and modifying the decision-making process along the continuum between acceptance and refusal of vaccination, respectively. Additionally, Mesch and Schwirianb,¹⁸ clearly show how the fear of a deadly disease, such as Ebola virus disease, influences the willingness of getting vaccinated in view of exposure. This could explain why individuals in populations like Guinea and Sierra Leone, who had previously encountered epidemics of Ebola virus disease, might exhibit reduced vaccine hesitancy for COVID-19. Having experienced the positive impact of such preventive measures in the past, they may be more inclined to accept the COVID-19 vaccination. Unfortunately, our study fails to demonstrate whether awareness of the severity of the disease outweighs the fear of vaccine side effects as shown in a previous study.¹⁹ This element is clearly relevant for the design of communication strategies since previous research has shown that while transparent communication about the negative characteristics of COVID-19 vaccines increases trust, it can also decrease acceptance.²⁰ This indicates that building communication strategies around the consequences of the disease might be more effective in swaying those who are hesitant to get vaccinated against COVID-19.

Further, our findings suggest that a perceived improvement in respondents' financial situation was associated with a lower willingness to get vaccinated against COVID-19 during the second, third and fourth survey waves. This result only reached statistical significance in Wave III ($p=0.002$) but with an OR 0.97 in Wave IV. This result can be considered within the wider economic context during the pandemic at the time, which was characterised by short-term economic benefits but longer-term negative financial impacts on individuals.²¹ More research is needed to explore whether economic changes at the individual level translate into variations in the degree of vaccine hesitancy, including the possibility that improvements in

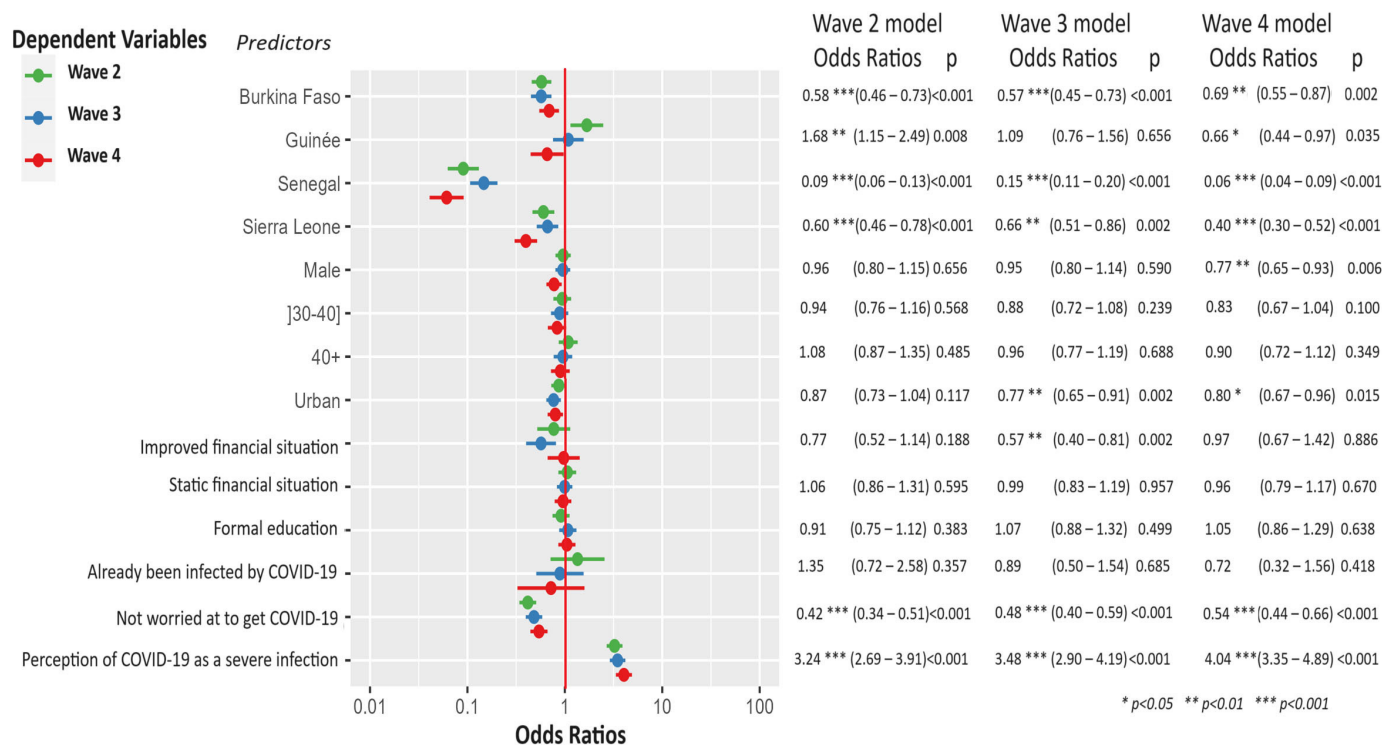


Figure 4 Logistic regression analysis of factors associated with COVID-19 vaccination willingness by survey waves.

the personal financial situation due to the impact of infectious disease spread can encourage vaccine hesitancy for fear of losing economic gains with increased disease control. If confirmed, these findings could help to work on the concept of social solidarity as a driver for better health services, especially in settings with limited resources.²²

Interestingly, sex does not seem to be a factor influencing vaccine decision-making processes except in the last survey wave where men seem more hesitant to get vaccinated against COVID-19 than women. This stands in contrast to findings from studies in the Western, Educated, Industrialised, Rich and Democratic²³ countries, as well as in other countries of the world, where women, especially those of child-bearing age,^{24–26} are commonly more hesitant towards COVID-19 vaccination.²⁷ A higher hesitancy among women is expected to have a more detrimental effect on overall vaccination coverage since women tend to be the main caregivers and decision-makers for children, and they often constitute a large proportion of healthcare workers at the primary level of care,²⁷ which is normally central to vaccination strategies.²⁸ Thus, our findings support the need for community-based awareness campaigns that particularly address women in the five West African countries included in this study to capitalise on their potential as key persons for vaccination advocacy.^{29–30}

Finally, urbanisation and education do not seem to play a role in influencing vaccine hesitancy across the countries included in this study and across survey waves (figure 4). A limitation of the present study is

that the rural population has been selected within the rural surrounding areas of the capital cities of the five countries that participated in this study. This should be further explored, expanding this type of research to more rural areas in order to allow for a more nuanced comparison. Similarly, since education has been proven to be among the factors associated with vaccine hesitancy in several countries,³¹ we can speculate that our study population over-represents those with access to formal education, which might underestimate the effect of the variable. For some of the variables (such as age, education and previous infection), the associations are not statistically significant; hence, a higher sample size might change the direction of associations. The study design, which uses repeated cross-sectional surveys with different participants, may inherently lead to the appearance of selection bias over time. This is illustrated by the decreasing percentage of participants reporting a previous COVID-19 infection, despite the increasing likelihood of infection over time. Acknowledging the potential for selection bias, the decline in reported infection rates from 5% to 2.9% between Waves II and IV likely reflects expected fluctuations in sample sizes, with values remaining within a similar range. These lower percentages contrast sharply with the high seroprevalence rates reported in West Africa. This discrepancy is largely due to limited access to PCR testing, which is costly and primarily available to a specific subset of the population, particularly those who travel internationally.

Conclusions

In conclusion, our study shows that COVID-19 vaccine willingness and hesitancy varies across five West African countries and over time, due to a wider range of individual- and contextual-level factors. This highlights that vaccine willingness and hesitancy is a dynamic phenomenon, which needs to be monitored over time and in different settings in order to design tailored communication strategies to improve vaccination uptake. At the individual level, awareness of the severity of COVID-19, in particular, emerged as an important factor in shaping decisions around COVID-19 vaccinations in West Africa. Further, women in West Africa appear to be less hesitant to get vaccinated against COVID-19 than men. Thus, empowering women to become key drivers of vaccine advocacy could not only play a crucial role in improving overall vaccination coverage in Africa but could also contribute to achieving the Sustainable Development Goal 5, which aims to bridge the gender gap in terms of overall access to health services for women.

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