scientific reports

OPEN

Knowledge, attitudes, and practices towards COVID-19 prevention among indigenous population in Malaysia: A cross-sectional study

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The COVID-19 pandemic has become a significant challenge to humanity, especially marginalized groups such as indigenous people. This study aimed to assess the knowledge, attitude, and practice towards COVID-19 prevention among the indigenous population in Lipis district, Pahang, Malaysia. A cross-sectional study was conducted among the indigenous population and the data were collected through face-to-face interviews using a validated questionnaire. The mean score of knowledge, attitude, and practice were 2.35 (SD 1.104), 32.84 (SD 4.756), and 9.64 (SD 3.227), respectively. In the bivariable analysis, the younger the age (p < 0.001), and the higher the education level (p = 0.001) of the participants, the higher the knowledge score on COVID-19. Meanwhile, the female participants (p = 0.043) and the higher the household income, the higher the attitude score of the participants (p = 0.006). Factors that contributed to a higher score of practice towards COVID-19 prevention were younger age (p = 0.013), female (p < 0.001), no religion (p = 0.026), unemployed (p < 0.001), and higher household income (p = 0.012). There was a positive correlation between knowledge score and practice score (p = 0.001) and a positive correlation between attitude score and practice score (p < 0.001), respectively. Multivariable regression analysis showed that the younger age (p < 0.001) was significantly associated with a higher knowledge score. Furthermore, female (p = 0.018), unemployed (p = 0.001), higher knowledge score (p < 0.001), and higher attitude score (p < 0.001) were significantly associated with a higher score of practice towards COVID-19 prevention among the participants, respectively. Indigenous people in Malaysia have a good knowledge, attitude, and practice towards COVID-19. However, strategic planning and programmes related to preventive practices against infectious disease outbreaks need to be conducted continuously to reduce the outbreaks in the future.

The coronavirus disease 2019 or well-known as COVID-19, is a newly virus discovered at the end of December 2019, which was first originated in Wuhan, China[1,2]. The World Health Organization (WHO) has been declared COVID-19 as a global pandemic since it has been spread throughout the world[3,4]. To date, over 772 million confirmed COVID-19 cases have been reported, and at least 6.9 million deaths recorded globally as a result of this pandemic[5].

On January 24, 2020, the first confirmed cases of COVID-19 in Malaysia were identified involving three Chinese tourists[6]. As of 9th December 2023, Malaysia has recorded more than 5.1 million positive COVID-19 cases involving more than 37.2 thousand deaths[7]. On March 18, 2020, the Malaysian government announced a Movement Control Order (MCO) with a strict Standard Operating Procedure (SOP) as an initiative to prevent

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the spread of COVID-19 infection to the community. Additionally, the Malaysian government also actively uses media platforms to give information about the development of COVID-19 infection to the public[8].

The indigenous people of Peninsular Malaysia, well-known as Orang Asli, are a minority community that has lagged in terms of socioeconomic status, health, and education. Since the indigenous population is considered as one of the important marginalized populations in Malaysia, it is crucial to investigate their knowledge, attitude, and practice (KAP) towards COVID-19 prevention. Moreover, the indigenous community is also considered vulnerable and have a high risk of being infected with the COVID-19 epidemic[9]. Based on Rosnon et al. (2022), the findings of their study revealed that the level of awareness and practice of COVID-19 prevention among the indigenous elderly in Peninsular Malaysia was still at the very surface level, and lack of practicing precaution measures[10].

On the other hand, a survey conducted among indigenous people in the Brazilian, Peruvian, and Ecuadorian Amazon showed that the level of implementation of prevention practices of COVID-19 was at the bottom level in the community[11]. Moreover, a group of indigenous people in Malaysia took the pandemic seriously and took proactive actions to keep their community safe. These actions included performing rituals and prayers for health maintenance, building barricades to control movement into their villages, and retreating into the forest[12,13]. Similar actions have also been seen in other indigenous people in other countries, such as in the Mexico and United States[14,15].

Better knowledge, attitude, and practice related to COVID-19 infections could assist the indigenous community to fight against COVID-19 if only the community is given access to resources and services that allow them to take immediate action. Previous experiences with infectious disease outbreaks including those caused by the H1N1, HIV, Zika virus, and SARS have shown that myths and misinformation were also prevalent, making it more challenging for the authorities to implement containment and mitigation strategies[16]. Misconceptions concerning the disease during the Ebola outbreak in Guinea and Nigeria resulted in a lack of preventive behavior, mistrust, and threats to healthcare professionals[17].

Similarly, in order to raise awareness regarding COVID-19 prevention, spread, and treatment among particular population clusters, a locale-specific strategy is imperative[18]. This is only achievable if it is known whether the community is willing to adopt the behaviors and precautions that health authorities have recommended[19]. So far, there have been limited studies examining the KAPs towards COVID-19 prevention, especially among the indigenous population in Malaysia. In addition, indigenous people has a complex knowledge of health and disease especially when it comes to the COVID-19 pandemic. Therefore, it is important to conduct research to measure the level of knowledge, attitude, and practice towards COVID-19 prevention. The findings of this study are important to help the Malaysian Government implement strategies for pandemic control among the indigenous community in future crises.

Materials and methods
Study design and participants
In this study, a cross-sectional survey with a quantitative approach was conducted on the indigenous population in Lipis District, Pahang, Malaysia, to assess the knowledge, attitude, and practice towards COVID-19 prevention. The representative sample size needed was calculated with a sample size calculator of two proportions cross-sectional study[20]. The minimum sample required with a 95% confidence level and 80% power was found to be 258. Anticipating 10% incomplete responses, a minimum of 284 participants were considered. However, a total of 300 participants aged 18 years old and above were involved in this study. The participants were selected based on convenience sampling. The study population included all the indigenous adults of the Semai tribe living in the Pos Sinderut settlement in a remote rural area located in the Lipis district, Pahang, Malaysia.

Study setting and sites
Pos Sinderut is an Aboriginal settlement located approximately 90 km from the town of Kuala Lipis, Pahang and 180 km from Kuala Lumpur (Fig. 1). It is comprised of villages lead by "Tok Batin" and consists of approximately 2,600 villagers. These Aborigines originate from the ethnic group of Semai and most of them can speak Malay (the national language) in addition to their own distinct language.

Study instrument
The questionnaire was adapted originally from previous studies that have both English and Malay versions[21,22]. The face validity of the questionnaire was evaluated involving ten indigenous adults to determine if any items were unclear or confusing. The comprehension of every single item was checked to achieve understanding of the targeted participants. Further, the questionnaire was validated among 30 indigenous participants from different settlements in Lipis District, Pahang, Malaysia to assess the construct validity and reliability of the questionnaire.

The construct validity testing for knowledge, attitude, and practice was performed through an analysis of Kaiser–Meyer–Olkin (KMO) and exploratory factor analysis (EFA)[23,24]. In EFA, factor extraction was performed using principal component analysis (PCA) and varimax rotation. Factors were retained based on Kaiser criteria with eigenvalues > 1. As a result, four items from the KAP questionnaire were removed during the process due to low factor loading (< 0.05). Finally, the internal consistency reliability was determined by calculating the Cronbach coefficient alpha. The reliability analysis for the knowledge, attitude, and practice questionnaires was 0.695, 0.711, and 0.782, respectively. Taber et al. (2018) stated that Cronbach's Alpha value greater than 0.6 is considered acceptable and indicates good internal consistency[25].

The final questionnaire administered in this study consisted of five main sections: 1) socio-demographic section that include age, gender, religion, education level, occupation, and household income.; 2) sources of COVID-19 infections 3) the knowledge regarding COVID-19; 4) attitude towards COVID-19; and 5) practice

Fig. 1. Study site.

towards COVID-19 prevention. The survey was offered only in the Malay language since the indigenous population in this study can understand Malay language very well compared to the English language.

To measure the knowledge regarding COVID-19, five items were adapted from the previous study[21]. This section comprised of five questions regarding general knowledge about COVID-19 prevention with three options for the answers: "Yes", "No" and "Don't Know". Participants with correct answers were given 1 mark, while participants with incorrect answers or do not know answers were given 0 mark. Accordingly, the total score for this section ranged from 0 – 5, in which participants with a higher score indicate a higher knowledge regarding COVID-19. The overall correct response rate of knowledge regarding COVID-19 was calculated (average correct answers/ total questions $\times$ 100)[22].

To measure the attitude towards COVID-19, eight items were adapted from previous research[22]. This section comprised of eight questions regarding the attitude towards the prevention measures of COVID-19 with a five-point Likert scale which are "strongly disagree" to "strongly agree" ranging from "1" to "5" marks. Reverse scoring was given to the negative statements. Accordingly, the total score for this section ranged from 8 – 40, in which participants with a higher score indicate a more positive attitude towards COVID-19 prevention. The overall positive attitude towards COVID-19 was calculated (average correct answers/ total questions $\times$ 100)[22].

To measure the practice of COVID-19 prevention, five items were adapted from previous research[21]. This section comprised of five questions regarding the practice towards the prevention of COVID-19 disease with four options for the answers: "Every time (3), "Frequent (2)", "Sometimes (1)" and "Never (0)". Accordingly, the total score for this section ranged from 0 – 15, in which participants with a higher score indicate a better practice on COVID-19 prevention. The overall good practice of COVID-19 prevention was calculated (average correct answers/ total questions $\times$ 100)[22].

Data collection
The data was gathered by 10 trained enumerators by face-to-face interviews. The enumerators were fluent in Malay and informed about the background and objectives of the study before the survey was conducted.

Study duration
The study was conducted between 12th August 2023 to 16th August 2023.

Ethical approval and consent to participate
The study was carried out after the protocol was approved by the ethics committee of the Universiti Kebangsaan Malaysia (FF-2023–193). Permission was also obtained from the Department of Orang Asli Development (JAKOA*).* It was confirmed that all the methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all the study participants.

Statistical analysis

The collected data in this study were analyzed using the Statistical Package for the Social Sciences (SPSS), version 26.0. Descriptive analysis was presented as frequencies, percentages, and mean ± standard deviation. The bivariable analysis namely independent sample t-test, Pearson correlation, and Spearman rho correlation was used to determine the association between dependent and independent variables. Finally, before multivariable linear regression analysis was performed, several assumptions needed to be fulfilled for the variables tested. Multicollinearity was performed before the final model was selected. The value of the Variance Inflation Factor (VIF) between 1 to 10 and the value of Tolerance above 0.1, indicate that there are no multicollinearity. Multiple linear regression was used to assess the factors influencing the knowledge, attitude, and practice towards COVID-19 prevention. Data analysis for variables that have more than two categories were recategorized into dichotomous variables for bivariable analysis and multivariable analysis in this study. The significance level was set as $p \leq 0.05$, two-sided[26,27].

Results

Demographic characteristics

A total of 300 participants were involved in this study. Out of the total, the mean age of the participants was 36.18 ± 15.23 years old ranging from 18 to 90 years old. Of this, 53.0% were female, the majority were Christian (78.0%), and 34.7% had a secondary education level. Among all the participants, 48.0% were unemployed and the mean of household income of the participants was RM 158.07 ± 283.75. The details of the demographic characteristics are presented in Table 1.

The main source of COVID-19 information was television (85.7%), followed by government clinics (52.7%), and Tok Batin (village headman) (45.3%). The other sources of COVID-19 information reported by participants were WhatsApp, the Department of Orang Asli Development (JAKOA), radio, Telegram, and newspapers. Figure 2 shows the details of the source of COVID-19 information.

Knowledge regarding COVID-19 among participants

The mean (SD) knowledge score regarding COVID-19 was 2.35 (1.104) ranging from 0 to 4 scores. The overall correct response rate of the knowledge on COVID-19 questions was 47.0% (2.35/5*100), while the range of correct response rates for all participants was between 18.7% to 87.0%. Most participants knew all the signs and symptoms of COVID-19 (71.4%). However, only 18.7% of participants answered correctly when asked that influenza vaccination may prevent COVID-19, and also 18.7% answered correctly when asked about the World Health Organization has declared COVID-19 as a pandemic, respectively. Moreover, 31.7% of the participants answered correctly that the COVID-19 virus that sticks to a surface made of plastic has a life span of up to a few days, followed by the majority of participants (87.0%) answered correctly when asked about Movement Control Order (MCO) may prevent the spread of the COVID-19 outbreak. The details of the responses of the participants to the knowledge questionnaire are shown in Table 2.

Characteristics	Mean ± SD	Number, n	Percentage, %
Age (years)			
Mean ± SD	36.18 ± 15.23		
Gender			
Male		141	47.0
Female		159	53.0
Religion			
Animism		61	20.3
Islam		5	1.7
Christian		234	78.0
Education level			
No education		93	31.0
Primary school		103	34.3
Secondary school		104	34.7
Occupation			
Not employed		144	48.0
Farmer		68	22.7
Housewife		46	15.3
Plantation worker		33	11.0
Self-employed		6	2.0
Public sector		3	1.0
Household income (RM)			
Mean ± SD	158.07 ± 283.75		

Table 1. Demographic characteristics of participants (N = 300). Source of COVID-19 information

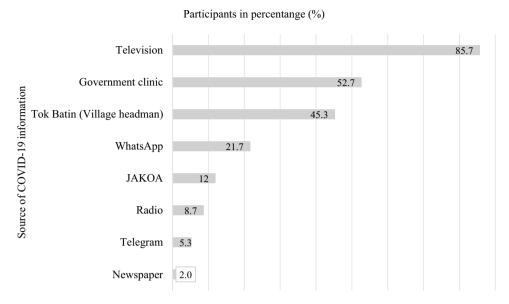**Fig. 2.** Source of COVID-19 information.

Knowledge on COVID-19 statement		Correct, (n,%)	Incorrect, (n,%)
1	I know all the signs and symptoms of COVID-19*	214 (71.3)	86 (28.7)
2	Influenza vaccination may prevent COVID-19	56 (18.7)	244 (81.3)
3	World Health Organization has declared COVID-19 as a pandemic*	79 (18.7)	221 (73.7)
4	COVID-19 virus that sticks to a surface made of plastic has a life span of up to a few days*	95 (31.7)	205 (68.3)
5	Movement Control Order may prevent the spread of the COVID-19 outbreak*	261 (87.0)	39 (13.0)

Table 2. Knowledge regarding COVID-19. *Indicates yes is the correct answer.

The differences in mean knowledge scores among different sociodemographic characteristics were analyzed using independent t-tests (Tables 3, 4, 5) and Spearman rho correlation (Table 6). The results showed that the knowledge scores were significantly associated with age and education levels. The knowledge scores were significantly higher with the younger age ($p < 0.001$). Additionally, higher knowledge scores were obtained among those participants who have primary and secondary education as compared to those without education ($p = 0.001$) (Table 7).

Attitude towards COVID-19 statement		Strongly disagree (n,%)	Disagree (n,%)	Neutral (n,%)	Agree (n,%)	Strongly agree (n,%)
1	I believe, not going to crowded places is important to prevent COVID-19	11 (3.7)	6 (2.0)	7 (2.3)	136 (45.3)	140 (46.7)
2	I believe, maintain social distancing at least 1 m (3 feet) from others, particularly those who are coughing, sneezing, and having a fever is not important to prevent COVID-19*	135 (45.0)	81 (27.0)	16 (5.3)	33 (11.0)	35 (11.7)
3	I believe, practicing proper cough and sneeze etiquette is not important to prevent the transmission of COVID-19*	134 (44.7)	94 (31.3)	32 (10.7)	19 (6.3)	21 (7.0)
4	I believe, frequent hand wash with water and soap or hand sanitizer is important to prevent COVID-19	5 (1.7)	2 (0.7)	10 (3.3)	150 (50.0)	133 (44.3)
5	I believe, wearing face masks when going out is important to prevent COVID-19	5 (1.7)	3 (1.0)	7 (2.3)	144 (48.0)	141 (47.0)
6	I believe, disinfection of frequently touched objects or surfaces is not important to prevent transmission of COVID-19*	129 (43.0)	83 (27.7)	44 (14.7)	22 (7.3)	22 (7.3)
7	I will isolate myself if I have fever and cough	10 (3.3)	9 (3.0)	16 (5.3)	138 (46.0)	127 (42.3)
8	I will accept quarantine in a health facility or quarantine center if I get COVID-19	21 (7.0)	35 (11.7)	26 (8.7)	101 (33.7)	11 (39.0)

Table 3. Attitude towards COVID-19. *Refers to negative statements.

Practice towards COVID-19 prevention statement		Never (n,%)	Sometimes (n,%)	Frequent (n,%)	Every time (n,%)
1	I practice social distancing while in public	4 (1.3)	51 (17.0)	139 (46.3)	106 (35.3)
2	I wash my hands with soap and water for at least 20 seconds	6 (2.0)	46 (15.3)	149 (49.7)	99 (33.0)
3	I clean and disinfect the households using disinfectant	74 (24.7)	113 (37.7)	63 (21.0)	50 (16.7)
4	I wear face masks when having cough or flu when leaving the house	3 (1.0)	42 (14.0)	137 (45.7)	118 (39.3)
5	I avoid participating in mass gathering	23 (7.7)	99 (33.0)	89 (29.7)	89 (29.7)

Table 4. Practice towards COVID-19 prevention.

Variables		Knowledge score	Attitude score	Practice score
Knowledge score	Pearson Correlation Coefficient (r)	1.000	0.012	0.194
	P-value		0.830	**0.001**
Attitude score	Pearson Correlation Coefficient (r)	0.012	1.000	0.470
	P-value	0.830		**<0.001**
Practice score	Pearson Correlation Coefficient (r)	0.194	0.470	1.000
	P-value	**0.001**	**<0.001**	

Table 5. Correlation between knowledge, attitude, and practice scores among participants. Embolded: P < 0.05

Variables	N	Knowledge score			Attitude score			Practice score		
		Mean (SD)	r / t	P- value	Mean (SD)	r / t	P- value	Mean (SD)	r / t	P- value
Age (years)	300	36.18 (15.226)	− 0.275[a]	**<0.001**	36.18 (15.226)	− 0.071[a]	0.220	36.18 (15.226)	− 0.143[a]	**0.013**
Gender										
Male	141	2.38 (1.125)	0.487[b]	0.627	32.25 (4.344)	− 2.035[b]	**0.043**	8.77 (2.954)	− 4.517[b]	**<0.001**
Female	159	2.32 (1.087)			33.35 (5.051)			10.41 (3.271)		
Religion										
No religion	61	2.38 (1.186)	2.245[b]	0.831	33.80 (4.953)	0.521[b]	0.604	10.46 (2.873)	2.245[b]	**0.026**
Has religion[€]	239	2.34 (1.084)			32.60 (5.079)			9.43 (3.284)		
Education level										
No formal education	93	2.03 (1.118)	− 3.401[b]	**0.001**	32.11 (5.104)	− 1.778[b]	0.076	9.40 (3.695)	− 0.794[b]	0.429
Primary and secondary	207	2.49 (1.070)			33.16 (4.567)			9.47 (2.996)		
Occupation										
Unemployed	190	2.38 (1.110)	0.596[b]	0.551	32.92 (4.990)	0.435[b]	0.664	10.25 (3.243)	4.565[b]	**<0.001**
Employed[#]	110	2.30 (1.097)			32.68 (4.341)			8.58 (2.925)		
Household income (RM)	300	158.1 (283.8)	− 0.042[a]	0.466	158.1 (283.8)	0.159[a]	**0.006**	158.1(283.8)	0.145[a]	**0.012**

Table 6. The bivariable analysis of the sociodemographic factors associated with knowledge, attitude, and practice towards COVID-19 prevention. [€] "Has religion" includes Islam and Christian. [#] "Employed" includes farmer, plantation worker, public sector, and self-employed. Ref-reference group. **Embolded:** *P* < 0.05.

Attitude of participants towards COVID-19

The mean (SD) attitudes score regarding COVID-19 for participants was 32.84 (4.756) ranging from 19 to 40 scores. The overall positive attitude for the questionnaire was 82.1% (32.84/40*100). The majority of the participants (95.0%) agreed that wearing face masks when going out is important to prevent COVID-19, followed by 94.3% agreed that frequent hand wash with water and soap or hand sanitizer is important to prevent COVID-19, respectively. Moreover, most of the participants (92.0%) agreed that not going to crowded places is important to prevent COVID-19. The details of the responses of the participants to the attitude towards the COVID-19 questionnaire are shown in Table 3.

The bivariable analysis shows that the mean attitude scores were significantly associated with gender and household income (Table 6). The female participants showed a higher attitude score compared to male participants (p = 0.043), meanwhile the higher the household income, the higher the attitude scores of the participants (p = 0.006).

Practice of participants towards COVID-19 prevention

The mean (SD) practice score towards COVID-19 prevention for participants was 9.64 (3.227) ranging from 1 to 15 scores. The overall good practice for the questionnaire was 64.3% (9.64/15*100). Overall, the majority of

Variables	Knowledge		Attitude		Practice	
	B (95% CI)	P- value	B (95% CI)	P- value	B (95% CI)	P- value
Age (years)	− 0.017 (− 0.027,−0.007)	**0.001**	0.003 (− 0.039, 0.045)	0.888	− 0.014 (− 0.041, 0.012)	0.286
Gender						
Male	Ref		Ref		Ref	
Female	− 0.174 (− 0.445, 0.098)	0.209	0.502 (− 0.579, 1.583)	0.362	0.827 (0.144, 1.509)	**0.018**
Religion						
No religion	Ref		Ref		Ref	
Has religion$^{\epsilon}$	0.039 (- 0.261, 0.338)	0.800	− 0.467 (− 1.658, 0.725)	0.441	− 0.601 (− 1.357, 0.155)	0.119
Education level						
No formal education	Ref		Ref		Ref	
Primary and secondary	0.120 (− 0.218, 0.458)	0.484	1.213 (− 0.126, 2.552)	0.076	− 0.660 (− 1.513, 0.193)	0.129
Occupation						
Unemployed	Ref		Ref		Ref	
Employed$^{\#}$	0.101 (− 0.182, 0.383)	0.485	1.282 (0.165, 2.399)	0.025	− 1.205 (− 1.909,−0.502)$^{}$	**0.001**
Household income (RM)	< 0.001 (− 0.001, 0)	0.222	< 0.001 (− 0.001, 0.002)	0.604	0.001 (0. 0.002)	0.071
Knowledge			− 0.419 (− 0.875, 0.038)	0.072	0.550 (0.264, 0.835)	**< 0.001**
Attitude	− 0.026 (− 0.055, 0.002)	0.072			0.296 (0.231, 0.361)	**< 0.001**

Table 7. The multivariable linear regression analysis to determine sociodemographic factors influencing knowledge, attitude, and practice towards COVID-19 prevention. $^{\epsilon}$ "Has religion" includes Islam and Christian. $^{\#}$ "Employed" includes farmer, plantation worker, public sector, and self-employed. Model assumptions were fulfilled. No multicollinearity was detected. There were no significantly biologically meaningful interactions found. Ref-reference group; **Embolded:** $P < 0.05$.

the participants (85.0%) wear a face mask when having a cough or flu when leaving the house, followed by 82.7% wash their hands with soap and water, respectively. In addition, a greater portion (81.6%) of the participants practice social distancing while in public. However, only 59.4% of the participants avoid participating in mass gatherings every time. The least practiced COVID-19 prevention was clean and disinfect the households using disinfectant (37.7%). The details of the responses of the participants to the practice towards the COVID-19 questionnaire are shown in Table 4.

The bivariable analysis shows that the mean practice scores were significantly associated with age, gender, religion, occupation, and household income (Table 6). The practice scores were significantly higher in younger age participants (p = 0.013), female participants compared to males (p < 0.001), and participants with no religion compared to those with religion (p = 0.026). Additionally, higher practice scores were obtained among participants who were unemployed (p < 0.001) and having higher household income (p = 0.012).

Correlation between knowledge, attitude, and practices towards COVID-19 prevention

Table 5 demonstrates the correlation between the knowledge, attitude, and practice towards COVID-19 prevention among the indigenous population in Lipis district, Pahang, Malaysia. The results showed that the knowledge scores have a weak positive correlation with the attitude scores (r = 0.012, p = 0.830), however, it is not significant. The knowledge scores have a significant weak positive correlation with practice scores, respectively (r = 0.194, p = 0.001). Additionally, the attitude scores showed a moderate positive correlation with practice scores (r = 0.470, p < 0.001) as shown in Table 5.

Factors associated with knowledge, attitude, and practice towards COVID-19 prevention

Table 7 demonstrates the multivariable linear regression analysis on factors associated with knowledge, attitude, and practice towards COVID-19 prevention. Regarding the knowledge scores as the outcome variable, the results showed that only age was significantly associated with knowledge regarding COVID-19. The younger the age of the participants (B = 0.017, p < 0.001), the higher the knowledge scores regarding COVID-19. The results also showed that none of the sociodemographic factors were associated with the attitude scores.

Meanwhile, the regression analysis on practice scores as outcome variable showed that female participants (B = 0.827, p = 0.018) were more likely to have higher practice scores towards COVID-19 prevention compared to male participants. In terms of occupation, unemployed participants (B = 1.205, p = 0.001) had a significantly higher practice scores towards COVID-19 prevention compared to those participants who were employed. Moreover, the higher the knowledge scores (B = 0.550, p < 0.001) and the higher the attitude scores (B = 0.296, p < 0.001) the higher the practice scores among the participants, respectively.

Discussion

The infectious virus known as the coronavirus disease (COVID-19) was recognized as a worldwide pandemic in March 2020 and has been declared as a public health crisis. Indigenous peoples are among the most vulnerable populations around the world, particularly when they are dealing with the COVID-19 pandemic[28]. Indigenous people are at a higher risk of getting an infection considering that they rarely have access to clean water and basic

sanitation supplies like soap and sanitizer[28,29]. In addition, it is vital to ascertain the community's preparedness for adopting recommended behavior practices and precautions from health authorities in order to prevent the spread of COVID-19 infection. Therefore, in this study, we assessed the knowledge, attitude, and practice towards COVID-19 prevention among the adult indigenous population in Lipis district, Pahang, Malaysia.

The findings of this study showed that the main sources of COVID-19 information were television, government clinics, and Tok Batin (village headman). A study conducted among the indigenous population in the Republic of Congo revealed that the majority of participants used radio and television as their main source of COVID-19 information during the pandemic[30]. Compared to a study conducted among the general population in Malaysia, the main source of information regarding COVID-19 was smartphone applications such as WhatsApp and Telegram[29]. This is similar to a survey conducted in Bhutan where the majority of participants reported television is among the main sources of COVID-19 information[31]. However, according to Cheng & Cheng (2020), indigenous people may not evaluate information appropriately compared to the urban population[32]. Therefore, it is vital to strengthen awareness among this at-risk population through exposure to health promotion and accessing information sources.

In the present study, the mean knowledge score among participants was 2.35 (SD 1.104) ranging from 0 to 4 scores with overall correct answer rate of 47.0%, while the range of correct response rates for all participants was between 18.7% to 87.0%. The findings of this study are in line with the study done in central India[33], eastern India[34], and Bangladesh[35], which reported a higher knowledge mean score among the tribal population. However, this finding is in contrast with other studies conducted among indigenous population in Nigeria[36] and Peninsular Malaysia[10], which reported low knowledge scores among the participants involved. This could be due to inaccurate information regarding COVID-19 and limited access to information such as the internet and social media, making it difficult for these indigenous populations to understand the accurate knowledge regarding COVID-19[37].

The mean knowledge scores in this study are significantly higher in younger participants. Previous research conducted in Bhutan[31], Saudi Arabia[38], and Ethiopia[39] also showed that young people were more likely to have higher knowledge scores. This could be due to the fact that, in comparison to older people, younger people have greater exposure and easy access to information on various social media platforms[27]. On the other hand, participants who have primary and secondary education scored among the highest knowledge scores as compared to participants without formal education in this study. The present study corresponds to a study among indigenous populations in the Republic of Congo that also reported primary education level has a significant association with a higher level of knowledge as compared to participants without formal education[30]. However, the study conducted among general population in Turkey[40], Southeast and South Asia[41], and Indonesia[42] reported higher knowledge with those participants who have tertiary education. This happened because the dropout of indigenous people from school is high among them due to the geographical factors of indigenous settlement. The indigenous population has a negative view of education in which the parents emphasized their children to be working to continue their lives without thinking about future plans[43,44]. Therefore, it is suggested that in order to improve the public knowledge of COVID-19 infection, the public health authorities should implement an educational programme for individuals or groups in the community with lower educational levels[39,43].

In this study, the mean attitude score for participants was found to be higher at 32.84 (SD 4.756), ranging from 19 to 40 scores with an overall positive attitude of 82.1%. These findings were much higher than the previous study in Northwest Ethiopia[39], Southeast and South Asia[41], Vietnam[45], and Malawi[46]. However, the current study corresponds to a study done among the indigenous people in Malaysia[10] and India[47], which reported optimistic mean attitude scores towards COVID-19. This may be the result of the government's extraordinary measures and immediate implementation of best practices from around the world to ensure their people's health and safety, as well as ongoing information on COVID-19 updates across various kinds of media platforms[27].

Additionally, the current study showed that attitude scores are significantly associated with gender and household income. Female participants were found to have a higher attitude score compared to males. Similar results were found in a study conducted in Bangladesh[48], Iran[49], and Sudan[50] that reported females have a higher attitude score compared to male participants. Meanwhile, this study also showed that the higher the household income, the higher the attitude scores among the participants. This contradicts other research done in Malaysia, in which the attitude scores were not significantly associated with household income[51]. However, a previous study conducted in Bangladesh found that a higher household income contributed to a lower attitude which could be explained by differences in the country currencies, backgrounds, and periods of the data collection[52].

Concerning the practice, our results revealed that the mean practice score towards COVID-19 prevention for participants was 9.64 (3.227) ranging from 1 to 15 scores with overall good practice for the questionnaire was 64.3%. The present study contradicts a study conducted among the indigenous population in Eastern India[34] and Northwest Ethiopia[27] which showed the mean practice score towards COVID-19 prevention was lower than the present study. However, higher mean scores of practice and higher overall practice were reported among the general population in Malaysia[22], Bhutan[31], India[53], Indonesia[54], and Pakistan[55]. Meanwhile, a lower practice score than the current study was revealed in a study conducted in India[56] and Saudi Arabia[57].

The findings of this study showed that practice scores are significantly associated with age, gender, religion, occupation, and household income. Younger age was more likely to have higher practice scores compared to older age participants which could be explained by the increased usage of different social media platforms compared to older group[58]. These findings are in accordance with a study conducted in South India[59], which reported younger age was significantly associated with higher practice. However, research conducted among poor and marginalized communities in central India, showed that the older age more than 55 years old have higher practice scores compared to younger age[47]. Moreover, our results demonstrated female participants were more likely to have higher practice scores compared to male participants. This study is similar to a study conducted in South India[59], central Iran[60], Saudi Arabia[58], China[61], and Pakistan[62] that reported females have higher practice

scores compared to male participants. However, research conducted in Pakistan[63] revealed that males are more likely to have higher practice scores compared to females. Additionally, participants in this study who were of no religion, unemployed, and had a higher household income were more likely to have a higher practice score. The previous study done in Pakistan[63] and rural areas in India[64] revealed that employed and having higher household incomes have higher practice scores among participants.

Multivariable linear regression analysis confirmed that a higher knowledge score on COVID-19 was associated with younger age among the participants. Our result is consistent with a study conducted in rural areas in India[64], that younger age had the highest knowledge score. However, these findings contradict the study done in Saudi Arabia[65], and the United Arab Emirates[66] which reported older age had higher knowledge scores, which is possibly due to a higher perceived risk of acquiring COVID-19 and its complications.

In terms of practice, multivariable linear regression analysis showed that a higher practice score on COVID-19 prevention were influenced by employment status, a higher knowledge score, and a higher attitude score among the participants. This study corresponds to a study among the indigenous population in Thailand which reported the practice of COVID-19 prevention was influenced by employment status[67]. Unemployed participants had higher practice scores towards COVID-19 prevention. The findings are similar to a study conducted in South India[56], which reported unemployed respondents have higher practice scores compared to employed participants. However, the previous study among the indigenous population revealed that the employed participants have higher practice towards COVID-19 prevention compared to the unemployed participants[68].

Furthermore, the higher knowledge and the higher attitude scores were associated with the higher scores of practice among the participants in this study. These findings were similar to a study conducted among Indian indigenous people in Eastern India[33], the general population in the United Arab Emirates[66], and Saudi Arabia[65] which reported the higher the knowledge score, the higher the practice of COVID-19 prevention. However, research done among the indigenous people in Ebonyi, Nigeria reported that participants who showed negative attitudes were more likely to have poor preventive practices[36]. These may be due to wrong information as well as inaccurate communication, especially among the indigenous communities lead to a negative attitude towards COVID-19, thus contributing to poor prevention practices towards COVID-19[69]. These results emphasized the significance of knowledge in altering behavior, and practice and reinforcing funding for successful educational efforts[66].

Overall, the majority of participants in this study showed adequate knowledge levels, positive attitudes, and good practices of COVID-19 prevention. These findings demonstrated that the adult indigenous population in Malaysia had higher positive attitude scores and appropriate practice regarding COVID-19 prevention, which may indicate they have a valuable role to play as role models for the indigenous population for future health crises in Malaysia. Finally, it is imperative that the Ministry of Health in collaboration with its State Health Department, and with support from the Department of Orang Asli Development (JAKOA) and other non-governmental organizations (NGOs), maintain and expand their ongoing efforts towards delivering the information, knowledge, practice prevention, and health campaign regarding COVID-19 infection for the indigenous community across Malaysia (Supplementary information).

Strength and limitation

As far as our concern, this is the first study assessing the knowledge, attitude, and practice towards COVID-19 prevention among the adult indigenous population in Malaysia. Additionally, the result of this study provides significant implications for the Malaysian government and the Department of Orang Asli Development (JAKOA) to strengthen the awareness efforts in the face of the COVID-19 pandemic and other diseases in the future. On top of that, this study contributes to the development of strategies by public health authorities to recognize vulnerable populations, especially indigenous population, as well as enhance their understanding of infectious diseases such as COVID-19.

Meanwhile, this study has a few limitations. First, since the current study was a cross-sectional study and only measures data at a single time point, it is incapable of assessing the changes in KAPs related to COVID-19 over the course of the pandemic. Second, due to social desirability bias, some participants might have failed to provide accurate information in this survey since it was based on their self-reported data, which is not representative of the real situation. Finally, the questionnaire's administration tended to increase the likelihood and impact of social desirability due to the enumerator being a non-indigenous individual.

Conclusion

In summary, the present study was able to contribute a comprehensive examination of the knowledge, attitude, and practice towards COVID-19 prevention among the adult indigenous population in Malaysia. Overall, the findings of this study demonstrated that indigenous people in Malaysia have adequate knowledge levels, positive attitudes, and good practices of COVID-19 prevention. Our findings also suggested that a higher level of knowledge and attitude scores contributed to higher practice levels of COVID-19 prevention among the indigenous adults in Malaysia. In order to ensure that the standard level of knowledge, attitude, and practice regarding COVID-19 and its preventive measures is achieved, particular measures must be taken especially among Malaysia's indigenous population. Finally, this study delivers guidance to public health officials and policymakers on how to identify the most vulnerable groups for immediate preventative measures and health education campaigns to prevent future potential health crises.

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

References

1. Lee, M., Kang, B. A. & You, M. Knowledge, attitudes, and practices (KAP) toward COVID-19: A cross-sectional study in South Korea. *BMC Public Health* **21**, 295 (2021).
2. Guo, Y.-R. *et al.* The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak – an update on the status. *Mil. Med. Res.* **7**, 11 (2020).
3. Molla, K. A. & Abegaz, S. B. Community knowledge, attitude and practices to SARS-CoV-2 disease 2019 (COVID-19): A cross-sectional study in Woldia town. *Northeast Ethiopia. PloS one.* **16**(4), e0250465 (2021).
4. Cucinotta, D. & Vanelli, M. WHO declares COVID-19 a pandemic. *Acta bio medica: Atenei parmensis.* **91**(1), 157 (2020).
5. World Health Organization (WHO). Number of COVID-19 cases reported to WHO. (2023). Accessed on 20 Feb 2024.
6. Malaysia confirms first cases of coronavirus infection. Reuters. (2020). Accessed on 21 Feb 2024.
7. KKMNOW. Ministry of Health Malaysia. What is the latest situation in Malaysia?. Accessed on 20 Feb 2024.
8. Kurubaran Ganasegeran, Alan Swee Hock Ch'ng & Irene Looi. 2020 COVID-19 in Malaysia: Crucial measures in critical times. Journal of Global Health. 10(2), 020333 (2020).
9. Chinnasamy, S., Rosnon, M. R. & Gill, S. S. Crisis communication relief management and preparedness: Covid-19 disease outbreak for indigenous peoples in Malaysia. *Int. J. Acad. Res. Bus. Soc. Sci.* **11**(11), 2499–2511 (2021).
10. Rosnon, M. R., Zuhairi, M. H., Razak, M. A. A., Jalaludin, M. L. & Ibrahim, R. Knowledge, Attitudes and Practice Towards Covid-19 Among the Orang Asli Elderly in Peninsular Malaysia. *Int. J. Acad. Res. Bus. Soc. Sci.* **12**(10), 209–224 (2022).
11. Albertoni, L., Reategui, J. & Campo, C. Application of the Knowledge, Attitudes, and Practices survey (KAP) associated with COVID-19, in the Amazon Indigenous Health Route Project in Maranhão-Brazil, Madre de Dios-Peru, and the Ecuadorian Amazon. (2021).
12. Idrus, R., Man, Z., Williams-Hunt, A. & Chopil, T. Y. Indigenous resilience and the COVID-19 response: a situation report on the Orang Asli in Peninsular Malaysia. AlterNative: An International Journal of Indigenous Peoples 17(3): 439–443. (2021).
13. Yusof, N. Pasang penghadang jalan halang orang luar masuk kampung. Sinar Harian. https://www.sinarharian.com.my/article/142792/edisi/pahang/pasang-penghadang-jalan-halang-orang-luar-masuk-kampung (2021).
14. Leonard, K. Medicine lines and COVID-19: Indigenous geographies of imagined bordering. *Dial. Hum. Geogr.* **10**(2), 164–168 (2020).
15. Cohen, J. H. & Mata-Sánchez, N. D. Challenges, inequalities and COVID-19: Examples from indigenous Oaxaca Mexico. *Glob. Public Health* **16**(4), 639–326 (2021).
16. Ransing, R. *et al.* Infectious disease outbreak related stigma and discrimination during the COVID-19 pandemic: Drivers, facilitators, manifestations, and outcomes across the world. *Brain Behav. Immun.* **89**, 555–558 (2020).
17. Muzembo, B. A. *et al.* Misconceptions and Rumors about Ebola Virus Disease in Sub-Saharan Africa: a systematic review. *Int. J. Environ. Res. Public Health* **19**(8), 4714 (2022).
18. Kaushik, M., Agarwal, D. & Gupta, A. K. Cross-sectional study on the role of public awareness in preventing the spread of COVID-19 outbreak in India. *Postgrad. Med. J.* **97**(1154), 777–781 (2021).
19. Azlan, A. A., Hamzah, M. R., Sern, T. J., Ayub, S. H. & Mohamad, E. Public knowledge, attitudes and practices towards COVID-19: A cross-sectional study in Malaysia. *PLoS One* **15**(5), 1–15 (2020).
20. Sample size calculator: two proportion cross-sectional. https://www2.ccrb.cuhk.edu.hk/stat/epistudies/x2.htm (Accessed on 15 Jun 2024).
21. Mohamad Nor, N. A. U. Knowledge, attitude and practice (KAP) towards COVID-19 prevention among Malaysian adults during the period of Movement Control Order (MCO): An online cross-sectional survey. *Int. J. Res. Pharm. Sci.* **11**(SPL 1), 1458–1468. Retrieved from https://ijrps.com/home/article/view/1953 (2020).
22. Elias, R. *et al.* Covid-19: Knowledge, attitude, practice in Malaysia. *Int. J. Curr. Res. Rev.* **13**(4), 69–81 (2021).
23. Hair, J. F., Black, W. C., Babin, B. J. & Anderson, R. E. *Multivariate Data Analysis* 7th edn. (Pearson, 2010).
24. Tabachnick, B. G. & Fidell, L. S. Multivariate analysis of variance and covariance using multivariate statistics. Allyn and Bacon, Boston. 243–310 (2007).
25. Taber, K. S. The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Res. Sci. Educ.* **48**, 1273–1296 (2018).
26. Tenny, S. & Abdelgawad, I. Statistical Significance. In *StatPearls* (StatPearls Publishing, Treasure Island, FL, 2023). PMID: 29083828.
27. Yangzom, T., Cheki, T., Koirala, N. & Rai, D. Knowledge, attitude, and practices towards COVID-19 preventive measures among adults in Bhutan: A cross-sectional study. *PLoS One* **17**(12), e0278535 (2022).
28. Khor, G. L. & Shariff, Z. Do not neglect the indigenous peoples when reporting health and nutrition issues of the socio-economically disadvantaged populations in Malaysia. *BMC Public Health* **19**(1), 1685 (2019).
29. L. Ferrante, P.M. Fearnside. 2020 Protect indigenous peoples from COVID-19. Sciences 368. 251 (2020).
30. Mavoungue, *et al.* Knowledge and Practices of Indigenous Populations on COVID-19 in the Republic Of Congo: Case of the Sangha Department, 2021. *Open J. Public Health* **4**(2), 1035 (2022).
31. Dorji, T., Tamang, S. T. & Tilak, T. V. S. V. G. K. Self-learning on COVID-19 among medical students in Bhutan: A cross-sectional study. *Heliyon* **7**(7), e07533 (2021).
32. Chen, X. W. & Chen, H. L. Differences in Preventive Behaviors of Covid-19 between urban and rural residents: Lessons Learned from a Cross-Sectional Study in China. *Int. J. Environ. Res. Public Health* **17**(12), 4437 (2020).
33. Dwivedi, R. *et al.* A community cross-sectional study on knowledge attitude and practice of prevention of COVID-19 among traditional tribal healers in the tribal subpopulation zone of Sirohi district of Rajasthan. *Int. J. Commun. Med. Public Health* **9**, 1324–1417 (2022).
34. Samanta, S., Biswas, D., Sarkar, P. & Bandyopadhyay, A. Assessment of knowledge and preventive practices towards COVID-19 among tribals living in tea gardens of Eastern India: An analytical cross-sectional study. *MRIMS J. Health Sci.* **11**(3), 201–206 (2023).
35. Morshed, M. M. *et al.* The knowledge and perception about COVID-19 among three tribal population of Khagrachari hill district, Bangladesh: A community based cross sectional study on ongoing outbreak. *Int. J. Commun. ity Med. Public Health* **8**(7), 3207 (2021).
36. Chinyere Ada Alo, Moses Alo, Edith Nkiru Obande-Ogbuinya and Precious I. Igwenyi. Knowledge and Attitude of Indigenous People towards COVID-19 Pandemic in Ebonyi State, Southeastern, Nigeria. American Journal of Educational Research. 9(4), 162–168 (2021).
37. Abu Hasan, N. I., Abidin, S. Z., Ganggayah, M. D., Jamal, N. F. & Aziz, W. N. H. W. A. 328 2022. Knowledge, Attitude and Practices (KAP) theory towards preventive measures 329 among Malaysians in early outbreak of COVID-19. Malaysian Journal of Public Health 330 Medicine 22(1): 38-47.
38. Prabhu, N. *et al.* Knowledge, Attitude and Practice towards the COVID-19 Pandemic: A Cross-Sectional Survey Study among the General Public in the Kingdom of Saudi Arabia. *Vaccines* **10**(11), 1945 (2022).

39. Asmelash, D. *et al.* Knowledge, attitudes and practices toward prevention and early detection of COVID-19 and associated factors among religious clerics and traditional healers in Gondar Town, Northwest Ethiopia: A Community-Based Study. *Risk Manag. Healthcare Policy* **13**, 2239–2250 (2020).

40. Al-Abed, A. A. A. A. *et al*. Knowledge, attitudes and practices regarding COVID-19 among the Turkish and Malaysian general populations during lockdown: A cross-sectional online survey. *Ethiop. J. Health Dev.* **34**(4), 243–252 (2020).

41. Rahman, M. M. *et al.* Knowledge, attitude and practice toward Coronavirus disease (COVID-19) in Southeast and South Asia: a mixed study design approach. *Front. Public Health* **10**, 875727 (2022).

42. Muslih, M., Susanti, H. D., Rias, Y. A. & Chung, M. H. Knowledge, attitude, and practice of indonesian residents toward covid-19: A cross-sectional survey. *Int. J. Environ. Res. Public Health* **18**(9), 4473 (2021).

43. Golam Hassan, A. A. *et al.* Impak COVID-19 ke atas status sosioekonomi dan kesihatan masyarakat Orang Asli. *Tech. Rep.* https://doi.org/10.13140/RG.2.2.23723.87842 (2020).

44. Nor, M. M., Sukimi, M. F. & Nor, M. N. Kesedaran pendidikan dan minat kerja pelajar Orang Asli suku kaum Jakun di Rompin, Pahang. Geografia Malaysian. *J. Soc. Space* **14**(1), 72–86 (2018).

45. Van Nhu, Ha, Tran Thi Tuyet-Hanh, Nguyen Thi Anh Van, Tran Nu Quy Linh, and Truong Quang Tien. Knowledge, attitudes, and practices of the Vietnamese as key factors in controlling COVID-19. Journal of community health. 45, 1263-1269 (2020).

46. Li, Y. *et al.* Knowledge, attitudes, and practices related to COVID-19 among Malawi adults: A community-based survey. *Int. J. Environ. Res. Public Health* **18**(8), 4090 (2021).

47. Murali, K. *et al.* Knowledge, attitude, and practices related to COVID-19 among poor and marginalized communities in central India: A cross-sectional study. *Plos One* **17**(4), e0264639 (2022).

48. Paul, A. *et al.* Knowledge, attitudes, and practices toward the novel coronavirus among Bangladeshis: Implications for mitigation measures. *PloS One* **15**(9), e0238492 (2020).

49. NeJhaddadgar, N., Pirani, N., Heydarian, N., Ebadi Fard Azar, A. A., Yazdi, F., Toghroli, R., Foroughinia, A. Knowledge, attitude, and practice toward the COVID-19 infection among adults Iran: A cross-sectional study. Journal of public health research. 11(4), 22799036221129370, (2022).

50. Mousa, K. N. A. A., Saad, M. M. Y. & Abdelghafor, M. T. B. Knowledge, attitudes, and practices surrounding COVID-19 among Sudan citizens during the pandemic: An online cross-sectional study. *Sudan J. Med. Sci.* **15**(2), 32–45 (2020).

51. Suet, S. P. C. *et al.* Are Malaysians ready to resume the new norm? findings from a Nationwide Study. *Front. Public Health* **10**, 823047 (2022).

52. Rabbani, M. G. *et al.* COVID-19 knowledge, attitudes, and practices among people in Bangladesh: telephone-based cross-sectional survey. *JMIR Form. Res.* **5**(11), e28344 (2021).

53. Singh, P. K., Anvikar, A. & Sinha, A. COVID-19 related knowledge, attitudes, and practices in Indian Population: An online national cross-sectional survey. *PloS One* **17**(3), e0264752 (2022).

54. Lee, F. & Suryohusodo, A. A. Knowledge, attitude, and practice assessment toward COVID-19 among communities in East Nusa Tenggara, Indonesia: A cross-sectional study. *Front. Public Health* **10**, 957630 (2022).

55. Kumar, N., Sulaiman, S. A. S. & Hashmi, F. K. An evaluation of public understanding regarding COVID-19 in Sindh, Pakistan: A focus on knowledge, attitudes and practices. *J. Res. Pharmacy* **25**(6), 881–889 (2021).

56. Osborn, J., Priya, K., Satheesh, T. & Ramalingam, S. Knowledge, attitude and practice of COVID 19 and the factors influencing them among a Rural Population in South India Indian. *J. Commun. Health* **33**(1), 193–197 (2021).

57. Faqihi, E. *et al.* Awareness, knowledge, attitudes, and practices before the second wave of the COVID-19 pandemic in Saudi Arabia. *Eur. Rev. Med. Pharmacol. Sci.*. **26**(13), 4926–4946 (2022).

58. Alahdal, H., Basingab, F. & Alotaibi, R. An analytical study on the awareness, attitude and practice during the COVID-19 pandemic in Riyadh, Saudi Arabia. *J. Infect. Public Health* **13**(10), 1446–1452 (2020).

59. Patan, S. K. *et al.* A descriptive cross-sectional study on COVID-19 knowledge, attitude, and practices of South Indian population. *J. Educ. Health Promot.* **10**, 420 (2021).

60. Moradzadeh, R., Nazari, J., Shamsi, M. & Amini, S. Knowledge, attitudes, and practices toward coronavirus disease 2019 in the central area of Iran: A population-based study. *Front. Public Health* **8**, 599007 (2020).

61. Yuan, T. *et al.* Impact of the eHealth literacy, knowledge and attitudes on COVID-19 prevention behavior among residents in the second year of the COVID-19 pandemic: A cross-sectional study in Anhui Province China. *Front. Public Health* **10**, 1015803 (2022).

62. Rizwan, M. *et al.* Social media use, psychological distress and knowledge, attitude, and practices regarding the COVID-19 among a sample of the population of Pakistan. *Front. Med.* **8**, 754121 (2021).

63. Afzal, M. S. *et al.* Community-based assessment of knowledge, attitude, practices and risk factors regarding COVID-19 among Pakistanis residents during a recent outbreak: a cross-sectional survey. *J. Commun. Health* **46**, 476–486 (2021).

64. Taksande, A., Panwar, R. A. S., Saqqaf, S. A., Rao, R. & Meshram, R. Study of Knowledge, Attitude and Practice (KAP) towards COVID-19 Pandemic in Rural Area. *Med. Sci.* **24**, 4144–4157 (2020).

65. Alhazmi, A. *et al.* Knowledge, attitudes and practices among people in Saudi Arabia regarding COVID-19: A cross-sectional study. *J. Public Health Res.* https://doi.org/10.4081/jphr.2020.1867 (2020).

66. Alremeithi, H. M., Alghefli, A. K., Almadhani, R. & Baynouna AlKetbi, L. M. Knowledge, attitude, and practices toward SARS-COV-2 infection in the United Arab Emirates population: An online community-based cross-sectional survey. *Front. Public Health* **9**, 687628 (2021).

67. Srichan, P. *et al.* Knowledge, attitudes and preparedness to respond to COVID-19 among the border population of northern Thailand in the early period of the pandemic: A crosssectional study. *WHO South East Asia J. Public Health.* **9**(2), 118–125 (2020).

68. Akwaowo, C. D. *et al.* Knowledge, attitude, perception and practices towards covid-19 among rural dwellers in AkwaIbom State Nigeria. *Ibom Med. J.* **14**(3), 343–360 (2021).

69. Driedger, S. M. *et al.* There's a little bit of mistrust: Red River Metis experiences of the H1N1 and COVID-19 pandemics. *Risk Anal.* **44**(8), 1770–1787 (2024).

Acknowledgements

Author contributions

S.F.A.B., Z.M.I, Roszita I., A.I., F.D., and Rozita I. carried out conceptualization. S.F.A.B., Z.M.I., and Roszita I. involved in data curation. S.F.A.B. involved in formal analysis. S.F.A.B., Z.M.I., Roszita I., A.I., F.D., and Rozita

Competing interests

The authors declare no competing interests.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-024-72519-4.

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