Research paper

The relationship between COVID-19-related prevention cognition and healthy lifestyle behaviors among university students: Mediated by e-health literacy and self-efficacy

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ABSTRACT

Background: At present, few studies have explored the mediating effect of e-Health literacy and self-efficacy on prevention cognition and healthy lifestyle behaviors during the normalization stage of COVID-19 prevention and control. This study aimed to determine the associations among COVID-19-related prevention cognition, self-efficacy, e-Health literacy, and healthy lifestyle behaviors at university students.
Methods: By using a stratified cluster random sampling method, 971 students from five universities were recruited between May and August 2021 in Guangzhou, China. We collected participants' demographic characteristics, and assessed self-efficacy, COVID-19-related prevention cognition, e-Health literacy, and healthy lifestyle behaviors. A structural equation model was used for mediation analysis.
Results: The overall mean value of healthy lifestyle behaviors of college students was 0.307 (SD 0.389). Between COVID-19-related prevention cognition, e-Health literacy, self-efficacy, and healthy lifestyle behaviors ($r = 0.132$–0.505, $P < 0.01$) were a significant positive correlation. The COVID-19-related prevention cognition had a direct and positive predictive effect on healthy lifestyle behaviors, with a direct effect value of 0.136. e-Health literacy and self-efficacy played both an independent mediating and serial-multiple mediating roles in the association between COVID-19-related prevention cognition and healthy lifestyle behaviors, and the indirect effect values were 0.043, 0.020 and 0.035, respectively.
Conclusions: The results showed that the emphasis on improving college students' prevention cognition, supplemented by improving e-Health literacy and self-efficacy, could improve college students' healthy lifestyle behaviors.
Limitations: This study was a cross-sectional investigation with no causal relationship between variables.

1. Introduction

The COVID-19 pandemic has posed a serious threat to the lives and health of people around the world (Li et al., 2021). Epidemic prevention and control has become a topic of common concern around the world, and needs the joint efforts of the whole society (Schantz and Tsang, 2003; Zhang and Liu, 2014). For the public, it is an effective way to protect themselves and minimize the risk of the spread of the disease through good personal protection. As a special group of social members, university students are strong and healthy. Even if they are infected with infectious diseases, they often have mild symptoms. In addition, Chinese university students have a high migration rate and great mobility. All

these will have a negative effect on epidemic prevention and control (Ding et al., 2020). Hence, improving the students' personal protection has become an important challenge for universities to deal with the epidemic.

Healthy lifestyle behavior is composed of personal protection during the normalization stage of COVID-19 prevention and control in China, which is reflected in various health protection activities that people take to enhance their physical fitness, maintain and promote physical and mental health, and avoid diseases. Examples of these activities are such as open windows for ventilation, healthy eating, exercise, washing hands frequently, and wearing goggles and masks when going out. Therefore, healthy behavior can be understood as the external

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performance of individuals in a good state of physical, psychological, and social adaptation. Studies have suggested that public adherence to preventive behaviors will facilitate scaling back the unfolding of COVID-19 (Nguyen et al., 2020; Chen and Chen, 2020; Duan et al., 2020). In addition, individual traditional health behaviors, like exercise and diet, additionally compete a vital role in maintaining physical and mental state throughout the COVID-19 epidemic (Li et al., 2021). Moreover, a healthy lifestyle was a cost-efficient and pragmatic relief strategy for students to deal with negative emotions during a pandemic (Y. Zhang et al., 2020).

Social cognition as the driving factor of behavioral decision cognition and subsequent behavior, and utilizing the power of social perceptions was key to strengthening disease prevention, fighting the virus and protecting life (Peterson et al., 2021). For example, COVID-19-related educational exerts a subtle influence on freshman students' mood and health behaviors (Copeland et al., 2021). Another important finding was that COVID-19 knowledge had a significant positive effect on the health behavior of coping with COVID-19. It recommended that health interventions geared toward increasing COVID-19 knowledge levels and fostering positive attitudes would be more efficient for a particular group (M. Zhang et al., 2020). Accordingly, healthy lifestyle behaviors may be associated with COVID-19-related prevention cognition. According to the analysis above, we propose the first hypothesis:

H1. COVID-19-related prevention cognition positively predicts healthy lifestyle behaviors.

The theory of Knowledge-Attitude-Practice (KAP) suggests that there's not just a single linear relationship between cognition and behavior, and the process of knowledge transforming into behavior will be affected by many factors (Murray et al., 2009). For the past few years, with the rapid development of Internet technology, electronic equipment and media have become vital carriers for people to get health-related info. E-health literacy is the ability to search, understand, and evaluate health information through electronic media devices and use the information obtained to unravel personal health issues (Norman and Skinner, 2006), which is a significant part of health literacy (Hsu et al., 2014). Health literacy is one among the public health goals within the twenty first century, and individuals with good health literacy have a healthy lifestyle (Berkman et al., 2011). Therefore, the acquisition of electronic health information resources can help individuals develop healthy behaviors and improve their physical health. Studies had shown that e-health literacy was the result of both personal determinants (i.e., personal behavior and cognitive factors) and social environmental factors. As one of the personal determinants, health knowledge seeking behavior has a positive effect on e-Health literacy (Zhou and Fan, 2019). In addition, e-Health literacy also has a positive influence on the healthy lifestyle among college students (Brown and Dickson, 2010), and e-Health literacy plays a mediating role between personal factors (i.e., knowledge of health-related issues) and healthy lifestyle. Accordingly, we propose the second hypothesis:

H2. COVID-19-related prevention cognition affects healthy lifestyle behaviors through the mediating role of e-Health literacy.

Self-efficacy has a positive effect on maintaining and stimulating health promotion behaviors (Jung et al., 2012). It refers to people's judgment of the organization and execution ability of the action process when they accomplish a specific goal. People with high levels of self-efficacy tend to make more efforts to implement healthy behaviors. According to the Trans Theoretical Model, the key to health behavior change is individual cognitive change, and both self-efficacy and decision balance play a mediating role based on cognition (Prochaska and Velicer, 1997; Velicer et al., 1996). Previous studies have confirmed that self-efficacy may be the mediating variable between patients' cognition and self-management behavior (Jiang et al., 2019; Xie et al., 2020; Guo et al., 2019). Therefore, based on the above analysis, we propose the third hypothesis:

H3. COVID-19-related prevention cognition affects healthy lifestyle behaviors through the mediating role of self-efficacy.

Squiers creatively constructed the Health Literacy Skills Framework (Squiers et al., 2012) on the basis of sorting out and summarizing the previous relationship model between health literacy and health output. The Health Literacy Skills Framework consists of the following parts: (a) factors that influence individual health literacy skills, including demographic characteristics, capabilities (i.e., vision, memory, and cognitive functioning, etc.), and prior knowledge (i.e., health and prevention knowledge, and disease prevention and control knowledge); (b) health literacy skills for individuals to understand health-related stimuli, including written communication skills, communication skills and information acquisition skills; (c) mediating factors between health literacy and health outcomes (i.e., self-efficacy, health status, and individual health belief); (d) health-related behaviors and outcomes. Thus, the Framework suggests a possible conduction path of influencing factors, health literacy skills, mediating factors, and health behaviors, which can help individuals reduce the occurrence of health risk factors, make correct health decisions, and form favorable health behaviors. In addition, it is unclear whether the model still works during the normalization stage of COVID-19 prevention and control. Therefore, based on the above analysis, we propose the fourth hypothesis:

H4. COVID-19-related prevention cognition affects healthy lifestyle behaviors through the sequential mediating effects of e-Health literacy and self-efficacy.

In short, a multiple mediation model was applied to examine the associations between COVID-19-related prevention cognition, self-efficacy, e-Health literacy, and healthy lifestyle behaviors among university students (Supplemental Fig. 1).

2. Methods

2.1. Study design

We used a cross-sectional survey in Guangzhou. To create the sample a lot of representative, the stratified cluster random sampling was utilized. Applied the grade on a tiered basis and taken class as the sampling unit, the students of five universities in Guangzhou were selected to conduct questionnaire surveys. Students in each university were selected by grade, and all students in 1–2 classes in each grade were randomly selected as the research object. Students who met the following inclusion criteria were recruited at the five universities: 1) volunteered to participate in the questionnaire survey after providing informed consent; 2) and were university students. Exclusion criteria were as follows: 1) incomplete questionnaire; 2) the answers had logical errors, e.g. the answers to all items were the same. From May to August 2021, 1050 college students were recruited for the survey. After excluding participants who did not complete all surveys or whose response was invalid, we obtained 971 valid surveys (92.5%). This study was supported by the Ethics Committee of Southern Medical University, Guangzhou, Guangdong Province, China (approval number: NFYKDX002).

2.2. Participants

None of the university students was infected with COVID-19 in the survey. The respondents completed the paper version of the questionnaire at their school. Before the respondents had filled out the questionnaire, we accounted for the aim of the study, the strategy of data acquisition, and the way to finish the questionnaire. The respondents were additionally familiar that their participation was fully anonymous and voluntary.

2.3. Measurements

2.3.1. e-Health literacy

e-Health literacy was investigated by the Chinese version (Guo et al., 2013) of the e-Health Literacy Scale for College Students, originally designed by Norman and Skinner (2006) to evaluate people's ability to acquire and understand health information through electronic media, using the information to resolve health issues. The scale consisted of three dimensions: application ability, evaluation ability, and decision-making ability. There were eight items, each of which was rated on a 5-point Likert scale starting from one = powerfully disagree to five = powerfully agree. The total score ranged from 8 to 40; the higher the score, the higher the e-Health literacy. The Cronbach α coefficient for the scale in this study was 0.93.

2.3.2. Self-efficacy

The self-efficacy scale was measured using the General Self Efficacy Scale (Schwarzer and Jerusalem, 1995). The Chinese version of the scale had good reliability and validity (Chiu and Tsang, 2004) and was widely used (Wang et al., 2016; Yang et al., 2014). The self-efficacy scale contained ten questions, including "You have confidence to efficiently respond to sudden events," and "Sticking to your dream and realizing it is easy with no difficult to you." All ten items were rated on the five-point Likert scale, which ranges from one to five to estimate whether individuals are able to make subjective judgments about behavior. A higher score indicated an individual's ability or confidence to perform health-related behaviors. The Cronbach α coefficient for the scale in this study was 0.93.

2.3.3. Healthy lifestyle behaviors

The Healthy Lifestyle Scale for University Students (HLSUS) was developed based on the Pender's Health Promotion Model, and the validity and reliability of the scale have been verified in previous studies (Wang et al., 2013; Wang et al., 2012). In this study, the scale assessed scores for healthy lifestyle behaviors during the pandemic compared to pre-pandemic. It was divided into eight dimensions: exercise behavior, regular behavior, nutrition behavior, health risk behavior, health responsibility, social support, stress management, and life appreciation. For example, "frequency of regular breakfasts compared to pre-pandemic." and "frequency of alcohol consumption compared to pre-pandemic." The Likert Scale was used to report the frequency of behaviors in a five-point response format, with the rating score ranging from −2 to 2. 0 is the intermediate state, which is the theoretical median value. If the value is greater than 0, the state of lifestyle is good; if the value is less than 0, the state of lifestyle is poor. The Cronbach α coefficient for the scale in this study was 0.91.

2.3.4. COVID-19–related prevention cognition

Based on previous studies (State Council of the PRC, 2020) we designed a 39-item questionnaire consisting of three dimensions, namely acceptance of prevention and control measures, perceived usefulness, and perceived ease of use, to measure COVID-19-related prevention cognition. The questionnaire was reviewed by two expert groups, consisting of emergency management consultants, public health consultants and psychologists, who removed 13 items from the acceptance of prevention and control measures, and six items from the perceived usefulness, respectively. Therefore, the final questionnaire consisted of 20 items in three dimensions.

The 20-item questionnaire focused on prevention cognition, such as acceptance of wearing masks scientifically, and acceptance of strengthening ventilation and disinfection, prevention. Also acceptance of control measures that can reduce your risk of infection, such as prevention, and control measures that are easy to grasp, such as prevention, and control measures that can ensure your regular study and life. Each item used a five-level scoring method. Therefore, for this questionnaire, the higher the score, the higher the level of COVID-19-related

prevention cognition. The Cronbach α coefficient for the scale in this study was 0.92.

2.4. Statistical analyses

Frequency analysis, reliability testing, and Pearson's correlation analysis were conducted by SPSS 25.0. Amos 24.0 was applied to construct a standardized path test, and examine the hypothesis testing results. The bootstrap methodology was applied to evaluate the mediating effect.

3. Results

3.1. Participant characteristics

The sociodemographic characteristics of participants. The mean age of the participants was 22.7 years (SD 2.5), ranging from 18 to 41 years. Of the 971 participants, 559 (57.6%) were female, 761 (78.4%) had good self-reported health status, while 82 (8.4%) had chronic diseases, and 178 (18.3%) had a higher family economic level (Table 1).

3.2. Healthy lifestyle behaviors of college students during the normalization of COVID-19 prevention and control

Compared with before the epidemic, the overall mean value healthy lifestyle of college students was 0.307 (SD 0.389), higher than the theoretical median value of 0, indicating an overall good healthy lifestyle. Among them, the mean values of exercise behavior and health risk were less than 0, showing a negative change; The mean values of regular behavior, nutrition behavior, health responsibility, social support, stress management, and life appreciation were greater than 0, showing positive changes. There was a relatively large change in health responsibilities (0–0.663) and a relatively small change in exercise behavior (−0.106–0) (Table 2).

3.3. Associations between COVID-19-related prevention cognition, self-efficacy, e-Health literacy, and healthy lifestyle behaviors in college students

The results of Pearson correlation coefficients of COVID-19-related prevention cognition, self-efficacy, e-Health literacy, and healthy

Table 1
Descriptive statistics of sociodemographic characteristics of the study participants.

Variables	N (%)
Gender	
Male	412 (42.4)
Female	559 (57.6)
Residence	
Urban	512 (52.7)
Rural	459 (47.3)
Education attainment	
Junior college	137 (14.1)
Undergraduate	328 (33.8)
Master	458 (47.2)
Doctor	48 (4.9)
Family per capita monthly income (CNY)	
>10,000	178 (18.3)
4000-10,000	462 (47.6)
<4000	331 (34.1)
Self-reported health status	
Good	761 (78.4)
Medium	182 (18.7)
Bad	28 (2.9)
Chronic diseases	
Yes	889 (91.6)
No	82 (8.4)

Table 2
Descriptive statistics of healthy lifestyle behaviors of college students.

HLSUS	Mean	SD
Exercise behavior	−0.106	0.759
Regular behavior	0.338	0.614
Nutrition behavior	0.169	0.453
Health risk	−0.203	0.568
Health responsibility	0.663	0.597
Social support	0.431	0.601
Stress management	0.499	0.614
Life appreciation	0.421	0.631
HLSUS	0.307	0.389

lifestyle behaviors are presented in Table 3. Results show that COVID-19-related prevention cognition, self-efficacy, e-Health literacy, and healthy lifestyle behaviors are positively related to each other.

3.4. Structural model and bootstrap test

Healthy lifestyle behaviors were the dependent variable, while COVID-19-related prevention cognition, self-efficacy, and e-Health literacy were used as independent variables. As shown in Fig. 1, all paths in the research model were statistically significant, which verifies all hypotheses. According to results, CMIN/DF = 4.367 < 5; GFI = 0.938, AGFI = 0.917, TLI = 0.939, and CFI = 0.949 were all greater than 0.9, and RMSEA = 0.059 < 0.08. Therefore, the data and model matched very well. The results indicated that the path through e-Health literacy alone and self-efficacy alone were significant. Moreover, the path through both mediators was also significant.

Results of the multiple mediation of e-Health literacy and self-efficacy in the relationship between COVID-19-related prevention cognition and healthy lifestyle behaviors based on the bootstrap method are in Table 4. The total indirect effect of COVID-19-related prevention cognition through e-Health literacy and self-efficacy on healthy lifestyle behaviors was statistically significant (estimate = 0.099; 95% CI [0.066, 0.137]). When considering the mediating variables separately and together, single mediation of e-Health literacy (estimate = 0.043; 95% CI [0.012, 0.083]), serial-multiple mediation of e-Health literacy and self-efficacy (estimate = 0.035; 95% CI [0.018, 0.056]), and single mediation of self-efficacy (estimate = 0.020; 95% CI [0.005, 0.042]) were found statistically significant.

4. Discussion

Based on advisory opinions, a COVID-19-related prevention cognition questionnaire was designed and validated for school students. The questionnaire had been proven to be effective and reliable in assessing prevention cognition during the pandemic. The cross-sectional investigation showed an overall improvement in healthy lifestyle behaviors during the epidemic compared with pre-epidemic. In addition, we examined the relationship between COVID-19-related prevention cognition and healthy lifestyle behaviors, and also explored whether e-

Table 3
Correlation m06atrix of COVID-19-related prevention cognition, self-efficacy, e-Health literacy, and healthy lifestyle behaviors.

Variable	COVID-19-related prevention cognition	Self-efficacy	e-Health literacy	Health lifestyle behaviors
COVID-19-related prevention cognition	1			
Self-efficacy	0.246**	1		
e-Health literacy	0.370**	0.505**	1	
Healthy lifestyle behaviors	0.132**	0.280**	0.237**	1

** *P* < 0.01 (2-tailed).
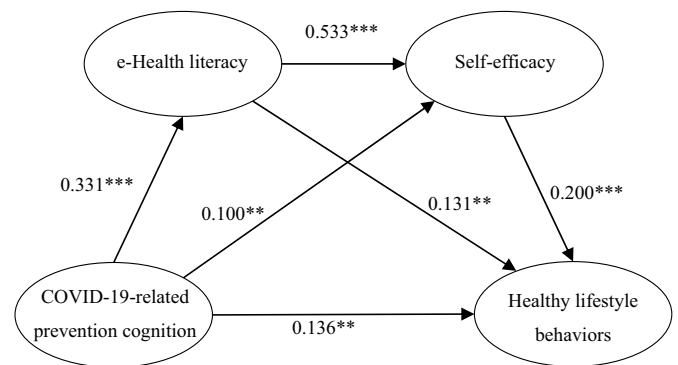
Fig. 1. The multiple mediation of e-Health literacy and self-efficacy between COVID-19-related prevention cognition and healthy lifestyle behaviors. **P < 0.01, ***P < 0.001.

Table 4
Standardization effect and direct effect in the model.

	Standardized estimate	P	95% confidence interval		Ratio of effect
			Lower	Upper	
COVID-19-related prevention cognition → e-Health literacy → Self-efficacy → Healthy lifestyle behaviors	0.035	<0.001	0.018	0.056	14.89%
COVID-19-related prevention cognition → e-Health literacy → Healthy lifestyle behaviors	0.043	0.007	0.012	0.083	18.30%
COVID-19-related prevention cognition → Self-efficacy → Healthy lifestyle behaviors	0.020	0.007	0.005	0.042	8.51%
Total Indirect effect	0.099	<0.001	0.066	0.137	42.13%
Direct effect	0.136	0.003	0.044	0.225	57.87%
Total effect	0.235	<0.001	0.138	0.315	

Health literacy and self-efficacy act as mediators in this association. The results demonstrated that COVID-19-related prevention cognition had a positive effect on healthy lifestyle behaviors. e-Health literacy and self-efficacy mediated the relationship between COVID-19-related prevention cognition and healthy lifestyle behaviors, with the total mediation effect accounting for 42.13% of the total effect.

Descriptive statistics indicated that compared with the pre-epidemic stage, the overall healthy lifestyle behaviors of college students were good, possibly owing to the important demonstration and leading role played by government departments during the normalization stage of COVID-19 prevention and control, as well as the increase of health knowledge popularization after the implementation of the health-center reform policy. All dimensions, excluding exercise behavior and health risk, were good. Among them, the reduction of health risk behavior was beneficial to promoting a healthy lifestyle. The decrease in exercise behavior might be owing to the measures of going outdoors as little as possible during the normalization stage of COVID-19 prevention and control, as well as the development of transportation and technology that brought convenience, such as take-out food, which greatly reduced the frequency of outdoor sports. Therefore, we should always listen to the sports and exercise education of college students, and cultivate awareness of a healthy lifestyle combining medical and physical education, which promotes students' health.

This study also examined the direct and indirect effects of the COVID-19-related prevention cognition on healthy lifestyle behaviors. First, the COVID-19-related prevention cognition had a direct positive impact on healthy lifestyle behaviors. This direct effect value was 0.136, accounting for 57.87% of the total effect, indicating that COVID-19-related prevention cognition level was an important factor affecting healthy lifestyle behaviors. The higher the COVID-19-related prevention cognition level of college students was, the more they realized that certain prevention and control measures could bring benefits to their health, and they actively took healthy behaviors. Therefore, relevant departments should be advocated to fully implement the overall prevention and control strategy for college students and strengthen the publicity and education of normalized epidemic prevention and control measures.

Second, e-Health literacy played a single mediating role in between COVID-19-related prevention cognition and healthy lifestyle behaviors, Which was in step with the previous study (L. Zhang et al., 2020), and the indirect effect value accounted for 18.30% of the total effect value. Compared with other indirect paths, the indirect effect value was relatively large, which might be owing to the rapid development of the Internet, and increasingly health departments, medical organizations, and non-profit organizations share health knowledge on the Internet. The Internet has become an important resource for the public to get health information, and the ability to obtain and use such resources has become a significant part of public health literacy (Hsu et al., 2014). Simultaneously, as one of the foremost active teams on the Internet, college students have a better education, a strong ability to accept knowledge (Stellefson et al., 2011), and a significant effect on family radiation. Therefore, on the basis of a high level of COVID-19-related prevention cognition, improving the e-health literacy of college students can not only improve their own healthy lifestyles, but also have great significance to comprehensively improve the healthy behavior of residents in the future.

Third, self-efficacy also played an independent mediating role between COVID-19-related prevention cognition and healthy lifestyle behaviors, accounting for 8.51% of the total effect value; however, its role should not be ignored. In the Health Belief Model (Janz and Becker, 1984), relevant health knowledge plays a decisive role in the implementation of healthy behaviors, and the premise for individuals to consider health behaviors is to perceive the susceptibility or severity of certain diseases. However, self-efficacy is an important part of adopting healthy behaviors, that is, whether they believe that they have the ability to control internal and external factors to successfully adopt healthy behaviors and achieve the desired results. Individuals' perception of benefits, obstacles, susceptibility, and severity provides an analytical basis for adopting healthy behaviors to a certain extent, but it also requires individuals to fully feel the possibility of realizing healthy behaviors (Bao, 2018). Therefore, the higher cognitive level, the stronger self-efficacy is, the more an individual's drive for healthy behavior. The study suggests that students' high COVID-19-related prevention cognition level can clearly recognize the benefit and value of epidemic prevention and control behavior, to enhance self-efficacy, prompt individuals to use more positive coping styles and avoid serious health threats posed by the outbreak.

Finally, e-Health literacy and self-efficacy played serial-multiple mediating roles in COVID-19-related prevention cognition and healthy lifestyle behaviors, accounting for 15.63% of the total effect, which was consistent with the Baker (2006) health literacy model. Therefore, the higher COVID-19-related prevention cognition level, the higher the e-Health literacy of individuals, the consolidation and strengthening of health knowledge, the formation of a strong self-efficacy, and ultimately promote the change to a healthy lifestyle. According to the KAP theory, health knowledge is the foundation of establishing positive and correct beliefs and attitudes, and then changing health-related behaviors. In general, the richer the knowledge acquired by individuals, the stronger their tendency to change his behavior. Also, the transformation process of knowledge and behavior is complicated and influenced by a variety of factors. e-Health literacy is a cognitive and social skill that can transform health knowledge into health promotion behavior (Zhou and Fan, 2019). In acquiring and evaluating resources through electronic media, health knowledge reserve and health responsibility, individuals' consciousness is further strengthened, and self-efficacy and the belief in healthy behavior are improved (Zhou and Fan, 2019). Moreover, self-efficacy and belief, as a continuous motivation, are embedded in individual health decisions or practices and play a role in correcting or improving health-related behaviors.

5. Conclusions

During the normalization stage of COVID-19 prevention and control, the healthy lifestyle behaviors of college students was good. When considering the mediating variables separately and together, single mediation of e-Health literacy, serial-multiple mediation of e-Health literacy and self-efficacy, and single mediation of self-efficacy were statistically significant. Therefore, in promoting a healthy lifestyle of college students, the focus should be on improving university students' COVID-19-related prevention cognition, supplemented by guiding the improvement of e-Health literacy and self-efficacy, and a positive response to the lifestyle change brought about by the epidemic to improve the healthy lifestyle behaviors of college students.

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CRediT authorship contribution statement

Xiaolu Bao, Dong Wang contributed to the design of this study. Data were collected by Xiaolu Bao, Dongxue Chen, Lushaobo Shi, Yi Xia, Zengping Shi. Data analysis was conducted by Xiaolu Bao, Dongxue Chen, Lushaobo Shi, Dong Wang. The manuscript was written by Xiaolu Bao and Dong Wang, with some edits from all authors. All authors approved the final manuscript submitted.

Conflict of interest

The authors in this study declare that there is no conflict of interest.

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