Research Paper

Typology of Knowledge, Attitudes, and Practices Toward Vaccines Among Medical Science Students in the Latest Epidemic

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ABSTRACT

Background and Purpose: Knowledge, attitude, practices, and concerns (KAPC) are important components for the COVID-19 vaccine. Identifying the typology of KAPC can provide health care professionals insight into ways to encourage vaccination uptake among the student population. The study pursues two specific objectives: Classification of Mazandaran University of Medical Sciences students based on KAPC about the COVID-19 vaccine, determining the relationship between these patterns, and performing COVID-19 vaccine injection.

Materials and Methods: A cross-sectional study design was used to collect the data about the students' COVID-19 vaccination and their perception of KAPC toward the COVID-19 vaccine. The analysis of data was conducted in two steps. First, we conducted a latent profile analysis (LPA) to identify subgroups of the COVID-19 vaccine KAPC patterns. Second, the associations between the typology of KAPC and vaccine injection were assessed by logistic regression analysis. Also, the scores of KAPC were compared using an analysis of variance and Bonferroni post hoc tests.

Results: The current study showed three profiles (patterns) of the COVID-19 vaccine KAPC. These patterns included "moderate to high for KAPC" (profile 1: 70.5%), "high knowledge, attitude, practices, and low concerns" (profile 2: 25.4%), "moderate knowledge and low attitude, practices, and high concerns" (profile 3: 4.1%). Students in the three profiles differed significantly in their KAPC factors. The individuals with membership in profile 2 and profile 3 relative to profile 1 have 73% and 99% less odds of injecting the vaccine, respectively.

Conclusion: The patterns of KAPC have various distributions in vaccine injection. It seems that governmental authorities should take measures to improve the knowledge, attitude, and practice of the people appropriate to each profile and identify any obstacles to their promotion.

Keywords: Knowledge, Attitude, Practices, Concerns, COVID-19, Vaccine, Latent profile analysis (LPA), Iran

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Introduction

Originating in China and rapidly spreading worldwide, COVID-19 was declared a public health emergency of international concern by the World Health Organization (WHO) on January 30, 2020 [1]. Due to its rapid transmission from person to person, initial global strategies focused on early detection, isolation, and treatment of patients to curb the virus's spread [2].

As the pandemic continued, it became evident that preventive measures such as social distancing and personal protective equipment alone were insufficient to control the virus's widespread impact. This realization underscored the urgent need for effective vaccines to prevent transmission and mitigate severe outcomes associated with COVID-19 [3]. Vaccination has long been recognized as one of the most effective public health interventions, playing a crucial role in reducing mortality and controlling infectious diseases such as polio and measles. Besides providing individual protection, widespread vaccination establishes herd immunity, thereby protecting vulnerable populations who cannot be vaccinated [4].

However, the success of vaccination depends on its acceptance by society, given the production of vaccines by many countries [5]. Despite many efforts to produce a safe and effective vaccine, people are reluctant to accept the vaccine [6]. The WHO's Strategic Advisory Group on Immunization (SAGE) [7] defined vaccine hesitancy as a "delay in accepting or rejecting vaccination despite the availability of vaccination services," which could vary in form, time, place, and intensity [7-9]. Concerns and hesitancy about vaccines are growing worldwide, and WHO identified it as one of the top ten global health threats in 2019 [10]. In many countries, misinformation and hesitancy about vaccination create fundamental barriers to achieving community coverage and immunity [11, 12]. Vaccine acceptance is influenced by several factors, including knowledge of the potential for COVID-19 release, perceived safety of the vaccine, perceived effectiveness of the vaccine, perceived risk as well as negative perceptions, fear of transmission to relatives, fear of long-term side effects, and depression symptoms [11, 13]. Silva et al. indicated that older people's perceptions, knowledge, and attitudes were significantly associated with acceptance of COVID-19 vaccination, and also, concerns about the safety and efficacy of COVID-19 vaccines were significant predictors of higher vaccination rates [14].

We rely on vaccines to help us return to normal circumstances, so addressing the issue of vaccine rejection is essential. Hence, interpreting people's knowledge, attitudes, practices, and concerns (KAPC) about the COVID-19 vaccine is crucial to improving its widespread acceptance [15]. Although some previous studies [16, 17] examined the association between KAPC and vaccine injection, there is no study of the relationship between the typology of KAPC and vaccine injection among medical students. The typology of KAPC refers to categorizing people into discrete groups according to patterns of knowledge, attitudes, practices, and concerns about the COVID-19 vaccine [18]. In addition, information about examining the relationship between the typology of KAPC and vaccine acceptance can help manage the COVID-19 vaccine program. Also, the findings of this study can provide health care professionals insight into ways to encourage vaccination uptake by uncovering patterns of KAPC about the vaccine among the student population.

Therefore, this study pursues two specific objectives: Classification of Mazandaran University of Medical Sciences students based on KAPC about the COVID-19 vaccine and determining the relationship between these patterns and performing COVID-19 vaccination.

Materials and Methods

Study setting and population

A cross-sectional study design was used to collect the data about the students' injection of COVID-19 vaccine and their perception of KAPC toward COVID-19 vaccine.

Students were recruited from the Public Health, Medicine, Dentistry, Nursing, Pharmacy, and Paramedicine faculties at Mazandaran University of Medical Sciences in north Iran from May 22 to June 23, 2021. A sample of 413 students was chosen from various academic levels, ranging from the second semester of undergraduate programs to final-year students. Pre-clinical and clinical students were included to capture diverse knowledge, attitudes, and practices regarding vaccination. The sample size was determined using the single population proportion formula (Equation 1), assuming a 5% margin of error, a 95% confidence interval, and 50% the expected proportion of vaccine acceptance.

1. $$n = \frac{(Z_{1-\frac{\alpha}{2}})^2\, p(1-p)}{d^2}$$

The current study collected the data using the Google Form platform as an online survey, and the generated link was shared with the WhatsApp Group of each college and the students' email addresses. The link was also shared personally to the contact list of investigators and research assistants. The inclusion criterion was students currently enrolled in the Mazandaran University of Medical Sciences faculties. The exclusion criteria were students actively attending classes or clinical rotations and incomplete questionnaires. Also, students who could not receive the COVID-19 vaccine due to medical contraindications were excluded from the analysis. Informed consent was obtained from study participants by including the details of the study objectives at the beginning of the survey and expressing voluntary and confidential information via anonymous filling of the questionnaire.

Study measures

The questionnaire in this study had two sections. The first section included sociodemographic variables such as age, gender, field, and a question regarding getting the COVID-19 vaccine (vaccine injection: "No" with code=0; "yes (one dose)" with code=1; and "yes (two doses) with code=2").

The second section of the questionnaire was the items related to KAPC toward the COVID-19 vaccine that was developed and validated among the Indian general population aged above 18 years by Kumari et al. [19]. The Persian version of the COVID-19 vaccine KAPC questionnaire was validated by explanatory factor analysis (EFA) [20]. The internal consistency reliability subscales were acceptable (Appendix 1). The questionnaire comprised 10 questions for the knowledge scale, 5 for the attitude scale, 10 for the practice scale, and 6 for the concerns scale. The response options for knowledge scale questions were "eligible" (code=2)/ "not eligible" (code=0) and "do not know" (code=1). The response options of attitude, practices, and concerns scale questions were "strongly agree" (code=5)/ "agree" (code=4), "neither agree nor disagree" (code=3), "disagree" (code=2), and "strongly disagree" (code=1). The scores for related questions of each subscale were summed to calculate the total score of each subscale. Higher scores indicate more positive knowledge, attitudes, and practices toward vaccination. Lower total scores on the concern scale reflect fewer concerns or hesitancies regarding the vaccine.

Data analysis

The analysis of data was conducted in two steps. First, we conducted a latent profile analysis (LPA) to identify subgroups of the COVID-19 vaccine KAPC patterns. Second, the association between the typology of KAPC and vaccine injection was measured by logistic regression analysis. Also, the scores of KAPC were compared by one-way analysis of variance (ANOVA) and Bonferroni post hoc test. In addition, the chi-square was performed to examine the typology of the relationship between KAPC and gender.

To identify the optimal typology of KAPC by LPA, we used an iterative approach with an increasing number of profiles. The KAPC subscales were converted to z-scores for ease of interpretation. The analysis started with a 2-profile model, gradually increasing successive models until the model was no longer interpretable. Fit was assessed using the Akaike information criterion (AIC), Bayesian information criterion (BIC), sample size adjusted Bayesian information criterion (aBIC), Lo–Mendell–Rubin likelihood ratio test (LMR-LRT), and Vuong-Lo–Mendell–Rubin likelihood ratio test (VLMR-LRT) [21]. Low BIC, AIC, and aBIC values show a better model fit. Nylund et al., in a simulation study, showed that aBIC is a superior index compared to BIC and AIC. A significant LMR-LRT and VLMR-LRT indicate that the latent profile model with k profiles was better than the simpler k - 1 profile model [22].

Furthermore, the entropy value (0–1) was considered to assess the quality of the classification of individuals into profiles, and values closer to 1 showed a more desirable classification [23]. LPA was performed using Mplus software, version 8.3, and ANOVA and logistic regression were performed by STATA software, version 16.

Results

A total of 413 (189 male and 224 female) medical science students from various fields participated in the study (Table 1). The Mean±SD age of students was 22.4±2.5 years (ranges 18 to 38).

A series of 2 to 5 latent profile models were estimated based on the KAPC scales (Table 2). The AIC, BIC, and a-BIC had a decreasing trend with the increase in the number of profile models, and they never reached a minimum value, so they did not identify the best-fitting model. However, the LMR-LRT and VLMR-LRT were favored for the 3-profile model as the greatest number of profiles for which the P of the test was significant.

Table 1. The characteristics of study participants (n=413)

Variables		No. (%)
Gender	Male	189(45.76)
	Female	224(54.24)
Vaccine injection	Not received yet	33(7.99)
	Received a dose	94(22.76)
	Received two doses	286(69.25)
Fields of students	Health information technology	19(4.6)
	Laboratory sciences	39(9.44)
	Occupational health	5(1.21)
	Public health	7(1.69)
	Environmental health	20(4.84)
	Medicine	64(15.5)
	Emergency medicine	15(3.63)
	Dentistry	23(5.57)
	Midwifery	21(5.08)
	Pharmacy	29(7.02)
	Nursing	121(29.3)
	Radiology	2(0.48)
	Operating room technology	21(5.08)
	Anesthesiology	24(5.81)
	Occupational therapy	3(0.73)
	Total	413(100)

The nonsignificant P for the 3-profile model indicated that a 4-profile model would not improve model fit over a 3-profile model. The entropy values were high for all the latent profile models, although they were highest for the 2-profile model.

Considering both fit indices and substantive interpretation, the 3-profile model was selected as the preferred model. Figure 1 shows the latent indicator means for the 3-profile model. As shown in Figure 1, Profile 1 (70.5% of the sample, n=291) was characterized by low moderate to up for KAPC scales and was labeled as "moderate to up for KAPC." Profile 2 (25.4% of the sample, n=105) was characterized by high knowledge, attitude, practices, and low concerns scales and was labeled as "high KAP & low C." Profile 3 (4.1% of the sample, n=17) was characterized by moderate knowledge, low attitude, practices, and high concerns, and was labeled as "moderate K & low AP & high C."

Also, the mean scores of the COVID-19 vaccine KAPC scales are compared within- profiles and presented in Table 3.

The associations of the COVID-19 vaccine KAPC typologies with vaccine injection by logistic regression are given in Table 4. The individuals with membership in profile 2 relative to profile 1 have 73% less odds of injecting the vaccine. Also, individuals with membership in profile 3 relative to profile 1 have 99% less odds of injecting the vaccine.

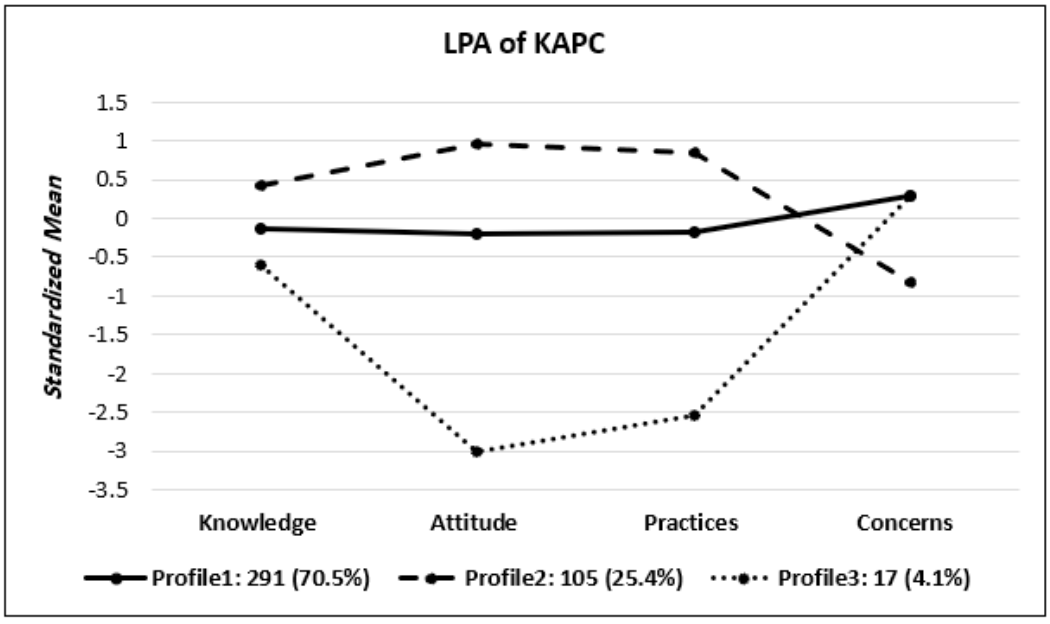

Figure 1. Latent profile plot of mean KAPC factors

Discussion

The current study showed three profiles (patterns) of the COVID-19 vaccine KAPC. These patterns included "moderate to up for KAPC," "high KAP & low C," and "moderate K & low AP & high C." Students in the three profiles differed significantly in their KAPC factors. In other words, important heterogeneity or diversity of KAPC factors among students provides posterior probabilities of each individual's membership in each profile. The most common pattern was "moderate to high for KAPC," which included 70% of the study population, while the lowest pattern was "moderate K & low AP & high C," with 4% of the study population.

Profile 3 was especially characterized by a very negative attitude towards COVID-19. Profile 3's knowledge was almost similar but lower than that of the other two profiles. In addition, profile 3 had the highest value regarding the level of concern compared to profile 1. However, one of the characteristics of profile 2 was their highest level of knowledge, practices, and attitude. Profile 1 had a moderate attitude, knowledge, practices, and concern. The results showed that profile 3 had a 99% lower chance of vaccination than group 1. Moreover, the chance of vaccination in profile 2 was 63% lower than in profile 1.

Numerous studies have been performed on different strata of the medical staff, from physicians, nurses, dentists, and public health specialists, indicating an appropriate level of knowledge and attitude toward COVID-19 [24-27]. However, in the current study, participants were

Table 2. Fit statistics for LPA

No. Profile	Log-likelihood	AIC	BIC	SSA-BIC	LMR-LRT	VLMR-LRT	Entropy
2	-4323.9	8673.9	8726.2	8685.1	190.5***	196.9***	0.981
3	-4242.2	8520.5	8592.9	8535.8	158.2**	163.4**	0.837
4	-4216.3	8478.6	8571.1	8498.1	50.2	51.9	0.875
5	-4202.4	8460.8	8573.5	8484.6	26.8	27.7	0.897

Abbreviations: AIC: Akaike's information criteria; BIC: Bayesian Information criteria; SSABIC: Sample size adjusted Bayesian information criteria; LMR-LRT: Lo–Mendell–Rubin likelihood ratio test; VLMR-LRT: Vuong-Lo–Mendell–Rubin likelihood ratio test.

**P<0.01, ***P<0.001.

Table 3. Mean values of the three latent profiles for the KAPC scales and gender and vaccine injection

Variables	Mean±SD/No. (%)				Statistics	Groups Comparison
	Total	Moderate to High for KAPC	High KAP & Low C	Moderate K & Low A P & High C		
Knowledge	6.3±2.9	5.9±2.9	7.8±2.3	4.5±3.9	19.5***	2>1, 3
Attitude	20.7±2.9	20.3±1.6	23.7±1.2	12.7±2.9	389***	2>1, 2; 1>3
Practices	37.5±4.3	36.7±3.1	41.3±2.7	26.8±4.2	191***	2>1, 2; 1>3
Concerns	21.5±4.4	22.9±3.3	17.3±4.3	22.5±5.9	88.9***	2<1, 3
Gender					0.309	
Female	189(45.8)	132(69.8)	50(26.5)	7(3.7)		
Male	224(54.2)	159(71.0)	55(24.5)	10(4.5)		
Vaccine injection					118.8***	
No	33(8.0)	9(27.3)	11(33.3)	13(39.4)		3>1, 2
Yes	380(92.2)	282(70.5)	94(25.4)	4(1.1)		3 <1, 2; 1>2

Abbreviations: K: Knowledge; A: Attitude; P: Practices; C: Concerns.

***P<0.001.

categorized according to knowledge, attitudes, and practices related to COVID-19. Classifying individuals in homogeneous groups can help create interventions for increasing the tendency to accept and subsequently for injection vaccines. Interventions should be comprehensive and specific to the target population. Intervenors should apply appropriate strategies for the best combination of interventions based on the typology.

As mentioned, profile 1, with a medium to a high level in terms of KAPC, is more inclined to receive vaccines than the others. Therefore, an average KAPC about COVID-19 increases the chance of receiving the vaccine. These findings are consistent with a previous study in Korea, which showed that individuals' knowledge of COVID-19 and their concern and attitudes toward preventive measures can affect their performance concerning vaccination [28]. The finding is reasonable because high KAP leads to low concerns and vaccine acceptance.

Knowledge is a prerequisite for creating prevention beliefs, forming a positive attitude, and promoting positive behaviors, and people's knowledge and attitude toward the disease can affect their coping strategies and behaviors [29]. Naturally, the audience of the present study (medical students) is expected to have an acceptable knowledge of COVID-19 and its vaccine. Also, various training sources at different levels, from university to society, have increased their knowledge about this epidemic, and usually, increasing knowledge leads to a change in people's attitudes and consequently changes their practice [30].

Table 4. Logistic regression analysis for the association between latent profiles and vaccine injection

Vaccine Injection	Odds Ratio (95% CI)
Profiles of KAPC (Ref: Moderate to up for KAPC)	
Profile 2: High KAP & Low C	0.27 (0.10, 0.75)**
Profile 3: Moderate K & Low AP & High C (N=17)	0.01 (0.004, 0.03)***
Intercept	31.3 (10.6, 92.8)***

Abbreviations: K: Knowledge; A: Attitude; P: Practices; C: Concerns.

**P<0.01, ***P<0.001.

Another studied component is attitude. It is influenced by knowledge, which can be obtained through experience [31]. Attitude in social psychology is evaluating a subject, which varies from negative to very positive [32]. Each person's complex and unique psychological structure is acquired through individual experience and modeling. Attitude combines beliefs and emotions to evaluate different concepts in different ways and predict future behaviors [33]. According to the theory of planned behavior, attitude plays a vital role in health care behaviors [34], such as having a better function and receiving the vaccine because they feel optimistic about dealing with COVID-19, socially and individually.

Another component is concerns, which occur when a stimulus or event threatens our physical, mental, or social health. Thus, concerns and fear have an external source as a common emotion to increase energy to preserve life [35, 36]. The fear and concern about the recurrence of the disease persist even after treatment. COVID-19 concern means anxiety about being infected due to anonymity and cognitive ambiguity [37]. A moderate level of concern and anxiety creates the motivation to pursue treatment and seek prevention.

Therefore, students should have a reasonable understanding of what behaviors are appropriate for the prevention and control of COVID-19 disease (awareness and knowledge). This knowledge benefits their attitude and practice [38] to promote their health and show a greater willingness to be vaccinated for improvement. According to profile 1, acceptable knowledge about COVID-19 changes attitudes, and moderate attitude and concern affect the practice and, consequently, the desire to receive the COVID-19 vaccine.

Conclusion

This study divided individuals into three categories according to KAPC about COVID-19. The relationships between these categories and the receiving COVID-19 vaccine were found to be significant. These patterns of KAPC have various distributions in vaccine injection and even in controlling the pandemic. It seems that governmental authorities should take measures to improve the knowledge, attitude, and practice of the people appropriate to each profile and identify any obstacles to their promotion.

Study limitations

The current study has several limitations. First, knowledge and attitude in epidemic conditions are unstable. However, our study showed that the knowledge and attitude for participation during data collection was stable (Appendix 2). Second, the survey was conducted online, so respondents may not represent all medical sciences students. Third, this study's population was medical students, so the generalizability of these findings to other population subgroups is with caution. Finally, the study design was cross-sectional, and the extracted profiles of KPAC were extracted simultaneously. Some ambiguities, such as "Is there change between latent profiles across time? If so, how can this change be characterized?" Need to be addressed in future research by longitudinal study design.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Ethics in Research Committee of Mazandaran University of Medical Sciences, Sari, Iran (Code: IR.MAZUMS.REC.1400.335). The inquired data were anonymous and unidentifiable. Informed consent was obtained from all participants, and all methods were followed, following the relevant guidelines and regulations.

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Authors contributions

Conceptualization, visualization, and funding acquisition: Zeinab Solimani and Maysam Rezapour; Data curation, writing the original draft: Zeinab Solimani and Hamed Mahmoodi; Supervision, formal analysis, methodology, project administration, and software: Maysam Rezapour; Investigation and validation: Zeinab Solimani and Hadis Amiri; Resources: Hamed Mahmoodi and Hadis Amiri; Review, and editing: All authors.

Conflict of interest

The authors declared no conflict of interest.

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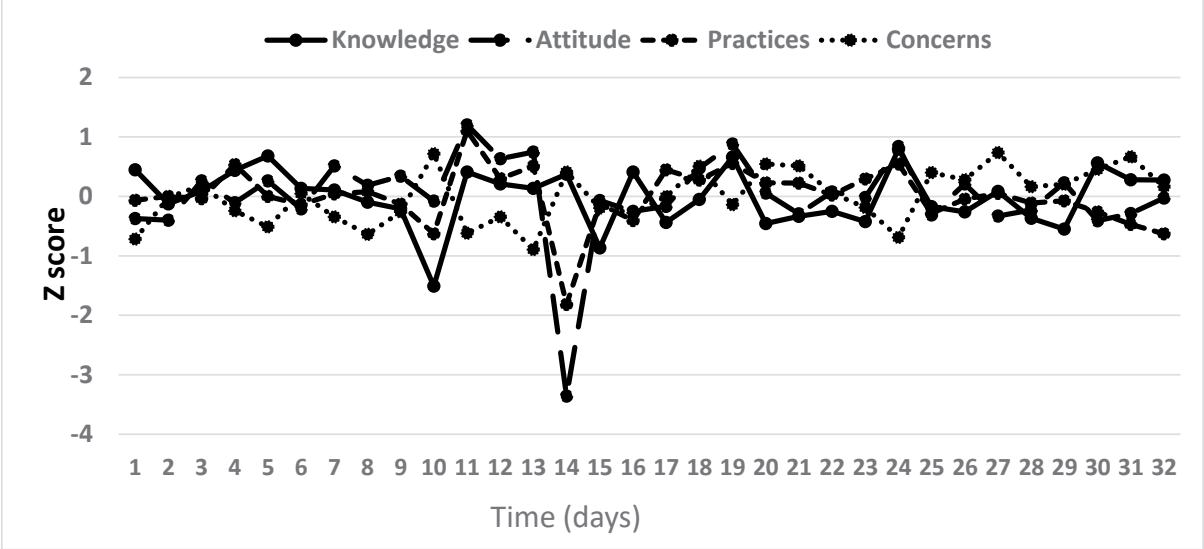
Appendix

Appendix 1. The EFA and Alpha Cronbach (α) for each scale of KAPC toward COVID-19 vaccine for Persian version

Knowledge	h^2	EFA: Factor Loading	
		Factor 1	Factor 2
Factor 1: High risk for COVID-19 (% of variance=23.7, eigenvalue=2.13; α=0.69)			
What is your opinion about receiving vaccines for pregnant ladies and lactating mothers?	0.60	0.62	
What is your opinion about receiving vaccines for patients with chronic diseases like diabetes, hypertension, and heart disease?	0.53	0.66	
What is your opinion about receiving vaccines for persons allergic to food items/drugs?	0.39	0.79	
What is your opinion about receiving vaccines for immunocompromised patients?	0.40	0.78	
Factor 2: Low necessity for vaccine (% of variance=21.5, eigenvalue=1.94; α=0.61)			
What is your opinion about receiving vaccines for infants <1 year of age?	0.38		0.77
What is your opinion about receiving vaccines for children and adolescents <18 years of age?	0.31		0.81
What is your opinion about receiving vaccines for adults > 18 years?	0.77		0.48
What is your opinion about receiving vaccines for persons having active COVID-19 infection?	0.84		0.38
What is your opinion about receiving vaccines for persons recovered from COVID-19 infection?	0.76		0.48
Attitude	h^2	Factor loading	
Factor 1: Attitude toward COVID-19 vaccine (% of variance = 49.91, eigenvalue =2.496)			
When my turn of vaccination comes, I am willing to take the COVID-19 vaccine.	0.63	0.79	
Declining COVID-19 disease is not possible without vaccination.	0.55	0.74	
I will prefer to acquire immunity against COVID-19 naturally (by having the disease/subclinical infection) rather than by vaccination.	0.32	0.57	
I am willing to get the COVID-19 vaccine, even if I have to pay to get it.	0.35	0.59	
I will recommend that my family and friends get vaccinated against COVID-19.	0.64	0.80	
Concerns	h^2	Factor loading	
Factor 1: Concerns toward COVID-19 vaccine (% of variance=53.140, eigenvalue =3.188)			
I am concerned that the COVID-19 vaccine might not be easily available to me.	0.26	0.51	
I am concerned that I might have immediate serious side effects after taking the COVID-19 vaccine.	0.53	0.73	
I am concerned that the COVID-19 vaccine may be faulty or fake.	0.67	0.82	
I am concerned that the COVID-19 vaccine was rapidly developed and approved.	0.59	0.77	
I am concerned that I might have some unforeseen future effects of the COVID-19 vaccine.	0.59	0.77	
I am concerned that the COVID-19 vaccine is being promoted for commercial gain by pharmaceutical companies.	0.55	0.74	
Practices	h^2	Factor loading	
Factor 1: Acceptance for COVID-19 vaccine (% of variance =41.8, eigenvalue =3.76; α=0.81)			

Knowledge	h^2	EFA: Factor Loading	
		Factor 1	Factor 2
I have taken/will take the COVID-19 vaccine because I think there is no harm in taking COVID-19 vaccine.	0.57	0.65	
I have taken/will take the COVID-19 vaccine because I believe the COVID-19 vaccine will be useful in protecting me from the COVID-19 infection.	0.45	0.74	
I have taken/will take the COVID-19 vaccine because the COVID-19 vaccine is available free of cost.	0.74	0.51	
I have taken/will take the COVID-19 vaccine because my healthcare professional/doctor has recommended it to me.	0.53	0.69	
I have taken/will take the COVID-19 vaccine because I feel the benefits of taking the COVID-19 vaccine outweigh the risks involved.	0.48	0.72	
I have taken/will take the COVID-19 vaccine because I believe that taking the COVID-19 vaccine is a societal responsibility.	0.74	0.51	
I have taken/will take the COVID-19 vaccine because There is sufficient data regarding the vaccine's safety and efficacy released by the government.	0.75	0.50	
I have taken/will take the COVID-19 vaccine because I think it will help eradicate COVID-19 infection.	0.46	0.74	
I have taken/will take the COVID-19 vaccine because My role models/political leaders/ senior doctors/scientists have taken the COVID-19 vaccine.	0.51	0.70	
Note: h^2, commonality/ Factor loadings of Explanatory Factor Analysis.			



Appendix 2. The Z-score trends of KAPC over time (the days of questionnaire completion)

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