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Cross-sectional study: mindset towards Coronavirus in developing countries and lessons learned: the case of Sudan

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Introduction: People's mindset towards COVID-19 in developing countries has an impact on how they perceive and react to the preventative measures taken by the governments to contain the virus. Understanding the factors influencing the mindset and identifying lessons learned amidst COVID-19 are critical to inform any future intervention strategy.

Methods: This was a cross-sectional, community-based study conducted to assess the mindset changes and lessons learned post-COVID-19 in developing countries, focusing on Sudan. The study adopted a sequential mixed approach (SMA), combining qualitative and quantitative methods. The study used a structured questionnaire with 300 respondents and in-depth interviews with two experts. To identify the factors influencing the mindset of the people towards COVID-19, the study employed logistic regression. The data was analyzed using SPSS software.

Results: Of the total ($N = 300$) respondents, 59.0% are female, 59.3% are between the ages of 20 and 39, 79.7% have a university education, 25.3% have the Coronavirus, and 42.3% has their family or relative contracted the virus. Further, only 22.7% had taken the vaccine. Reasons for vaccine hesitancy include lack of trust (29.5%), fear of side effects (24.1%), and absence of the need to travel outside the country (25.5%). When the virus first appeared, 77.3% thought it posed a health risk, while 22.7% perceived it as a hoax or conspiracy. After 3 years, 73% still regarded it as a health threat, while 27% believed it was a hoax or conspiracy. The mindset was found to be influenced by age, history of the disease, the extent of trust in foreign media coverage, and the belief in the effectiveness of the vaccination.

Conclusion: Assessing the mindset towards the virus and identifying the lessons learned from the pandemic could be of vital importance to control the spread of the virus in developing countries. Making use of such lessons and influencing the mindset of the people towards positive attitudes and behaviours are required to enhance the effectiveness of the health precaution measures adopted. Further research is required on the public's mistrust of foreign media coverage and the contribution of local media to educate the public about the virus, particularly among the elderly.

Keywords: COVID-19, developing countries, lessons learned, logistic regression, mindset, Sudan

Introduction

The outbreak of COVID-19 in early 2020 and its rapid spread across the globe have caused huge health, economic, and social consequences[1–5]. Recent statistics in August 2022 showed that there had been 589 680 368 confirmed cases globally, with 41.6% in Europe, 29.4% in the United States, 13.4% in the Western Pacific, 10.1% in South-East Asia, 3.9% in Eastern Mediterranean,

HIGHLIGHTS

- The mindset towards Coronavirus plays an important role in the way people perceive the disease and react to the government preventive measures.
- A belief that Coronavirus is a conspiracy or a hoax is quite prevalent among the Sudanese, which is reflected in their risky behaviours and attitudes.
- The factors influencing the mindset towards the pandemic include age, the history of the disease among the family or relatives, the trust in foreign media coverage, and the belief in the effectiveness of the vaccination.
- The lessons learnt from COVID-19 to create a positive mindset towards the virus include: promoting the capacity for resilience, enhancing healthcare and infrastructure, adhering to standard operating procedures (SOP), and remembering and recognizing the devastating history of COVID-19 and its social, economic and health consequences.

and 1.6% in Africa, while the number of death cases amounted to 6 436 519[6].

The impacts of the pandemic were severe, especially in emerging economies and developing countries. Research showed that

the pandemic has worsened inequality within and across countries, increased global poverty, and raised temporary unemployment among workers with primary education in 70% of all countries[2]. Other studies showed that more than 50% of households in emerging and advanced economies were not able to sustain basic consumption for more than three months in the event of income losses due to COVID-19[7]. Moreover, the negative impact of the pandemic on the overall mental health of the people has been well documented[1,8,9]. The mental health effect originated from extreme distress, fear of contracting disease, concerns about health and survival, losing jobs, partial and complete lockdowns, and social isolation of relatives[3,5,10].

One area that has attracted extensive research on COVID-19 in developing countries is the people's knowledge, attitude, and perception about the virus. For example, Tejamaya et al.[11]. examined the risk perception and tolerance of COVID-19 among 1,043 Indonesians aged 18 years and older. Respondents indicated good knowledge about the nature of the virus, transmission modes, and control measures. Moreover, the study showed that respondents believed that the virus was serious and the efficacy of the measures taken was low. Mahmood et al.[12]. assessed the attitude, perception, and knowledge of Pakistani people towards COVID-19 disease using a cross-sectional survey of 1000 respondents. The results revealed that respondents had good knowledge about the disease and a positive attitude towards protective measures. In terms of the public perception of the virus, 46.0% of those polled believed COVID-19 was a bioweapon. 59% of respondents think everyone is susceptible. Adenubi et al.[13]. confirmed that while the knowledge among the veterinarians in Nigeria about the virus was high, their general attitude was poor.

According to Haftom et al.[14]. , 42.9% of respondents in an Ethiopian survey were aware of the virus. In terms of attitude, about half of the respondents reported that they had gone to crowded places; 46% did not wear face masks when leaving homes, and 54.4% had not practiced preventive measures given by local health authorities. In Uganda, Kamacooko et al.[15]. revealed that 83.9% of the healthcare workers (HCWs) had sufficient knowledge about the virus, 78.4% had a positive attitude, but only 37.0% had good practices. Choudhary et al.[16]. identified the factors contributing to the second wave of COVID-19 in India. This included the complex interplay of mutant strains, violation of COVID-appropriate behaviour, and government and public complacency on initiation of the vaccination. For preventing the further spread of the virus, the study recommended following Standard Operating Procedures (SOP) and replicating and implementing the success stories of a few states in India, such as Mizoram, which implemented time to time SOP to control the pandemic and consistently maintained a higher recovery rate with a low fatality rate.

For the vaccination, studies have revealed a significant reluctance in developing countries to receive the COVID-19 vaccine. According to Batholomew et al.[17]. 53.0% of Nigerians had unfavourable opinions on the virus because they had suspicions about it. Awuni, Ayamga, and Dagunga[18] demonstrated that literate Ghanaians' intentions to get vaccinated are significantly impacted negatively by their mistrust about the safety and effectiveness of vaccines. Abeid et al.[19]. showed that even while 81.0% of Kenyan adults said the vaccine was crucial for COVID-19 protection, 40.5% were afraid to get the dose because of potential negative effects. According to a survey of 71 papers on COVID-19 vaccination in African nations that were published in reputable journals, the acceptance rate of the vaccine varied from 6.9 to 97.9%[20]. The main reasons for vaccination reluctance were concerns about vaccine safety and side effects, a lack of faith in the pharmaceutical corporations, and inaccurate or contradictory media reports.

Sudan is one of the developing countries that has witnessed an unprecedent record of infection with the virus, resulting in immense societal and economic disruptions. The latest statistics showed that there were 63 275 positive cases in September 2022, and the number of death cases reached almost 5000 cases[6]. Recent data in Sudan is not available due to the ongoing war that erupted since April 2023. The control measures adopted by the government to the virus included closing borders, preventing social and religious crowds, transferring critical patients to hospitals, isolating some individuals at home, placing others in quarantine, changing workflow, and offering online college courses and remote schooling.

Most of the studies attempting to explain the rising cases in Sudan have focused on knowledge, attitude, and perceptions. For instance, Mohamed et al.[21]. demonstrated that although Sudanese people have good knowledge about the virus, only 27% avoid shaking hands, and 13.5% use face masks. In a community-based survey of 812 Sudanese residents, Hezima et al.[22]. revealed that the average knowledge and attitude scores about COVID-19 were 78.2% and 66.9%, respectively, while the practice of avoiding hand shaking was 57.9% and wearing masks was 34.1%. A research gap exists regarding the mindset of the Sudanese people towards the virus and the dynamics of that on attitudes and behaviour. According to Carol[23], mindset refers to the people's mental attitude and behaviour that determines their interpretation and response to events in a wide range of situations in life. It is acquired from past experiences and individual personalities. Understanding the determinants of the mindset towards the virus helps in the way policymakers frame the nature of the disease to the public, and hence informs best practices for public messaging or targeted interventions for future societal disruptions. Burnette et al.[24]. found that participants given information in a way that emphasized how to change the trajectory of the spread of the virus, reported stronger growth mindsets and more self-efficacy relative to participants who were given information in a way that emphasized fighting the virus. In a study that included 5365 American adults, Zion et al.[25]. showed that mindsets developed in the first 10 days of the COVID-19 pandemic influenced people's emotions and health behaviours—and ultimately predicted their well-being 6 months later.

This study intends to investigate if mindsets have changed after 3 years of the epidemic outbreak in Sudan and how early beliefs concerning COVID-19 affect people's attitudes and behaviours. The primary outcome of the study is to identify the factors influencing people's mindset, while the secondary outcome is to determine what can be learned from the virus incidence to deal with it more effectively in the future. This study is one of the few that were carried out to assess the shift in the mindset of the Sudanese people towards COVID-19.

Methods

Study design

A cross-sectional, descriptive, community-based survey was used to evaluate the shift in the mindset of the Sudanese people

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towards COVID-19 and identify the lessons learned. The study adopted a sequential mixed approach (SMA) which entails starting with in-depth interviews with two experts, followed by structured questionnaires to combine qualitative and quantitative data about the virus. Since more than 70% of the COVID-19 reported cases in the country were in Khartoum State[26]. Khartoum City has been surveyed only, with surrounding capital states, particularly Omdurman and North Khartoum, being excluded due to security reasons. Another inclusion criterion involved participants of age 18 years and older. The work has been reported in line with the STROCSS guidelines[27].

Data collection and sampling frame

For a wider coverage of the target population, the study included both manual and online questionnaires. All participants had to sign the informed consent embedded in the questionnaire, in which they agreed to participate voluntarily with the right to withdraw at any time and were guaranteed to be anonymous and kept confidential. They also agreed to the publication of the results of the research and any accompanying images. The data were gathered using a 20-item, Arabic-language, closed-ended questions, and self-administered online questionnaire. Researchers also used a printed copy of the questionnaire to capture responses from participants who were in person. In addition to demographic questions, the questionnaire asked about the mindset towards the virus, the vaccination, and the lessons learned. The first section included the respondent's age, sex, education level, and if they had received the Corona vaccine or if any members of their family or close relatives had previously contracted the disease. The second section addresses the mindset, the lessons learned, and the best strategies to deal with the virus in the future. The answers were provided on a 5-level Likert scale (strongly disagree, disagree, neutral, agree, and strongly agree).

The self-developed questionnaire was subjected to validity and reliability testing. The questionnaire has been validated by a statistician, psychologist and epidemiologist who checked the face and content validity. The outcome of this process is that some questions have been added, others have been deleted or rephrased for more clarity. Then the questionnaire was tested for reliability using a pilot sample of 20 respondents to minimize any reporting biases. Cronbach's alpha test was applied to the pilot sample to assess the internal consistency of the questionnaire constructs. The result showed a coefficient of 0.86 indicating that there is high internal consistency of the questionnaire items, and the tool is reliable in measuring what is meant to measure. Between the first and third week of January 2023, respondents were given access to the survey online. A week later, respondents were given access to the survey manually. The questionnaire sample size was estimated using the Cochrane formula as follows:

$$n = \frac{z^2 * p * (1 - p)}{d^2}$$

where
n = sample size
z = level of confidence, 1.96 (95% CI)
P = prevalence
d = margin of error
A sample of 318 respondents was obtained using a 95% confidence level, with a margin error of 5.5%, and a prevalence

rate of 50%. Due to the lack of studies on the Sudanese mindset towards the virus, and to provide the largest sample size, a prevalence rate of 50% was assumed. The final sample size taken was 300 respondents, after excluding the questionnaires with incomplete data. This large sample size ensures generalizability of the study over the population from which it was drawn. The sample of respondents was self-recruited via social media (WhatsApp) using Google Forms. In addition, the convenience sampling technique was used via manual distribution. To provide adequate representation of the population, encompassing various sectors and backgrounds, the respondents were chosen from a variety of locations in Khartoum, including transportation hubs, residential neighbourhoods, key roadways, and local markets. Three researchers have participated in the data collection after a two-day training. All participants had to sign the informed consent embedded in the questionnaire, in which they agreed to participate voluntarily with the right to withdraw at any time and were guaranteed to be anonymous and kept confidential. Moreover, ethical clearance was obtained from the institutional review board (IRB) with the ethical number: 20-12-22, before conducting data collection. To supplement the questionnaire data, in-depth interviews have been conducted with an epidemiologist and a psychologist. The interviews addressed the mindset of the Sudanese towards the virus and how this mindset may be changed to encourage positive attitudes and behaviours. Following the World Medical Association's Declaration of Helsinki 2013, the research has been registered in Research Registry, with the unique identifying number 9497: https://www.researchregistry.com/browse-the-registry#home

Data analysis

Data entry and analysis have been done using SPSS, version 20.0. To calculate the frequencies regarding the mindset of respondents towards the pandemic and the lessons learned, descriptive statistics were used. Moreover, a logistic regression model was fitted to examine the factors influencing the shift in the mindset of the Sudanese after three years of the spread of the virus.

Logistic regression is a transformation of the linear model to generate a probability outcome for a binary variable of the mindset shift that is bounded between 1 and 0, indicating whether there is a shift or not. Consider the linear regression given below.

$$\hat{y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots \beta_k x_k$$

Taking the logistic function (z) such that:

$$\theta(z = \hat{y}) = \frac{1}{1 + e^{-\hat{y}}} = \frac{1}{e^{-(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots \beta_k x_k)}}$$

Expressing the outcome as a probability and taking the LOG yields the logistic regression equation:

$$\hat{y} = Log \frac{\theta}{(1 - \theta)}$$

Or

$$\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots \beta_k x_k = Log \frac{\theta}{(1 - \theta)}$$

Taking exponentials for both sides, we get the following equation:

$$e^{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \beta_k x_k} = \frac{\theta}{(1 - \theta)}$$

This will provide the odds ratio as follows:

$$\text{Odds ratio} = \frac{\theta}{(1 - \theta)}$$

Empirical findings

Table 1 shows that of the total ($N = 300$) respondents who participated in the survey, 123 were male (41.0%) and 177 were female (59.0%). The majority of respondents (79.7%) had a university education or earned more than \$239 per month. Most of the respondents were in the age range of 20–29 years (48.3%). A quarter of the respondents had been infected with the virus, and 42.3% had one or more family members who had been infected with the virus. Regarding the vaccine, only 22.7% had it; the majority had not taken it, mainly because they lacked trust in the

Table 1

Shows characteristics of respondents participating in the survey.

Characteristics	Number ($N = 300$), N (%)
Sex	
Male	123 (41.0)
Female	177 (59.0)
Level of education	
Primary and below	11 (3.6)
Secondary	50 (16.7)
University +	239 (79.7)
Age (in years)	
< 20	87 (29.0)
20–29	145 (48.3)
30–39	33 (11.0)
40–49	18 (6.0)
50 +	17 (5.7)
Have you been infected with the virus?	
Yes	76 (25.3)
No	224 (74.7)
Is there any of your family or relatives infected with virus	
Yes	127 (42.3)
No	173 (57.7)
Have you taken the vaccine of the virus?	
Yes	68 (22.7)
No	232 (77.3)
Reasons for not taking the vaccine	
Lack of trust on the vaccine	65 (29.5)
Afraid of the side effects	53 (24.1)
No need for taking it	56 (25.5)
Other	46 (20.9)
Perceptions on the virus when it starts	
I consider it a health threat	232 (77.3)
I consider it a hoax or conspiracy	68 (22.7)
Post-COVID perceptions of the virus	
I consider it a health threat	219 (73.0)
I consider it a hoax or conspiracy	81 (27.0)

Source: Authors' calculations.

vaccine (29.5%) or because they did not have the need to take it (25.5%), as the vaccine has only been mandatory for travelling purposes. Those who were travelling had to have it. Concerning the perception of the respondents about the virus, 77.3% considered it a health threat when it started, compared to 22.7% who regarded it as a hoax or conspiracy. After the virus has been contained, 73% still believe it is a health threat, while 27% believe it is a hoax or conspiracy.

The following can be observed from Table 2:

There is a clear pattern in the responses regarding agreement or disagreement with the given statements about COVID-19 according to the χ^2 test, which produces significant results for all 10 statements with a P value of less than 5%.

Approximately 68% of respondents agree and strongly agree that it is important to remember and acknowledge COVID-19's past. 18.1% of respondents are indifferent, whereas just 15.1% strongly disagree with the statement. The vicious loop of "panic-then-forget" has hindered the global development of efficient health emergency preparedness as demonstrated by Shafaati et al.[28].

About 72% of respondents strongly think that masks should be the main pandemic preventive approach. 8% are impartial. Furthermore, just 10% of the respondents strongly disagree with that.

Regarding the ability to visit their patients remotely through telehealth, a sizeable portion of respondents—roughly 65%—agree and strongly agree. 21% of people are neutral, while 14.3% of respondents disagree. A new Global Initiative on Digital Health (GIDH), a joint effort between the WHO and the G20 India presidency was announced in August 2023[29]

A little under 47% of those surveyed concur—often with a strong concurrence—that the vaccine is robust and effective, and they strongly advise it. Neutrality is expressed by 30.7% of respondents. A little over 23% of respondents indicated disagreement.

Over 72% of respondents strongly or somewhat believe that there is a need to promote the capacity for resilience. Comparatively, 7.3% disagree and strongly disagree with this requirement, whereas 19.7% are neutral.

37.1% of those surveyed believe that the media accurately reports information regarding the virus. 35.1% of respondents are skeptical of the media's reporting on the virus, while 27.8% are neutral.

The government has responded to the pandemic effectively, according to 37.5%, while 43.5% disagree with that, and 19.1% are neutral about the effectiveness of this response.

73% of respondents agree that the infrastructure and health services during the pandemic were inadequate, 10.3% are neutral, and 16.7% strongly disagree with that statement.

Most respondents (66%) indicated that an early lockdown had been successful in slowing the COVID-19 outbreak's progress; 7% were undecided; and only 18.4% disagreed.

More than 50% said that local media campaigns had been successful in containing the virus's spread, while 21.3% were neutral and 23.7% had doubts.

Table 3 displays the multiple logistic regression model for identifying the risk factors that affect people's mindset in Sudan towards COVID-19. There were 15 independent variables identified and utilized to build a multiple logistic regression model. The Wald test and the estimated parameters from the fitted model are also included. Only four characteristics ($P < 0.05$) were significantly correlated with the Coronavirus mindset. According to

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Shows the lessons learned from corona pandemic.

Item	SD	D	N	A	SA	Chi^2	P
(1) It is important to remember and recognize the history of COVID-19.	6.3	8.8	18.1	50.3	17.3	189.3	0.000
(2) I consider masks a key COVID-19 prevention strategy.	3.0	7.0	18.3	50.0	21.7	204.5	0.000
(3) Telehealth allows for remote patient visits.	5.0	9.3	21.0	46.3	18.3	155.4	0.000
(4) I recommend the vaccine as it is a powerful prevention tool.	8.0	14.7	30.7	27.3	19.3	51.1	0.000
(5) There is a need to promote the capacity for resilience.	3.3	4	19.7	52.2	20.7	234.5	0.000
(6) I trust the coverage of the virus in the foreign media.	13.7	21.4	27.8	25.4	11.7	29.9	0.000
(7) The government response has been effective during the pandemic.	19.4	24.1	19.1	26.1	11.4	19.3	0.000
(8) There was a lack of healthcare and infrastructure during the time of the pandemic.	7.0	9.7	10.3	39.3	33.7	139.5	0.000
(9) A stringent and early lockdown is more efficient for controlling the pandemic.	7.7	10.7	15.7	37.7	28.3	95.9	0.000
(10) The local media campaign has been effective in controlling the virus.	10.0	13.7	21.3	33.3	21.7	48.4	0.000

Source: Authors' calculations.

the total classification statistics, the model accurately predicted more than 80% of the cases relating to a shift in the mindset of the people towards Coronavirus as a serious health concern. The mindset model for COVID-19 is shown by equation 1 and the results are displayed in Table 4.

$$\log(\Phi/1 - \Phi) = 0.778 + 0.955\text{Age}(20 - 29)$$
$$+ \text{Age}(30 - 39) - 0.630\text{FRI} \qquad (1)$$
$$- 0.405\text{TFMC} - 0.347\text{VACC}\dots.$$

The Wald test for the coefficient of variable age shows that the age level significantly helps to predict the mindset of the people towards the virus ($p < 0.05$) when accounting for all other variables. The odd ratios (OR) of the mindset change towards Coronavirus in the age groups of 20–29 and 30–39 are 2.599 and 4.278 times, respectively, higher than in the group of those under 20. The respective 95% CIs for these two age groups were (1.273, 5.306) and (1.644, 11.134). The negative coefficient shows that older ages have a more pessimistic outlook on the Coronavirus than younger ages.

Additionally, it was revealed that the history of the disease among the family or close relatives, the faith in international media coverage, and the confidence in the vaccine's efficacy all had a favourable impact on people's mindset. The greater the number of infections with the disease in the family or relatives, the more trust in the international media reporting, the more the confidence in the vaccine's efficacy, the more is the optimistic

Logistic regression model for mindset towards Coronavirus in Sudan.

Variables	B	S.E.	Wald	df	Sig.	Exp (B)	95% CI for Exp (B)	
							Lower	Upper
Sex (male)	0.598	0.316	3.585	1	0.058	1.818	0.979	3.376
Education (illiterate)			1.614	3	0.656			
Primary	− 0.671	1.918	0.122	1	0.727	0.511	0.012	21.934
Secondary	− 1.46	1.558	0.878	1	0.349	0.232	0.011	4.925
University +	− 1.01	1.512	0.445	1	0.505	0.365	0.019	7.065
Age (< 20 years)			10.64	4	0.031			
20–29	− 1.01	0.411	6.052	1	0.014	0.364	0.162	0.814
30–39	− 1.67	0.560	8.969	1	0.003	0.187	0.062	0.560
40–49	− 0.867	0.652	1.772	1	0.183	0.420	0.117	1.507
50 +	− 0.085	0.775	0.012	1	0.912	0.918	0.201	4.197
Infected with virus (No)	− 0.439	0.406	1.168	1	0.280	0.645	0.291	1.429
Family/relative infected (FRI) (No)	0.768	0.361	4.517	1	0.034	2.155	1.062	4.373
Remembering history of COVID-19	0.198	0.147	1.809	1	0.179	1.219	0.913	1.627
Masks are a key prevention strategy	0.058	0.174	0.110	1	0.740	1.059	0.754	1.489
Telehealth facilitates patient visits	− 0.274	0.161	2.914	1	0.088	0.760	0.555	1.041
Vaccine is a powerful prevention tool (VACC)	0.369	0.148	6.217	1	0.013	1.447	1.082	1.934
The need for promoting resilience	− 0.012	0.179	0.005	1	0.945	0.988	0.695	1.403
Trust of foreign media coverage (TFMC)	0.479	0.147	10.60	1	0.001	1.614	1.210	2.153
Government responses were effective	− 0.140	0.134	1.096	1	0.295	0.869	0.669	1.130
Healthcare and infrastructure are lacking	− 0.151	0.141	1.140	1	0.286	0.860	0.652	1.134
Stringent and early lockdown was efficient	0.049	0.141	0.122	1	0.727	1.050	0.797	1.384
Local media campaign has been effective	0.234	0.145	2.619	1	0.106	1.264	0.952	1.679
Constant	− 0.115	1.744	0.004	1	0.947	0.891		
Overall classification (%)	80.1							

Source: Authors' calculations.
Exp, experiment; Sig., significance.

Table 4

Logistic regression model for mindset towards Coronavirus in Sudan with significant factors only.

Coefficients	B	S.E.	Wald test	df	Sig.	Exp (B) Lower	95% CI for Exp (B) Upper
Constant	0.778	0.511	2.320	1	0.128		
Age (< 20 years)			10.827	4	0.029		
20–29	− 0.955	0.364	6.884	1	0.009	2.599	1.273	5.306
30–39	− 1.453	0.488	8.870	1	0.003	4.278	1.644	11.134
40–49	− 0.842	0.611	1.899	1	0.168	2.320	0.701	7.682
50 +	− 0.333	0.702	0.226	1	0.635	1.396	0.353	5.523
Family/relative infected (FRI) (No)	0.630	0.297	4.484	1	0.034	0.533	0.297	0.954
Trust of foreign media coverage (TFMC)	0.405	0.126	10.376	1	0.001	0.667	0.522	0.853
Vaccine is a powerful prevention tool (VACC)	0.347	0.128	7.348	1	0.007	0.707	0.550	0.908

Source: Authors' calculations.
Exp, experiment; Sig., significance.

people's mindset towards the virus as a genuine threat to human health rather than a hoax or conspiracy. The confidence interval for these three covariates is [OR = 0.533 with 95% CI (0.297, 0.954)]; [OR = 0.667 with 95% CI (0.522, 0.853)]; and [OR = 0.707 with 95% CI (0.550, 0.908)], respectively.

To supplement the results of the questionnaire with qualitative data, two semi structured interviews were conducted with a psychologist and epidemiologist in Khartoum. The sex of the experts is female and male with ages of 55, and 47, respectively. The summary of the interviews is presented in Table 5.

Discussion

COVID-19 has been a threat to global health since its outbreak in early 2020, and its repercussions on the economy and society are still being felt. Despite efforts made by researchers worldwide to examine COVID-19, little is known about people's mindset towards the virus, particularly in developing countries like Sudan. A positive mindset affects people's attitudes and behaviours, which are essential for slowing the disease's progression and reducing its overall burden.

According to our study, there were more female respondents than male, and more than 59% of respondents were between the ages of 20 and 39. Almost 80% of the respondents had a university degree. The survey also revealed that 42.3% of people have the virus in their family or close relatives, in addition to the 25.3% who have the virus themselves. Only 22.7% of those participating in this study had received the vaccine. Since vaccination is only necessary for those travelling outside Sudan, there is a low vaccination rate. This is ascribed to a lack of trust, fear of adverse consequences, and a lack of need to get vaccinated.

Table 5

Results of the in-depth interviews.

The theme	Summary of the interviews
Sudanese mindset toward Covid-19	Exp 1: When the pandemic first began, most of the Sudanese thought of the virus as a hoax. After the virus has been well contained in the world, still for most of the Sudanese this belief has not changed so much. Social media and greater exposure to politicians and personal contacts have played a role in intensifying conspiracy beliefs, which in turn caused low compliance with government regulations and a reluctance to undergo testing or vaccinations. Exp 2: The conspiracy theory of the virus is quite dominant in the heads of many Sudanese: that the virus was developed by the Chinese to reduce the world population. Local media has a limited impact, and the news from external media is not trusted by most people.
Implication of Mindset on attitudes and practices	Exp 1: One implication of the mindset of the people in Sudan that the virus is a hoax and not a catastrophic illness, was reflected in their adverse attitudes and practices. The majority have not complied with wearing a mask, avoiding social gatherings, or undertaking the vaccination.
	Exp 2: The compliance with the government-set measures was very low. This is related to people's mindset that the virus is a conspiracy and to the economic conditions of the people to comply with these measures.
Effectiveness of Government measures to contain the virus	Exp 1: The various measures adopted by the government, such as preventing social and religious crowds, closing borders, transferring critical patients to hospitals, isolating some individuals at home, placing others in quarantine, changing workflow, or suspending schools, have limited impact due to the noncompliance of the people with these measures, and there is no strict enforcement. Exp 2: With the widespread poverty and the daily needs of the people, these measures are not effective. The lockdowns and placing sick people under quarantine aggravated their sense of isolation, mental health, and well-being. No financial compensation has been provided to people to convince them to stay at home. Striking a balance is required. The government lacks the resources to do that.
Suggestions to enhance the mindsets	Exp 1: continuous awareness campaigns and dedicated health education regarding the benefits of the vaccine to reduce vaccine reluctance and promote a positive mindset about the government's measures to contain the virus. Exp 2: The role of international organizations is very important in providing financial packages, medical equipment, and supporting the health system in the country.

Source: Authors' calculations.

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As is the case in many developing countries, the conspiracy hypothesis had a clear impact on Sudanese mindsets towards COVID-19. Many factors have contributed to this mindset, including age, history of the disease among the family or close relatives, faith in international media coverage, and confidence in the vaccine's efficacy, leading to negative attitudes and risky behaviours[4,12,17]. Several human-to-human transmission episodes, including illnesses in a healthcare provider and family members, have been identified as risk factors for similar viruses such as monkeypox[30]. Moreover, Choudhary et al.[16]. emphasized the complex interactions between mutant strains, inappropriate COVID behaviour, and public and governmental complacency with vaccination as real causes of the second wave of COVID-19 in India.

The factors influencing Sudanese mindsets towards COVID-19 obtained by our study are minimally informative for causal inference. This may be one of the limitations of the cross-sectional design upon which this study was based. These factors are susceptible to reverse causality, may be limited to assessment of COVID-19 prevalence rather than incidence, or may only provide estimates of current rather than past exposures[31].

Our research also showed that when the pandemic first appeared, 77.3% of survey respondents perceived it as a significant health concern, while only 23% believed it to be a hoax or conspiracy. This might be attributed to the effective coverage of the foreign media, as the model has confirmed. Three years later, thoughts about the virus as a hoax or conspiracy have climbed to 27%. During the in-depth interviews, it was clearly stressed how prevalent conspiracy theories are among Sudanese people and how this influences their risky behaviour. According to the interviews, social media contributed to the conspiracy beliefs, which in turn caused low compliance with government regulations and a reluctance to undergo testing or vaccinations[32].

Further, this could be evidence of two things: first, that the government's response to the crisis has been ineffective; second, that the local media has done a poor job of portraying the epidemic as a major health danger, encouraging people not to take it seriously and behave in an irresponsible manner. The lack of support for vaccinations was a result of the people's negative mindset towards the virus. Only 22.7% of people had received the vaccine, according to the survey's results. Numerous studies have shown that low-income communities and persons with poor levels of education have a high level of reluctance to receive the virus vaccine[17,18,33]. The major causes of vaccine reluctance in Sudan were attributed to a lack of faith in the pharmaceutical industry, apprehension over potential side effects, a lack of necessity for vaccination, and inaccurate or contradictory media reports. The experts in the interviews placed a strong emphasis on the necessity of health education regarding the benefits of the vaccine and the part that families and primary care physicians play in vaccination campaigns to reduce vaccine reluctance.

The study provided a wealth of insights and lessons that can improve future pandemic crisis management strategies. More than 70% of the responders stressed the importance of encouraging resilience and creating effective infrastructure and health services during the pandemic. The epidemic exposed the weakness and lack of crisis readiness of Sudan's medical and health systems. Comparing mandatory mask use to optional mask use, it has been demonstrated that mandatory mask use reduces infection cases by 25–40%[34–36]. Masks do not only lessen exposure to cold settings but also aid in the prevention of virus transmission[37]. According to numerous researchers[21,22], steps must be taken to improve awareness to increase the low rates of wearing masks in Sudan. A little over 68% of the respondents emphasized the importance of recalling and understanding the virus's past. This might be done by selecting a specific day on which the Ministry of Health can conduct a campaign in all media reminding people of the pandemic's impacts, prevention measures and replicating the success stories achieved elsewhere in the world[16]. Moreover, the concept of one health approach suggested by Choudhary et al.[38,39]. can work well in containing emerging infectious diseases. The approach calls for a close collaboration among related scientists from several disciplines, such as epidemiologists, virologists, ecologists, veterinarians, and social scientists.

Another lesson is that the pandemic can be controlled more effectively with a strict lockdown that begins as soon as possible[40,41]. The interviews have indicated that lockdowns are one of the few tools available to societies to contain the spread of the Coronavirus. But for those placed under quarantine, the sense of isolation placed a strain on mental health and well-being. Interventions that helped people establish a growth mindset can play a vital role in supporting those in quarantine. The people would have complied with the measures adopted by the Ministry of Health if the government had been able to strike a balance between total lockdown and people's survival, given the widespread poverty in Sudan. A lockdown should have been let off gradually.

The local media should be crucial in spreading information about the government and the health authorities' efforts to fight the virus. This could involve creating an effective media campaign that targets fundamental hygiene and sanitation behaviours at the household and community levels, such as safe water storage at the household level, hand-washing techniques, and proper disposal of human waste. The in-depth interviews confirmed that greater exposure to politicians and digital media and personal contacts are associated with greater conspiracy and misinformation beliefs[42]. A proper crisis message communication strategy is required to influence people's mindsets. The message should focus on raising awareness about the virus, convincing people to change their daily behaviour, and finally influencing their attitude towards vaccination. This strategy should make use of social media in a transparent manner, with the presence of famous political and religious personalities on social media. This will help counter fake news and conspiracy theories circulating around COVID-19[43].

No work is complete. The main limitation of this study is inherited in the drawbacks of the cross-sectional design that was used by the study. Despite the merits of the cross-sectional design, its primary limitation lies in its inability to separate exposure and outcomes. The factors influencing Sudanese mindsets towards COVID-19 obtained by our study are minimally informative for causal inference. These factors are susceptible to reverse causality, may be limited to assessment of COVID-19 prevalence rather than incidence, or may only provide estimates of current rather than past exposures 28. Another limitation may be attributed to the non-response bias that might occur due to the inability or unwillingness of respondents to respond to the survey questions or an entire survey. The implication of non-response bias represented in inconclusive results and biased estimates. The study attempted to avoid the potential causes of the non-response

bias by validating the questionnaire tool, avoiding asking sensitive questions and selecting the right target populations.

Conclusion

The mindset is crucial for disease transmission and control. With infections like COVID-19, people's mindsets must be changing to ones of swift response. The research examines the mindset towards Coronavirus in developing countries, concentrating on Sudan as a case study. The majority of the study's data came from questionnaires and interviews, which were considered primary sources. The paper's key findings show that Sudanese people have a negative mindset towards Coronavirus. 27% of Sudanese people still believe the virus is a hoax or a conspiracy 3 years after it first started. The implication is that many people have not taken the virus seriously, resulting in negative attitudes and risky behaviour. The age, the history of the disease among the family or close relatives, the faith one places in foreign media, and the conviction that vaccination is an effective technique for lowering infection, were all found to have an impact on people's mindset towards the virus. Due to the public's lack of trust in foreign media, it is required to raise awareness through local media, with a wide presence of famous public personalities on social media.

From the study, some lessons have been drawn that can help shift people's mindsets to perceive the virus as a real health threat. This includes promoting the capacity for resilience, enhancing healthcare and infrastructure, adhering to standard operating procedures (SOP), and remembering and recognizing the devastating history of COVID-19 and its social, economic, and health consequences. The study was limited by focusing only on Khartoum City due to the war. Although the study provided interesting insights, further research is required on the public's mistrust of foreign media coverage and the contribution of local media to educate the public, particularly the elderly, about the virus. Moreover, other factors such as marital status, employment status, urban and rural settings have been overlooked as determining factors for the mindset towards Coronavirus in Sudan, which we recommend for future research.

Ethical approval

Ethical clearance was obtained from the institutional review board (IRB) of the National University, Khartoum, Sudan (Ethical number: 20-12-22) before conducting data collection.

Consent

All participants had to sign the informed consent embedded in the questionnaire, in which they agreed to participate voluntarily with the right to withdraw at any time and were guaranteed of being anonymous and kept confidential. They also agreed for the publication of the results of the research and any accompanying images. A copy of the questionnaire and the informed consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

Z.O. contributed with the concept and the design. G.Z., S.S., and A.M.A. collected the data. Z.O. and Y.K. contributed to the data analysis. All authors contributed to the drafting and the critical revision of the manuscript.

Conflicts of interest disclosure

The author declares no conflict of interest.

Research registration unique identifying number (UIN)

Registry used: Research Registry Unique identifying number is: 9497. Hyperlink to registration: https://www.researchregistry.com/browse-theregistry#home/

Guarantor

Zeinab Omer, the corresponding author of the manuscript, accepts full responsibility for the work and the conduct of the study, had access to the data, and controlled the decision to publish.

Data availability statement

The data supporting the findings of this study are available from the corresponding author, [Z.O.A.], upon reasonable request.

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