Beliefs and barriers of COVID-19 vaccination hesitancy among Sudanese healthcare workers in Sudan: A cross sectional study

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ABSTRACT
Vaccine hesitancy is one of the major global health impediments. Due to the unprecedented developing rate, the COVID-19 vaccine engendered a high level of hesitancy worldwide. The aim of this study is to assess hesitancy of COVID-19 vaccine among healthcare workers in Sudan. An online-based cross-sectional survey was conducted in Sudan between May and June 2021 using conventional sampling. An anonymous online questionnaire was distributed to healthcare workers (HCW) through different social media platforms and 930 healthcare workers agreed to participate. Data were cleaned in excel sheet and then statistically analyzed using R software version 4.0.2. Of total participants, 67.3% of them were females. Over three-fifths of the study participants agreed that COVID-19 vaccine is important and should be mandatory. A total of 570 (61.3%) agreed that COVID-19 vaccines are safe, whilst 584 (62.8%) had concerns regarding side effects of the vaccine and 533 (57.3%) believe insufficient trials were conducted. A total of 375 (40.3%) accept vaccination absolutely, while 292 (31.4%) accept with some hesitation and 48 (5.2%) refuse absolutely. Insufficient information about side effects (42.6%) and the vaccine (39.9%) were the most common concerns regarding COVID-19 vaccination. Majority of Sudanese healthcare workers believed that COVID-19 vaccination should be mandatory. A high reliance on social media was observed among healthcare workers in Sudan for information on the COVID-19 pandemic.

Introduction
Coronavirus disease-19 (COVID-19) was first reported in December 2019 in Wuhan, China. The transmissibility of COVID-19 has since left a lasting impact on global health systems.

It is well known that vaccination is one of the key strategies in controlling pandemics, decreasing transmission and rate of admission. In addition, vaccines can decrease transmission of a specific disease even among non-vaccinated individuals through herd immunity if a sufficient proportion of the population is vaccinated. Recent updates by the WHO in August 2022 show that 198 COVID-19 vaccines are in the pre-clinical development stage, 170 in the clinical development stage and 11 COVID-19 vaccines have been granted Emergency Use listing. Governments encouraged the pharmaceutical sector and academic institutes to focus significant resources on the development of safe and effective vaccines, as well as treatments and rapid diagnostic testing. Various types of vaccines had been covered, including nucleic acid vaccines, subunit vaccines, vector vaccines, and live attenuated vaccines.

The development and use of an effective COVID-19 vaccine was faced with numerous challenges, including selection of an appropriate formulation, reviewing and approving a large number of potential vaccine candidates, mass manufacturing, and post-marketing surveillance, in addition to cost and logistics concerns.

As the COVID-19 pandemic has now reached over 270 million people, it is thus crucial to increase public trust in vaccine and decrease hesitancy among recipients. World Health Organization (WHO) defined vaccine hesitancy as "a delay in acceptance or refusal of vaccination although availability of vaccination services" and consider it one of the major threats to global health. False information has also spread through multiple media platforms, which was cited as the main cause of hindrance to vaccine administration, despite the accelerated pace of vaccine has many effects on vaccine acceptance and here comes the role of healthcare workers (HCWs). The frontline healthcare providers in Sudan has suffered extremely at the personal, social, and professional levels and they where under heavy stressors due to many reasons such as; lack of personal-protection equipment (PPE), they were working in clinics crowded with patients and their relatives and most of them don’t use masks or social distancing, the stress of living away from home in campuses near the isolation centers in which they work, and the pain they've been through when they have lost some of their colleagues and those whom they love. Also, they've went through a stigma that they are a source of transmission of the disease which has hit hard on their feelings and mental health. HCWs play a major role in vaccination and therefore, vaccine hesitancy among HCWs has a strong influence on vaccination,
as their confidence in the COVID-19 vaccine influences public trust.\textsuperscript{18}

In March 2021, Sudan had first received 800,000 doses of AstaZeneca vaccine via the COVID-19 Vaccines Global Access (COVAX) Facility. It was the only type available at the study time.\textsuperscript{19} After a while, quantities of Pfizer, Sinopharm and Johnson & Johnson vaccines were also available. The schedule of vaccination in Sudan was variable according to availability of the vaccines.

The study was motivated by the scarcity of data in Sudan on COVID-19 vaccine acceptance at the time the study was performed. The study was also motivated by the potential effect of spreading false information on social media platforms on the perception of healthcare staff and the general public toward COVID-19 vaccinations. The aim of this study was to assess vaccine hesitancy among HCWs in Sudan. Also, this study sought to assess the factors affecting perception and hesitancy toward the COVID-19 vaccine among HCWs in Sudan and to determine the most dependable sources of information on the COVID-19 pandemic.

Materials and methods

Study design and participants

This was a cross-sectional study which was conducted in 16 states of the Republic of the Sudan between May and June 2021.

Participants

In this study, we included all healthcare workers who were working at hospitals in Sudan, from all specialty and agreed to fill the given questionnaire.

Study instrument development

The study questionnaire was taken from another study conducted in Egypt.\textsuperscript{20} The authors in this study pretested the questionnaire on 20 students who were not included in the final analysis; its internal consistency was assessed by calculating the Cronbach’s alpha as 0.790. The final draft of the questionnaire consisted of the following sections:

(1) Demographic characteristics: age, gender, the study participants’ residency, profession, monthly income, chronic illnesses, overall health impression, previous COVID-19 diagnosis or his surroundings and overall impression of knowledge about the COVID-19 pandemic.

- Attitude and beliefs toward the COVID-19 vaccine: consisted of five questions about beliefs surrounding COVID-19 vaccination importance and 11 statements about personal perception toward the vaccine. These questions adopted a 5-point Likert scale consist of the following responses: strongly disagree, disagree, not sure, agree, or strongly agree. In correct statements, the highest score was given strongly agree and the lowest score to strongly disagree. But the opposite occurred for the false statements.

(2) Dependence on COVID-19 information sources: consisted of seven questions rating the level of dependence on each source of information regarding the COVID-19 pandemic.

- COVID-19 vaccination hesitancy: consisted of 4 questions regarding motives for COVID-19 vaccination, measure of hesitancy toward the vaccine, personal concerns of the COVID-19 vaccine development. All these questions are multiple choices questions with no definitive scoring.

The questionnaire was initially written in English, then translated into Arabic. A final draft was agreed upon following forward and backward translation of both languages by bilingual interpreters.

Data sampling techniques

A convenience sampling method was used to acquire the responses from the participants. The overall sample size was calculated using the Fischer et al. equation: \( n = \frac{z^2 P (1-P)}{d^2} \). A 50% response distribution was applied based absence of previous studies, under a 95% confidence margin. A minimum sample size of 386 was yielded. As a result of convenience sampling limitations, a design effect was applied in this study (386*2), therefore creating a minimum sample of 772 participants.

Data collection

The questionnaire was distributed as a Google Form document through multiple social media platforms (Facebook, Twitter, WhatsApp, Telegram), non-governmental organizations (NGOs) and academic institutions. Only one response was recorded from each participant in this study. A total of 930 responses were collected from participants in this study.

Statistical analysis plan

Data collected from the participants was initially cleaned using Microsoft Excel, then analyzed using R software version 4.0.2. Chi-square testing, independent-\( t \) testing and Fischer exact tests were used to identify factors associated with beliefs and barriers of COVID-19 vaccination among Sudanese healthcare workers in this study. A p-value of \( p < .05 \) was considered significant.

Results

Participants’ demographic characteristics

A total of 930 health care workers with a mean age of 28.7 ± 6.7 participated in this study. This represent 0.93% of the total health care workers in Sudan (100,000). Nearly two-third of them were female (67.3%). Majority of them were residing inside Khartoum state (81.9%). A total of
585 (62.9%) doctors participated in this survey and they were considered as the most common participants in this survey. Further details are shown in Table 1.

Table 1. Baseline characteristics of health care workers. (n = 930).

| Characteristics                       | N         | Overall, N = 9301 | Female, N = 6261 | Male, N = 3041 | p-value2 |
|---------------------------------------|-----------|-------------------|------------------|----------------|----------|
| Age, years                            | 929       | 28.7 ± 6.7        | 28.7 ± 6.6       | 28.7 ± 6.8     | >0.9     |
| Residency                             | 930       |                   |                  |                | <0.001   |
| Inside Khartoum state                 | 762 (81.9%) | 534 (85.3%)       | 228 (75.0%)      |                |          |
| Outside Khartoum state                | 168 (18.1%) | 92 (14.7%)        | 76 (25.0%)       |                |          |
| Profession                            | 930       |                   |                  |                |          |
| Anesthesiologist                      | 2 (0.2%)  | 2 (0.3%)          | 0 (0.0%)         |                |          |
| Dentist                               | 92 (9.9%) | 66 (10.5%)        | 26 (8.6%)        |                |          |
| Doctor                                | 585 (62.9%) | 386 (61.7%)       | 199 (65.5%)      |                |          |
| Medical laboratory scientist          | 70 (7.5%) | 46 (7.3%)         | 24 (7.9%)        |                |          |
| Nurse                                 | 27 (2.9%) | 21 (3.4%)         | 6 (2.0%)         |                |          |
| Pharmacist                            | 118 (12.7%) | 78 (12.5%)        | 40 (13.2%)       |                |          |
| Physiotherapist                       | 4 (0.4%)  | 4 (0.6%)          | 0 (0.0%)         |                |          |
| Radiologist                           | 6 (0.6%)  | 4 (0.6%)          | 2 (0.7%)         |                |          |
| Staff in medical university           | 26 (2.8%) | 19 (3.0%)         | 7 (2.3%)         |                |          |
| Average monthly income                | 930       |                   |                  |                | <0.001   |
| Less than 10,000 SDG                  | 315 (33.9%) | 247 (39.5%)       | 68 (22.4%)       |                |          |
| 10,000–30,000 SDG                     | 361 (38.8%) | 256 (40.9%)       | 105 (34.5%)      |                |          |
| 31,000–50,000 SDG                     | 120 (12.9%) | 64 (10.2%)        | 56 (18.4%)       |                |          |
| 51,000–70,000 SDG                     | 53 (5.7%) | 29 (4.6%)         | 24 (7.9%)        |                |          |
| more than that                        | 81 (8.7%) | 30 (4.8%)         | 51 (16.8%)       |                |          |
| Do you have a chronic illness (Yes)?  | 930       | 144 (15.5%)       | 96 (15.3%)       | 48 (15.8%)     | 0.9      |
| How do you evaluate your health condition in general? | 930 | 71 (7.6%) | 48 (7.7%) | 23 (7.6%) | 0.002 |
| Bad                                   | 71 (7.6%) | 48 (7.7%)         | 23 (7.6%)        |                |          |
| Very bad                              | 37 (4.0%) | 24 (3.8%)         | 13 (4.3%)        |                |          |
| Neutral                               | 275 (29.6%) | 188 (30.0%)       | 87 (28.6%)       |                |          |
| Good                                  | 368 (39.6%) | 267 (42.7%)       | 101 (33.2%)      |                |          |
| Very good                             | 179 (19.2%) | 99 (15.8%)        | 80 (26.3%)       |                |          |
| Have you been diagnosed with Corona virus previously? | 930 | 74 (8.0%) | 47 (7.5%) | 27 (8.9%) | 0.5 |
| I have no idea                        | 74 (8.0%) | 47 (7.5%)         | 27 (8.9%)        |                |          |
| No, I have not had COVID-19           | 478 (51.4%) | 331 (52.9%)       | 147 (48.4%)      |                |          |
| Yes, a confirmed case                 | 132 (14.2%) | 84 (13.4%)        | 48 (15.8%)       |                |          |
| Infection not confirmed               | 246 (26.5%) | 164 (26.2%)       | 82 (27.0%)       |                |          |
| Has someone in your close circle (such as a family member or close friend) been infected with the COVID-19 previously? | 930 | 74 (8.0%) | 47 (7.5%) | 27 (8.9%) | 0.3 |
| I have no idea                        | 34 (3.7%) | 19 (3.0%)         | 15 (4.9%)        |                |          |
| No, I have not had COVID-19           | 194 (20.9%) | 130 (20.8%)       | 64 (21.1%)       |                |          |
| Yes, a confirmed case of medical examinations | 518 (55.7%) | 345 (55.1%) | 173 (56.9%) | 0.029 |
| Yes, but infection is not confirmed  | 184 (19.8%) | 132 (21.1%) | 52 (17.1%) |          |
| What is your percentage of risk of exposure to the infection with COVID-19? | 930 | 7.0 ± 2.6 | 6.8 ± 2.6 | 7.2 ± 2.4 | 0.2 |
| Describe your attitude toward Evidence based practice | 930 | 113 (12.2%) | 75 (12.0%) | 38 (12.5%) | 0.2 |
| I don't know about it                 | 113 (12.2%) | 75 (12.0%) | 38 (12.5%) |          |
| I find it difficult to keep up with all changes happening now. | 282 (30.3%) | 201 (32.1%) | 81 (26.6%) |          |
| I'm aware of it and know how to search for evidence-based information. | 535 (57.5%) | 350 (55.9%) | 185 (60.9%) |          |
| Do you think there is enough information about the safety of vaccination against COVID-19? | 930 | 239 (25.7%) | 153 (24.4%) | 86 (28.3%) | 0.004 |
| How would you rate the level of your knowledge about COVID-19? | 852 | 61 (7.2%) | 37 (6.4%) | 24 (8.9%) |          |
| Bad                                   | 61 (7.2%) | 37 (6.4%)         | 24 (8.9%)        |                |          |
| Good                                  | 392 (46.0%) | 280 (48.2%) | 112 (31.3%) |          |
| Neutral                               | 273 (32.0%) | 195 (33.6%) | 78 (28.8%) |          |
| Very bad                              | 16 (1.9%) | 8 (1.4%)          | 8 (3.0%)         |                |          |
| Very good                             | 110 (12.9%) | 61 (10.5%) | 49 (18.1%) |          |

1Mean ± SD; n (%)
2Two Sample t-test; Pearson's Chi-squared test; Fisher's exact test

Attitude and beliefs toward the COVID-19 vaccine

Participants rated different responses related to COVID-19 and vaccine. A total of 385 (41.4%) participants strongly agree that
COVID-19 vaccine is important, and more than half of participants agreed that the vaccine for COVID-19 should be mandatory to all healthcare workers. Further information are shown in Table 2.

Regarding the vaccine of COVID-19, 382 (41.1%) agreed that the vaccine’s validation and its provision ensure its safety for users. Also, more than half of participants agree and strongly agree that vaccination toward COVID-19 would prevent complications and side effects of COVID-19 (Table 3).

**COVID-19 vaccination hesitancy**

Regarding the hesitancy for taking COVID-19 vaccination, 375 (40.3%) participants absolutely accepted the vaccination, and 818 (88.0%) participants accepted taking the vaccine. In addition, no significant difference between male and female groups in acceptance of taking COVID-19 vaccine (p = .7). Many reasons were identified by health care workers and 396 (42.6%) of participants identified lack of sufficient information about the side effects as the most common concern about the new COVID-19 vaccine (Table 5).

Also, no significant difference was demonstrated between demographic groups regarding the acceptance for taking COVID-19 vaccines among participants (Table 6).

**Discussion**

This study sought to assess the acceptance of COVID-19 vaccinations among healthcare staff in Sudan. It was found that over two-fifths (40.3%) of the study participants would accept

### Table 2. Beliefs surrounding COVID-19 vaccination importance (n = 930).

| Statements                                                                 | Strongly disagree | Disagree | Not sure | Agree   | Strongly agree |
|-----------------------------------------------------------------------------|-------------------|----------|----------|---------|----------------|
| How important do you believe the COVID-19 vaccine is?                       | 34 (3.7%)         | 39 (4.2%)| 178 (19.1%)| 294 (31.6%)| 385 (41.4%)    |
| In your opinion, how important do you think it is for all members of the society to obtain the COVID-19 vaccine? | 35 (4.1%)         | 56 (6.6%)| 149 (17.5%)| 257 (29.2%)| 355 (41.7%)    |
| Do you see that the COVID-19 vaccine should be mandatory?                  | 80 (9.4%)         | 111 (13.0%)| 191 (22.4%)| 200 (23.5%)| 270 (31.7%)    |
| How much do you care about the COVID-19 vaccine?                           | 52 (6.1%)         | 64 (7.5%)| 186 (21.8%)| 250 (29.3%)| 300 (35.2%)    |
| Is it a must for all health care workers to obtain the COVID-19 vaccination? | 40 (4.7%)         | 46 (5.4%)| 130 (15.3%)| 145 (17.0%)| 491 (57.6%)    |

Data were presented as n (%)

### Table 3. Personal perception toward the vaccine (n = 930).

| Statements                                                                 | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|-----------------------------------------------------------------------------|-------------------|----------|---------|-------|----------------|
| I think the vaccine’s validation and its provision ensure that it is safe for users. | 44 (4.7%)         | 93 (10.0%)| 223 (24.0%)| 382 (41.1%)| 188 (20.2%)    |
| Mass vaccination will result in overcoming the COVID-19 pandemic.           | 40 (4.3%)         | 113 (12.2%)| 202 (21.7%)| 356 (38.3%)| 219 (23.5%)    |
| The best way to beat COVID-19 effects and complications is the vaccination. | 39 (4.2%)         | 109 (11.7%)| 182 (19.6%)| 355 (38.2%)| 245 (26.3%)    |
| I think that the preparation of the COVID-19 vaccine was rushed without enough trials conducted. | 45 (4.8%)         | 131 (14.1%)| 221 (23.8%)| 325 (34.9%)| 208 (22.4%)    |
| I have concerns about the potential side effects of the vaccine.           | 46 (4.9%)         | 100 (10.8%)| 200 (21.5%)| 361 (38.8%)| 223 (24.0%)    |
| I have some doubts about the vaccine’s effectiveness against COVID-19      | 102 (11.0%)       | 181 (19.5%)| 190 (20.4%)| 288 (31.0%)| 169 (18.2%)    |
| I had bad experiences with side effects from previous vaccinations.        | 235 (25.3%)       | 260 (28.0%)| 177 (19.0%)| 156 (16.8%)| 102 (11.0%)    |
| I am against all vaccinations absolutely.                                  | 498 (53.5%)       | 186 (20.0%)| 84 (9.0%)| 84 (9.0%)| 78 (8.4%)      |
| I am fearful to get infected with the COVID-19 via the vaccine itself      | 315 (33.9%)       | 201 (21.6%)| 149 (16.0%)| 145 (15.6%)| 120 (12.9%)    |
| I don't need to get vaccinated because if I were to get infected I would be treated and recover with no complications. | 337 (36.2%)       | 228 (24.5%)| 151 (16.2%)| 123 (13.2%)| 91 (9.8%)      |
| I don't need to get vaccinated because I think I am not among those who are immunocompromised | 363 (39.0%)       | 236 (25.4%)| 125 (13.4%)| 114 (12.3%)| 92 (9.9%)      |

Data were presented as n (%)

### Table 4. Rating the dependence on source of information among health care workers (n = 930).

| Statements                                                                 | Strongly low | Low      | Neutral | High    | Strongly high |
|-----------------------------------------------------------------------------|--------------|----------|---------|---------|---------------|
| Television programs and news outlets                                       | 172 (18.5%)  | 209 (22.5%)| 251 (27.0%)| 186 (20.0%)| 112 (12.0%)    |
| Newspapers and magazines                                                   | 238 (25.6%)  | 280 (30.1%)| 258 (27.7%)| 112 (12.0%)| 42 (4.5%)      |
| Medical sites on the internet                                              | 49 (5.3%)    | 97 (10.4%)| 218 (23.4%)| 334 (35.9%)| 232 (24.9%)    |
| Social media                                                               | 83 (8.9%)    | 83 (8.9%)| 223 (24.0%)| 288 (31.0%)| 253 (27.2%)    |
| Government sources                                                         | 186 (20.0%)  | 224 (24.1%)| 287 (30.9%)| 154 (16.6%)| 79 (8.5%)      |
| Doctors and Health care providers                                          | 55 (5.9%)    | 147 (15.8%)| 272 (29.2%)| 286 (30.8%)| 170 (18.3%)    |
| Family, relatives and friends                                              | 180 (19.4%)  | 249 (26.8%)| 260 (28.0%)| 145 (15.6%)| 96 (10.3%)     |

Data were presented as n (%)
COVID-19 vaccinations without hesitation—the higher proportion being female (36.4%). A total of 346 (37.2%) of the respondents were motivated by the fear of contracting COVID-19, while over one-fifth (23.1%) would opt for COVID-19 vaccination by virtue of its accessibility and being free of charge. Recent similar studies examining the acceptance of COVID-19 vaccination among healthcare professionals have demonstrated considerably higher acceptance rates in Europe and the Americas. In Colombia, it was found that 77–90.7% of screened physicians would readily undergo vaccination against COVID-19 in accordance with vaccine efficacy rates of 60% and 80% respectively.21 Similarly, it was found that those healthcare professionals in France and the United States demonstrated acceptance rates of 76.9% and 70% respectively toward receiving the COVID-19 vaccine—approximately the same proportions as the general public in both nations.22

In contrast, studies conducted on acceptance of the COVID-19 vaccine in Africa amongst healthcare staff have portrayed comparable results. In the Republic of Congo, it was observed that only 27.7% of staff working in healthcare settings would agree to obtain the COVID-19 vaccine. Discrepancies in vaccine acceptance between these regions

| Characteristics | Overall, N = 930 | Female, N = 626 | Male, N = 304 | p-value |
|-----------------|-----------------|-----------------|--------------|--------|
| Choose what expresses your hesitation of vaccination with the Corona virus | | | | 0.003 |
| I accept vaccination absolutely | 375 (40.3%) | 228 (36.4%) | 147 (48.4%) | |
| I accept, but with some delay and a little bit of rejection | 151 (16.2%) | 116 (18.5%) | 35 (11.3%) | |
| I accept, but with some hesitation | 292 (31.4%) | 205 (32.7%) | 87 (28.6%) | |
| I refuse to be vaccinated absolutely | 48 (5.2%) | 30 (4.8%) | 18 (5.9%) | |
| I refuse vaccination with some hesitation | 64 (6.9%) | 47 (7.5%) | 17 (5.6%) | |
| Do you accept taking vaccine (Yes) | | | | |
| You are not worried about getting vaccinated. | 330 (35.5%) | 205 (32.7%) | 125 (41.1%) | 0.012 |
| Lack of sufficient confidence in the source of the vaccine. | 343 (36.9%) | 253 (40.4%) | 90 (29.6%) | 0.001 |
| Lack of sufficient information about the vaccine. | 371 (39.9%) | 257 (41.1%) | 114 (37.5%) | 0.3 |
| Lack of sufficient information about the side effects. | 396 (42.6%) | 293 (46.8%) | 103 (33.9%) | <0.001 |
| Others | 39 (4.2%) | 31 (5.0%) | 8 (2.6%) | 0.1 |
| What are the reasons for your concerns/worries about the new Corona virus vaccine? (You can choose more than one) | | | | |
| Fear of getting infected | 346 (37.2%) | 242 (38.7%) | 104 (34.2%) | 0.2 |
| Fear for the members of my family especially my parents who are susceptible | 593 (63.8%) | 409 (65.3%) | 184 (60.5%) | 0.2 |
| My belief in the safety and effectiveness of the vaccination | 308 (33.1%) | 204 (32.6%) | 104 (34.2%) | 0.6 |
| Free vaccination and availability | 215 (23.1%) | 146 (23.3%) | 69 (22.7%) | 0.8 |
| Others | 52 (5.6%) | 39 (6.2%) | 13 (4.3%) | 0.2 |

| Variables | N | Overall, N = 930 | Acceptance of vaccine | p-value |
|-----------|---|-----------------|-----------------------|--------|
| Age, years | 929 | 28.7 ± 6.7 | 28.6 ± 6.9 | 28.7 ± 6.7 | >0.9 |
| Gender | 930 | | | | 0.7 |
| Female | 626 (67.3%) | 77 (68.8%) | 549 (67.1%) | |
| Male | 304 (32.7%) | 35 (31.2%) | 269 (32.9%) | |
| Residency | 930 | | | | 0.5 |
| Inside Khartoum state | 762 (81.9%) | 89 (79.5%) | 673 (82.3%) | |
| Outside Khartoum state | 168 (18.1%) | 23 (20.5%) | 145 (17.7%) | |
| Profession | 930 | | | | |
| Anesthesiologist | 2 (0.2%) | 0 (0%) | 2 (0.2%) | |
| Dentist | 92 (9.9%) | 10 (8.9%) | 82 (10.0%) | |
| Doctor | 585 (62.9%) | 55 (49.1%) | 530 (64.8%) | |
| Medical laboratory | 70 (7.5%) | 17 (15.2%) | 53 (6.5%) | |
| Nurse | 27 (2.9%) | 8 (7.1%) | 19 (2.3%) | |
| Pharmacist | 118 (12.7%) | 11 (9.8%) | 107 (13.1%) | |
| Physiotherapist | 4 (0.4%) | 1 (0.9%) | 3 (0.4%) | |
| Radiologist | 6 (0.6%) | 4 (3.6%) | 2 (0.2%) | |
| Staff in medical university | 26 (2.8%) | 6 (5.4%) | 20 (2.4%) | |
| Average monthly income: | 929 | | | | 0.2 |
| Less than 10,000 SDG | 314 (33.8%) | 42 (37.5%) | 272 (33.3%) | |
| 10,000–30,000 SDG | 361 (38.9%) | 47 (42.0%) | 314 (38.4%) | |
| 31,000–50,000 SDG | 120 (12.9%) | 7 (6.2%) | 113 (13.8%) | |
| 51,000–70,000 SDG | 53 (5.7%) | 8 (7.1%) | 45 (5.5%) | |
| More than that | 81 (8.7%) | 8 (7.1%) | 73 (8.9%) | |
| Do you have a chronic illness (Yes) | 930 | 144 (15.5%) | 24 (21.4%) | 120 (14.7%) | 0.064 |

1Mean ± SD; n (%)
2Two Sample t-test; Pearson’s Chi-squared test; Fisher’s exact test
may be attributed to false information on social media platforms.\textsuperscript{21}

Further attributions to wide differences in COVID-19 vaccine acceptance include a poverty of public trust in government sources and dependence on social media itself as a COVID-19 news outlet. The majority (58.2\%) of respondents in this study were strongly dependent on social media as a COVID-19 news outlet, which is a source of inconsistent and incomplete information during the pandemic.\textsuperscript{23} While 44.1\% distrusted the credibility of COVID-19 vaccine information issued by the Sudanese government. This was also fortified by the fact that insufficient confidence in the source of information about the COVID-19 vaccine would concern 36.9\% of participants in this study, these reasons lead to the noticeable lack of information among the participants. Acceptance of COVID-19 vaccination among healthcare professionals is crucial to the achievement of public trust in the vaccine, subsequently leading to the achievement of herd immunity and the hindrance or halt of community transmission. In France and the United States, the acceptance of the general population was attributed to highly positive attitude and perception of healthcare staff and physicians toward the COVID-19 vaccine, which was followed by public confidence in its credibility.\textsuperscript{21}

In terms of motivation to obtain the COVID-19 vaccine, results were similar to previous studies examining reasons for physicians to opt into public vaccination programs in the respect that the most common reason given was self-protection against the virus.\textsuperscript{21}

This study also sought to identify factors influencing the acceptance and hesitation of receiving COVID-19 vaccinations among Sudanese healthcare professionals.

Gender had a significant effect on hesitation to opt into the national vaccination programme among Sudanese healthcare professionals. Insufficient confidence in the vaccine source, insufficient knowledge of side effects and insufficient knowledge about the vaccine itself were all significantly associated with female gender (p < .05). This is likely attributed to the sample of the study, in which females constituted 626 of 930 participants, thus likely attributing to significantly higher hesitancy among female physicians in Sudan.

Although not found to be significant in this study, it was observed that acceptance of COVID-19 vaccinations was considerably higher among residents within the limits of Khartoum State. Only 89 of 762 residents would refuse to obtain COVID-19 vaccines. Previous studies have also portrayed higher rates of opt-ins to COVID-19 vaccination programs among physicians in capital cities – in Lima, Peru and Bogota, Colombia, whereby 81–94\% of physicians.\textsuperscript{22} A possible attribution to these differences is likely the capital cities being the first point of distribution of COVID-19 vaccines through the COVAX program in developing countries. In Sudan, healthcare professionals are given the highest priority in receiving COVID-19 doses in the first phase of distribution, intended to cover 4\% of the general population, in conjunction with over-45s with chronic morbidities.\textsuperscript{21,24}

**Strength and limitations**

The main strength of this study is its standing as the first study in Sudan assessing and identifying factors related to acceptance the and hesitation of healthcare professionals, together with its inclusion of personnel from beyond the borders of Khartoum State. However, the authors acknowledge that this study is not without limitations. The study was conducted at a time during which travel restrictions applied within and outside Khartoum, leading to the use of a convenience sampling technique rather than a multiple cluster sampling technique which would yield more accurate and more generalized results. In addition, the results may have been influenced by recall bias as the study itself was dependent on retrospective accounts from the study participants. Another limitation of this study was the majority of the study population were youths who had close contact with confirmed cases of COVID-19 infection. Those populations are more inclined to accept COVID-19 vaccines after noticing its complications. Finally, the information provided to study participants was based on social media platforms which may have spread false information, thus affecting the perception of HCWs and the general public toward COVID-19 vaccinations. Despite these limitations, the authors believe the results depict an approximate picture of acceptance of COVID-19 vaccinations among Sudanese healthcare professionals.

**Conclusion**

In this study, it was found that the majority of Sudanese healthcare workers believed that COVID-19 vaccination should be mandatory. A high reliance on social media was observed among healthcare workers in Sudan for information on the COVID-19 pandemic.

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**Authors contributions**

Conceptualization: MaME and LSA; Methodology and study design: MaME, LSA, MHE, ABB and LEA; Questionnaire designing: MaME, LSA, MHE, ABB, LEA and EAH; Data collection: MaME, LSA, MHE, ABB, LEA; Data Analysis: EAH; Results and data interpretation: EAH, OKOE; Manuscript drafting: MaME, LSA, MHE, ABB, LEA, EAH, OKOE. All authors revised the manuscript and approved it for publication.

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Institutional review board statement
Ethical approval of the study was obtained on April 2021 from the Institutional Review Board (IRB) committee of the faculty of medicine, University of Khartoum, Khartoum, Sudan. The study was carried out following the relevant ethical guidelines and regulations.

Informed consent statement
The participants were asked to give consent that they agree to participate in the study by filling the questionnaire for research purposes in the online form.

Consent for publication
No personal data was collected from the participants.

Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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