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ORIGINAL RESEARCH

Face Mask Practice and Technique During the COVID-19 Pandemic: A Nonrepresentative Cross-Sectional Study in Sudan

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Background: The World Health Organization issued guidelines for face mask use in community settings during the current COVID-19 pandemic. However, data are limited on public compliance with those guidelines in Sudan. Therefore, this study assessed face mask-wearing practice and technique during the COVID-19 pandemic among residents of Sudan.

Methods: A cross-sectional study was conducted from July to September 2021 among Sudanese aged ≥18 years. A web-based questionnaire was shared through different social media platforms. Personal characteristics, four knowledge-associated items, three attitude-associated items, one item concerning mask-wearing practice, and five items related to mask-wearing technique were determined. Univariate, bivariate, and multivariable analyses were performed using STATA v17.

Results: The survey included 1059 participants (48% males, 52% females) from different regions of Sudan. The overall mean ± SD was 3 ± 0.73 for knowledge of COVID-19 transmission; 2.3 ± 0.71 for attitude toward wearing face masks; 0.38 ± 0.49 for the practice of wearing a face mask; and 4.17 ± 0.97 for face mask-wearing technique. Approximately one-third (38%) of participants always wore a face mask during the pandemic, with age, sex, education level, family income, face mask attitude, occupation, and history of COVID-19 infection affecting the practice. All steps of face mask-wearing technique were performed by 46% of participants (59% performed hand hygiene before putting on a mask and 86% after removing it; 98% covered mouth and nose; 90% adjusted masks at the nose bridge, and 84% tied masks securely), and associated with age, occupation, family income, history of COVID-19 infection, and face-mask attitude.

Conclusion: Although knowledge and attitude were relatively good, the practice of wearing a face mask and using proper techniques among participants were low. To ensure optimal face mask use and proper mask-wearing techniques, educational intervention and establishing governmental regulations are highly recommended.

Keywords: knowledge, technique, practices, Sudan, face mask, COVID-19, pandemic

Introduction

Because of the COVID-19 pandemic, face masks have been worn for more than one and a half years in public places.[1] Effectiveness of wearing face masks in public settings has been subject to worldwide debate.[2,3] The World Health Organization (WHO) and the Centers for Disease Control and Prevention have recommended the use of face masks in the community, but direct evidence from such settings to support face mask use is limited.[4,5] Multilayer cloth masks block 50% to 70% of small droplets and particles in laboratory experiments;[6,7] the filtering respirator masks N95, N99, and N100 block 95%, 99%, and 99.97%, respectively, of particles with a median diameter of 0.3 μm, according to NIOSH standards;[8] and surgical masks can reduce the outward emission rate of particles by 90% during speaking and coughing.[9] In a systematic review and meta-analysis of six studies with a total of 1233 participants, face mask use was associated with a significant decrease in risk of COVID-19 infection.[10] In another systematic review and meta-analysis that included

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21 studies, face mask use provided protection against transmission of respiratory viral infection.[11] In a recent sample of US Navy staff, rate of COVID-19 infection was lower (55.8%) among those wearing a mask than among those who did not (80.8%).[12] However, the sample in that study was nonrepresentative of the general public. In a meta-analysis that examined the effects of face mask use, physical distancing, and eye protection on the spread of COVID-19, SARS, and MERS in both health care and public settings, face masks helped to significantly reduce the risk of those infections.[13] Although the effects of consensual or mandatory face mask use on COVID-19 infection rates have been examined in some studies, none were conducted in African countries.[14–18]

Sudan is among the largest African countries and covers 1.886 million km^2. It has a diverse ethnic (African and Afro-Arab) population of 40.53 million, but the country is underdeveloped.[19] From January 3, 2020, to February 8, 2022, total confirmed COVID-19 cases were 59,294 with 3632 deaths. A total of 4,991,228 vaccine doses had been administered as of October 16, 2021.[20] The first COVID-19 case was diagnosed on March 12, 2020, and the Sudanese government initially imposed national restrictions on domestic travel and implemented a partial lockdown as preventive measures. However, those measures were ineffective because of poor adherence within the community.[21] A steady increase occurred in numbers of cases and deaths in Sudan because of limited testing capacity and hospital beds.[19,21] In response, a mandatory face mask-wearing policy in state institutions, workplaces, schools, public transport, and all gathering places subject to overcrowding was announced by Sudan's Minister of Health.[22]

The practice of wearing masks in the community can limit the spread of the SARS-CoV-2 virus.[23] Therefore, the more widely the community adopts mask wearing, the greater the protection for the whole community, which is similar to the principle of herd immunity for vaccination.[24] Thus, widespread mask use in the community is more important than the type of mask worn,[25] and public compliance with WHO recommendations is a key feature of successful risk management for highly contagious diseases such as COVID-19. The WHO issued guidelines on the correct use of masks in the context of COVID-19, derived from best practices in health-care settings.[26] An understanding of knowledge, attitudes, and practices (KAPs) regarding face mask use during the COVID-19 pandemic is essential for health-care authorities to determine readiness to accept behavioral change measures. Assessing KAPs of the general population could help identify gaps in understanding of KAPs, and such an assessment could serve as a guideline to develop timely and required strategies to promote health. This study is the first to assess the practice and technique of wearing face masks among Sudanese residents during the COVID-19 pandemic.

Methods

Study Design and Setting

A web-based, nonrepresentative cross-sectional study of Sudanese adults was conducted from July to September 2021 during the COVID-19 pandemic.

Questionnaire Preparation and Description

An online questionnaire was prepared using Google Forms, and the link was shared through social media platforms, initially to the contacts of one of the authors. Participants were asked to send the survey link to family and friends on their contact lists whom they considered would fulfill the criteria for this study; their friends were also encouraged to send the link to their own contact networks. The questionnaire was based on a literature review of face masks and WHO guidelines.[26–29] Content and face validity of the questionnaire were ensured by experts. The questionnaire was pilot-tested among a sample of 35 subjects, and the final version was reviewed and approved. The questionnaire comprised five sections: sociodemographic information, knowledge of route of transmission of COVID-19, attitude toward face masks, practice of face mask use during the pandemic, face mask-wearing technique, and barriers to wearing a face mask. Monthly family income was grouped into three categories: ≤US$23 (≤10,000 Sudanese pounds (SDG)) per month (low income), >$23 (>10,000 SDG) to $125 (55,000 SDG) per month (middle income), and >$125 (>55,000 SDG) per month (high income).[30] Knowledge about route of transmission of COVID-19 was assessed by four items (K1–4), which were used to calculate a knowledge score. Three items (A1–3) were used to assess attitudes toward COVID-19 and use of face masks, with each item categorized as either positive or negative. Practice of face mask use was assessed by one item (P1), categorized as always or sometimes/never. Face mask-

wearing technique was assessed in five steps (S1–5), and categories were either always performed all steps of face mask-wearing technique or sometimes/never. In knowledge, practice, and technique sections, each correct question received one point, with zero given for an incorrect one. In the attitude section, a positive attitude received one point, with zero assigned for a negative attitude (Table 1). The objective and inclusion/exclusion criteria of the study were included on the cover page of the survey, and consent to participate was required before beginning the questionnaire.

Sample Size Calculation

Sample size was calculated using OpenEpi software. The minimum sample size was 500 participants with 80% statistical power and 5% type I error. The practice of wearing face masks was assumed to be 50% in order to attain the maximum sample size, taking into account 30% expected incomplete and missing responses.

Statistical Analyses

Data were obtained in an Excel sheet after exporting to STATA v17 (StataCorp, College Station, TX, USA). Data are presented as mean ± SD for continuous variables and as percentage for categorical variables. Continuous variables were compared using either Student's *t*-tests or one-way ANOVAs for more than two groups, and chi-squared tests were performed to compare categorical variables. Multivariable regression analysis was performed to identify determinants of knowledge, attitude, practice, and technique of wearing face masks. Variables at $p < 0.25$ in the bivariate analysis were included in the multivariable analysis. A multiple linear regression analysis was conducted to determine factors that affected the knowledge score. A multiple logistic regression analysis was performed to identify factors that affected attitudes, practice, and technique of face-mask wearing. Odds ratios (ORs), beta coefficients, and 95% confidence intervals (CIs) are reported. A *p*-value ≤0.05 was considered as strong evidence against the null hypothesis.

Results

Sociodemographic Characteristics

A total of 1059 participants responded to the survey. Of the participants, 664 (63%) were aged 18 to 30 years, 548 (52%) were females, 527 (50%) had secondary school education or higher, 711 (67%) were single, 507 (48%) were employed, 504 (48%) had family income of 10,000 to 55,000 SDG, 203 (19%) had chronic disease, and 257 (24%) had a history of COVID-19 infection (Table 2).

Knowledge About Route of Transmission of COVID-19

The mean score for knowledge was 3 (SD = 0.73, range 1–4), and the range of correct responses was from 49% to 94%. According to bivariate analysis, respondents with a higher level of education had significantly higher knowledge scores ($p = 0.004$; Table 2).

Table 3 displays the multiple linear regression on age group (31–40 vs 18–29 years; β = 0.15 [CIs: −0.01, 0.31]; $p = 0.074$), gender (female vs male; β = 0.08 [CIs: −0.01, 0.17]; $p = 0.075$), and education level (postgraduate vs bachelor's degree; β = 0.15 [CIs: −0.003, 0.29]; $p = 0.056$), which had a borderline positive influence on the knowledge mean score.

Attitude Toward Wearing Face Masks

The mean attitude score was 2.3 (SD = 0.71, range 0–3), and the positive attitude rate ranged from 48% to 94% (Table 1). Associations between attitudes and independent variables in bivariate analyses are displayed in Table 4. The multiple logistic regression showed negative responses to A1 ("Do you think that you are vulnerable to infection?") more often among males (vs females; aOR 1.48, $p = 0.005$) and those with history of COVID-19 infection (vs no history of COVID-19 infection; aOR 1.99, $p < 0.001$) and less often among those with postgraduate education (vs secondary school education or below; aOR 0.57, $p = 0.026$). Negative responses to A3 ("Do you think wearing a mask can reduce the chance of getting COVID-19?") were more common among those with a family income of ≤$23 (vs >$23–125; aOR 2.28, $p = 0.015$; Table 5).

Table 1 Knowledge, Attitudes, Practice, and Technique Regarding Wearing of Face Masks During the COVID-19 Pandemic in Sudan (n = 1059)

Variables	Response	Determination (Score)	N (%)
Section I: Knowledge about route of transmission of COVID-19			
K1: Coughing	Yes	Correct (1)	993 (94)
	No	Incorrect (0)	66 (6)
K2: Talking	Yes	Correct (1)	655 (62)
	No	Incorrect (0)	404 (38)
K3: Shaking hands	Yes	Correct (1)	989 (93)
	No	Incorrect (0)	70 (7)
K4: Swimming	Yes	Incorrect (0)	543 (51)
	No	Correct (1)	516 (49)
Section II: Attitude toward wearing of face masks			
A1: Do you think that you are vulnerable to infection with coronavirus?	Yes	Positive (1)	513 (48)
	No	Negative (0)	546 (52)
A2: Do you think it is necessary to wear masks during current COVID-19 pandemic?	Yes	Positive (1)	984 (93)
	No	Negative (0)	75 (7)
A3: Do you think wearing a mask can reduce the chances of getting COVID-19?	Yes	Positive (1)	991 (94)
	No	Negative (0)	68 (6)
Section III: Practice of wearing face masks			
P: Do you wear a face mask during current COVID-19 pandemic?	Always	Correct (1)	401 (38)
	Sometimes	Incorrect (0)	608 (57)
	Never	Incorrect (0)	50 (5)
Section IV: Technique of wearing face masks (n = 1009)			
Steps of face-mask wearing (n = 1009)			
S1: Do you perform hand hygiene before putting on your mask?	Always	Correct (1)	592 (59)
	Sometimes/ never	Incorrect (0)	417 (41)
S2: Do you ensure it covers the mouth and nose?	Always	Correct (1)	984 (98)
	Sometimes/ never	Incorrect (0)	25 (2)
S3: Do you adjust it at the bridge of the nose?	Always	Correct (1)	910 (90)
	Sometimes/ never	Incorrect (0)	99 (10)

(*Continued*)

Table 1 (Continued).

Variables	Response	Determination (Score)	N (%)
S4: Do you tie it securely to minimize any gaps between the face and the mask?	Always	Correct (1)	850 (84)
	Sometimes/ never	Incorrect (0)	159 (16)
S5: Do you wash your hands after removing the face mask?	Always	Correct (1)	872 (86)
	Sometimes/ never	Incorrect (0)	137 (14)

Abbreviations: K, knowledge; A, attitude; P, practice; S, steps for technique of face-mask wearing.

Table 2 Participant Socioeconomic Characteristics and Knowledge Level About Route of Transmission of COVID-19 in Sudan

Characteristics	Category	N (%)	Knowledge Score (Mean ± SD)	*p*-value
Age group[a]	18–30 years	664 (63)	2.96 ± 0.79	0.078
	31–40 years	160 (15)	3.13 ± 0.64	
	41–50 years	126 (12)	3.02 ± 0.69	
	51–60 years	67 (6)	3.03 ± 0.58	
	≥61 years	42 (4)	3.12 ± 0.50	
Gender[b]	Male	511 (48)	2.97 ± 0.73	0.123
	Female	548 (52)	3.04 ± 0.73	
Educational level[a]	Secondary school or below	527 (50)	2.94 ± 0.77	0.004*
	Bachelor's degree	369 (35)	3.04 ± 0.73	
	Postgraduate	163 (15)	3.14 ± 0.58	
Marital status[b]	Married	348 (33)	3.04 ± 0.67	0.246
	Single	711 (67)	2.98 ± 0.76	
Occupation[a]	Employed	507 (48)	3.03 ± 0.73	0.775
	Unemployed	87 (8)	3 ± 0.73	
	Student	406 (38)	2.98 ± 0.76	
	Housewife	59 (6)	2.95 ± 0.57	
Family income[a]	≤10,000 SDG (≤US$23)	162 (15)	2.99 ± 0.68	0.955
	>10,000–55,000 SDG (>$23–125)	504 (48)	3.01 ± 0.76	
	>55,000 SDG (>$125)	393 (37)	2.99 ± 0.73	
History of chronic conditions[b]	Yes	203 (19)	3.06 ± 0.75	0.186
	No	856 (81)	2.99 ± 0.73	
Have you caught COVID-19 infection?[b]	Yes	257 (24)	3.06 ± 0.75	0.136
	No	802 (76)	2.98 ± 0.73	

Note: [a]ANOVA, [b]Independent *t*-test, *$p < 0.05$.
Abbreviation: SDG, Sudanese pounds.

Table 3 Multiple Linear Regression on Factors Associated with Knowledge About Route of Transmission of COVID-19

Variables[a]	Coefficient	95% CI	*p*-value
Age group (31–40 vs 18–29)	0.15	−0.01, 0.31	0.074
Gender (females vs males)	0.08	−0.01, 0.17	0.075
Education level (postgraduate vs bachelor's degree)	0.15	−0.003, 0.29	0.056

Note: [a]Variables at p > 0.1 were not included.

Practice of Wearing Face Masks

Of participants, 38% (n = 401) always wore a face mask during the pandemic, 57% (n = 608) used the practice sometimes, and 5% (n = 50) never wore a face mask. Most participants (n = 707, 70%) used medical masks; whereas 30% (n = 302) used cloth masks. Approximately 37% (n = 375) replaced their mask with a new, clean and dry one as soon as it became damp, soiled, or wet, with 29% (n = 293) replacing it at least once daily, 19% (n = 192) replacing it every time they went outside their home, and 15% (n = 149) replacing it with uncertain frequency. According to bivariate analysis, factors significantly associated with never/sometimes wearing face masks were age group of 51–60 years ($p < 0.001$), males ($p < 0.001$), educational level of secondary school or below ($p < 0.001$), single marital status ($p = 0.002$), students ($p = 0.041$), family income of >$23–125 ($p = 0.029$), no history of chronic illnesses ($p = 0.001$), and attitude score ($p < 0.001$) (Table 6). A multiple logistic regression analysis on factors revealed that only males (aOR 1.65, $p = 0.001$) were more likely to never/sometimes wear face masks, whereas education level of postgraduate vs secondary school or below (aOR 0.38, $p < 0.001$), family income of ≤$23 vs >$23–125 (aOR 0.59, $p = 0.008$), family income of > $125 vs >$23–125 (aOR 0.70, $p = 0.019$), and attitude score (aOR 0.69, $p < 0.001$) were less likely to be associated with never/sometimes wearing face masks (Table 7).

Technique of Wearing Face Masks

The mean score for technique was 4.17 (SD = 0.97, range 0–5). Of the participants, 59% always performed hand hygiene before putting on a mask and 86% did so after removing it, 98% covered the mouth and nose, 90% adjusted masks at the bridge of the nose, and 84% securely tied masks (Table 1). All steps of face mask-wearing technique were performed by 46% (n = 468) of participants. According to bivariate analysis, factors associated with never/sometimes performing techniques of wearing face masks were age group of 18–30 years ($p < 0.001$), educational level of secondary school or below ($p = 0.004$), single marital status ($p = 0.002$), students ($p < 0.001$), history of COVID-19 infection ($p = 0.009$), and attitude score ($p < 0.001$) (Table 6). Multiple logistic regression analysis showed that never/sometimes performing techniques of face-mask wearing was more common among students (vs employed; aOR 1.68, $p = 0.032$) and those with a history of COVID-19 infection (aOR 1.42, $p = 0.027$), whereas it was less likely among age group 61+ vs 18–29 (aOR 0.39, $p = 0.029$), family income ≤$23 vs >$23–125 (aOR 0.65, $p = 0.029$), and attitude score (aOR 0.69, $p < 0.001$) (Table 7).

Concerns and Barriers to Wearing Face Masks

Of participants, 19% (n = 193) reported suffocation, 6% (n = 62) reported discomfort due to sweating inside the mask, and 6% (n = 61) held forgetfulness liable for noncompliance with face mask practices. Other reasons were cited by 20% (n = 202) of participants, including cost of face masks, obstructing/hindering verbal communication, conscious awareness of respiration, and difficulty during meals with the need to remove face masks while eating or drinking. However, 47% (n = 491) of participants did not express any concerns with wearing face masks.

Table 4 Bivariate Analysis of Factors Associated with Attitudes Regarding Practice of Wearing Face Masks

Characteristics	A1		A2		A3	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Age group (years)	Negative 546 (52)	Positive 513 (48)	Negative 75 (7)	Positive 984 (93)	Negative 68 (6)	Positive 991 (94)
18–30	371 (56)	293 (44)	52 (8)	612 (92)	48 (7)	616 (93)
31–40	81 (51)	79 (49)	11 (7)	149 (93)	8 (5)	152 (95)
41–50	50 (40)	76 (60)	8 (6)	118 (94)	8 (6)	118 (94)
51–60	29 (43)	38 (57)	3 (4)	64 (96)	2 (3)	65 (97)
≥61	15 (36)	27 (64)	1 (2)	41 (98)	2 (5)	40 (95)
Chi-squared		0.001*		0.595		0.597
Sex						
Female	260 (47)	288 (53)	32 (6)	516 (94)	37 (7)	511 (93)
Male	286 (56)	225 (44)	43 (8)	468 (92)	31 (6)	480 (94)
Chi-squared		<0.006*		0.103		0.649
Education level						
Secondary school or below	295 (56)	232 (44)	44 (8)	483 (92)	46 (9)	481 (91)
Bachelor's degree	186 (50)	183 (50)	19 (5)	350 (95)	13 (4)	356 (96)
Postgraduate	65 (40)	98 (60)	12 (7)	151 (93)	9 (6)	154 (94)
Chi-squared		0.001*		0.183		0.007*
Marital status						
Married	155 (45)	193 (55)	25 (7)	323 (93)	18 (5)	330 (95)
Single	391 (55)	320 (45)	50 (7)	661 (93)	50 (7)	661 (93)
Chi-squared		0.001*		0.928		0.246
Occupation						
Employed	253 (50)	254 (50)	33 (7)	474 (93)	28 (6)	479 (94)
Unemployed	43 (49)	44 (51)	4 (5)	83 (95)	1 (1)	86 (99)
Student	232 (57)	174 (43)	34 (8)	372 (92)	36 (9)	370 (91)
Housewife	18 (31)	41 (69)	4 (7)	55 (93)	3 (5)	56 (95)
Chi-squared		0.001*		0.550		0.030*
Family income (SDG: Sudanese pounds)						
≤10,000 (≤US$23)	88 (54)	74 (46)	15 (9)	147 (91)	17 (10)	145 (90)
>10,000–55,000 (>$23–125)	248 (49)	256 (51)	27 (5)	477 (95)	24 (5)	480 (95)
>55,000 (>$125)	210 (53)	183 (47)	33 (8)	360 (92)	27 (7)	366 (93)
Chi-squared		0.339		0.107		0.032*

(*Continued*)

Table 4 (Continued).

Characteristics	A1		A2		A3	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Chronic illness						
Yes	85 (42)	118 (58)	9 (4)	194 (96)	197 (97)	6 (3)
No	461 (54)	395 (46)	66 (8)	790 (92)	794 (93)	62 (7)
Chi-squared		0.002*		0.102		0.025*
Have you had COVID-19 infection?						
Yes	161 (63)	96 (37)	15 (6)	242 (94)	18 (7)	239 (93)
No	385 (48)	417 (52)	60 (7)	742 (93)	50 (6)	752 (94)
Chi-squared		<0.001*		0.371		0.661
Knowledge score, Mean [SD]	3.02 [0.77]	2.99 [0.69]	2.89 [0.84]	3.01 [0.73]	2.84 [0.92]	3.01 [0.72]
t-test		0.533		0.180		0.056

Note: *p-value <0.05.
Abbreviations: SD, standard deviation; A1, Do you think that you are vulnerable to infection with coronavirus?; A2, Do you think it is necessary to wear masks during current COVID-19 pandemic?; A3, Do you think wearing a mask can reduce the chances of getting COVID-19?.

Table 5 Multiple Logistic Regression on Factors Associated with Negative Attitudes Regarding Practice of Wearing Face Masks

Variables	aOR (95% CI)	*p*-value
A1: Negative (vs positive)		
Sex (male vs female)	1.48 (1.12, 1.95)	0.005*
Education level (postgraduate vs secondary school or below)	0.57 (0.35, 0.94)	0.026*
Occupation (housewife vs employed)	0.56 (0.29, 1.07)	0.078
History of COVID-19 infection (yes vs no)	1.99 (1.47, 2.69)	<0.001*
A2: Negative (vs positive)		
Sex (male vs female)	1.58 (0.97, −2.56)	0.064
Education level (bachelor's degree vs secondary school or below)	0.62 (0.35, 1.09)	0.095
A3: Negative (vs positive)		
Education level (bachelor's degree vs secondary school or below)	0.45 (0.19, 1.04)	0.064
Occupation (unemployed vs employed)	0.18 (0.02, 1.37)	0.09
Family income (≤10,000 vs >10,000–55.000 SDG (≤US$23 vs > $23–125))	2.28 (1.17, 4.45)	0.015*
Knowledge score	0.76 (0.55, 1.04)	0.089

Note: *p-value <0.05.
Abbreviation: aOR, adjusted odds ratio.

Discussion

The overall mean knowledge level score was 3 (of 4 total), which indicated that most study participants had good knowledge of the route of COVID-19 transmission. This result is consistent with those of studies conducted in Sudan, Egypt, Nigeria,

Table 6 Bivariate Analysis of Factors Associated with Practice and Technique of Wearing Face Masks

Characteristics	Practice of Face-Mask Wearing		Technique of Face-Mask Wearing	
	Never/Sometimes n (%) 658 (62.1)	Always n (%) 401 (37.9)	Never/Sometimes n (%) 541 (54)	Always n (%) 468 (46)
Age group (years)				
18–30	432 (65)	232 (35)	371 (59)	263 (41)
31–40	101 (63)	59 (37)	75 (51)	73 (49)
41–50	67 (53)	59 (47)	53 (43)	70 (57)
51–60	45 (67)	22 (33)	29 (45)	36 (55)
≥61	13 (31)	29 (69)	13 (33)	26 (67)
Chi-squared		<0.001*		<0.001*
Sex				
Female	312 (57)	236 (43)	272 (52)	256 (48)
Male	346 (68)	165 (32)	269 (56)	212 (44)
Chi-squared		<0.001*		0.161
Education level				
Secondary school or below	351 (67)	176 (33)	284 (57)	213 (43)
Bachelor's degree	237 (64)	132 (36)	190 (54)	163 (46)
Postgraduate	70 (43)	93 (57)	67 (42)	92 (58)
Chi-squared		<0.001*		0.004*
Marital status				
Married	193 (55)	155 (45)	154 (47)	177 (53)
Single	465 (65)	246 (35)	387 (57)	291 (43)
Chi-squared		0.002*		0.002*
Occupation				
Employed	313 (62)	194 (38)	241 (50)	245 (50)
Unemployed	47 (54)	40 (46)	47 (56)	37 (44)
Student	268 (66)	138 (34)	234 (61)	151 (39)
Housewife	30 (51)	29 (49)	19 (35)	35 (65)
Chi-squared		0.041*		<0.001*
Family income (Sudanese pounds per month)				
≤10,000 (≤US$23)	93 (57)	69 (43)	72 (47)	82 (53)
>10,000–55,000 (>$23–125)	334 (66)	170 (34)	256 (53)	225 (47)
>55,000 (>$125)	231 (59)	162 (41)	213 (57)	161 (43)

(*Continued*)

Table 6 (Continued).

Characteristics	Practice of Face-Mask Wearing		Technique of Face-Mask Wearing	
	Never/Sometimes n (%) 658 (62.1)	Always n (%) 401 (37.9)	Never/Sometimes n (%) 541 (54)	Always n (%) 468 (46)
Chi-squared		0.029*		0.099
Chronic illness				
Yes	105 (52)	98 (48)	95 (47)	105 (53)
No	553 (65)	303 (35)	446 (55)	363 (45)
Chi-squared		0.001*		0.053
Have you had COVID-19 infection?				
Yes	155 (60)	102 (40)	149 (61)	96 (39)
No	503 (63)	299 (37)	392 (51)	372 (49)
Chi-squared		0.489		0.009*
Knowledge score, Mean [SD]	2.99 [0.76]	3.02 [0.69]	2.99 [0.78]	3.02 [0.68]
t-test		0.613		0.510
Attitude score, Mean [SD]	2.23 [0.78]	2.54 [0.54]	2.29 [0.73]	2.49 [0.58]
t-test		<0.001*		<0.001*

Note: *p-value <0.05.

and Ethiopia, in which correct knowledge about route of transmission of COVID-19 was 89%, 95%, 94%, and 95%, respectively.[31–34] Similarly, in Nepal, knowledge about mode of transmission was overall 95.8%, but in Malaysia, only 43.3% of participants replied correctly when asked whether the virus was airborne, and only 35.7% replied correctly when asked whether touching and eating wild animals could transmit the infection.[27,35] In this study, there was an association between knowledge scores and educational level, with higher knowledge among participants with higher levels of education. This result is consistent with those of studies conducted in the general populations of Sudan, Egypt, and Nepal.[27,31,32] This association most likely occurs because with a higher level of education, a person is more likely to understand print and electronic information regarding new infections such as COVID-19.[36–38] Gender and age group were also associated with knowledge level, which is consistent with previous studies.[27,35] Thus, to improve health literacy of both genders, as well as that of aged and illiterate populations in the country, the recommendation is to explore options such as role-play, art, and radio programs. By increasing efforts to inform the public, effects of conflicting information regarding COVID-19 infection, a problem recently termed an "infodemic", can also be reduced.[39–42]

In the present study, attitudes toward COVID-19 infection and use of face masks were positive. Less than half of participants thought they were vulnerable to COVID-19 infection, and one significant predictor of positive attitude identified in the regression model was higher educational level. A relatively high level of education could directly increase awareness and therefore also the sense of being at risk of contracting COVID-19 infection. Furthermore, most participants believed that wearing masks during the current pandemic was necessary and were convinced that wearing a mask could reduce the chance of COVID-19 infection. These findings are consistent with those of studies conducted in China and Saudi Arabia, which also show a high level of positive attitude among participants.[43,44] The results in this study are also consistent with those of a study conducted in Saudi Arabia in which most participants had a positive attitude toward effective control of the pandemic by compliance with wearing of face

Table 7 Multiple Logistic Regression on Factors Associated with Never/Sometimes Practicing and Performing Techniques of Wearing Face Masks

Variables	aOR (95% CI)	*p*-value
Never/sometimes practice face-mask wearing (vs always)		
Age group (years) (31–40 vs 18–29)	1.61 (0.97, 2.68)	0.068
Age group (51–60 vs 18–29)	2.05 (0.99, 4.19)	0.051
Age group (61+ vs 18–29)	0.44 (0.19, 1.03)	0.058
Sex (male vs female)	1.65 (1.23, 2.22)	0.001*
Education level (postgraduate vs secondary school or below)	0.38 (0.22, 0.63)	< 0.001*
Family income ≤10,000 SDG vs >10,000–55,000 (≤US$23 vs >$23–125)	0.59 (0.40, 0.87)	0.008*
Family income >55,000 vs >10,000–55,000 SDG (>$125 vs >$23–125)	0.70 (0.52, 0.94)	0.019*
Face mask attitude score	0.53 (0.43, 0.65)	<0.001*
Never/sometimes performed all steps of face-mask wearing technique (vs always)		
Age group (years) (61+ vs 18–29)	0.39 (0.17, 0.91)	0.029*
Sex (male vs female)	1.32 (0.99, 1.75)	0.058
Occupation (student vs employed)	1.68 (1.05, 2.70)	0.032*
Family income ≤10,000 vs >10,000–55,000 SDG (≤$23 vs >$23–125)	0.65 (0.44, 0.96)	0.029*
Have you had COVID-19 infection? (yes vs no)	1.42 (1.04, 1.94)	0.027*
Face mask attitude score	0.69 (0.56, 0.84)	<0.001*

Note: *p-value <0.05.
Abbreviation: aOR, adjusted odds ratio.

masks.[28] High income was also associated with positive attitudes regarding wearing masks to reduce the chance of infection. High income likely increases the chances of having a smart television, smartphone, and advanced Internet connection, and the use of such technology ultimately increases access to health education provided through media sources.

In this study, approximately two-thirds of participants preferred to use a medical/surgical mask, whereas others used cloth masks for protection. Medical/surgical masks can reduce the outward emission rate of particles by 90% during speaking and coughing.[9] Although a similar choice of masks was reported by Al Naam et al[28] in Saudi Arabia, it is concerning that the use of any face mask can reduce infection exposure and risk irrespective of its type.[25,28] However, the key factor that should be considered while selecting a mask is its ability to protect against exposure to droplets.[45] Therefore, on the basis of this property, the N-95-type of face mask is more effective than medical masks.[46] By contrast, cloth masks provide 40% to 97% protection, depending on the type of cloth and number of layers.[47] Despite these differences, the primary reason most people choose medical masks is because they are disposable and widely accessible.[48] The WHO recommends essential mask use for health-care workers, the general population in public places and on transportation, people living in overcrowded places, and vulnerable populations, as well as for anyone showing any symptoms suggestive of COVID-19 infection.[5] In this study, more than one-third of participants always practiced wearing a face mask and more than half sometimes, which were lower rates than those in studies from different regions of Hong Kong,[49] Saudi Arabia,[28] Malaysia,[35] and Iran.[50] However, differences in the type of questions about the practice of face mask use should be considered.

In this study, most participants properly covered the nose and mouth and adjusted masks at the bridge of the nose for better fit, which are important recommendations for effective use of face masks, and also tied masks securely to minimize any gaps between face and mask. The rates in this study are higher than those in a study conducted in Nepal.[27] Particles escape from a mask either by direct penetration through the mask or by leakage from its sides, and both pathways are

critical factors affecting mask protection efficacy.[7,8,27] Medical masks that fit well to the head can significantly improve control of particle escape.[36] Fit can be improved by improved mask design, adjustment at the bridge of the nose, and adhesive tape or fluffed polypropylene fibers.[4,5,9] According to the WHO, masks are only effective when coupled with hand hygiene and also with knowledge of proper mask use and disposal.[5] In this study, many participants washed their hands after removing a face mask. This result is similar to that in a previous study on knowledge and practices regarding face mask use among the general population.[27] Multiple regression analysis revealed a significant association between technique of face-mask wearing and employment status and no history of COVID-19 infection. The association with employment was perhaps due to the perceived high risk of exposure to SARS-CoV-2 of participants within a work environment.[51] In addition, those with a previous COVID-19 infection might have felt they were protected by natural immunity after infection.[52] In this study, there was a positive correlation between practice and attitude scores, which suggested that a positive attitude can lead to better compliance with techniques of wearing a face mask.[28]

Some of the challenges associated with consistent use of face masks were also identified in the current study. Suffocation was the major concern of participants, whereas other reasons for not wearing a mask included sweating and forgetfulness. These results are supported by those of a Brazilian study that also identified suffocation as the most cited reason for discomfort caused by face masks.[53] Medical masks easily become damp, and sweating is primarily linked with cloth masks because they retain moisture and are reused.[54–56] However, discomfort is not the sole determinant of face mask compliance, and social factors are also important. One study found that when more mask-wearing practices are displayed by social groups in a society, the discomfort felt by its residents decreases.[57] Therefore, the solution to compliance lies in social acceptance of mask wearing as a new norm and in promotion of its adherence by health authorities.

There were some limitations in the current study. A web-based survey and nonprobability sampling technique were used, which may not be sufficiently accurate to represent the study population. Thus, the study most likely did not include the illiterate, the elderly, those without smartphones, and those with limited Internet access, which might lead to results that were overestimates because of better awareness and practices among the study participants. Another limitation was that the data were self-reported and therefore could have been affected by social desirability bias. Thus, the possibility that participants responded positively to attitude and practice questions on the basis of perceived expectations could not be excluded.

Conclusion

Although knowledge and attitude were relatively good, practice and technique of wearing face masks among Sudanese participants were low. Therefore, to ensure optimal levels of face mask use and proper techniques of wearing a face mask, increasing public awareness with training is highly recommended.

Ethical Approval

Ethical approval was received from the Ethics Committee at International University of Africa at Sudan (reference no. FMEC/21/2). All procedures performed in the study were in accordance with the ethical standards of institutional and national research committees and with the 1964 Helsinki Declaration and its later amendments. Informed consent was obtained from each participant before participating in the study.

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Author contributions

OW conceived and designed the survey. IA performed the investigation and revised the paper. OW and RK analyzed the data and wrote the original paper. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agreed to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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