



Assessment of knowledge, attitudes, practices, and risk perceptions regarding COVID-19: a cross-sectional study from China

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Received: 25 October 2022 / Accepted: 2 March 2023

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Abstract

Aim To analyze the level of knowledge, attitudes, practices, and risk perception regarding COVID-19 among Chinese residents 1.5 years after the pandemic.

Subject and methods A cross-sectional study was carried out with both online and paper questionnaires. We included a variety of covariates that were characteristic-related factors such as age, gender, education level, and retirement status, as well as those closely associated with risk perception regarding COVID-19.

Results Participants ($n = 3588$), 53.49 ± 18.88 years old, from two provinces of China, of which 44.7% were male and 52.03% had a high school or greater level of education, answered the questions. More than 90% of participants had adequate background knowledge about COVID-19 and agreed or even strongly agreed with many attitude items related to the government's role in diagnosis, treatment, and dealing with COVID-19 infections. About three fifths of the participants reported fear of contracting COVID-19, but only a minority (18.63%) felt they were more susceptible than others. Respondents aged 45 years or younger were more likely to fear contracting the virus than those older than 45 years (adjusted OR = 1.464, 95% CI 1.196 to 1.794, $P = 0.0002$). High education level (adjusted OR = 1.503, 95% CI 1.187 to 1.904, $P = 0.0007$) and non-retired status (adjusted OR = 1.679, 95% CI 1.354 to 2.083, $P < 0.0001$) were associated with a higher perception of susceptibility to infection than others. Moreover, respondents who were not retired had a significantly reduced practice score (adjusted OR = 1.554, 95% CI 1.261 to 1.916, $P < 0.0001$). Age, retirement status, and education level were also associated with knowledge, attitude, and practice level.

Conclusion Our findings suggest that the public generally has trust in the COVID-19 vaccine and the government with regard to COVID-19 in China. We recommend that high-risk groups of communities, such as elders and patients with chronic diseases, be given greater consideration in the outbreaks. Health education campaigns combined with workplace preventive intervention should be aimed at improving COVID-19 knowledge and beliefs in order to encourage more optimistic attitudes and to maintain safe practices.

Keywords COVID-19 · Attitudes · Knowledge · Risk perception

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Introduction

COVID-19 is a major public health threat with the fastest spread, the widest reach of infection, and the most difficulty in prevention and control in the past 100 years. In January 2020, the World Health Organization (WHO) declared it a pandemic of global public health significance (WHO 2020). Over the past 3 years, the emergence of novel variants of the COVID-19 virus has resulted in increased transmissibility, greater disease severity, and a notable reduction in neutralization by antibodies generated and thus decreased response to treatments and vaccines (Fernandes et al. 2022). By mid-December 2022, the COVID-19 pandemic had affected more than 640 million people across 216 countries and territories, with more than 6 million deaths worldwide (WHO 2022). Although it is possible to maintain a normal working and living order in most areas of China, China is still under great pressure to prevent the epidemic from being brought in from abroad and reigniting from within.

The effectiveness of controlling the pandemic is highly dependent on people's adherence to behavioral preventive measures (Norman et al. 2020; Zhong et al. 2020), which can be influenced to a great extent by their knowledge, attitudes, and practices related to COVID-19. Individuals' knowledge and perceived risk regarding the disease, their attitudes and beliefs about preventive measures, and their trust in the government health department have been reported to be significantly associated with the practice of infection prevention (Chen et al. 2020; Ferdous et al. 2020). Conversely, inadequate knowledge of COVID-19 and standardized preventative measures may influence attitudes and practices of people and directly increase their risk of infection (Zhang et al. 2021; Zhang and Ma 2020). Hence, this study aimed to evaluate the knowledge, attitudes, practices, and perceptions regarding COVID-19 infection among the general Chinese population, and thus to assess the level of compliance and outcome of epidemic prevention measures and to provide a scientific basis for the next step of epidemic control and health education in China. The novelty of this study is that it was conducted when COVID-19 in China had entered the stage of regular prevention and control.

Subject and methods

Study setting and population

This descriptive cross-sectional study was carried out in Henan and Zhejiang provinces of China in October 2021. Henan and Zhejiang provinces are located in the central and southeast regions of China, respectively, with

differences in levels of economic and technological development. We collected the data through both online and paper questionnaires. The online survey used an online platform for conducting survey studies, and the paper questionnaire was implemented through a community-based survey, both of which were conducted by a team comprising well-trained graduate students majoring in life science, clinicians, and university researchers. The sample size was calculated by applying the single population proportion formula. Given a 50% proportion (since there are no similar previous studies conducted on this topic), 95% confidence interval and margin of error (5%), and 10% nonresponse rate, it was found that a minimum sample size of 422 participants would be needed.

Survey questionnaire

The questionnaire consisted of four parts, which were based on previous publications (Faasse and Newby 2020; Saqlain et al. 2020): the demographic backgrounds of the participants, their knowledge, attitudes, and practice (KAP), and risk perceptions related to COVID-19. To be specific, (1) descriptive characters included age, sex, residence, education, nationality, retirement status, infection of people around them, and vaccination. (2) Fifteen questions regarding knowledge and preventive measures covered the main general information, mode of transmission, and methods of disease prevention, and each question was answered by either yes or no. (3) The attitudes section consisted of ten questions assessing individuals' attitudes toward COVID-19 as a preventable and controllable disease (four items), and toward regulations taken by the Chinese government to overcome the virus (six items), with the response to each item recorded on a five-point Likert scale as follows: strongly disagree, disagree, undecided, agree, strongly agree; (4) the risk perception section involved the following two questions: "I am afraid of being infected with COVID-19", and "I am more susceptible to COVID-19 virus infection compared with others." The corresponding responses to each question were "yes" or "no." The Cronbach's alpha value for the reliability of the questionnaire was within an acceptable range. The validity and acceptability of the questionnaire had been tested in a pilot study before the questionnaire was used for this study.

Ethical consideration

The ethical committee of Soochow University approved the study protocol (no. 2021-023). The confidentiality of the study participants' identities was maintained throughout the study by making the participants' information confidential and asking participants to give truthful answers. This was

voluntary and non-compensated participation. The study was conducted according to the Declaration of Helsinki established by the World Medical Association.

Covariates

We included a variety of covariates that were characteristic-related factors such as age, gender, education level, and retirement status, as well as those that were closely associated with risk perception of COVID-19, i.e., favorable COVID-19 knowledge score, COVID-19 attitudes level, and two factors (first factor: I, my friends, or my family have been diagnosed with COVID-19; second factor: Have you been vaccinated against COVID-19?).

Statistical analysis

Continuous variables were expressed as mean \pm standard deviation (SD) for normally distributed data, and median (interquartile range, IQR) for non-normally distributed data. Categorical variables were presented as numbers (percentages). Binary multivariable logistic regression analyses were performed to assess participants' risk perception of COVID-19. A binary logistic regression model was utilized to analyze the factors associated with the knowledge, attitudes, and practices related to COVID-19 for unadjusted and adjusted data. A score $\leq P_{50}$ for knowledge, attitudes, and practices was identified as positive events for knowledge, attitude, and practice, respectively (i.e., OR > 1, poor knowledge, poor attitude, and poor practice of COVID-19, respectively). Similarly, factors associated with the positive events for fear of contracting and being more susceptible in the risk perception portion were also analyzed via a binary logistic regression model. The dependent variable was created including only the two questions (1) I am afraid of being infected with COVID-19 and (2) I am more susceptible to COVID-19 virus infection compared with others. The unadjusted and adjusted odds ratio (OR) and 95% confidence interval (95% CI) were computed, and P -values < 0.05 were considered statistically significant. All statistical analyses were performed using Statistical Analysis System (SAS) version 9.4 software (SAS Institute, Cary, NC, USA).

Results

Characteristics of survey respondents

A total of 3588 participants took part in the study and responded to all the survey questions. The basic characteristics of the studied population are shown in Table 1. The mean age was 53.49 ± 18.88 years, and 44.7% of the participants were male. More than half (52.03%) had attained

Table 1 Descriptive statistics of survey respondents

Characteristics	Overall
No.	3588
Age, years (Mean \pm SD)	53.49 \pm 18.88
Sex (<i>n</i> , %)	
Male	1610 (44.70)
Female	1992 (55.30)
Residence (<i>n</i> , %)	
Henan	2218 (61.61)
Zhejiang	1372 (38.11)
Others	
Education level (<i>n</i> , %)	
Primary school or below	1176 (32.72)
Junior high school	548 (15.25)
High school or above	1870 (52.03)
Nationality (<i>n</i> , %)	
Ethnic Han	3492 (96.92)
Others	111 (3.08)
Retired (<i>n</i> , %)	
Yes	1445 (40.31)
No	2140 (59.69)
I, my friends, or my family have been diagnosed with COVID-19 (<i>n</i> , %)	
Yes	32 (0.89)
No	3567 (99.11)
Have you been vaccinated against COVID-19? (<i>n</i> , %)	
Yes	3465 (96.17)
No	138 (3.83)
Knowledge of COVID-19 score (median, IQR)	10 (9 to 12)
Attitudes of COVID-19 score (median, IQR)	45 (38 to 46)
Practice of COVID-19 score (median, IQR)	9 (8 to 9)
Fear of contracting COVID-19 (<i>n</i> , %)	
Yes	2157 (59.90)
No	1444 (40.10)
More susceptible to COVID-19 than others (<i>n</i> , %)	
Yes	671 (18.63)
No	2931 (81.37)

a high school or greater education, 32.72% had a primary school or lower level, and only 15.25% had a junior high school level of education. Most respondents (61.61%) lived in Henan province, and the others (38.11%) were in Zhejiang province. The great majority (96.92%) of participants were of Han ethnicity. The proportion of participants who were working was 59.69%, while the rest (40.31%) were retired. Only 0.89% of respondents reported that they, their friends, or family members had been diagnosed with COVID-19, and a total of 96.17% of survey participants had been vaccinated against COVID-19. The median knowledge, attitude, and practice scores were 10, 45, and 9, respectively. Regarding risk perception, about 59.9% of participants reported that

they were afraid of being infected with COVID-19, but only 18.63% believed that they were more susceptible to COVID-19 infection than others.

Knowledge, attitudes, and practices regarding COVID-19

The rate of correct answers regarding participants' knowledge about COVID-19 general information, ways of spread, and common symptoms are shown in Table 2. Correct

answers were identified for most items by the majority of participants with a significantly high correct ratio (more than 90%). The least correct answers were related to the question "COVID-19 is transmitted by dealing with domestic animals," where only 53.85% correctly identified that COVID-19 cannot be transmitted by dealing with domestic animals; also, only 56.43% of participants correctly identified that antibiotics were not the drug of choice for treating COVID-19. About half of the participants thought that COVID-19 was always fatal and was transmitted through

Table 2 Knowledge, attitudes, and practice about coronavirus disease 2019 (COVID-19)

	Overall (n, %)
Knowledge about COVID-19	Correct answers
COVID-19 is a viral disease	3481 (96.61)
COVID-19 is transmitted by direct contact with infected persons	3449 (95.73)
COVID-19 is transmitted by dealing with domestic animals	1939 (53.82)
The incubation period of the disease is from 2 to 14 days	3386 (93.98)
There is an available vaccine for COVID-19	3533 (98.06)
Antibiotics are the drug of choice in treating COVID-19	2033 (56.43)
The virus may be more dangerous in patients with chronic diseases	3384 (93.92)
The virus may be more dangerous for the elderly	3442 (95.53)
Health care workers are more prone to COVID-19	3277 (90.95)
COVID-19 always causes death	1765 (48.99)
COVID-19 is transmitted by droplets	3447 (95.67)
COVID-19 is transmitted through arthropods	1796 (49.85)
COVID-19 is transmitted through eating contaminated food	2595 (72.02)
Headache, fever, cough, sore throat, and flu are symptoms of COVID-19	3353 (93.06)
COVID-19 leads to pneumonia, respiratory failure, and death	3502 (97.20)
Attitudes regarding COVID-19	Answered agreed or strongly agreed
COVID-19 is a severe disease	3276 (90.92)
COVID-19 can be prevented	3317 (92.06)
Standard precautions can protect us against COVID-19	3317 (92.06)
COVID-19 cases will increase	909 (25.23)
I am confident that Egypt can overcome COVID-19	3415 (94.78)
I am confident in the information disseminated by the MOPH about COVID-19	3406 (94.53)
There are cases recovered from disease	3295 (91.45)
Regulations taken by the government are enough to combat disease	3349 (92.95)
COVID-19 is accurately diagnosed	3267 (90.67)
I am confident in hospitals dealing with and treating COVID-19 patients	3387 (94.00)
Practices regarding COVID-19	
Washing hands with soap, water, or alcohol	3534 (98.08)
Avoiding touching eyes, nose, and mouth	3530 (97.97)
Putting on face mask	3577 (98.36)
Covering the nose and mouth while coughing	3544 (98.36)
Avoiding crowded public places	3574 (99.20)
Frequently cleaning and disinfecting surfaces	3542 (98.31)
Keeping a distance of at least 1 m between people	3544 (98.36)
Washing nose with a salty solution	2681 (74.41)
Avoiding direct contact with colleagues (others)	3376 (93.70)

arthropods, and 72.02% of respondents correctly knew that COVID-19 was unlikely to be transmitted by eating contaminated food.

Regarding attitudes about COVID-19, although the majority of our participants considered COVID-19 a severe disease, they agreed that this disease could be prevented. The vast majority of respondents agreed that standard infection control precautions could protect against COVID-19 (92.06%). Only 25.23% of people agreed that COVID-19 cases would increase. More than 90% of participants agreed or even strongly agreed with many attitude items related to the government’s role in diagnosis, treatment, and dealing with COVID-19 infections, considered that the government could overcome the COVID-19 problem, and were confident in the information disseminated by the Ministry of Public Health (MOPH) in China about COVID-19.

The practices of personal protection were correctly identified by the majority of participants (more than 90%), except for the faulty understanding about washing the nose with a salty solution, as 74.41% identified that it had no

role in COVID-19 prevention. Also, the vast majority of the participants had avoided crowded public places (99.2%) and direct contact with others (93.7%) in recent days.

Risk perception of COVID-19

The most common statements accepted by participants as reasons for fear of COVID-19 infection were the following: “the disease is highly transmissible” (88.64%), “the disease may be fatal” (80.30%), “fear of transmission of infection to their family” (71.26%), “COVID-19 is a new disease with unknown treatment” (47.47%), and “fear of entering COVID-19 isolation hospitals” (45.62%) (Fig. 1). The most common reasons stated by the respondents for their higher susceptibility to COVID-19 infection than others were “it is a new emerging disease with limited data about it” (60.66%), “the personal protective equipment (PPE) is not always available” (56.48%), and “workplace circumstances are suitable for transmitting COVID-19 infection because of the crowdedness” (56.33%) and “poor ventilation” (42.32%) (Fig. 2).

Fig. 1 The reasons for “I am afraid of being infected with the COVID-19 virus”

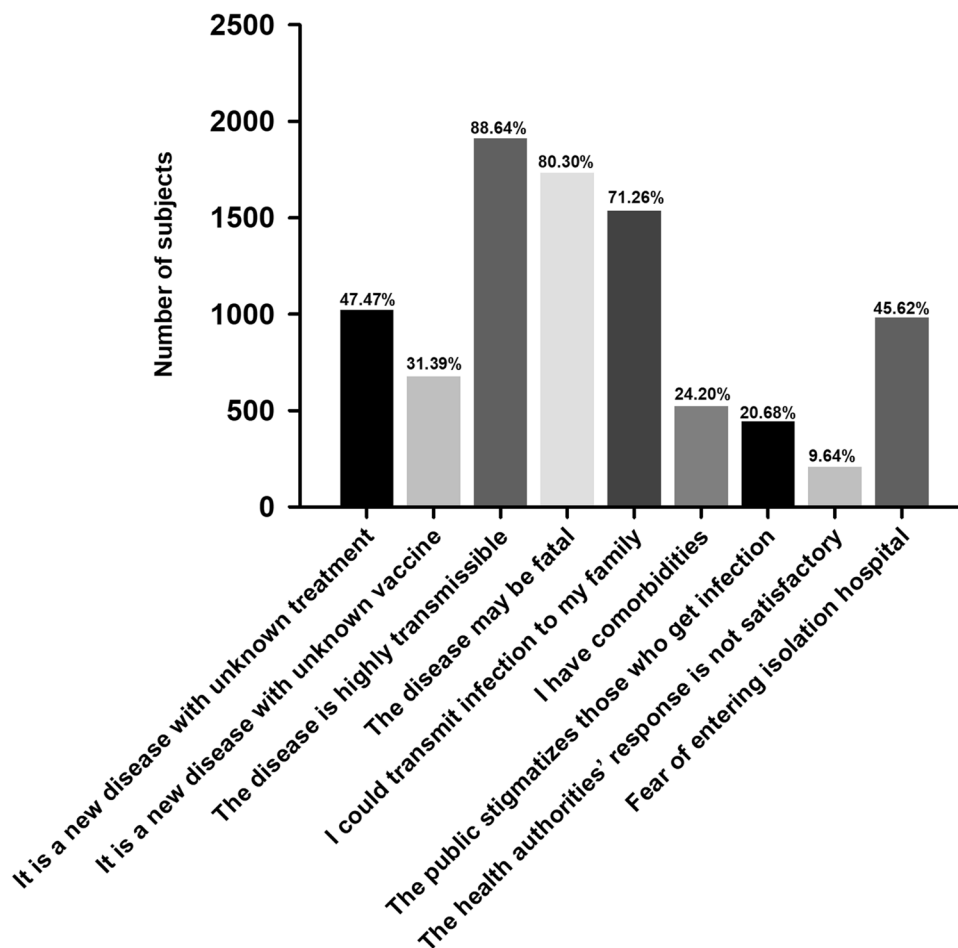
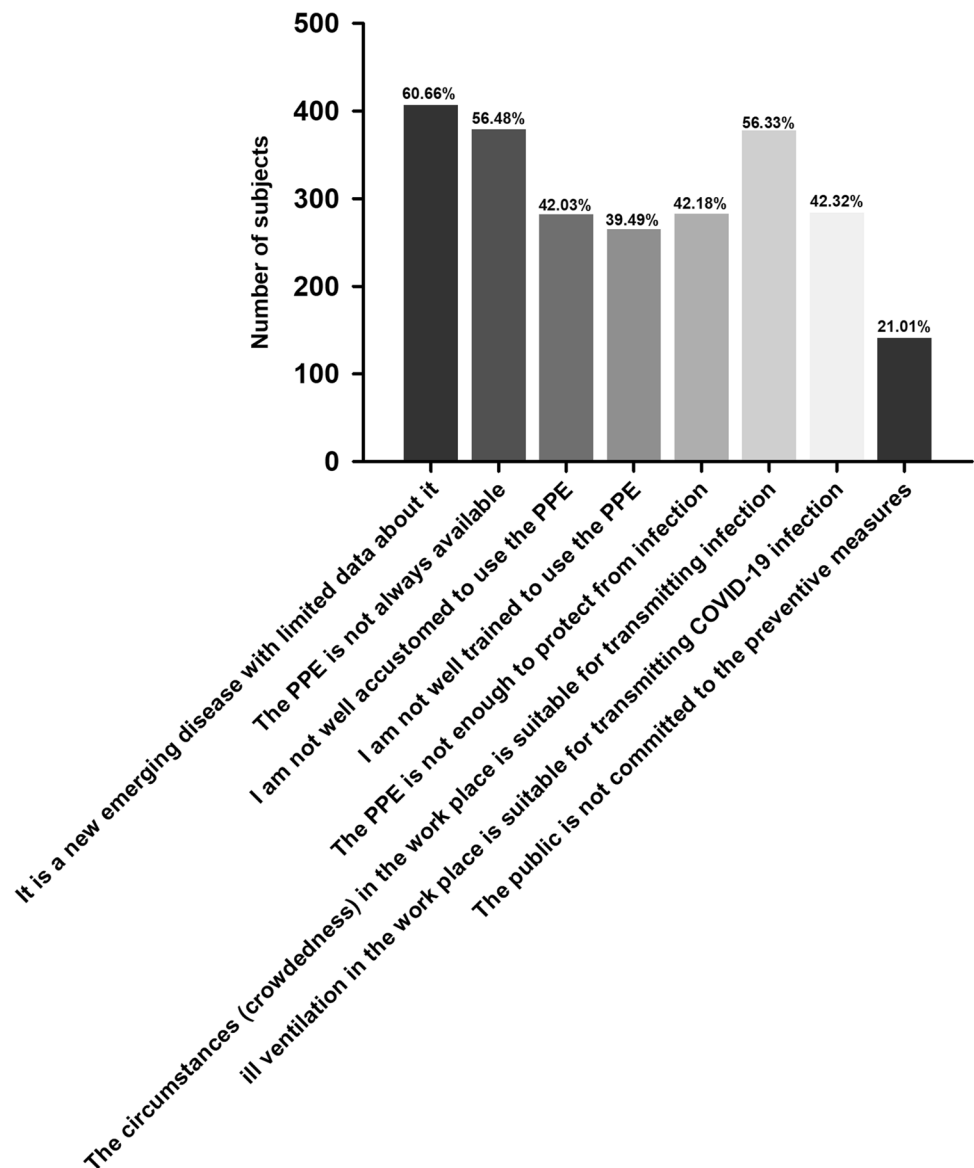


Fig. 2 The reasons for “I am more susceptible to being infected with COVID-19 than others”



Risk factors associated with perception and KAP regarding COVID-19

The relation between the characteristic-related factors and the risk perception of COVID-19 is demonstrated in Table 3. Age, education level, vaccination status, and attitudes significantly predicted a respondent's fear of contracting COVID-19 when the OR was unadjusted. When the OR was adjusted, these factors as well as sex remained significant predictors of fear about contracting COVID-19. Respondents aged 45 years or younger were significantly (about 1.5 times) more likely to fear contracting the virus than those older than 45 years (adjusted OR = 1.464, 95% CI 1.196 to 1.794, $P = 0.0002$). Women were more afraid of contracting COVID-19 than men (adjusted OR = 1.224, 95% CI 1.063 to 1.408, $P = 0.0048$). The odds of fear of

contracting the virus also showed a significant difference, about 1.9 times and 1.7 times more likely among respondents with education of junior high school and high school or above than those with primary school or below, respectively (adjusted OR = 1.885, 95% CI 1.486 to 2.315, $P < 0.0001$; adjusted OR = 1.730, 95% CI 1.422 to 2.104, $P < 0.0001$). Also, respondents who had not been vaccinated against COVID-19 or had a high attitude score might have reduced fear of contracting the virus (adjusted OR = 0.563, 95% CI 0.395 to 0.802, $P = 0.0015$; adjusted OR = 0.495, 95% CI 0.430 to 0.570, $P < 0.0001$).

Similarly, the predictors of perception of higher susceptibility to infection than others were younger age (adjusted OR = 2.019, 95% CI 1.587 to 2.569, $P < 0.0001$), higher education level (adjusted OR = 1.503, 95% CI 1.187 to 1.904, $P = 0.0007$), non-retired status (adjusted

Table 3 Ordered logistic regression analysis for factors associated with the risk perception of COVID-19

Characteristics	Fear of contracting COVID-19				More susceptible to COVID-19 than others			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	OR (95%CI)	P value	OR (95%CI)	P value	OR (95%CI)	P value	OR (95%CI)	P value
Age								
>45 (<i>ref.</i>)								
≤45	1.157 (1.008, 1.328)	0.0387	1.464 (1.196, 1.794)	0.0002	1.342 (1.121, 1.606)	0.0013	2.019 (1.587, 2.569)	<.0001
Sex								
Male (<i>ref.</i>)								
Female	1.132 (0.990, 1.295)	0.0688	1.224 (1.063, 1.408)	0.0048	1.050 (0.887, 1.243)	0.5724	1.149 (0.962, 1.371)	0.1252
Education level								
Primary school or below (<i>ref.</i>)								
Junior high school	1.645 (1.332, 2.032)	<.0001	1.885 (1.486, 2.315)	<.0001	1.220 (0.940, 1.582)	0.1346	1.249 (0.954, 1.635)	0.1060
High school or above	1.308 (1.129, 1.517)	0.0004	1.730 (1.422, 2.104)	<.0001	1.173 (0.969, 1.421)	0.1020	1.503 (1.187, 1.904)	0.0007
Retired								
Yes (<i>ref.</i>)								
No	0.952 (0.831, 1.091)	0.4821	1.040 (0.867, 1.248)	0.6710	1.186 (0.996, 1.411)	0.0549	1.679 (1.354, 2.083)	<.0001
Myself, friends, or family had been diagnosed with COVID-19								
Yes (<i>ref.</i>)								
No	1.702 (0.847, 3.419)	0.1351	1.926 (0.937, 3.957)	0.0745	0.500 (0.235, 1.060)	0.0706	0.541 (0.251, 1.164)	0.1159
Have you been vaccinated against COVID-19?								
Yes (<i>ref.</i>)								
No	0.524 (0.371, 0.739)	0.0002	0.563 (0.395, 0.802)	0.0015	1.127 (0.738, 1.723)	0.5794	1.142 (0.736, 1.773)	0.5526
COVID-19 knowledge level								
Low (<i>ref.</i>)								
High	0.876 (0.765, 1.003)	0.0545	0.948 (0.824, 1.092)	0.4600	1.467 (1.231, 1.747)	<.0001	1.554 (1.298, 1.862)	<.0001
COVID-19 attitudes level								
Low (<i>ref.</i>)								
High	0.501 (0.437, 0.574)	<.0001	0.495 (0.430, 0.570)	<.0001	0.631 (0.532, 0.748)	<.0001	0.616 (0.517, 0.734)	<.0001

Bold entries indicate $p < 0.05$

Adjusted for age, sex, education level, retirement status, and the answer to two COVID-19 questions: (1) I, my friends, or my family have been diagnosed with COVID-19; (2) Have you been vaccinated against COVID-19

OR = 1.679, 95% CI 1.354 to 2.083, $P < 0.0001$), and high knowledge score regarding COVID-19 (adjusted OR = 1.554, 95% CI 1.298 to 1.862, $P < 0.0001$), while high attitude score was associated with lower perception of susceptibility to infection than others (adjusted OR = 0.616, 95% CI 0.517 to 0.734, $P < 0.0001$).

We further analyzed the relation between the characteristic-related factors and the KAP regarding COVID-19 (Fig. 3). In the fully adjusted model, high school education level or above, non-retired status, and not perceiving

oneself as We further analyzed the relation between the characteristic-related factors and the KAP regarding COVID-19 (Fig. 3). In the fully adjusted model, high school education level or above, non-retired status, and not perceiving oneself as more susceptible to COVID-19 than others was associated with a higher knowledge level. Younger age (≤ 45 years) was associated with a higher attitude score, while high school education or above, non-retired status, not fearing contracting COVID-19, and not perceiving oneself as more susceptible to COVID-19 than

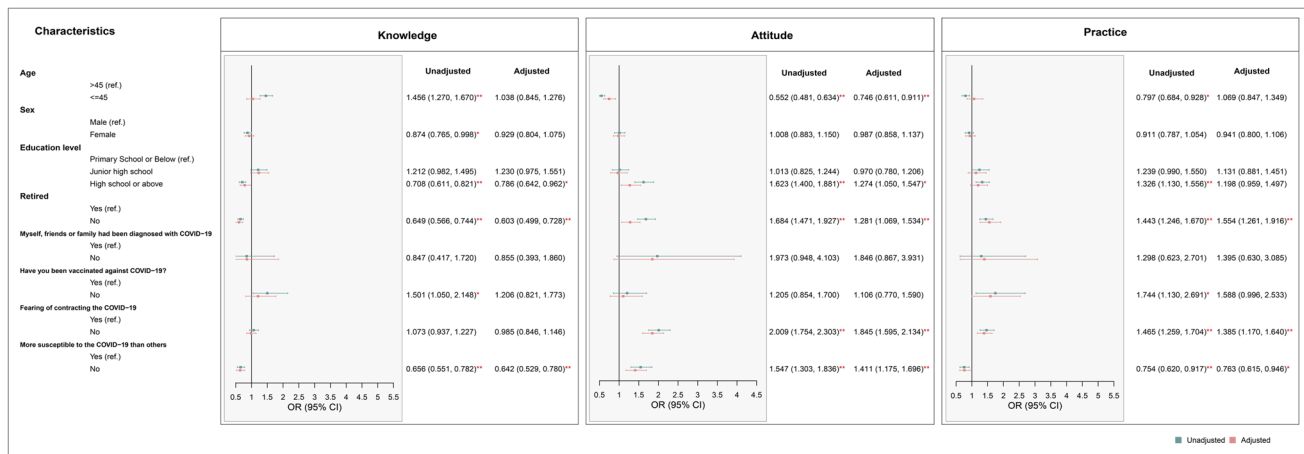


Fig. 3 Factors associated the knowledge, attitude, and practice level of COVID-19. A binary logistic regression model was utilized to analyze the factors associated with the knowledge, attitude, and practice level of COVID-19 for unadjusted and adjusted data. Data were adjusted for age, sex, education level, retirement status, and the

others was associated with lower attitude score. Similarly, non-retired status, not having been vaccinated against COVID-19, and not fearing contracting COVID-19 were associated with a lower practice level, not feeling more susceptible to COVID-19 than others, while not feeling susceptible to COVID-19 was associated with a higher practice level.

Discussion

Our current findings showed that the Chinese residents had adequate background knowledge about COVID-19 and held an optimistic attitude toward the government and control of the disease. Participants with a relatively high level of education and younger age—in particular women—had lower risk perception toward COVID-19.

The public knowledge and prevention awareness of COVID-19 has reached a high level at present, compared with the report of Li et al., in which they demonstrated that Chinese people only had a moderate level of knowledge about COVID-19 at the beginning of the COVID-19 outbreak (from 2 February to 9 February 2020) (Li et al. 2020). Almost all participants in our study had a good understanding of the virus spread route, symptoms, consequences, treatment, incubation time, and the most susceptible populations. But about half of respondents wrongly believed that the host of the virus could be domestic animals and arthropods and that antibiotics are an effective treatment for the virus. Compared with other similar studies in India (Dkhar et al. 2020) and the United States (Ferdous et al. 2020), the level of knowledge among the respondents in our study is

answer to two COVID-19 questions: [(1) I, my friends, or my family have been diagnosed with COVID-19; (2) Have you been vaccinated against COVID-19?] and the risk perception of COVID-19 [(1) Fear of contracting COVID-19; (2) more susceptible to COVID-19 than others)

higher, which is quite comparable to the findings reported in another study performed in China (Xu et al. 2020).

Although the COVID-19 pandemic in China has entered the stage of regular prevention and control, there are still sporadic outbreaks in some areas (Ni et al. 2021). Thus, good knowledge and favorable attitudes are particularly important for the prevention and control of the current epidemic. Our results revealed an overall positive attitude of participants toward COVID-19 as a preventable disease, despite the vast majority of the participants (90.92%) believing that COVID-19 is a severe disease. Most of the respondents were optimistic about the government's control measures and treatment of COVID-19 patients in hospital. Similarly, according to the study by Zhong et al. (2020), 97.1% of the respondents had confidence that China could win the battle against COVID-19. Citizens from Malaysia (Mohamed et al. 2021) and Vietnam (Van Nhu et al. 2020) also showed favorable attitudes toward overcoming the virus. But the public in Pakistan had much less faith in their government about fighting against the pandemic, and no more than half of the people were optimistic that COVID-19 would finally be successfully controlled (Ladiwala et al. 2021). It is worth mentioning that in some countries, wearing a mask was not compulsory for the general population (Feng et al. 2020; Javid et al. 2020). Even some healthcare workers believed the role of face masks in the prevention of the disease to be moderate to poor (Kumar et al. 2020).

It was found that the greater the perception of severity and susceptibility to acquiring the virus, the greater the likelihood of taking preventive measures (Pérez de Celis-Herrero and Cavazos-Arroyo 2021). The risk perception of the public could help to reduce the infection rate (Ye

and Lyu 2020). In our survey, about three fifths of the participants reported fear of contracting COVID-19, but only a minority (18.63%) felt they were more susceptible than others. At the start of the epidemic (March 2020), 40.3% of participants met the screening criteria for generalized anxiety disorder, indicating that people in China experienced high levels of anxiety regarding COVID-19 at that time (Ni et al. 2021). However, suitable risk perception can serve as a useful tool to promote increased preparedness. It may also explain the unexpected high uptake rate of vaccination and excellent compliance with preventive measures and regulations in China.

Regarding factors associated with risk perception, we found an association between high levels of education and higher levels of fear. Wolf et al. (2020) observed an association between high education level and high susceptibility, which was consistent with our current study. Another study also reported no difference in risk perception by education level (Salimi et al. 2020). Considering that educational attainment is often used as a proxy measure of socioeconomic status and knowledge level, in our study more educated participants had adequate knowledge, and poor knowledge was one predictor of the perception of higher risk of infection than others, suggesting that health education for people with lower education levels needs to be strengthened, which is in line with findings from other countries worldwide (Fawzy and AlSadrah 2022; Poddar et al. 2022). In addition, in our study the vaccination uptake of participants was 96.17%; however, those who had not been vaccinated were less concerned about COVID-19 infection. Our vaccination acceptance rate was much better than that in the UK (Sherman et al. 2021), Malaysia (Mohamed et al. 2021), and Saudi Arabia (Al-Mohaithef and Padhi 2020), and this is in accord with another study conducted in China (Wang et al. 2020). It was reported that the predicted vaccination uptake in an optimal vaccination scenario was 84.77% (Leng et al. 2021). Thus, our findings suggest that the public generally has trust in the COVID-19 vaccine and the government in China.

In our study, it is reasonable that those with higher education, were not retired, and did not believe that they were more susceptible to COVID-19 than others had a high knowledge level. This indicated that those who were well educated and not retired had obtained good knowledge of COVID-19. We further found that young subjects possessed a good attitude toward COVID-19, which is consistent with previous studies (Ghuloum et al. 2022). In contrast, we found that those with higher education and not retired had a poor attitude. This might be because they obtained conflicting information about COVID-19, and associated it with their life. Likewise, we further found that not being retired, not having been vaccinated against COVID-19, and not having fear of contracting COVID-19 was associated with a lower

practice level, suggesting that these are the key population needing to improve the practice level of COVID-19. Our studies suggest that those who were not retired had a low attitude and practice level; therefore, individual prevention should be combined with workplace adjustments, such as working remotely, ventilation, staggered shifts, and changing work hours to enable social distancing in the workplace, which might help to improve protection of the working population (Cummings et al. 2022).

Our study had its own strengths and limitations that need to be addressed. It is one of the few studies on the KAP among the Chinese general public, when COVID-19 in China has entered the stage of regular prevention and control. Additionally, it collected data through both online and paper questionnaires, and the paper questionnaire was implemented through a community-based survey; therefore, it included more infrequent internet users than the studies conducted online only. However, limitations should be mentioned. Firstly, it was a cross-sectional study; therefore, the data obtained and the results based on these data are merely representative of the survey time and do not incorporate long-term modifications to the pandemic phase. Secondly, participants were only recruited from Zhejiang and Henan provinces, so our results might be influenced by selection bias. Consequently, when generalizing the findings of this research to the general population, extreme caution is required.

In conclusion, it was encouraging that the level of knowledge, attitudes, practices, and perceptions toward COVID-19 infection among the Chinese population remained consistently high 1.5 years after the outbreak of this disease as revealed by this survey. Although the epidemic is basically at a plateau, with the combined efforts of the Chinese authorities and all Chinese residents, China will hopefully win the battle against COVID-19 in the near future by preventing cases imported from abroad and treating the occasional new confirmed cases at home in a timely manner.

Authors' contributions Guiping Wang, Canjie Zheng, Mingxia Lu: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing—original draft. Lan Luo: Methodology, Investigation, Data curation, Formal analysis. Zhongxiao Wan: Conceptualization, Methodology, Funding acquisition, Project administration, Writing—review & editing. All authors read and approved the final manuscript. Zheng Feei Ma: Conceptualization, Writing—review & editing.

Funding This study was supported by the National Natural Science Foundation of China (grant NO. 81872609), recipient: Zhongxiao Wan, the Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD), recipient: N/A and the University Science Research Project of Jiangsu Province (21KJB310021), recipient: Guiping Wang

Data availability The data for this study can be made available from the corresponding author on reasonable request.

Declarations

Ethics approval The ethical committee of Soochow University approved the study protocol, with a research registry number of 2021-023.

Consent to participate Each participant gave their informed consent before participation. Confidentiality of the study participants' identities was maintained throughout the study by making the participants' information confidential and asking participants to give truthful answers. This was voluntary and non-compensated participation.

Consent for publication Not applicable.

Conflict of interest/Competing interests The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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