Human Vaccines & Immunotherapeutics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/khvi20

Expanding Protection Motivation Theory to explain vaccine uptake among United Kingdom and Taiwan populations

Po-Ching Huang, I-Hua Chen, Luca Barlassina, James R. Turner, Felipe Carvalho, Alvaro Martinez-Perez, Jilly Gibson-Miller, Miklós Kürthy, Kuo-Hsin Lee, Mark D. Griffiths & Chung-Ying Lin

To cite this article: Po-Ching Huang, I-Hua Chen, Luca Barlassina, James R. Turner, Felipe Carvalho, Alvaro Martinez-Perez, Jilly Gibson-Miller, Miklós Kürthy, Kuo-Hsin Lee, Mark D. Griffiths & Chung-Ying Lin (2023): Expanding Protection Motivation Theory to explain vaccine uptake among United Kingdom and Taiwan populations, Human Vaccines & Immunotherapeutics, DOI: 10.1080/21645515.2023.2211319

To link to this article: https://doi.org/10.1080/21645515.2023.2211319

HUMAN VACCINES & IMMUNOTHERAPEUTICS
https://doi.org/10.1080/21645515.2023.2211319

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

OPEN ACCESS Check for updates

Expanding Protection Motivation Theory to explain vaccine uptake among United Kingdom and Taiwan populations

Po-Ching Huang[a†], I-Hua Chen[b†], Luca Barlassina[c], James R. Turner[c], Felipe Carvalho[d], Alvaro Martinez-Perez[e], Jilly Gibson-Miller[f], Miklós Kürthy[c], Kuo-Hsin Lee[g,h], Mark D. Griffiths[i], and Chung-Ying Lin[a,j,k,l]

[a]Institute of Allied Health Sciences, College of Medicine, National Cheng Kung University, Tainan, Taiwan; [b]Chinese Academy of Education Big Data, Qufu Normal University, Qufu, China; [c]Department of Philosophy, University of Sheffield, Sheffield, UK; [d]Department of Philosophy, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil; [e]Department of Sociological Studies, University of Sheffield, Sheffield, UK; [f]Department of Psychology, University of Sheffield, Sheffield, UK; [g]Department of Emergency Medicine, E-Da Dachang Hospital, I-Shou University, Kaohsiung, Taiwan; [h]School of Medicine, College of Medicine, I-Shou University, Kaohsiung, Taiwan; [i]International Gaming Research Unit, Psychology Department, Nottingham Trent University, Nottingham, UK; [j]Biostatistics Consulting Center, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan; [k]Department of Public Health, College of Medicine, National Cheng Kung University, Tainan, Taiwan; [l]Department of Occupational Therapy, College of Medicine, National Cheng Kung University, Tainan, Taiwan

ABSTRACT

Vaccination can sufficiently ameliorate the coronavirus disease-2019 (COVID-19). Investigating what factors influence vaccine uptake may benefit ongoing vaccination efforts (e.g. booster injections, annual vaccination). The present study expanded Protection Motivation Theory with possible factors including perceived knowledge, adaptive responses, and maladaptive responses to develop a proposed model investigating vaccine uptake among United Kingdom (UK) and Taiwan (TW) populations. An online survey collected responses from UK ($n = 751$) and TW ($n = 1052$) participants (August to September, 2022). The results of structural equation modeling (SEM) showed that perceived knowledge was significantly associated with coping appraisal in both samples (standardized coefficient [β] = 0.941 and 0.898; $p < .001$). Coping appraisal was correlated with vaccine uptake only in the TW sample (β = 0.319, $p < .05$). Multigroup analysis showed there were significant differences between the path coefficients of perceived knowledge to coping and threat appraisals ($p < .001$), coping appraisal to adaptive and maladaptive responses ($p < .001$), as well as threat appraisal to adaptive response ($p < .001$). Such knowledge may improve vaccine uptake in Taiwan. The potential factors for the UK population require further investigation.

ARTICLE HISTORY
Received 14 February 2023
Revised 17 April 2023
Accepted 2 May 2023

KEYWORDS
COVID-19; coping appraisal; knowledge; Protection Motivation Theory; vaccination

Introduction

The coronavirus disease 2019 (COVID-19) global pandemic has lasted for three years[1] and has caused almost seven million deaths worldwide.[2] Vaccination is considered to be one of the most effective strategies because it can reduce disease severity as well as suppressing the infectiousness by alleviating the symptoms that may spread the viruses (i.e., coughing and sneezing).[3] However, vaccine hesitancy derived from vaccination beliefs or attitudes toward the pandemic[4,5] may prevent individuals with such hesitancy from receiving the COVID-19 vaccination.[6] Moreover, the mutated virus variants as well as the fading of natural immunity effect have forced the scientists to investigate the necessity for additional immunization to maintain the vaccine efficacy and effectiveness.[7] If routine COVID-19 vaccination is needed in the future, it is important to investigate the factors that may affect the public's willingness for booster doses.

Protection Motivation Theory (PMT) is a social cognitive theory that is used to describe individuals' responses toward perceived threats.[8,9] More specifically, the theory proposes that coping and threat appraisal derived from fear appeal may affect individuals' motivations to take self-protection action.[8,10] A previous study[11] used PMT as a framework and added several possible factors (i.e., perceived knowledge, adaptive response, and maladaptive response) to develop a proposed model investigating the intention to uptake COVID-19 vaccination among Taiwanese university students. PMT with perceived knowledge, adaptive responses, and maladaptive response (hereafter, extended PMT) was supported because perceived knowledge was interpreted as the information that individuals received from either formal or informal resources.[12] Such information may influence the formation of coping or threat appraisal through evaluation involving self-efficacy, response efficacy, vulnerability and threat severity.[13] Consequently, individuals' attitudes toward the behavior could be altered.[14] Studies have shown that such knowledge may determine individuals' adherence to COVID-19-related policies such as social restrictions.[15,16] This knowledge could

CONTACT Chung-Ying Lin cylin36933@gmail.com Institute of Allied Health Sciences, College of Medicine, National Cheng Kung University, No. 1, University Rd., East District, Tainan 701401, Taiwan; Kuo-Hsin Lee peter1055@gmail.com Department of Emergency Medicine, E-Da Hospital, I-Shou University, No.1, Yida Rd, Yanchao District, Kaohsiung 824005, Taiwan.
†These authors contributed equally to this work.

Supplemental data for this article can be accessed on the publisher's website at https://doi.org/10.1080/21645515.2023.2211319

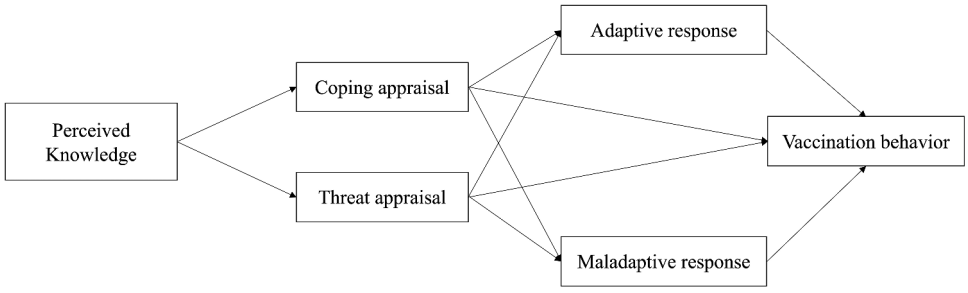

Figure 1. Proposed model illustrated using the protection motivation theory (PMT) to explain the COVID-19 vaccination behavior (vaccine uptake).

positively influence vaccination intention,[17] and lack of knowledge could predict lower vaccination willingness.[18,19]

Moreover, both coping and threat appraisal may further prompt individuals' adaptive or maladaptive responses.[20–22] Adaptive response is when individuals take appropriate precautionary action toward the stressful event for self-protection. Maladaptive response is when inadequate action may hurt individuals' own self-interests.[23] Appraisals may prompt adaptive responses such as self-responsibility or maladaptive responses such as optimistic bias,[24] and distinct appraisals work mutually to determine individuals' response toward the stressful event.[22] One study showed that appropriate information may prompt the implementation of adaptive responses and facilitate protective behavior of individuals.[22] However, the lack of fear, as well as coping and threat appraisal, may provoke maladaptive responses and result in dangerous behavior.[25] Another study reported that avoidance as a coping appraisal and low perception of COVID-19 as a threat fostered individuals' vaccine hesitancy as a maladaptive response. However, behaviors such as information-seeking or help-seeking may act as coping behaviors and be a response to threat appraisal to adaptively reduce vaccine hesitancy.[26]

Given that cultural differences or a government's health policy may affect the associations between studied variables, the United Kingdom (UK) and Taiwan (TW) were chosen as two different sample groups for comparison. Compared to the UK population who tend more toward individualism,[27] the TW population tend more toward collectivism.[27,28] The different regional characteristics and cultural features possessed by these two different populations may demonstrate the disparate associations regarding vaccination behavior among Western and Eastern populations. At the time of writing (May 2023), approximately 36.5% of total UK population had contracted COVID-19 with the mortality rate of 0.9%.[2] The proportions of individuals who had received the first, second or third (booster) doses were 93.9%, 88.8%, and 70.1% of the population aged 12 years and over, respectively.[29] There are eight vaccines that have been approved for use in the UK: *Moderna* (Spikevax and Spikevax Bivalent Original/Omicron BA.1), *Pfizer/BioNTech* (Comirnaty and Comirnaty Bivalent Original/Omicron BA.1), *Novavax* (Nuvaxovid), *AstraZeneca* (Vaxzevria), *Janssen* (Johnson & Johnson), and *Valneva* (Valneva).[30] Similarly (by May 2023), in Taiwan, approximately 43.45% of total population had contracted COVID-19 with the mortality rate of 0.1% (data accessed on 2023 May 7).[31] The proportions of individuals who had received the first, second or third (booster) dose were 94.3%, 89.5% and 74.3% of population aged 12 years and over, respectively.[31] There are six vaccines that have been approved for use in TW: *Moderna* (Spikevax and Spikevax Bivalent Original/Omicron BA.1), *Pfizer/BioNTech* (Comirnaty), *Novavax* (Nuvaxovid), *AstraZeneca* (Vaxzevria) and *Medigen* (MVC-COV1901).[32] With different severity levels of COVID-19 and different policies regarding vaccine uptake, it is unclear if the aforementioned extended PMT performs similarly across different countries and cultures. In order to maximize the utility of the extended PMT, it is important to use different country samples to cross-validate the theory.

Therefore, the purpose of the present study was to investigate the critical factors regarding COVID-19 vaccine uptake among UK and TW populations. PMT was used as the theoretical framework with added possible factors including perceived knowledge, adaptive responses, and maladaptive responses, along with the vaccination behavior (i.e., vaccine uptake), to develop the proposed model (Figure 1) in order to examine the interaction between factors. Moreover, the study examined the differences between the two studied samples to determine the factors that may affect vaccination behavior in different cultural populations.

Methods

Participants and procedure

The present study was a cross-sectional study conducted using internet-based self-administered snowball sampling to collect data. An online survey created by *Survey Monkey* (for TW data collection) and *Prolific* (for UK data collection) was distributed through social networking platforms (e.g., *LINE* and *Twitter*) and individuals were also asked to send the link of the survey to other individuals. The survey took place between August and September 2022. Participants who had lived in the UK or Taiwan for more than six months at the time of the survey took place were eligible to participate. Individuals who wanted to participate in the survey had to provide their (electronic) informed consent. Participants gave their consent by clicking the "yes" button. E-mail addresses and telephone numbers were collected in the survey because participants who completed the survey could receive the equivalent of 3–4 US$ reimbursement. Therefore, the e-mail addresses and telephone numbers were used to contact the participants regarding the financial payment. However, individuals could decline to participate if they had any concerns. One of the research assistants

screened the e-mail addresses and telephone numbers to identify if there were any duplicate responses. After cleaning the data to ensure no duplicate responses, the research assistant deleted the personal private information from the data and forwarded the anonymized dataset to the data managers of the present study. The data storage, electronic link circulation, data retrieval, and data management were controlled by Dr. Barlassina (for the UK data) and Dr. Lin (for the TW data). The study protocol was approved by the ethics committee at the University of Sheffield (Reference Number 047221).

There were 751 responses collected in the UK population and 1052 responses collected in the TW population with no missing data. In brief, participants in the UK population had an average age of 41.2 years (SD = 14.0) with approximately even numbers of males and females. In the TW population, the participants had an average age of 37.5 years (SD = 15.1) with slightly more females (n = 540, 51.3%).

Measures

Perceived knowledge was defined as individuals' knowledge regarding the COVID-19 vaccination. Three items rated on a seven-point Likert-like scale (1 = strongly disagree; 7 = strongly agree) were used for the assessment. A higher score indicates a higher knowledge level regarding the COVID-19 vaccination. Cronbach's alpha was 0.843 in the UK sample and 0.816 in the TW sample. Items are provided in the supplementary materials.

Coping appraisal was defined as the positive perception of COVID-19 vaccination as a disease preventive strategy. Four items rated on a seven-point Likert-like scale (1 = strongly disagree; 7 = strongly agree) were used for the assessment. A higher score indicates a higher agreement of perceiving vaccination as a self-protection strategy against COVID-19. Cronbach's alpha was 0.909 in the UK sample and 0.830 in the TW sample. Items are provided in supplementary materials.

Threat appraisal was defined as the strategies used to evaluate the risk of COVID-19 pandemics. Therefore, the Fear of COVID-19 Scale (FCV-19S)[33] was used to assess threat appraisal. The FCV-19S has seven items rated on a five-point Likert-like scale (1 = strongly disagree; 5 = strongly agree). The score was summed to generate a total score ranging from 5 to 35. A higher score indicates a higher level of perceived fear of COVID-19. The psychometric properties of the FCV-19S have been verified and found satisfactory in prior research on both TW and UK samples.[34,35] Cronbach's alpha was 0.899 in the UK sample and 0.925 in the TW sample. Items are provided in supplementary materials.

Adaptive response was defined as positive thoughts regarding COVID-19 vaccination. An item rated on a seven-point Likert-like scale (1 = strongly disagree; 7 = strongly agree) was used for the assessment. A higher score indicates a higher agreement of the COVID-19 vaccination to improve individuals' wellbeing. The item is provided in the supplementary materials.

Maladaptive response was defined as negative thoughts regarding COVID-19 vaccination. An item rated on a seven-point Likert-like scale (1 = strongly disagree; 7 = strongly agree) was used for the assessment. A higher score indicates a higher agreement that the COVID-19 vaccination may harm individuals' health. The item is provided in the supplementary materials.

Vaccination behavior concerned the receiving of the COVID-19 booster vaccination. The booster dose was defined as an extra vaccine administration after an earlier or primer dose.[36] Information regarding individuals' booster dose injection was recorded for statistical analysis.

For tool validation, variables using non-standardized measures (i.e., perceived knowledge, coping appraisal, threat appraisal, adaptive response and maladaptive response) underwent forward translation, back translation, reconciliation, and committee review.

Statistical analysis

Descriptive analysis for continuous variables (i.e., age and the scores of all the studied variables) and chi-square tests for categorical variables (i.e., gender and vaccine uptake) were used to summarize and compare participants' characteristics between the UK and TW groups. Pearson's correlation was used to calculate the correlation coefficients between the studied variables. Structural equation modeling (SEM) with the estimator of diagonally weighted least squares was set to test if the collected data fit well with the proposed model (Figure 1). Four indices including comparative fit index (CFI), Tucker – Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR)[37] were used to examine if the proposed model was supported. The path coefficients of SEM were further inspected if the fit indices were found to be satisfactory. That is, both CFI and TLI should higher than 0.95; and both RMSEA and SRMR should lower than 0.08.[37] Multigroup analysis in the confirmatory factor analysis was used to test if the path coefficients differed between the two groups (i.e., UK and TW). The differences of path coefficients between the two groups were examined using chi-square tests. The *lavaan* package in R software[38] was used to perform the SEM and multigroup analysis.[39] SPSS 26.0 (IBM, Corp., NY: Armonk) was used to perform the remaining data analyses. The significance level was set at $p < .05$.

Results

The scores of all the studied variables as well as the frequency of responses are reported in Tables 1 and 2. Briefly, the scores of all the studied variables were significantly different between the two populations (p-values ≤ 0.001). The bivariate associations between the studied variables among both UK and TW populations are separately reported in Tables 3 and 4.

In the UK population, all the variables were significantly correlated with each other, except for the correlation between threat appraisal and maladaptive response. In the TW population, perceived knowledge and coping appraisal were significantly correlated with all the other variables, except for threat appraisal. Threat appraisal was significantly correlated with maladaptive response ($r = -0.172$, p-value $< .001$), and adaptive response was significantly correlated with vaccination behavior ($r = 0.291$, p-value $< .001$).

Table 1. Participants' characteristics.

	United Kingdom population ($n = 751$)	Taiwanese population ($n = 1052$)	p-value
Age (years)	41.17 ± 14.01	37.45 ± 15.05	**< .001**
Gender			.163
Male	372 (49.5)	489 (46.5)	
Female	370 (49.3)	540 (51.3)	
Prefer to self-define	9 (1.2)	23 (2.2)	
Perceived knowledge (score range: 1–7)	5.32 ± 1.39	4.97 ± 1.15	**< .001**
Coping appraisal (score range: 1–7)	6.17 ± 1.62	4.88 ± 1.18	**< .001**
Threat appraisal (score range: 5–35)	12.63 ± 5.36	17.83 ± 6.77	**< .001**
Adaptive response (score range: 1–7)	5.19 ± 1.80	4.94 ± 1.25	**.001**
Maladaptive response (score range: 1–7)	4.45 ± 1.92	4.06 ± 1.66	**< .001**
Vaccination behavior (received booster shot)	526 (70)	879 (83.6)	**< .001**

Data are presented with mean±SD or n (%).

Table 2. Frequency response of study variables.

	Response; the UK, TW						
Item	1	2	3	4	5	6	7
Perceived Knowledge							
I know very well how vaccination protects me from COVID-19.	24 (3.2), 41 (3.9)	30 (4.0), 40 (3.8)	22 (2.9), 84 (8.0)	92 (12.3), 223 (21.2)	145 (19.3), 282 (26.8)	266 (35.4), 268 (25.5)	172 (22.9), 114 (10.8)
I understand how the COVID-19 jab helps fight the virus	20 (2.7), 21 (2.0)	33 (4.4), 23 (2.20	25 (3.3), 58 (5.5)	68 (9.1), 173 (16.4)	187 (24.9), 319 (30.3)	242 (32.2), 329 (31.3)	176 (23.4), 129 (12.3)
The contribution of the COVID-19 jab to my health is very important	55 (7.3), 9 (0.9)	37 (4.9), 33 (3.1)	36 (4.8), 76 (7.2)	76 (10.1), 242 (23.0)	126 (16.8), 323 (30.7)	223 (29.7), 269 (25.6)	198 (26.4), 100 (9.5)
Coping appraisal							
Vaccination is an effective way to protect me.	42 (5.6), 69 (6.6)	32 (4.3), 69 96.6)	22 (2.9), 101 99.6)	58 (7.7), 163 (15.5)	78 (10.4), 274 (26.0)	249 (33.2), 274 (26.0)	270 (36.0), 102 (9.7)
It is important that I get the COVID-19 jab	59 (7.9), 28 (2.7)	31 (4.1), 16 (1.5)	19 (2.5), 46 (4,4)	51 (6.8), 168 (16.0)	69 (9.2), 253 (24.0)	194 (25.8), 364 (34.6)	328 (43.7), 177 (16.8)
Vaccination greatly reduces my risk of catching COVID-19.	67 (8.9), 47 (4.5)	79 (10.5), 51 (4.8)	68 (9.1), 94 (8.9)	73 (9.7), 194 (18.4)	135 (18.0), 270 (25.7)	159 (21.2), 282 (26.8)	170 (22.6), 114 (10.8)
Getting the COVID-19 jab has positive influence on my health.	56 (7.5), 11 (1.0)	47 (6.3), 34 (3.2)	34 (4.5), 81 (7.7)	167 (22.2), 292 (27.8)	115 (15.3), 301 (28.6)	196 (26.1), 252 (24.0)	136 (18.1), 81 (7.7)
Threat appraisal							
I am most afraid of COVID-19	266 (35.4), 141 (13.4)	274 (36.5), 287 (27.3)	104 (13.8), 285 (27.1)	90 (12.0), 265 (25.2)	17 (2.3), 74 (7.0)	–	–
It makes me uncomfortable to think about COVID-19	235 (31.3), 158 (15.0)	254 (33.8), 246 (23.4)	96 (12.8), 275 (26.1)	151 (20.1), 302 (28.7)	15 (2.0), 71 (6.7)	–	–
My hands become clammy when I think about COVID-19	492 (65.5), 371 (35.3)	207 (27.6), 332 (31.6)	33 (4.4), 221 (20.1)	16 (2.1), 93 (8.8)	3 (0.4, 45 (4.3))	–	–
I am afraid of losing my life because of COVID-19	355 (47.3), 200 (19.0)	207 (27.6), 246 (23.4)	85 (11.3), 225 (21.4)	84 (11.2), 306 (29.1)	20 (2.7), 75 (7.1)	–	–
When watching news and stories about COVID-19 on social media, I become nervous or anxious.	296 (39.4), 221 (21.0)	223 (29.7), 271 (25.8)	95 (12.6), 280 (26.6)	116 (15.4), 218 (20.7)	21 (2.8), 62 (5.9)	–	–
I cannot sleep because I'm worry about getting COVID-19	542 (72.2), 346 (32.9)	175 (23.3), 326 (31.0)	24 (3.2), 213 (20.2)	8 (1.1), 128 (12.2)	2 (0.3), 29 (3.7)	–	–
My heart races or palpitates when I think about getting COVID-19	519 (69.1), 344 (32.7)	179 (23.8), 201 (28.6)	33 (4.4), 244 (23.2)	16 (2.1), 132 (12.5)	4 (0.5), 31 (2.9)	–	–
Adaptive response							
The COVID-19 jab plays an important role in protecting my life and others	55 (7.3), 9 (0.9)	37 (4.9), 33 (3.1)	36 (4.8), 76 (7.2)	76 (10.1), 242 (23.0)	126 (16.8), 323 (30.7)	223 (29.7), 269 (25.6)	198 (26.4), 100 (9.5)
Maladaptive response							
I feel under pressure to get the COVID-19 jab	48 (6.4), 50 (4.8)	90 (12.0), 153 (14.5)	147 (19.6), 207 (19.7)	93 (12.4), 166 (25.3)	76 (10.1), 128 (12.2)	156 (20.8), 143 (13.6)	141 (18.8), 105 (10.0)

Data are presented as n (%).

The results of SEM are shown in Figure 2. The model fitted well in both the UK and TW populations, as supported by all fit indices (CFI = 1.000 and 0.996, TLI = 1.005 and 0.989, RMSEA = 0.000 and 0.028, SRMR = 0.018 and 0.029), except for the significant χ^2 tests (p-value < .001). In the UK population, the SEM model showed that perceived knowledge was significantly associated with coping appraisal and threat appraisal (standardized coefficient [β] = 0.898 and 0.158). Coping appraisal and threat appraisal were significantly associated with adaptive response (β = 0.887 and 0.104) and maladaptive response (β = 0.378 and−0.083), respectively. In the TW population, the SEM model showed that perceived knowledge was significantly associated with coping appraisal and threat appraisal (β = 0.941 and −0.022). Coping appraisal and threat appraisal were significantly associated with adaptive response (β = 0.813 and 0.013) and maladaptive response (β = −0.073 and −0.173). Additionally, coping appraisal was significantly associated with vaccination behavior (β = 0.319).

Table 3. Correlations between studied variables in a United Kingdom population ($n = 751$).

	1	2	3	4	5	6
1 Perceived knowledge	–					
2 Coping appraisal	**0.840 (<0.001)**	–				
3 Threat appraisal	**0.154 (<0.001)**	**0.144 (<0.001)**	–			
4 Adaptive response	**0.851 (<0.001)**	**0.841 (<0.001)**	**0.230 (<0.001)**	–		
5 Maladaptive response	**0.326 (<0.001)**	**0.351 (<0.001)**	−0.030 (0.410)	**0.328 (<0.001)**	–	
6 Vaccination behavior	**0.511 (<0.001)**	**0.558 (<0.001)**	**0.086 (0.019)**	**0.541 (<0.001)**	**0.241 (<0.001)**	–

Table 4. Correlations between studied variables in a Taiwanese population ($n = 1052$).

	1	2	3	4	5	6
1 Perceived knowledge	–					
2 Coping appraisal	**0.850 (<0.001)**	–				
3 Threat appraisal	−0.042 (0.174)	−0.005 (0.862)	–			
4 Adaptive response	**0.829 (<0.001)**	**0.732 (<0.001)**	0.001 (0.963)	–		
5 Maladaptive response	**−0.097 (0.002)**	**−0.070 (0.023)**	**−0.172 (<0.001)**	−0.022 (0.476)	–	
6 Vaccination behavior	**0.318 (<0.001)**	**0.340 (<0.001**)	−0.057 (0.065)	**0.291 (<0.001)**	0.034 (0.275)	–

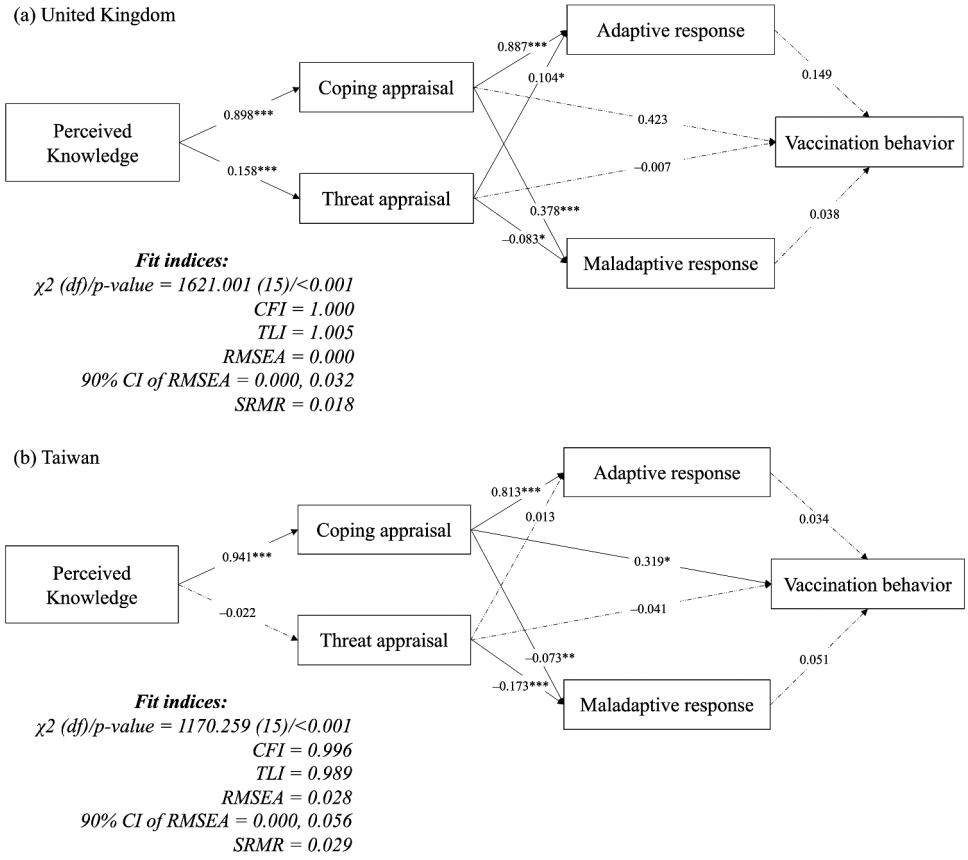

Figure 2. Confirmed model in explaining the COVID-19 vaccination behavior (vaccine uptake) among the (a) UK population and (b) Taiwanese population. Coefficients are presented using standardized coefficients. Solid lines indicate significant pathways while dashed lines indicate non-significant pathways. * $p < .05$; ** $p < .01$; *** $p < .001$; CFI = Comparative fit index; TLI = Tucker – Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

Table 5. Results of multigroup analysis.

	Unstandardized coefficient (SE)			
	UK	TW	Chi-square difference (df difference)	*p*-value (>chi-square)
Perceived knowledge (coping appraisal)	1.026 (0.078)	0.940 (0.064)	13.205 (1)	**< .001**
Perceived knowledge (threat appraisal)	0.061 (0.010)	−0.013 (0.015)	13.516 (1)	**< .001**
Coping appraisal (adaptive response)	1.004 (0.058)	0.889 (0.049)	19.898 (1)	**< .001**
Coping appraisal (maladaptive response)	0.456 (0.037)	−0.106 (0.036)	78.976 (1)	**< .001**
Threat appraisal (adaptive response)	0.348 (0.139)	0.024 (0.073)	22.488 (1)	**< .001**
Threat appraisal (maladaptive response)	−0.297 (0.147)	−0.426 (0.092)	0.818 (1)	.366
Coping appraisal (vaccination behavior)	0.122 (0.085)	0.103 (0.043)	0.207 (1)	.649

The results of multigroup analysis are shown in Table 5. Significant differences in the path coefficients between the two populations were found in the correlations of perceived knowledge with coping appraisal and threat appraisal ($\Delta\chi^2(\Delta df) = 13.205$ (1) and 13.516 (1), all p-value < .001), the associations of coping appraisal and threat appraisal with adaptive response ($\Delta\chi^2(\Delta df) = 19.898$ (1) and 22.488 (1), all p-value < .001), as well as the association between coping appraisal and maladaptive response ($\Delta\chi^2(\Delta df) = 78.976$ (1), p-value < .001).

Discussion

The present study investigated the potential factors associated to the vaccination behavior between UK and TW populations. The results from the UK sample showed that perceived knowledge was significantly correlated with coping and threat appraisals. Coping and threat appraisals were respectively associated with adaptive and maladaptive responses. However, none of the factors were associated with vaccination behavior. The results from the TW sample showed that perceived knowledge was significantly correlated with coping appraisal. Coping appraisal was significantly associated with adaptive and maladaptive responses, while threat appraisal was only significantly associated with maladaptive response. However, coping appraisal was associated with vaccination behavior in the TW sample, forming a significant pathway from perceived knowledge to explain the vaccination behavior. In addition, the results from the multigroup analysis showed significant differences in the correlations between (i) perceived knowledge and coping and threat appraisal, (ii) coping appraisal and adaptive and maladaptive responses, and (iii) threat appraisal and adaptive response. Regarding the present findings, the cultural differences between the UK and TW might be crucial in determining the willingness of vaccine uptake. Such cultural differences might explain the different results between the two countries.

The significant correlations between perceived knowledge and coping appraisal as well as coping appraisal and vaccination behavior demonstrated a possible mechanism to explain COVID-19 vaccination behavior in the TW population. Knowledge has been found to be one of the effective factors in controlling the spread of viruses in pandemics[40] because knowledge may affect the individuals' attitude,[41,42] increase self-efficacy[43] and response efficacy[44] to facilitate (even enhance) the adoption of coping strategies as self-protection measures.[11,40] Previous research has found response efficacy to be the most influential psychosocial predictor[44,45] that dominates the willingness to get vaccinated. One study showed that the information regarding the COVID-19 vaccine efficacy may prompt individuals' response efficacy and further strengthen vaccination intention.[45] Accordingly, studies investigating the factors associated with COVID-19 vaccination report that perceived knowledge is usually a pro-vaccination factor.[11,41,42,46] More specifically, perceived knowledge influences individuals' attitude toward the COVID-19 vaccine.[42] With perceived response efficacy[45] and self-efficacy to vaccination,[9,45] individuals tend to develop vaccination intention and acceptance[11,42,46] to cope with the COVID-19 pandemic.

However, the findings from the TW sample were somewhat different from the those in the UK sample. The SEM results demonstrated a significant correlation between perceived knowledge and coping appraisal, but the correlation did not extend to vaccination behavior. The multi-group analysis further corroborated the findings that several path coefficients were found to be different between the two studied groups. Literature indicates that the correctness of knowledge may play an important role in deciding the public perception to the COVID-19 vaccine.[47] It appears that UK participants had lowered their trust toward the British government early in the pandemic because of perceived misinformation[47] and conspiracy beliefs.[48,49] One study reported that misinformation regarding COVID-19 may confuse the public and cause psychological distress, therefore contributing to vaccine hesitancy.[47] In addition, the individuals who believed in conspiracy theories may be misguided[49] and resulted in distrust with government and authorities,[50] which was may have been a factor in suppressing their willingness to get vaccinated.[50] Moreover, compared to Taiwan, which embraces a collectivism culture,[27,28] the individualistic culture of UK society[27] may imperceptibly cause the spread of COVID-19.[51] Individualistic societies may be more vulnerate to

infectious diseases[52,53] because compared to collective cultures which put the group benefits over self, individualistic cultures value the freedom and personal rights.[53] Therefore, misinformation and the increase in COVID-19-related conspiracies may interfere with the knowledge perceived by the UK public.[47,54] This, alongside living in an individualistic cultural orientation, UK citizens would be more hesitant to obey social restraint regulations (e.g., staying at home, avoiding social interaction, etc.)[52] or COVID-19 preventive strategy (e.g., COVID-19 vaccination),[48,55] resulting in the delay of essential responses and very high death tolls.[51,52]

The present study provides informative knowledge regarding COVID-19 vaccine uptake in the UK and TW populations. The findings showed a clear path from perceived knowledge to vaccination behavior in the TW sample, suggesting that knowledge may be a potential facilitator in enhancing COVID-19 preventive strategy. Fear or concern regarding injection, as well as a lack of knowledge regarding COVID-19 vaccine, were reported to be the potential barriers to prevent the vaccine uptake in TW.[56] In the UK sample, the investigated variables failed to demonstrate a significant pathway in explaining vaccine uptake and the present study provides some possible insights considering sociological characteristics of UK residents. Studies suggest that effective communication strategies[46] as well as valid and reliable information[50] may help restore the potential influence of knowledge, reduce the negative attitude toward COVID-19 vaccination,[47] and facilitate vaccine uptake among individuals in the UK population. In addition, several studies have reported that misinformation may be a potential barrier for the UK population.[47,57] Therefore, governmental action is needed to help overcome this problem in order to promote the vaccine uptake.

The present study has several limitations. First, the study adopted a cross-sectional study design. The lack of temporal measures restricts the evidence regarding causal relationships between the studied variables. Second, the self-reported data may result in bias and misrepresentation. For example, participants may have social desirability biases and provided responses that were more pro-vaccination. Third, the present study was conducted using snowball sampling (resulting in a modest sample size for each country). Therefore, the samples were unlikely to be representative and lack generalizability. Fourth, a few variables in the present study were assessed using a single item which may have limited the accuracy in assessing these specific variables. Fifth, there may have been some selection bias given that not everybody uses social media platforms. More specifically, it has been reported that 84.3% of the UK population[58] and 89.4% of the TW population[59] use social media platforms. Therefore, individuals who do not use social media platform could not participate which impacts on the generalizability of the present findings. Sixth, the response rate in the present study was unknown because it was conducted using snowball sampling. Therefore, it is not known how many individuals were sent the link to participate in the survey.

Conclusion

The present study expanded the PMT with several potential factors including perceived knowledge, adaptive responses, and maladaptive responses to develop a proposed model investigating vaccination behavior among UK and Taiwanese populations. The SEM results showed that perceived knowledge was significantly associated to coping appraisal in both groups. However, the association between coping appraisal and vaccination behavior was only observed in the TW group. Therefore, vaccination behavior among Taiwanese individuals can be improved by providing reliable knowledge regarding COVID-19 vaccination. As for the UK, the potential facilitators for vaccination behavior require further investigation. Moreover, health communication and information clarification may help rebuild some of the public's trust toward authority that helps inhibit the spread of COVID-19.

Acknowledgments

We thank all the participants who responded to the online survey.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The present study was supported in part by a research grant from the Ministry of Science and Technology, Taiwan (MOST109-2327-B-006-005; MOST111-2321-B-006-009), the National Science and Technology Council, Taiwan (NSTC 112-2321-B-006-008-), the WUN Research Development Fund (RDF) 2021 and the Higher Education Sprout Project, the Ministry of Education at the Headquarters of University Advancement at the National Cheng Kung University (NCKU).

ORCID

Po-Ching Huang http://orcid.org/0000-0002-2047-2246
Felipe Carvalho http://orcid.org/0000-0002-0584-3424
Chung-Ying Lin http://orcid.org/0000-0002-2129-4242

References

1. Velavan TP, Meyer CG. The COVID-19 epidemic. Trop Med Int Health. 2020;25(3):278–80. doi:10.1111/tmi.13383.
2. WHO COVID-19 dashboard. Geneva (Switzerland): World Health Organization; [accessed 2023 May 7]. https://covid19.who.int/.
3. Lipsitch M, Dean NE. Understanding COVID-19 vaccine efficacy. Science. 2020;370(6518):763–5. doi:10.1126/science.abe5938.
4. Sherman SM, Sim J, Cutts M, Dasch H, Amlot R, Rubin GJ, Sevdalis N, Smith LE. COVID-19 vaccination acceptability in the UK at the start of the vaccination programme: a nationally representative cross-sectional survey (CoVaccs - wave 2). Public Health. 2022;202:1–9. doi:10.1016/j.puhe.2021.10.008.
5. Biasio LR, Bonaccorsi G, Lorini C, Pecorelli S. Assessing COVID-19 vaccine literacy: a preliminary online survey. Human Vacc Immunother. 2021;17(5):1304–12. doi:10.1080/21645515.2020.1829315.
6. Rieger MO. Willingness to vaccinate against COVID-19 might be systematically underestimated. Asian J Soc Health Behav. 2021;4(2):81–3. doi:10.4103/shb.shb_7_21.

7. Shekhar R, Garg I, Pal S, Kottewar S, Sheikh AB. COVID-19 vaccine booster: to boost or not to boost. Infect Dis Rep. 2021;13(4):924–9. doi:10.3390/idr13040084.
8. Rogers RW. A Protection Motivation Theory of fear appeals and attitude change1. J Psychol. 1975;91(1):93–114. doi:10.1080/00223980.1975.9915803.
9. Maddux JE, Rogers RW. Protection motivation and self-efficacy: a revised theory of fear appeals and attitude change. J Exp Soc Psychol. 1983;19(5):469–79. doi:10.1016/0022-1031(83)90023-9.
10. Rad MK, Fakhri A, Stein L, Araban M. Health-care staff beliefs and coronavirus disease 2019 vaccinations: a cross-sectional study from Iran. Asian J Soc Health Behav. 2022;5(1):40–6. doi:10.4103/shb.shb_13_22.
11. Huang PC, Hung CH, Kuo YJ, Chen YP, Ahorsu DK, Yen CF, Lin CY, Griffiths MD, Pakpour AH. Expanding Protection Motivation Theory to explain willingness of COVID-19 vaccination uptake among Taiwanese university students. Vaccines. 2021;9(9):1046. doi:10.3390/vaccines9091046.
12. Camerini AL, Diviani N, Fadda M, Schulz PJ. Using Protection Motivation Theory to predict intention to adhere to official MMR vaccination recommendations in Switzerland. SSM-Popul Health. 2019;7:005–5. doi:10.1016/j.ssmph.2018.11.005.
13. Cameron KA. A practitioner's guide to persuasion: an overview of 15 selected persuasion theories, models and frameworks. Patient Edu Couns. 2009;74(3):309–17. doi:10.1016/j.pec.2008.12.003.
14. Fadda M, Depping MK, Schulz PJ. Addressing issues of vaccination literacy and psychological empowerment in the measles-mumps-rubella (MMR) vaccination decision-making: a qualitative study. BMC Public Health. 2015;15(1):836. doi:10.1186/s12889-015-2200-9.
15. Elhadi M, Msherghi A, Alsoufi A, Buzreg A, Bouhuwaish A, Khaled A, Alhadi A, Alameen H, Biala M, Elgherwi A, et al. Knowledge, preventive behavior and risk perception regarding COVID-19: a self-reported study on college students. Pan Afr Med J. 2020;35(Suppl 2):75. doi:10.11604/pamj.supp.2020.35.2.23586.
16. Al-Hasan A, Khuntia J, Yim D. Threat, coping, and social distance adherence during COVID-19: cross-continental comparison using an online cross-sectional survey. J Med Internet Res. 2020;22(11):e23019. doi:10.2196/23019.
17. Zheng H, Jiang S, Wu Q. Factors influencing COVID-19 vaccination intention: the roles of vaccine knowledge, vaccine risk perception, and doctor-patient communication. Patient Educ Couns. 2022;105(2):277–83. doi:10.1016/j.pec.2021.09.023.
18. Tabacchi G, Costantino C, Napoli G, Marchese V, Cracchiolo M, Casuccio A, Vitale F, The Esculapio Working G. Determinants of European parents' decision on the vaccination of their children against measles, mumps and rubella: a systematic review and meta-analysis. Human Vacc Immunother. 2016;12(7):1909–23. doi:10.1080/21645515.2016.1151990.
19. Kotecha IS, Vasavada DA, Kumar P, Nerli LMR, Tiwari DS, Parmar DV. Knowledge, attitude, and belief of health-care workers toward COVID-19 vaccine at a tertiary care center in India. Asian J Soc Health Behav. 2022;5(2):63–7. doi:10.4103/shb.shb_20_21.
20. Tan G, Teo I, Anderson KO, Jensen MP. Adaptive versus maladaptive coping and beliefs and their relation to chronic pain adjustment. Clin J Pain. 2011;27(9):769–74. doi:10.1097/AJP.0b013e31821d8f5a.
21. Ball TM, Gunaydin LA. Measuring maladaptive avoidance: from animal models to clinical anxiety. Neuropsychopharmacology. 2022;47(5):978–86. doi:10.1038/s41386-021-01263-4.
22. Rippetoe PA, Rogers RW. Effects of components of Protection-Motivation Theory on adaptive and maladaptive coping with a health threat. J Pers Soc Psychol. 1987;52(3):596–604. doi:10.1037/0022-3514.52.3.596.
23. Norman P, Boer H, Seydel ER, Mullan B, Conner M, Norman P, editors. Protection Motivation Theory. New York (NY): McGraw-Hill Education; 2015. p. 70–106.
24. Westcott R, Ronan K, Bambrick H, Taylor M. Expanding Protection Motivation Theory: investigating an application to animal owners and emergency responders in bushfire emergencies. BMC Psychol. 2017;5(1):13. doi:10.1186/s40359-017-0182-3.
25. Eppright DR, Hunt JB, Tanner JF, Jr., Franke GR. Fear, coping, and information: a pilot study on motivating a healthy response. Health Mark Q. 2002;20(1):51–73. doi:10.1300/J026v20n01_05.
26. Morstead T, Zheng J, Sin NL, DeLongis A. Perceived threat and coping responses during the COVID-19 pandemic: prospective associations with vaccine hesitancy. Vaccine. 2022;40(52):7586–92. doi:10.1016/j.vaccine.2022.10.081.
27. Hofstede GH, Hofstede G. Culture's consequences: comparing values, behaviors, institutions and organizations across nations. Newbury Park (CA): Sage; 2001.
28. Yang WY, Tsai CH. Democratic values, collective security, and privacy: Taiwan people's response to COVID-19. Asian J Public Opin Res. 2020;8(3):222–45. doi:10.15206/ajpor.2020.8.3.222.
29. GOV.UK Coronavirus (COVID-19) in the UK. London (United Kingdom): UK Health Security Agency; [accessed 2023 May 7]. https://coronavirus.data.gov.uk/.
30. United Kingdom of Great Britain and Ireland. Montreal (Canada): COVID-19 vaccine tracker. [accessed 2023 May 7]. https://covid19.trackvaccines.org/country/united-kingdom-of-great-britain-and-northern-ireland/.
31. COVID-19 dashboard. Taipei (Taiwan): National Center for High-performance Computing; [accessed 2023 May 7]. https://covid-19.nchc.org.tw/index.php?language=en.
32. TAIWAN. Montreal (Canada): COVID-19 vaccine tracker. [accessed 2023 May 7]; https://covid19.trackvaccines.org/country/taiwan/.
33. Ahorsu DK, Lin CY, Imani V, Saffari M, Griffiths MD, Pakpour AH. The fear of COVID-19 scale: development and initial validation. Int J Ment Health Aaddict. 2020:1–9. doi:10.1007/s11469-020-00270-8.
34. Lin CY, Hou WL, Mamun MA, Aparecido da Silva J, Broche-Perez Y, Ullah I, Masuyama A, Wakashima K, Mailliez M, Carre A, et al. Fear of COVID-19 scale (FCV-19S) across countries: measurement invariance issues. Nurs Open. 2021;8(4):1892–908. doi:10.1002/nop2.855.
35. Alimoradi Z, Lin CY, Ullah I, Griffiths MD, Pakpour AH. Item response theory analysis of the fear of COVID-19 scale (FCV-19S): a systematic review. Psychol Res Behav Manag. 2022;15:581–96. doi:10.2147/PRBM.S350660.
36. Abdelmoneim SA, Sallam M, Hafez DM, Elrewany E, Mousli HM, Hammad EM, Elkhadry SW, Adam MF, Ghobashy AA, Naguib M, et al. COVID-19 vaccine booster dose acceptance: systematic review and meta-analysis. Trop Med Infect Dis. 2022;7(10):298. doi:10.3390/tropicalmed7100298.
37. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Modeling. 1999;6(1):1–55. doi:10.1080/10705519909540118.
38. Rosseel Y. Lavaan: an R package for structural equation modeling. J Stat Softw. 2012;48(2):1–36. doi:10.18637/jss.v048.i02.
39. Evermann J. Multiple-group analysis using the sem package in the R system. Struct Equ Modeling. 2010;17(4):677–702. doi:10.1080/10705511.2010.510070.
40. Li JB, Yang A, Dou K, Wang LX, Zhang MC, Lin XQ. Chinese public's knowledge, perceived severity, and perceived controllability of COVID-19 and their associations with emotional and behavioural reactions, social participation, and precautionary behaviour: a national survey. BMC Public Health. 2020;20(1):1589. doi:10.1186/s12889-020-09695-1.
41. Balan A, Bejan I, Bonciu S, Eni CE, Ruta S. Romanian medical students' attitude towards and perceived knowledge on COVID-19 vaccination. Vaccines. 2021;9(8):854. doi:10.3390/vaccines9080854.
42. Mannan DKA, Farhana KM. Knowledge, attitude and acceptance of a COVID-19 vaccine: a global cross-sectional study. Int J Acad Res Bus Soc Sci. 2020;6(4). doi:10.2139/ssrn.3763373.

43. Bashirian S, Jenabi E, Khazaei S, Barati M, Karimi-Shahanjarini A, Zareian S, Rezapur-Shahkolai F, Moeini B. Factors associated with preventive behaviours of COVID-19 among hospital staff in Iran in 2020: an application of the Protection Motivation Theory. J Hosp Infect. 2020;105(3):430–3. doi:10.1016/j.jhin.2020.04.035.
44. Wang PW, Ahorsu DK, Lin CY, Chen IH, Yen CF, Kuo YJ, Griffiths MD, Pakpour AH. Motivation to have COVID-19 vaccination explained using an extended Protection Motivation Theory among university students in China: the role of information sources. Vaccines. 2021;9(4):380. doi:10.3390/vaccines9040380.
45. Davis CJ, Golding M, McKay R. Efficacy information influences intention to take COVID-19 vaccine. Br J Health Psychol. 2022;27(2):300–19. doi:10.1111/bjhp.12546.
46. Gallè F, Sabella EA, Roma P, De Giglio O, Caggiano G, Tafuri S, Da Molin G, Ferracuti S, Montagna MT, Liguori G. Knowledge and acceptance of COVID-19 vaccination among undergraduate students from central and southern Italy. Vaccines. 2021;9(6):638. doi:10.3390/vaccines9060638.
47. Lockyer B, Islam S, Rahman A, Dickerson J, Pickett K, Sheldon T, Wright J, McEachan R, Sheard L, Bradford Institute for Health Research Covid-19 Scientific Advisory G. Understanding COVID-19 misinformation and vaccine hesitancy in context: findings from a qualitative study involving citizens in Bradford, UK. Health Expect. 2021;24(4):1158–67. doi:10.1111/hex.13240.
48. Bacon AM, Taylor S. Vaccination hesitancy and conspiracy beliefs in the UK during the SARS-COV-2 (COVID-19) pandemic. Int J Behav Med. 2022;29(4):448–55. doi:10.1007/s12529-021-10029-7.
49. Freeman D, Waite F, Rosebrock L, Petit A, Causier C, East A, Jenner L, Teale AL, Carr L, Mulhall S, et al. Coronavirus conspiracy beliefs, mistrust, and compliance with government guidelines in England. Psychol Med. 2022;52(2):251–63. doi:10.1017/S0033291720001890.
50. Cook EJ, Elliott E, Gaitan A, Nduka I, Cartwright S, Egbutah C, Randhawa G, Waqar M, Ali N. Vaccination against COVID-19: factors that influence vaccine hesitancy among an ethnically diverse community in the UK. Vaccines. 2022;10(1):106. doi:10.3390/vaccines10010106.
51. Marginson S. The relentless price of high individualism in the pandemic. High Educ Res Dev. 2020;39(7):1392–5. doi:10.1080/07294360.2020.1822297.
52. Jiang S, Wei Q, Zhang L. Individualism versus collectivism and the early-stage transmission of COVID-19. Soc Indic Res. 2022;164(2):791–821. doi:10.1007/s11205-022-02972-z.
53. Rajkumar RP. The relationship between measures of individualism and collectivism and the impact of COVID-19 across nations. Public Health Pract. 2021;2:100143. doi:10.1016/j.puhip.2021.100143.
54. Stein RA, Ometa O, Pachtman Shetty S, Katz A, Popitiu MI, Brotherton R. Conspiracy theories in the era of COVID-19: a tale of two pandemics. Int J Clin Pract. 2021;75(2):e13778. doi:10.1111/ijcp.13778.
55. Eberhardt J, Ling J. Predicting COVID-19 vaccination intention using Protection Motivation Theory and conspiracy beliefs. Vaccine. 2021;39(42):6269–75. doi:10.1016/j.vaccine.2021.09.010.
56. Wang CW, de Jong EP, Faure JA, Ellington JL, Chen CH, Chan C-C. A matter of trust: a qualitative comparison of the determinants of COVID-19 vaccine hesitancy in Taiwan, the United States, the Netherlands, and Haiti. Hum Vaccines Immunother. 2022;18(5):2050121. doi:10.1080/21645515.2022.2050121.
57. Husted M, Gibbons A, Cheung W-Y, Keating S. COVID-19 vaccination hesitancy in adults in the United Kingdom: barriers and facilitators to uptake. Health Psychol. 2023. (Advance online publication) doi:10.1037/hea0001256.
58. Social media in the great British - 2023 stats & platform trends. (Singapore): OOSGA; [accessed 2023 Mar 15]. https://zh.oosga.com/social-media/gbr/. [In Chinese].
59. Social media in Taiwan - 2023 stats & platform trends. (Singapore): OOSGA; [accessed 2023 Mar 15]. https://oosga.com/social-media/twn/.