

Behaviors, bias, and decision-making in health

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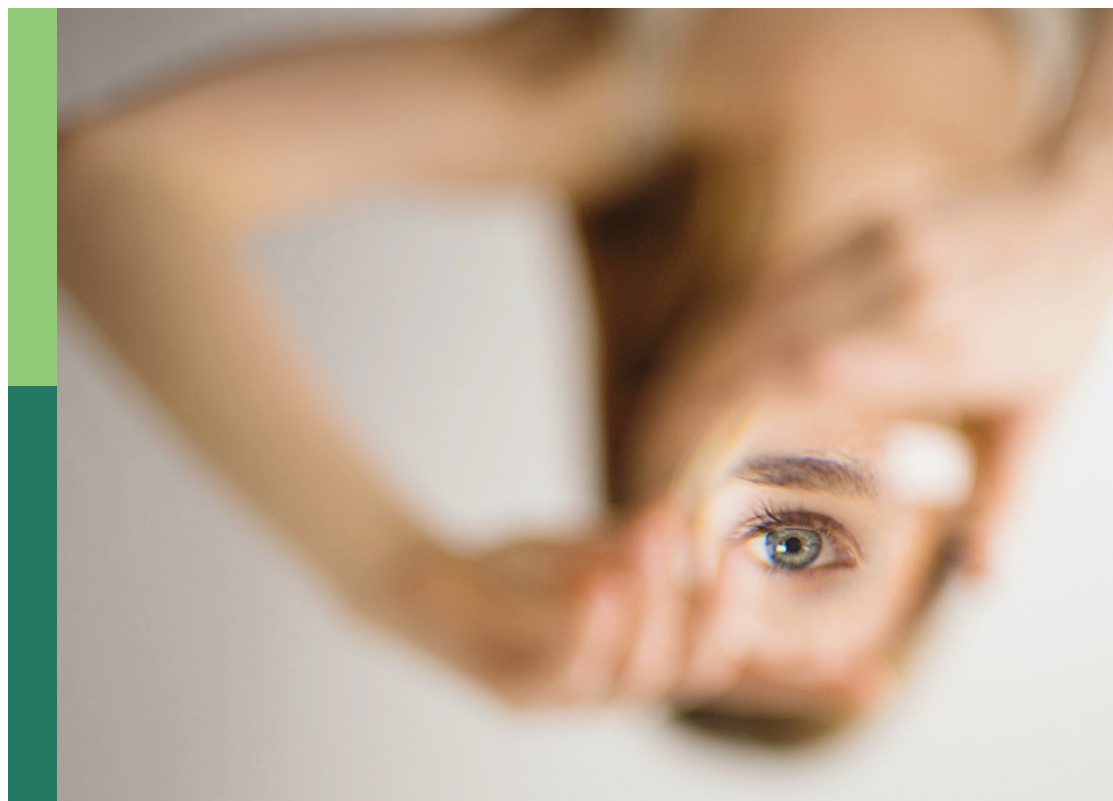
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Behaviors, bias, and decision-making in health

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Editorial: Behaviors, bias, and decision-making in health

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health, behavior, bias, decisions, behavioral insights

Editorial on the Research Topic

Behaviors, bias, and decision-making in health

The nexus of mental health, cognitive functions, and health-related behavior presents a rich field for applied psychological research, shedding light on how psychological, emotional, and social factors influence health decisions, be they social, clinical, or related to individual strategies. The research call, *Behaviors, bias, and decision-making in health*, was intentionally created to make a meaningful contribution in this applied domain. Thirteen interdisciplinary contributions explore the cognitive and emotional factors, mechanisms, and potential interventions that shape behavior in health contexts.

One of the key contexts in which to explore health-related behaviors has been the extraordinary case of the COVID-19 pandemic. A Korean study revealed the potential adaptive effects of the *maximization* personality trait, the tendency to carefully evaluate options in pursuit of the best possible outcome, during the pandemic (Jun et al.). Certain aspects of maximization may promote wellbeing under stress, particularly when mediated by effective coping mechanisms such as cognitive reappraisal and preventive behaviors (e.g., wearing masks).

Importantly, one key lesson from the pandemic is that such knowledge should not be forgotten but rather integrated into everyday health and preventive policy. Sustained public health messaging and targeted interventions to support long-term protective behaviors are crucial, especially in anticipation of possible future outbreaks. This is one of the main practical implications of Luo et al.'s study.

However, although people in post-pandemic China retain a good understanding of protective measures, actual adherence to these behaviors has declined compared to the peak of the pandemic. This decline appears to be linked to a reduced sense of vulnerability and a prevailing belief that the pandemic is now behind us, elements that are particularly important to address in preventive contexts (Luo et al.). At the same time, such an exceptional event has the potential to shift some behaviors in a more health-conscious direction. For instance, another study suggested that the pandemic acted both as a barrier and a catalyst: urban residents encountered restricted access to safe walking and cycling infrastructure and pandemic-related anxieties, but at the same time, the crisis triggered a shift toward sustainable transport, as public awareness of health and environmental benefits increased (Du S. et al.). These ambivalent effects illustrate the dynamic interplay between environmental constraints and motivational shifts.

Building on this, this psychological framing is equally relevant in the context of chronic disease management, where sustained behavioral change is crucial. Chronic disease management demands more than clinical instruction; it relies on individuals' cognitive and

emotional capacity to transform knowledge into sustained action. Across several studies in this Research Topic, psychological mechanisms such as health literacy, self-efficacy, illness perception, and stigma consistently emerge as critical drivers of health-related behavior. In China, research on hypertension and rheumatoid arthritis shows that it is not merely what patients know, but how they interpret and internalize their illness that shapes their ability to engage in effective self-management (Liu T. et al.; Liu Y. et al.). These cognitive and emotional variables mediate the transition from understanding to action, influencing medication adherence, symptom monitoring, and lifestyle change.

This pattern is echoed in studies on diabetes and chronic heart failure. Patients with type 2 diabetes often underestimate the long-term consequences of their condition, delaying care-seeking and underutilizing available health resources due to low perceived threat and high perceived barriers (Du Q.-h. et al.). Similarly, individuals with chronic heart failure frequently avoid recommended physical activity due to Kinesiophobia, a fear of movement that stems from emotional distress and perceived vulnerability (Xiang et al.). In both cases, behavioral disengagement is not the result of ignorance, but of underlying belief systems and emotional responses.

In addition, health-related decisions and behaviors are closely linked to stress and its impact on body functioning. Zhang et al. show that poor sleep is not just a physiological response to stress but also influenced by maladaptive coping strategies like rumination and excessive smartphone use. Similarly, Giaume et al. found that first responders in high-stress simulations experienced anticipatory anxiety and reduced body awareness, affecting their performance and recovery. Both studies highlight the need to address emotional regulation and behavioral habits to improve health outcomes in high-stress environments.

Finally, other contributions have offered valuable suggestions for the promotion of interventions. Bientzle et al. show that interventions rooted in storytelling—like narrative writing and narrative reading—can promote empathic concern and reduce stigma toward individuals who engage in socially disapproved health behaviors (e.g., smoking while pregnant). This study found that the less time-consuming technique of narrative reading is as effective as narrative writing in increasing empathic concern, perspective-taking, and attitudinal change. This opens the door to scalable, time-efficient formats for empathy-based health communication. The importance of social support is also emphasized in the study by Pan et al.. These authors report that perceived social support had a positive effect on the vision-related quality of life of elderly individuals with dry eye disease. Patients with social support had greater health outcomes; specifically, social support improved the patients' illness perception and confrontational coping style, suggesting a potential wider role of social support for healthcare interventions. These results reinforce the role of emotional and relational factors in sustaining healthy behaviors, especially in older populations. They also suggest the benefit of integrating social resources into personalized care pathways.

Finally, two conceptual contributions address broader behavioral frameworks. A systematic review of nudging strategies

in chronic obstructive pulmonary disease management highlights how behavioral science can improve adherence and outcomes (Wu et al.). This study explored the role of nudges such as social influence, gamification, reminders, and feedback on a range of health behaviors. Medication adherence was improved by both reminders and feedback on mobile devices. Additionally, reminders through text materials also improved inhalation techniques and vaccination in patients. A discussion paper by Bonazza et al. examines patient-centered care at the end-of-treatment. Ethical and psychological tensions that impact shared decision-making were examined, in particular in instances when patients' autonomy challenges best clinical treatment and when proposed treatment challenges the patient's preferences. The study contributes to the ongoing discourse on the balance between paternalism and autonomy in medical decision making.

Together, these studies highlight a crucial insight: effective public health and clinical interventions must move beyond information provision. Addressing cognitive distortions, emotional readiness, and belief systems is essential to supporting long-term behavioral change. A psychologically informed approach can better align interventions with the realities of how individuals experience and respond to illness, thus helping bridge the gap between knowledge and action in diverse health contexts.

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Adaptive aspects of maximizing in times of COVID-19: coping efforts linking maximization to well-being

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Introduction: Maximization, the tendency to make the best choices by thoroughly searching and comparing alternatives, has long been considered a negative correlate of well-being. However, recently, it was proposed that having a maximizing tendency can lead to better coping efforts in some stressful situations and thus could be more adaptive. The objective of the present research was to demonstrate positive features of maximization and identify the coping strategies that mediate the relationship between maximization and well-being during the COVID-19 pandemic.

Methods: A sample of 3,493 participants responded to an online survey from January 20 to October 11 of 2020. The 13-item Maximization Scale assessed individuals' maximizing tendency in terms of the maximization index and its three subdimensions (i.e., high standards, alternative search, and decision difficulty). The use of four coping strategies (i.e., preventive measures, cognitive appraisal, self-distraction, and social connection) during the COVID-19 pandemic was assessed. Hedonic and eudaimonic aspects of well-being were measured. We developed a mediation model and examined both whether there was an indirect link between maximization and well-being through the coping strategies and whether there was a direct link between maximization and well-being.

Results: Path analysis revealed negative direct associations between maximization measures (i.e., an index and three subdimensions) and well-being. In addition, significant indirect paths were found with varying directions depending on maximization dimensions and coping strategy types. There were positive indirect associations between the maximization index and well-being via preventive measures, between high standards and well-being through preventive measures and cognitive appraisal, and between alternative search and well-being through self-distraction and social connection. Negative indirect associations were found between decision difficulty and well-being through cognitive appraisal, self-distraction, and social connection.

Discussion: The current study confirmed the existence of inconsistent mediation effects between maximization and well-being via coping and highlighted coping efforts as one of the positive aspects of maximization. Discussion addressed the double-edged effect of maximization on well-being and its beneficial nature in times of distress. Future studies should examine other potential situations and moderators that can delineate maximization's various characteristics with a longitudinal design and samples from diverse backgrounds.

KEYWORDS

maximizing, coping strategies, well-being, COVID-19, inconsistent mediation

1 Introduction

People differ in the ways they make choices. Maximization is one of the intrapersonal factors that explain individual differences in decision-making. It consists of three subdimensions (i.e., high standards, alternative search, and decision difficulty; Schwartz et al., 2002; Nenkov et al., 2008). *High standards* involve holding high standards both for oneself and things across the board. *Alternative search* refers to exhaustively going through available options before making up one's mind. Finally, *decision difficulty* indicates having a hard time deciding on things such as a gift for a friend or the best wording for a letter. Maximizers with higher levels of such maximizing tendencies are individuals who strive to make the best choice through an exhaustive search and comparison of alternatives (Schwartz et al., 2002; Cheek and Schwartz, 2016). They also tend to put great effort into the decision process by comparing more options (Schwartz et al., 2002; Chowdhury et al., 2009; Dar-Nimrod et al., 2009; Polman, 2010; Yang and Chiou, 2010) and spending more time (Schwartz et al., 2002; Chowdhury et al., 2009; Misuraca and Teuscher, 2013). On the other hand, satisficers seek to choose options that are “good enough” and stop searching once they identify choices that satisfy their standards (Schwartz et al., 2002; Cheek and Schwartz, 2016).

Past research has drawn a pessimistic picture of maximizers in that maximizers tend to set unattainable goals and have problematic decision-making styles (e.g., Schwartz et al., 2002; Parker et al., 2007; Purvis et al., 2011; Hughes and Scholer, 2017). Regarding the influence of having a maximizing tendency on psychological well-being, it has been considered dysfunctional for general well-being due to its negative associations with various well-being indicators (i.e., life satisfaction, depression, and happiness; Schwartz et al., 2002; Iyengar et al., 2006; Parker et al., 2007; Cheek and Schwartz, 2016; Kim and Miller, 2017; Newman et al., 2018). For instance, compared to satisficers, maximizers are known to be less happy (Schwartz et al., 2002; Purvis et al., 2011), less optimistic (Schwartz et al., 2002), and less open (Purvis et al., 2011). They also report lower life satisfaction (Schwartz et al., 2002; Chang et al., 2011; Newman et al., 2018), have reduced self-esteem (Schwartz et al., 2002), and experience more regret (Schwartz et al., 2002; Lai, 2011; Purvis et al., 2011; Ma and Roese, 2014; Kokkoris, 2019). Furthermore, being a maximizer is positively correlated with perfectionism (Schwartz et al., 2002; Chang et al., 2011; Dahling and Thompson, 2013), depression (Schwartz et al., 2002; Bruine de Bruin et al., 2016) and often engaging in counterfactual thinking (Schwartz et al., 2002; Leach and Patall, 2013) and social comparison (Schwartz et al., 2002; Weaver et al., 2015; Cheek and Schwartz, 2016; Luan and Li, 2019). Iyengar et al. (2006), for example, showed that even though graduating college seniors with maximizing inclinations got jobs with higher salaries than seniors with satisficing inclinations, maximizers' satisfaction levels were lower than those for satisficers.

But do maximizing tendencies always play a negative role in one's well-being? In recent years, some researchers have begun to explore novel and positive aspects of maximizing tendencies and their positive effects on well-being (e.g., Kokkoris, 2016; Misuraca et al., 2016; Zhu et al., 2017; Peng et al., 2018; Schei et al., 2020; Brannon, 2021; Ma et al., 2021; Li et al., 2023). They highlighted maximizers' greater level of future-oriented thinking (Misuraca et al., 2016; Zhu et al., 2017) and intrinsic and achievement motivation (Lai, 2011; Peng et al., 2018), qualities which have been regarded as valuable predictors of

adaptability (e.g., Griffin and Hesketh, 2005; Bell and Kozlowski, 2008; Stokes et al., 2010; Anagnostopoulos and Griva, 2012). For example, Ma et al. (2021) found that the past-positive and future-time perspectives served as mediators of the positive relationship between maximization and meaning in life. In addition, in a recent study by Peng et al. (2018), feelings of regret and achievement motivation were considered to be significant intervening variables in the relationship between maximization and subjective well-being. They found that maximizing fostered achievement motivation, which in turn was positively associated with SWB, while it also negatively influenced SWB through feelings of regret. Li et al. (2023) also demonstrated the long-term positive influence of the maximizing tendency on adaptability and well-being by showing that student maximizers acquired more eudaimonic well-being, and enhanced eudaimonic well-being, in turn, helped them adapt better to their new college life.

In addition to these positive aspects of maximization, researchers identified coping attempts as prominent features manifested by those predisposed to maximizing (Schwartz et al., 2002); maximizers may put greater effort into coping with physical and psychological distress. Coping refers to behavioral and psychological efforts that people consciously employ to master, minimize, or tolerate stressors (Lazarus and Folkman, 1984), and in general, the use of coping mechanisms is known to be helpful in maintaining one's well-being (Shiota and Levenson, 2012; Gross, 2015; Polizzi et al., 2020; Kim et al., 2022). Although some evidence suggests that there is a positive association between maximization and well-being indicators (e.g., meaning in life; Ma et al., 2021) and the mediators in the associations (e.g., achievement motivation; Peng et al., 2018), the mechanisms accounting for the relationship between maximization and well-being (defined by hedonic and eudaimonic well-being), particularly the role of coping efforts, remain understudied.

The COVID-19 pandemic was a specific context that allowed us to examine potential positive aspects of maximizing in relation to coping and well-being. Thus, in the present study we sought to identify the relationships among maximization, coping, and well-being by establishing a mediation model in which maximization is related to well-being through coping strategies.

1.1 Coping as a positive aspect of maximization

In the general discussion of the potential positive role of a maximizing strategy in maintaining well-being, Schwartz et al. (2002) endorsed the view that responding to health threats with a maximizing strategy, characterized by exhaustive information search and active efforts to acquire the best possible treatment, can lead to better outcomes than a strategy that simply selects a treatment considered sufficient. Utilizing active coping practices under stress is one example well representing the general tendency of maximizers' future-oriented thinking — “the present anticipation of future goals and consequences of current actions” (Zhu et al., 2017, p. 94). Maximizers tend to give greater consideration to the future consequences of their actions and attend more to future goals than satisficers (Misuraca et al., 2016; Zhu et al., 2017). Such future-oriented thinking has been linked to greater engagement in proactive and adaptive coping strategies (Aspinwall, 2005, 2011; Sohl and Moyer, 2009; Anagnostopoulos and Griva, 2012; Chua et al., 2015). Chua et al. (2015) found that adolescents who

express high levels of future orientation are more inclined than others to employ adaptive coping strategies while avoiding maladaptive ones as they work towards achieving positive future outcomes. Furthermore, maximizers tend to possess stronger aspirations and a more unwavering dedication to achieving favorable goals and success than those with lower maximizing tendencies (Peng et al., 2018; Zhu et al., 2022). Therefore, despite lots of demands such as planning and preparation (Iyengar et al., 2006; Polman, 2010), maximizers work harder (e.g., Schwartz et al., 2002), investing more time (Nenkov et al., 2008) and resources (Misuraca et al., 2016) while resisting temptations (Besharat et al., 2014) and risky behaviors (Lai, 2010) that may reduce the likelihood of goal achievement. Indeed, maximizers exhibit greater levels of achievement motivation (Peng et al., 2018), which leads to a stronger internal drive and motivation system for overcoming external challenges and addressing difficulties (Te Wang and Eccles, 2013; Michou et al., 2014). All these perspectives highlight the possibility that maximizers may utilize various coping strategies in times of crisis in order to improve the situation and secure a good future. The coping efforts, in turn, can bring better well-being.

During the COVID-19 pandemic, certain types of coping were more likely to be used due to the contagious nature of COVID-19. Kim et al. (2022) developed the eight items that have been widely implemented during the pandemic based on the Brief COPE Scale (Carver, 1997) and the distress regulation literature supporting their effectiveness (Folkman and Lazarus, 1980; Carver et al., 1989). The internal and external validity of these eight items were confirmed (Kim et al., 2022) by conducting exploratory factor analysis (EFA) and examining associations between coping strategies and changes in well-being in a longitudinal analysis. Three constructs were revealed in the EFA using the eight items: cognitive appraisal, behavioral strategies, and preventive measures. Cognitive appraisal represents cognitive efforts to reduce the stress or negative emotions aroused by the COVID-19 pandemic. Behavioral strategies refer to participation in activities or social interaction to avoid distress, and two items were highly loaded on this factor; 'self-distraction' involves participating in activities to take one's attention away from stressors, and 'social connection' indicates communicating with people, even remotely (e.g., texting, phone calls), to activate one's social support system, which was especially important during times of social distancing. Finally, preventive measures refer to preventive behaviors people employ to protect themselves from COVID-19, and include mask-wearing, hand hygiene, and social distancing. These constructs were found to be positively correlated with each other. Accordingly, the present study focused on these coping strategies to investigate their roles in mediating the association between maximization and well-being. The two items for behavioral strategies were considered separately to capture the nature of the activities, resulting in the assessment of four distinct coping strategies (i.e., cognitive appraisal, self-distraction, social connection, and preventive measures; Brooks et al., 2020; Polizzi et al., 2020; Kim et al., 2022).

We expected that maximizers would be more likely to practice these coping strategies to deal with physical and psychological distress during the pandemic. In particular, considering their concerns about the long-term consequences of their current actions (Misuraca et al., 2016; Zhu et al., 2017) and higher internal motivation to attain favorable outcomes (Peng et al., 2018; Zhu et al., 2022), they would be more willing to stick to public health rules and recommendations such as mask-wearing, hand hygiene, and social distancing and to attempt various activities in times of long-lasting pandemic crisis.

Yet, there were no *a priori* hypotheses about the relationships between specific maximization dimensions (i.e., high standards, alternative search, decision difficulty) and types of coping strategies. In fact, previous researchers have discovered different correlations between respective subdimensions and diverse psychological traits (Nenkov et al., 2008; Rim et al., 2011; Richardson et al., 2014). For example, Nenkov et al. (2008) found that while all three subdimensions had positive correlations with regret, only alternative search had a significant negative correlation with people's satisfaction with life. Similarly, decision difficulty was the only dimension negatively related to optimism. Finally, high standards did not relate negatively to people's happiness, optimism, or life satisfaction but were positively linked to perfectionism and the need for cognition (Nenkov et al., 2008). Given the distinct nature of each dimension and empirical findings on different relationships between the three subdimensions and various psychological traits, we decided to consider each maximization dimension in addition to global maximization in examining the mediation model and expected that each dimension would relate to coping strategies in different ways.

1.2 Coping strategies and well-being

Regarding the relationships between each coping strategy and well-being, engagement in cognitive appraisal, self-distraction, and social connection have all been found to be positively associated with well-being. For instance, cognitive appraisal has been shown to be helpful in decreasing the level of fear or anxiety (Folkman and Lazarus, 1980; Folkman et al., 1986). Reinterpreting and paying attention to positive sides by discovering lessons and meaning out of negative events can assist people in managing restrictions caused by the outbreak (Tennen and Affleck, 2002; Shiota and Levenson, 2012). Indeed, various studies have demonstrated the essential role of cognitive appraisal in dealing with psychological distress (Lazarus and Folkman, 1984; Carver and Scheier, 2012; Gross, 2015).

Self-distraction has also been found to be effective in lowering psychological distress and overcoming boredom and helplessness incurred by social isolation (Klinger, 1975; Polizzi et al., 2020). Lastly, during times of social distancing, connections with others, even remotely, have been shown to be effective ways to reduce psychological distress (Thoits, 1995; Kim et al., 2008, 2022). Social support systems activated by social connection can buffer negative emotions evoked by social distancing (Fiorillo and Gorwood, 2020; Holmes et al., 2020). As such, greater use of coping strategies during epidemic outbreaks can help maintain well-being.

Preventive measures have been recognized as effective ways to prevent the spread of the virus (Brooks et al., 2020; Ferguson et al., 2020). The high mortality rate and contagious nature of COVID-19 can make people feel fearful and insecure when out in public (Ahorsu et al., 2020). Moreover, higher engagement in measures such as wearing a mask, washing one's hands, and refraining from close contact with others can be beneficial for maintaining mental and physical health. Unlike other coping strategies, however, it has been proposed that preventive measures may be accompanied by a cost to well-being. Kim et al. (2022) found that those who strictly followed preventive measures experienced a significant decrease in well-being during the first phase of the pandemic. Indeed, many have experienced difficulties while engaging in the preventive measures (Moore et al.,

TABLE 1 Demographic characteristics ($N = 3,493$).

	<i>N</i>	%
Gender		
Female	3,062	87.7
Male	431	12.3
Age		
10s	1,193	34.2
20s	1,392	39.9
30s	525	15.0
40s	271	7.8
50s	92	2.6
over 60s	20	0.6
Regions		
Capital	2,028	58.1
Others	1,465	41.9
Total	3,493	100

2021) and have refused to comply with the recommendations (Waldrop and Gallman, 2020). This study provides additional evidence regarding the relationship between practicing preventive measures and well-being during the COVID-19 pandemic.

1.3 The present study

The purpose of the present study is to investigate whether maximizers used higher levels of coping strategies and whether these coping attempts enhanced well-being during the COVID-19 pandemic. We predicted that maximizers would thoroughly search for optimal ways to manage the current situation and thereby would be inclined to explore and engage more in specific coping strategies. Ultimately, their increased attempts to cope with stress would help them to maintain a higher level of well-being. In addition to the hypothesized positive indirect paths, we did not overlook the previous findings that maximization has been negatively linked to well-being indicators (e.g., Schwartz et al., 2002; Cheek and Schwartz, 2016; Kim and Miller, 2017; Newman et al., 2018). Thus, when testing the mediation model, we can confirm the existence of an inconsistent pattern of mediation in which the direct and the indirect paths are significant and have opposite directional signs.

Inconsistent mediation (MacKinnon et al., 2000; Shrout and Bolger, 2002) is one example of partial mediation where the direct and the indirect paths have opposite signs, and it is distinct from a general mediation model in which both indirect and direct paths have the same direction. Inconsistent mediation is also called “competitive mediation” (Zhao et al., 2010) because the direct and indirect paths are competing with each other. This analytic approach has been widely used by scholars who explored the nature of various psychological traits (Kühnel et al., 2009; Widmer et al., 2012; Ang and Malhotra, 2016; Cauberghe et al., 2021; Zhou et al., 2022). For instance, Zhou et al. (2022) examined whether nostalgia counteracts loneliness by increasing happiness. In testing an inconsistent mediation model from loneliness to happiness via nostalgia using three different national samples, they found that although lonely people tended to experience

decreased happiness (i.e., a negative direct path), they felt more nostalgia than less lonely people, and greater nostalgia, in turn, was associated with greater happiness (i.e., a positive indirect path). In the same vein, the present study tests an inconsistent mediation model involving a negative direct link between maximization and well-being and a positive indirect link between maximization and well-being through coping strategy.

It is also important to reiterate that the inconsistent mediation model was tested with the three subdimensions of maximization separately in addition to their summed maximization scores to identify more nuanced influences of maximization on coping efforts and well-being.

2 Materials and methods

2.1 Participants

A sample of 3,493 Koreans aged 14–71 (87.7% Female; $M_{\text{age}} = 27.24$, $SD_{\text{age}} = 9.94$) provided information on the variables of interest via Kakao online surveys (Table 1). Kakao Corporation is one of the biggest SNS companies in South Korea, and 86% of the Korean population uses it. Since 2019, the Center for Happiness Studies at Seoul National University has been collecting data on Koreans' daily well-being and various psychological measures in collaboration with Kakao Corporation (see Choi et al., 2021 for detailed information on the data). The dataset has been widely used by researchers whose interests are to clarify the psychological and environmental mechanisms underlying well-being (Choi et al., 2021; Na et al., 2021; Suk et al., 2021; Kim et al., 2022). Any Kakao user can voluntarily participate in the survey at any time through its website¹ or application (i.e., KakaoTalk). Participants indicated their gender and birth year when they first signed up to participate in the survey. See Table 1 for information about participants' characteristics.

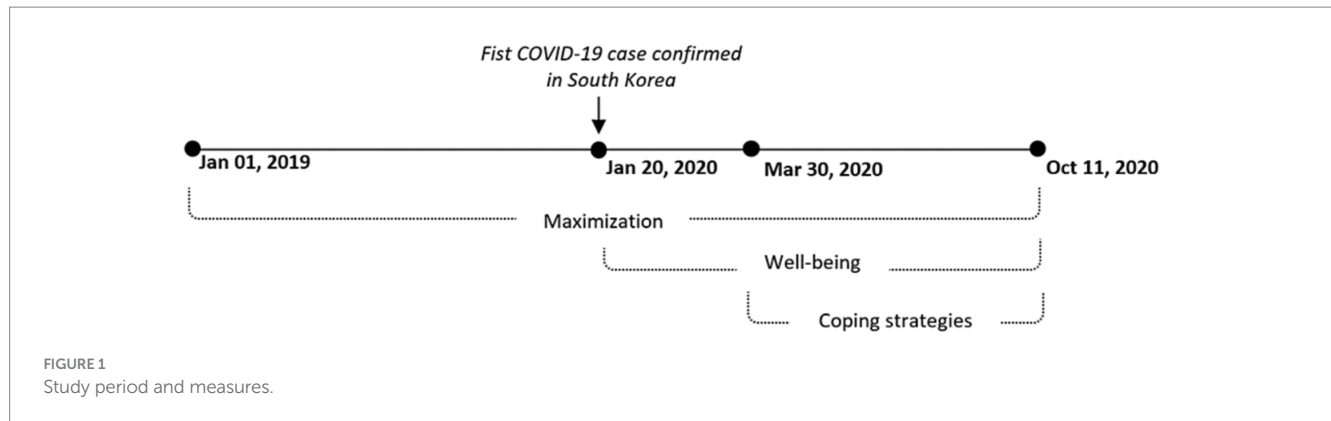
This study used the responses provided during the study period shown in Figure 1. Since users were allowed to respond to the survey items multiple times, well-being responses obtained more than once from each participant were averaged (The number of responses on well-being per person: $M = 5.92$, $SD = 6.66$). For maximization and coping measures, only the first response was used because most participants only responded once (The number of responses per person was: $M = 1.21$, $SD = 0.79$ for maximization; $M = 1.08$, $SD = 0.39$ for coping). The secondary data analysis of the Kakao data was approved by the Institutional Review Board at Kangwon National University in South Korea (#201910009002).

2.2 Measures

2.2.1 Well-being

Well-being was measured using a 10-item well-being questionnaire, assessing hedonic well-being (i.e., life satisfaction, stress, positive affect, and negative affect) and eudaimonic well-being (i.e., meaning in life) (Diener, 1984; Diener et al., 1985; Ryff and

¹ <http://together.kakao.com/hello>



Singer, 1998). Previous studies have validated the 10-item index among the Korean population and found excellent internal consistency for the selected items (Choi et al., 2021; Suk et al., 2021).

Life satisfaction, meaning in life, and stress were each assessed with a single question, respectively (e.g., “How satisfied are you with your life right now?” was the measure of life satisfaction). For positive and negative affect, participants were asked the extent to which they felt each of three positive (PA: happy, pleasant, relaxed) and four negative (NA: bored, annoyed, depressed, anxious) emotions, respectively. Participants responded on an 11-point Likert scale, ranging from 0 = not at all to 10 = very much (see [Supplementary materials](#) for the full survey items). The well-being index was created by averaging the ten items with reversed scores for stress and negative affect ($\alpha = 0.912$).

2.2.2 Maximization

The 13-item Maximization Scale (MS; Schwartz et al., 2002) is composed of three subdimensions (i.e., high standards, alternative search, and decision difficulty). The high standards subscale consisted of three items (e.g., “I never settle for second best.”), asking about the standards people have both for themselves and life events. Alternative search included six items (e.g., “Although I am satisfied with my current job, I try to look for better opportunities.”), asking whether people seek better options. Lastly, decision difficulty was measured with four items (e.g., “It is hard to choose which movie to watch.”), representing whether people find it hard to decide on things such as a gift for a friend or the best words to say. Participants responded on a 7-point scale (1 = completely disagree, 7 = completely agree). The present study used a composite score averaging across all 13 items ($\alpha = 0.677$) and three subscale scores averaging items on each subscale ($\alpha = 0.580$ for high standards, $\alpha = 0.574$ for alternative search, and $\alpha = 0.585$ for decision difficulty). The index and each MS dimension fall in the acceptable range of internal consistency (Nunnally, 1978; Kline, 2000).

2.2.3 Coping strategies

Individuals’ coping strategies used during the pandemic (i.e., preventive measures, cognitive appraisal, self-distraction, and social connection) were measured with eight items developed based on the revised Brief COPE Scale (Carver, 1997). The Brief COPE contains measures of 12 coping strategies with each measure including two items. It has been widely used with a few modifications to reflect responses to specific stress-evoking situations such as the COVID-19 pandemic (e.g., Cauberghe et al., 2021). Accordingly, Kim et al. (2022)

developed a scale consisting of eight items measuring coping strategies relevant to the COVID-19 pandemic, and they confirmed its internal and external validity (Kim et al., 2022).

Participants were asked to indicate the extent to which they used each coping strategy and responded on a 5-point scale, ranging from 1 = strongly disagree to 5 = strongly agree. In the current study, we averaged responses on three items for preventive measures (e.g., “I’ve been wearing a mask to prevent from the COVID-19.”) ($\alpha = 0.693$) and three items for cognitive appraisal (e.g., “I’ve been trying to view the COVID-19 outbreak in a positive way.”) ($\alpha = 0.564$), respectively. Social connection and self-distraction were measured with single items (“I’ve been communicating with my family and friends via phone/texts more than usual.” and “I’ve been doing other activities to take my mind off COVID-19.”, respectively). Thus, the use of four different coping strategies was measured.

2.3 Analytic strategy

We tested two models of the mediation relationships between maximization and well-being via coping strategies: one with the maximization index and the other with maximization’s three subdimensions. Path analysis was performed in Mplus Version 7.3. In the path analysis, one type of structural equation modeling (SEM) in which the model variables are observed, all variables of interest were entered into the model. Then, the indirect paths amongst the model variables and the direct relationships between variables were generated simultaneously.

The model variables satisfied the normality assumption (i.e., skewness <3; kurtosis <10) (Kline, 2011) (see [Table 1](#)), and maximum likelihood (ML) estimation was used to estimate the model parameters. Goodness-of-fit indices used to evaluate the path model included chi-square (nonsignificant), CFI (comparative fit index ≥ 0.95), RMSEA (root mean square error of approximation ≤ 0.06), and SRMR (standardized root mean square residual ≤ 0.08) (Hu and Bentler, 1999). The significance of the indirect paths was confirmed using 10,000 bootstrapped samples. According to previous findings that men are known to report higher levels of maximization compared to women (Iyengar et al., 2006; Parker et al., 2007), and older adults tend to engage less in maximizing decision strategies (Tanius et al., 2009; Bruine de Bruin et al., 2016), gender and age were statistically adjusted in the mediation analyses. The cutoff for statistical significance was set at

TABLE 2 Descriptive statistics ($N = 3,493$).

Variables	Mean	SD	Median	Range	Min	Max	Skewness	Kurtosis
<i>Maximization</i>								
Maximization index	4.22	0.94	4.23	6.00	1.00	7.00	0.10	0.17
High standards	4.73	1.21	4.67	6.00	1.00	7.00	-0.27	-0.04
Alternative search	4.05	1.05	4.00	6.00	1.00	7.00	0.13	0.09
Decision difficulty	4.10	1.32	4.00	6.00	1.00	7.00	0.03	-0.36
<i>Coping strategies</i>								
Preventive measures	4.17	0.77	4.33	4.00	1.00	5.00	-1.08	1.48
Cognitive appraisal	3.45	0.87	3.33	4.00	1.00	5.00	-0.04	-0.43
Self-distraction	3.42	1.27	4.00	4.00	1.00	5.00	-0.43	-0.86
Social connection	2.94	1.36	3.00	4.00	1.00	5.00	0.09	-1.18
<i>Well-being</i>	5.24	2.00	5.10	10.00	0.00	10.00	-0.02	0.03

TABLE 3 Correlations among main study variables ($N = 3,493$).

Variable	1	2	3	4	5	6	7	8
<i>Well-being</i>								
1. Well-being index	–							
<i>Maximization</i>								
2. Maximization index	-0.21***	–						
3. High standards	-0.13***	0.71***	–					
4. Alternative search	-0.17***	0.85***	0.43***	–				
5. Decision difficulty	-0.21***	0.81***	0.46***	0.48***	–			
<i>Coping</i>								
6. Preventive measures	0.10***	0.06***	0.12***	0.02	0.04*	–		
7. Cognitive appraisal	0.24***	-0.01	0.03	0.00	-0.04*	0.15***	–	
8. Self-distraction	0.26***	0.04*	0.02	0.07***	-0.01	0.14***	0.24***	–
9. Social connection	0.23***	0.03	0.02	0.07***	-0.03*	0.13***	0.13***	0.29***

Note. * $p < 0.05$, *** $p < 0.001$.

$\alpha = 0.05$. Table 2 presents the descriptive statistics for all study variables, and Table 3 presents the correlations among the study variables.

3 Results

3.1 Mediation paths from a maximization index to well-being via coping

We examined whether the relationship between maximization and well-being is mediated by coping strategies. The path model linking the overall maximization index to well-being via four coping strategies showed a good fit to the data according to model indices ($\chi^2[3] = 6.464$, $p = 0.091$, CFI = 0.998, TLI = 0.977, RMSEA = 0.018, SRMR = 0.005) (see Figure 2). Results revealed a negative direct effect of maximization on well-being ($b = -0.477$, $SE = 0.036$, $p < 0.001$), indicating that those with higher maximization tendencies tend to have lower levels of well-being. However, more importantly, we found that preventive measures

significantly and positively mediated the maximization and well-being link; those who scored higher on maximization followed the preventive measures more actively ($b = 0.054$, $SE = 0.015$, $p < 0.001$), which in turn had a positive effect on well-being ($b = 0.120$, $SE = 0.043$, $p = 0.006$) (Indirect effect: $b = 0.007$, $SE = 0.003$, $p = 0.030$, 95% CI = [0.001, 0.012]) (Figure 2; Table 4). The significance of the indirect relation was confirmed with 10,000 bootstrapped samples (Table 4). No additional significant mediation relationships were found for the other three coping strategies (i.e., cognitive appraisal, self-distraction, and social connection). Overall, we confirmed the inconsistent mediation paths, including both a negative direct path and a positive indirect path.

3.2 Mediation paths from maximization subdimensions to well-being via coping

Next, we examined the path model with three subdimensions of maximization. The model also showed a good fit to the data (χ^2

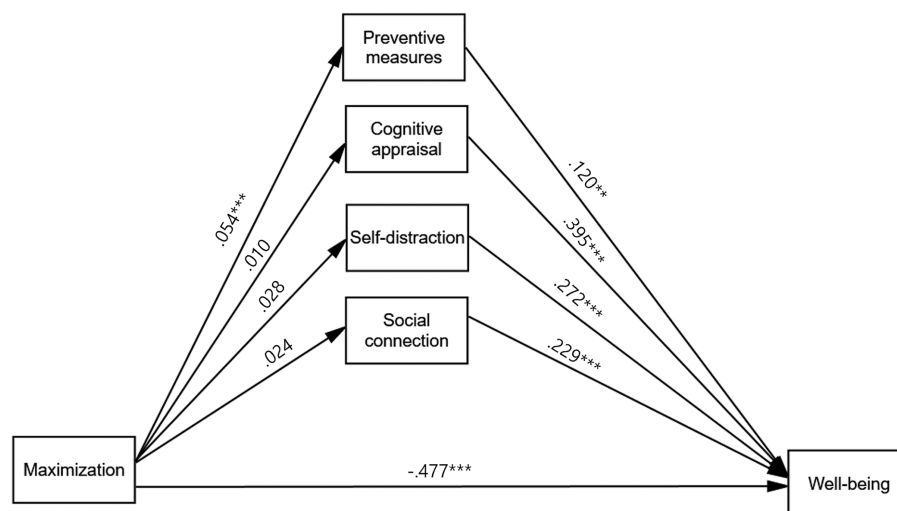


FIGURE 2

Parallel mediation model from a maximization index to well-being via coping strategies. Unstandardized estimates are present. Model fit: $\chi^2 [3] = 6.464$, $p = 0.091$, CFI = 0.998, TLI = 0.977, RMSEA = 0.018, SRMR = 0.005. Statistical controls include sex (Male = 1) and two age groups (Reference group: Age_{10s-20s}, Comparison groups: Age_{30s-40s}, Age_{50s and over}), but they were not depicted in the figure for model simplicity. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

[5] = 17.733, $p = 0.003$, CFI = 0.992, TLI = 0.937, RMSEA = 0.027, SRMR = 0.007) (Figure 3).

Consistent with the path model with a maximization index, there was a negative direct relation between each maximization subdimension and well-being. Among the three maximization subdimensions, alternative search showed the strongest negative relationship to well-being ($b = -0.210$, $SE = 0.038$, $p < 0.001$), followed by decision difficulty ($b = -0.182$, $SE = 0.032$, $p < 0.001$) and high standards ($b = -0.077$, $SE = 0.031$, $p = 0.014$).

Further, we found that the association between maximization and well-being was significantly mediated by coping strategies. Notably, the significance and directions of the indirect paths depended on maximization subdimensions and coping strategy types (Figure 3; Table 4). For high standards, there were positive indirect associations between high standards and well-being through preventive measures and cognitive appraisal. Participants with higher standards practiced preventive measures more actively ($b = 0.095$, $SE = 0.013$, $p < 0.001$) and used more cognitive appraisal strategies ($b = 0.034$, $SE = 0.015$, $p = 0.027$), which, in turn, led to higher levels of well-being ($b = 0.116$, $SE = 0.044$, $p = 0.008$ from preventive measures to well-being, $b = 0.394$, $SE = 0.040$, $p < 0.001$ from cognitive appraisal to well-being) (see Table 4 for bootstrapped estimates of indirect effects).

The relationship between alternative search and well-being was also positively mediated by self-distraction and social connection. Those scoring high on the alternative search subscale were more likely to use self-distraction ($b = 0.106$, $SE = 0.025$, $p < 0.001$) and social connection strategies ($b = 0.120$, $SE = 0.028$, $p < 0.001$), and greater use of those strategies was associated with increased well-being ($b = 0.271$, $SE = 0.028$, $p < 0.001$ from self-distraction to well-being, $b = 0.227$, $SE = 0.026$, $p < 0.001$ from social connection to well-being).

Decision difficulty was the only dimension of the maximization scale that showed negative indirect relationships to well-being through coping strategies. Decision difficulty negatively related to cognitive

appraisal ($b = -0.033$, $SE = 0.014$, $p = 0.021$), self-distraction ($b = -0.074$, $SE = 0.021$, $p < 0.001$), and social connection ($b = -0.100$, $SE = 0.022$, $p < 0.001$). In addition, less use of these coping strategies during the pandemic reduced well-being.

Consistent with the previous model using the global maximization scale, we found inconsistent mediations linking three maximization subdimensions to well-being through coping strategies. Although those who scored high on high standards, alternative search, and decision difficulty tended to show lower well-being, the maximizing tendencies represented by high standards and alternative search led people to practice coping strategies more, and the increased coping efforts in turn enhanced well-being.

4 Discussion

This study is one of the first studies examining coping strategies as mediating mechanisms underlying the relationship between maximizing and well-being. We found that maximization, as measured by an overall maximization index and three subdimensions (i.e., high standards, alternative search, and decision difficulty), was negatively related to well-being. However, at the same time, higher maximization, excluding decision difficulty, led to greater use of coping strategies, which, in turn, increased well-being during the COVID-19 pandemic. The findings confirmed the inconsistent mediation between maximization and well-being via coping strategies, and showed that maximization has double-edged effects on well-being.

4.1 Positive aspects of maximizing tendency in the COVID-19 pandemic

Maximization has long had a negative reputation, with many studies showing negative relationships between maximization and

TABLE 4 Bootstrapped estimates of unstandardized total, total indirect, and indirect effects from three subdimensions of maximization (or maximization index) to well-being via coping strategies.

	Total effect (IV-DV)			Total indirect effect (IV-M and other Ms-DV)			Indirect effect (IV-M-DV)		
	<i>b</i> (<i>SE</i>)	95% CI	<i>p</i>	<i>b</i> (<i>SE</i>)	95% CI	<i>p</i>	<i>b</i> (<i>SE</i>)	95% CI	<i>p</i>
IV: Maximization M: Preventive measures DV: Well-being	−0.454*** (0.040)	−0.532, −0.375	0.000	0.023 (0.015)	−0.006, 0.053	0.124	0.007* (0.003)	0.001, 0.012	0.030
IV: High standards M: Preventive measures DV: Well-being	−0.044 (0.034)	−0.111, 0.023	0.200	0.033* (0.013)	0.007, 0.059	0.013	0.011* (0.004)	0.002, 0.020	0.013
IV: High standards M: Cognitive appraisal DV: Well-being	−0.044 (0.034)	−0.111, 0.023	0.200	0.033* (0.013)	0.007, 0.059	0.013	0.013* (0.006)	0.001, 0.026	0.031
IV: Alternative search M: Self-distraction DV: Well-being	−0.151*** (0.043)	−0.235, −0.067	0.000	0.059*** (0.016)	0.029, 0.090	0.000	0.029*** (0.007)	0.014, 0.043	0.000
IV: Alternative search M: Social connection DV: Well-being	−0.151*** (0.043)	−0.235, −0.067	0.000	0.059*** (0.016)	0.029, 0.090	0.000	0.027*** (0.007)	0.013, 0.041	0.000
IV: Decision difficulty M: Cognitive appraisal DV: Well-being	−0.239*** (0.035)	−0.307, −0.171	0.000	−0.056*** (0.012)	−0.080, −0.033	0.000	−0.013* (0.006)	−0.025, −0.001	0.027
IV: Decision difficulty M: Self-distraction DV: Well-being	−0.239*** (0.035)	−0.306, −0.172	0.000	−0.056*** (0.012)	−0.080, −0.033	0.000	−0.020** (0.006)	−0.032, −0.008	0.001
IV: Decision difficulty M: Social connection DV: Well-being	−0.239*** (0.035)	−0.306, −0.172	0.000	−0.056*** (0.012)	−0.080, −0.033	0.000	−0.023*** (0.006)	−0.034, −0.012	0.000

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

well-being (e.g., Schwartz et al., 2002; Purvis et al., 2011; Oishi et al., 2014; Cheek and Schwartz, 2016). It is only recently that some scholars have raised skepticism regarding the negative associations and turned their attention to potential positive aspects of maximization (e.g., Kokkoris, 2016; Misuraca et al., 2016; Zhu et al., 2017; Peng et al., 2018; Schei et al., 2020; Brannon, 2021; Ma et al., 2021; Li et al., 2023). Li et al. (2023) found that students with a strong maximizing tendency have better adjustment skills after their first year of studies and attain higher GPAs upon completing their bachelor's degrees. Peng et al. (2018) also demonstrated the inconsistent mediation between maximizing and subjective well-being (SWB). In their study, two competing indirect pathways simultaneously existed between maximizing and SWB. Specifically, maximizing often results in

feelings of regret, which can have a negative impact on SWB. On the other hand, maximizing can also generate strong feelings of hope for success, which are positively associated with SWB.

The present study extended the findings of previous studies by examining possible positive indirect paths from maximization to well-being through coping strategies. Maximizers were likely to engage more in specific coping strategies to address the challenging situations caused by the COVID-19 pandemic. The increased use of coping strategies, in turn, positively affected their well-being. These findings are well aligned with the growing body of literature on the positive side of maximization tendencies. Maximizers have increased concern for the future impacts of their current actions (Misuraca et al., 2016; Zhu et al., 2017) and they desire to make the best choice among

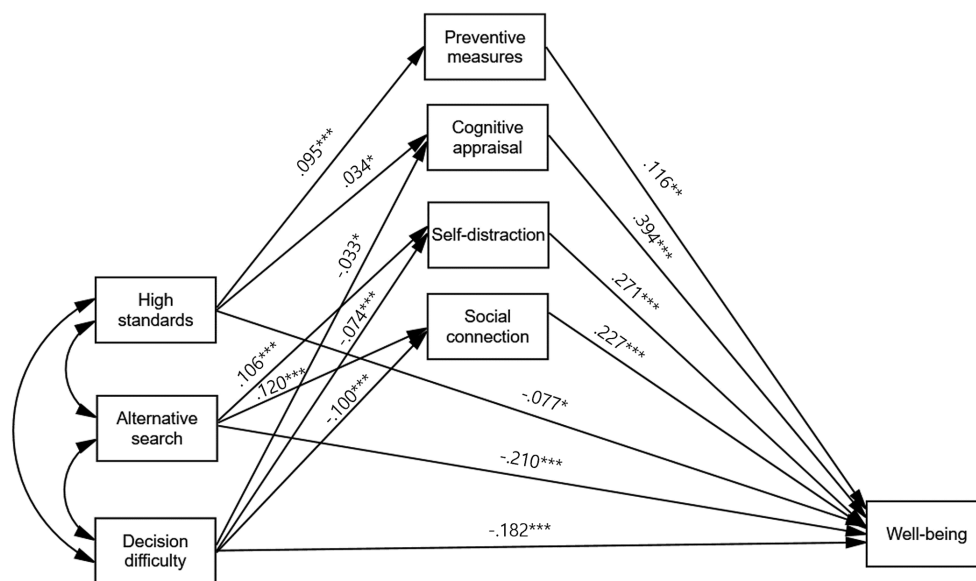


FIGURE 3

Parallel mediation model from three subdimensions of maximization to well-being via coping strategies. Only significant unstandardized estimates are present. Model fit: $\chi^2 [5] = 17.733$, $p = 0.003$, CFI = 0.992, TLI = 0.937, RMSEA = 0.027, SRMR = 0.007. Statistical controls include sex (Male = 1) and two age groups (Reference group: Age_{10s–20s}. Comparison groups: Age_{30s–40s}, Age_{50s and over}), but they were not depicted in the figure for model simplicity.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

alternatives (Schwartz et al., 2002; Cheek and Schwartz, 2016). Schwartz et al. (2002) addressed that maximizers tend to show increased coping efforts under stressful situations and their maximizing strategies can give rise to positive outcomes. Their high achievement motivation (Peng et al., 2018), additionally, functions as a stronger internal drive for overcoming the difficulties they face (Te Wang and Eccles, 2013; Michou et al., 2014).

Our findings made an important contribution to the maximization literature by showing that maximizers have unique adaptive strengths, specifically greater motivation to deploy coping strategies, that shine during difficult times such as the pandemic. Moreover, our research demonstrated that the COVID-19 pandemic is a context in which the noble and positive aspects of maximization are highlighted. Previous studies have shown that a maximizing tendency can play a positive role, especially when a limited number of options is available. For instance, although a maximizing strategy undermines well-being as the size of the choice set becomes large, when there are only a small number of choices, a maximizing strategy may actually be the optimal choice strategy (Dar-Nimrod et al., 2009; Álvarez et al., 2014; Cheek and Schwartz, 2016). The COVID-19 pandemic was a situation in which only a restricted number of options were available to cope with the stressors. A maximizing strategy could be particularly helpful in such conditions. In addition, in the face of the COVID-19 pandemic, governments implemented strict regulations and urged citizens to adhere to a set of rules in order to prevent the spread of the disease and protect their citizens. According to trait activation theory, the relation between traits and performance differs based on the context, and one of the most straightforward ways to activate traits is by establishing expectations for desired behaviors within a group (Tett and Burnett, 2003). From this perspective, the pandemic situation, marked by high stress, uncertainty, and clear expectations

for following regulations, was the optimal context for the activation of maximizing tendencies, especially in terms of coping. Our findings demonstrating maximizers' greater coping efforts and their positive links to well-being during the pandemic support the idea that maximizing can, in part, be beneficial.

4.2 Differences in the mediation paths by maximization dimensions

The positive mediational links between maximization and well-being via coping strategies were only supported by the maximization index and two subdimensions (i.e., high standards and alternative search). For the decision difficulty subdimension, however, the mediation paths were negative, indicating that decision difficulty decreased the use of coping strategies and well-being. Additionally, each maximization dimension had significant relationships with different types of coping strategies. The maximization index only had a positive relationship with preventive measures, and use of preventive measures in turn was associated with greater well-being. High standards were positively associated with preventive measures and cognitive appraisal, while alternative search had positive associations with social connection and self-distraction. On the other hand, decision difficulty had negative relationships with cognitive appraisal, social connection, and self-distraction.

As shown in the present study, in times of high stress and uncertainty, such as the COVID-19 pandemic, a global maximizing tendency may lead people to set a prominent goal of safety from infection, and more willingly follow preventive measures to achieve the goal they set. This was the case for those with a higher score on high standards, one of the maximization subdimensions. The voluntary practice of preventive measures driven by internal maximizing motivation, not by external

forces induced by the government, may not only reduce fear of infection but also satisfy individuals' needs for safety and enhance their well-being. Previous research has indicated that practicing preventive measures can decrease well-being over time (Kim et al., 2022). However, the present study demonstrated that practicing preventive measures can enhance well-being. The different findings may be because of different study designs (e.g., longitudinal vs. cross-sectional) or target study periods during the pandemic. Future research should investigate whether and how practicing preventive measures affects our mental health by observing their use over a prolonged period of the pandemic and considering various underlying motivations. Another important finding of our study is that individuals who set and maintain high standards tended to use positive appraisal of adverse situations as one of the effective coping strategies to deal with difficulties, and this, in turn, increased well-being. Thus, maximizers' strong motivation to achieve their goals and to deal with physiological and psychological distress is not limited to behavioral approaches but also includes cognitive efforts.

The nature of alternative search may drive people to exhaustively search for as many ways to cope with the negative consequences of COVID-19 as possible, such as engaging in activities or connecting with others remotely. These behavioral strategies were what people tried to alleviate heightened loneliness or boredom due to social distancing, and they were found to buffer the decrease in well-being over the initial period of the pandemic (Kim et al., 2022).

On the other hand, a tendency toward having difficulty with decisions may prevent people from actively dealing with the pandemic by leading them to just consider a variety of coping actions without ever deciding to adopt one and thereby losing chances to successfully mitigate stress caused by the pandemic. In fact, there has been a discussion on whether decision difficulty is a component of maximization or an outcome of it (e.g., Schwartz et al., 2002; Nenkov et al., 2008; Lai, 2010; Cheek and Schwartz, 2016; Cheek and Goebel, 2020). This study provided important empirical evidence on the construct of maximization; decision difficulty was linked to poor stress management skills, while high standards and alternative search were associated with greater coping efforts, ultimately leading to better mental health. This is in line with empirical evidence showing that maximizing has positive correlations with desired traits such as optimism, need for cognition, self-efficacy, and intrinsic motivation when the scale does not include a measure of decision difficulty (Lai, 2010).

The distinct mediation paths depending on subdimensions of maximization and different sets of relationships between maximization dimensions and types of coping strategies call for a fine-grained analysis that can delineate the distinctive nature of maximization dimensions.

4.3 Implications and strengths

Our findings demonstrate the need to explore the positive and unique features of various traits that may not ordinarily be thought of as positive. The maximizing tendency has long been viewed as maladaptive. Indeed, the vast majority of previous research has demonstrated negative associations between maximization and various well-being indicators (Schwartz et al., 2002; Iyengar et al., 2006; Parker et al., 2007; Chang et al., 2011; Dahling and Thompson, 2013; Oishi et al., 2014; Cheek and Schwartz, 2016). However, we identified adaptive aspects of maximizing that are helpful in times

of crisis. Cheek and Schwartz (2016) demonstrated that novel aspects of having a maximizing tendency can be found when considering how maximizing goals and strategies interact with contextual factors and individual differences. Thus, future research should further examine potential situations and moderators that can explore maximization's various characteristics. Similarly, it will be important for future research to explore various psychological traits in diverse contexts to uncover their unexpected features (e.g., loneliness; Zhou et al., 2022).

It is also important to note that our research investigated non-WEIRD (Western, educated, industrialized, rich, democratic) samples that have not been studied much in the maximization literature. In most previous maximization research, participants consisted of WEIRD samples (e.g., Schwartz et al., 2002; Diab et al., 2008; Richardson et al., 2014; Hughes and Scholer, 2017; Cheek and Ward, 2019). However, research studies limited to WEIRD cultures do not show a holistic picture of human psychology; instead, they may provide a biased understanding (Henrich et al., 2010). In addition, some preliminary studies have indicated that the relationships between maximization and well-being vary across cultures (Roets et al., 2012; Oishi et al., 2014; Datu, 2016). For instance, Roets et al. (2012) revealed that the maximizing tendency is a significant determinant of well-being in Western societies, but it still lacks a substantial association with well-being in non-Western societies. Thus, our attempt to clarify the role of maximization in maintaining well-being during the pandemic using a sample from South Korea provided another important piece of empirical evidence for understanding the mechanisms underlying the association between maximization and well-being.

4.4 Limitations and future directions

Our research, however, is not without limitations. First of all, the majority of participants in our sample were female (3,062 females, 87.7%) and young (2,585 people between 14 and 29 years of age, 74.0%). The survey was easily accessed through the Kakao application or website (see footnote 1), and any user could respond to the survey items at any time and multiple times. This way of data collection allowed us to collect a real-time dataset rather than retrospective responses on survey items. However, at the same time, due to voluntary participation, males and very old individuals were underrepresented in our sample. Although the absolute numbers of males (431 males, 12.3%), middle-aged individuals aged 30–49 years (796 people, 22.8%), and older adults aged 50–71 years (112 people, 3.2%) were not small, future research is needed that examines the relationships using more representative samples to increase generalizability.

Second, we only focused on the cross-sectional relationships among maximization, coping, and well-being. Although the maximizing tendency has been regarded as a dispositional decision style that remains relatively stable over time (Schwartz et al., 2002; Dar-Nimrod et al., 2009; Dalal et al., 2015), the design of our study did not permit the identification of cause-and-effect relationships among study variables. Employing a longitudinal approach can take into account the role of maximization in the dynamics of coping and well-being changes and clarify the causal relationships.

Finally, the current findings on the distinct nature of maximization dimensions in relation to coping efforts, especially decision difficulty—the only construct relating to poorer coping efforts—contained some surprises. Further research is warranted to more extensively examine the components of maximization. Indeed, there is still ongoing uncertainty regarding whether maximizing should be understood as a multi-dimensional or a unidimensional concept (Peng et al., 2018), and the measurement of maximizing has persistently presented a significant challenge for researchers within this domain (Cheek and Schwartz, 2016). While many different measures of maximizing have been created, there is no universally accepted approach to assessing it (Peng et al., 2018). Numerous researchers have discussed whether decision difficulty should be considered a component of maximization or a resultant outcome (e.g., Lai, 2010; Cheek and Schwartz, 2016; Cheek and Goebel, 2020). In forthcoming studies, alternative maximizing scales may be employed, specifically separating maximizing from decision difficulty, to clarify the relationship between maximizing and various psychological indicators.

5 Conclusion

During the pandemic, maximization served as a double-edged sword. On the one hand, maximization decreased well-being. However, on the other hand, having a maximizing tendency as assessed by the global index and two subdimensions (i.e., high standards and alternative search) led people to follow preventive measures more closely, appraise the situation positively, and find alternative ways to combat the negative consequences caused by the long-lasting pandemic situation by participating in various activities and making social connections. Ultimately, exploring and using these coping strategies, in turn, helped them to maintain greater well-being. The present study contributes to the growing body of research that addresses potential positive features of maximizing, and the findings on distinct mediation paths depending on subdimensions of maximization call for further studies on the constructs of maximization. This study also has public health implications regarding the importance of presenting a maximizing message during stressful situations such as the current pandemic. Based on our findings, future policymakers can utilize messaging to encourage maximization, highlighting the importance of aiming for the best, exploring various coping options, and putting into practice coping measures without hesitation to achieve greater well-being in times of crisis. An additional intriguing and underexplored area for potential future research is the identification of various contexts other than a pandemic in which a maximizing tendency predicts positive behaviors and outcomes. The potential situations and moderators that can delineate maximization's various characteristics can be further investigated with different research designs (e.g., longitudinal design) and samples from diverse backgrounds. This approach will provide a more comprehensive perspective on maximization.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The dataset is not publicly available due to a non-disclosure agreement with the Kakao Corporation. However, the

analysis dataset used for the present study is available from the Kakao Corporation (together@kakaocorp.com). Requests to access these datasets should be directed to together@kakaocorp.com.

Ethics statement

The studies involving humans were approved by the Institutional Review Board (IRB) at Kangwon National University in South Korea. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YJJ: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. IC: Formal analysis, Writing – review & editing. JHK: Data curation, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1268528/full#supplementary-material>

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Psychological, cognitive, and physiological impact of hazards casualties' trainings on first responders: the example of a chemical and radiological training. An exploratory study

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Background: First responders are among the first to respond to hazards casualties. They might operate in volatile, uncertain, complex, and ambiguous (VUCA) environments. While they have underlined the need to improve their knowledge and training to face these environments, there are few data regarding the stress induced by these trainings. Chemical, biological, radiological, and nuclear (CBRN) hazards casualties' trainings seem to be a good model of "in vivo" stress. First responders must operate in a hostile and encountered environment with a CBRN protective equipment that places demand on their psychological, cognitive, and physiological capacities. Current research recognizes that the activity of the parasympathetic system (PSS) can be used as an objective marker of stress adaptation, measured as heart rate variability (HRV).

Objectives: To compare between baseline and simulation the evolution of the parasympathetic activity (primary outcome), anxiety, emotions, cognitive load, and body posture awareness (secondary outcomes).

Methods: A total of 28 first responders attended to three simulated scenarios requiring CBRN management of casualties. One day before simulation, we collected HRV data (baseline). The simulations' day (pre-, post-simulation) we collected anxiety score (STAI-Y B), emotions (SPANE), cognitive load (NASA TLX), body posture awareness (PAS) and HRV. The morning after we collected the PAS score (recovery). We compare data' evolution between different times of the simulation.

Results: (i) A high level of anxiety at baseline [*Median* 51 (46; 56)] which decreased between pre- and post-simulation ($p = 0.04$; $F = 2.93$); (ii) a post-simulation decrease in negative feelings ($p = 0.03$); (iii) a decrease in body awareness after simulation which returned to the initial level at recovery ($p = 0.03$; $F = 3.48$); (iv) a decrease in mean RR between baseline, pre- and post-simulation ($p = 0.009$; $F = 5.11$). There were no significant difference between times on others analysis of HRV.

Conclusion: Prior to simulation, participants experienced anticipatory anxiety. Simulations training practiced regularly could be one way to combat anticipatory anxiety.

KEYWORDS

CBRN, simulation training, first responders, heart rate variability, parasympathetic system, stress, disaster medicine

1 Background

1.1 The physiological and psychological cost of stress on first responders

As they are often the first to arrive to the scene of an emergency or disaster, first responders face most pressing challenges such as accidents, or hazards casualties (Turner et al., 2016). Occasionally, they might operate in extreme and changing environments that place demand on their psychological, cognitive and physiological capacities and expose them to a higher risk of occupational stress injuries (Antony et al., 2020).

The stress response, initially termed *heterostasis*, refers to a costly mode of functioning that can be contrasted with *homeostasis*, the organism's most economical mode (Delgado-Moreno et al., 2019; Billman, 2020). Each physio-psychological response to a challenge is shaped by the concomitant stress response and the biological scars of earlier responses to past stressful experiences. It involves the body's capacity to recover and return to homeostasis, after experiencing stress. On a physiological point of view, Selye describe three stages of the body's response to stress in the General Adaptation Syndrome (Selye, 1950): (i) The alarm stage: the sympathetic system is activated to release stress hormones like adrenaline to prepare the body for immediate action; (ii) the resistance stage: the body attempts to adapt and cope with the ongoing stressor. Hormone levels, especially cortisol, remain elevated to help the body maintain its resistance to the stressor; and (iii) the recovery stage: when the stressor stops, the parasympathetic system is activated to help the body's recovery. However, when a stressor is too intense or last too long, the body resources are depleted, and the individual enters in the exhaustion stage. In this stage, the physiological response is deficient, and the individual is chronically exposed to stress hormones. The exhaustion stage can cause health issues such as cardiovascular pathology, weakened immune system, digestive disorders, sleep disorders, and mental health disorders like anxiety and depression. Thus, the quality of recovery determines the quality of the stress response during the next exposure.

On a psychological point of view, according to Lazarus and Folkman (1984), stress occurs when an individual perceives

a situation as being beyond his resources and potentially endangering his wellbeing. This process involves both the stressors and the personal resources. The stressors can be external (e.g., environment constraints, operational demands, shift schedules etc...) or internal (e.g., self-imposed expectations, negative thoughts, mind wandering etc...). Resources, on the other hand, encompass various aspects, such as physical and mental capabilities, social support, coping skills, personal traits like neuroticism (Schlatter et al., 2022) and are specific to each individual.

1.2 The impact of changing environment

Responses to environmental change are associated with changes in activity in the autonomic nervous system (ANS), and the enteric components of the visceral motor system that govern smooth muscle, heart muscle, and the glands (Critchley and Harrison, 2013). The neurovisceral integration model (Thayer and Siegle, 2002; Thayer et al., 2012; Smith et al., 2017) describes the role of the ANS in the regulation of emotions, behaviors, and adaptation, in interaction with the central autonomic nervous network (CAN). Environmental change is integrated and processed by CAN brain structures comprised of a set of cortical and subcortical regions (e.g., the hypothalamus, the insula, the prefrontal cortex, the amygdala), linked to parasympathetic activity. For example, the parasympathetic branch of the ANS promotes activation of the prefrontal cortex, which is itself involved in the regulation of emotions (specifically, the extinction of fear, *via* its role in inhibiting amygdala activity). Current theory emphasizes the bidirectional nature of the ANS. The activity of its sympathetic and parasympathetic branches is modulated to initiate physiological and behavioral changes adapted to the demands of the situation. Consequently, cardiac activity is thought to reflect not only muscular and electrophysiological functions, but also the regulatory balance of a higher-level complex neural network (Thayer et al., 2012). Regardless of whether these systems contribute to the maintenance of homeostasis, interindividual differences are found in healthy subjects. Specifically, the higher the basal parasympathetic activity, the more the individual can react to environmental stimuli, and, therefore, the more adaptable he is. Previous study argues that heart rate variability (HRV) may reflect vulnerability to stress and has a role in quantifying physiological elasticity and behavioral flexibility (Kim et al., 2018).

Abbreviations: ANS, autonomic nervous system; CAN, central autonomic nervous network; CBRN, chemical, biological, radiological, and nuclear; HRV, Heart rate variability; HCW, healthcare worker; HP, High parasympathetic; LP, Low parasympathetic; PFB, Paris Fire brigade; PPE, personal protective equipment; VUCA, volatile, uncertain, complex, and ambiguous.

1.3 Enaction and the experience of the individual in their environment

The individual is transformed by interactions with the world; he gives “form to his environment and is at the same time shaped by it” (Varela et al., 2016). Enaction is mediated by both *interoception*, which informs the subject about their state of homeostasis, and *exteroception*, which informs them about the state of their environment (Chen et al., 2021). This sensory engagement modulates the stress response, by adjusting regulatory systems to optimize homeostasis, and maintain health. Together, interoception and exteroception reflect our internal representation of our body in relation to the environment (Suzuki et al., 2013). These perceptions actively contribute to the adaptive response of subjects in environments with physical and psychological constraints (Levit-Binnun and Golland, 2011). The individual’s response relies on *sensory integration*, which refers to the process by which the brain receives a message through the senses and transforms it into an adaptive behavior. Body perception distortions have been mainly studied in clinical subjects, as subjects suffering from fibromyalgia (Viceconti et al., 2022). But less is known on the relationships between stress and body perception distortions in healthy subjects whereas experiments in isolates and/or confines and/or extrem and/or unusual suggest a relationship between the quality of body perception and representation and adaptation to the stressful environment (Le Roy et al., 2023). Adaptive behavior has been defined as the appropriate use of sensory inputs from the body’s receptors and involves two main modalities: ensuring survival (modulation) and relating to the environment (discrimination) (Kilroy et al., 2019). Both functions are essential to the individual’s adaptation to the environment, and are modulated by proprioceptive, interactive, and exteroceptive receptors, which make up the feedback loops involved in alliesthesia. Feedback loops link internal and external sensations, along with interactions between them, while receptors are closely linked to five major brain structures (spinal cord, the thalamus, the limbic system, the cortex, and the cerebellum) (Phelps and LeDoux, 2005). This dynamic process contributes to the stress response, and the maintenance of homeostasis.

1.4 Operating in VUCA environment: a challenge for first responders

Daily, first responders operate in changing environments. In the 90’s, The United States Army War College used the acronym VUCA (e.g., Volatile, Uncertain, Complex and Ambigue) to refer to turbulent and unpredictable environments that could affect and weaken organizations (Barber, 1992). Volatility refers to the rapid and unpredictable changes that occur in the external environment; Uncertainty refers to hesitation, indecisiveness, and the need for organizations to be more flexible to changing circumstances; Complexity refers to the intricate and interconnected nature of challenges faced in the VUCA environment; and Ambiguity represents the lack of clarity and the existence of multiple interpretations or perspectives on a situation (Raio et al., 2022).

1.5 The example of chemical and radiological hazards

One of the hazard casualties that might face first responders are chemical, biological, radiological, or nuclear (CBRN) hazards casualties. CBRN hazards casualties are particularly challenging because their occurrence is rare (Ramesh and Kumar, 2010). Most first responders have never been exposed to real CBRN situations, their level of training and knowledge are often insufficient (Kako et al., 2018). They must face the risk of exposure to life-threatening toxic agents and wear personal protective equipment (PPE) to limit the risk of intoxication and contamination. Several studies report that the use of CBRN PPE is linked to significantly higher stress levels, fatigue, the risk of dehydration, somatic anxiety, and adverse reactions on physical health such as headache, skin disorder and pressure injuries (Swaminathan et al., 2022). The continued use of gloves and respiratory protection also compromises communication, slows down triage and other life-saving activities, and alters external sensory information (Goetz et al., 2011; Blacker et al., 2013; Gómez-Oliva et al., 2019; Merchan and Clemente-Suárez, 2020).

The side effects induced by the use of CBRN PPE can also interfere with the relationship between the first responder and the victim as negative contextual factors triggering nocebo effects in nursing practice and may compromise the patient’s survival (Palese et al., 2019).

In highly demanding situation like CBRN hazards casualties, adequate training and preparation are essential to first responders for maintaining their knowledge and improving their performance. The literature highlights that simulation training can generate a high level of stress in participants (Rebera and Rafalowski, 2014; Bauer et al., 2016). In addition, training in an environment not regularly encountered like CBRN environment, and wearing a CBRN PPE with respiratory protection might further increase participants’ stress levels during their simulation trainings. Data suggest that immersion in non-ecological sensory environments may have deleterious effects on physiological, psychological, and cognitive capacities and lead to inappropriate responses to stress (Le Roy et al., 2023).

A CBRN hazard casualty training with CBRN PPE seems to be a good model of *in vivo* stress to study the psychological, physiological, and cognitive impact on participants and to better understand the stress response under an example of VUCA environment.

1.6 Experimental context

The Paris Fire Brigade (PFB) is the fire department of the City of Paris. It is a military institution that provides fire protection services, technical rescue/special operations services, chemical, biological, radiological, nuclear, and high-yield explosive/hazardous materials response services, and emergency medical response services within Paris and three adjacent departments (Seine Saint-Denis, Val-de-Marne, Hautes-Seine). All year round, 24 h a day, the PFB deploys six ALS ambulances each staffed by an emergency physician, a nurse, and an ambulance

operator. These ambulances form part of the Parisian prehospital rescue system, along with the civilian emergency medical service (called SAMU), serving an area of 762 km² and 7 million inhabitants, and receiving at the 1–1-2 call-center (the public access number for emergency services in France) 3,500 emergency calls per day. These ambulances are specialized in emergency medicine, disaster medicine, management of mass casualties, and CBRN hazards. In case of a CBRN attack in Paris and departments next door, they will be among the first to respond to manage CBRN casualties (SGDSN circulaire n°800, 2011; SGDSN circulaire n°700, 2018).

Whether it is terrorist attack (Tin and Ciotton, 2022), war (the nuclear power plant of Zaporijia in Ukraine targeted by Russian strikes in July 2022), pandemics such as Ebola (Hampton et al., 2023) or COVID-19 (Sachs et al., 2022), current events are a constant reminder that the CBRN threat is always present. Previous studies have focused on fatigue, cognitive, psychological, and physiological stress response in participants wearing PPE compared to control group with participants without equipment in the military (Merchan and Clemente-Suárez, 2020). In this study, the use of PPE produced significantly higher stress, fatigue, temperature, heart rate and somatic anxiety compared to the participants without PPE. Other studies focused only on the physical reactions of the wear on PPE (Jiang et al., 2020; Lin et al., 2020; Zuo et al., 2020).

Based on these findings, we decided to conduct an exploratory study on the evolution of psychological, cognitive and physiological parameters in CBRN PPE during CBRN hazards casualties' management training in first responders for a description of the stress response in an enactive framework.

Our primary aim was to compare between baseline and simulation day (pre- and post-simulation), the evolution of the parasympathetic activity measured by the RMSSD in order to evaluate the physiological stress response using the consensual biomarker of stress adaptation.

Our secondary aims focused the psychological simulation's response. They were to compare (i) during simulation day the evolution of the anxiety score measured by the STAI-Y B questionnaire, positive and negative feelings measured by the SPANE, and cognitive load measured by the NASA TLX score; and (ii) during simulation day and recovery, the evolution of the body posture awareness by PAS score. An exploratory aim focused on the ANS response to the NRBC simulation training and compared between baseline and simulation day the evolution of HRV features analysis such as *time domain analysis*: mean RR, the standard deviation of the normal-to-normal RR interval (SDNN), the percentage of adjacent NN intervals that differ from each other by more than 50 ms (pNN50), *frequency analysis*: low frequency (LF) high frequency (HF); and *non-linear analysis*: the standard deviation of the instantaneous variability of the interbeat interval (SD1), the standard deviation of the long-term continuous variability of RR (SD2), $\alpha1$, $\alpha2$, and sample entropy (the regularity and complexity of the time series).

Our hypothesis was that we might observe at the end of the trainings:

- A decreased RMSSD (primary outcome).

- A degraded psychological functioning (i.e., increased anxiety, increased negative feelings).
- Acognitive overload.
- A decreased attention to body awareness (secondary outcomes).
- Changes in HRV responses due to the stressful training situation (exploratory outcomes) induced by simulation training.

2 Methods

2.1 Design

This pragmatic, exploratory, interventional, low-risk quasi experimental study was conducted with members of the ALS ambulance staff of the PFB, during three successive simulation trainings in chemical and radiological hazard casualties' management.

Each emergency physician, nurse, and ambulance operator of PFB' ALS ambulance staff attend every 2 years to a morning session of three simulation trainings on CRN hazard casualties to manage.

During the simulation training, participants must wear CBRN PPE and respiratory protection. Their task is to manage casualties who have been exposed to factice chemical or radiological agents, and to deploy tactical and therapeutic measures in three, increasingly stressful scenarios: (i) two victims contaminated by a neurotoxic agent; (ii) three victims caused by a dirty bomb with a radio contaminated agent; and (iii) a hostage situation with neurotoxic agent poisoning, and six victims to be treated.

Our study was submitted to the Committee of the Protection of Persons (RIPH2; ID- 2021-A03057–34) Ile de France XI, and received a favorable opinion on November 10, 2022

2.2 Participants

Inclusion criteria were: (i) aged over 18; (ii) being a member of the PFB' ALS ambulance staff; (iii) participating in the simulation training of a CBRN hazard casualty management; and (iv) a recent medical checkup. Exclusion criteria were: (i) refusal to participate in the study; (ii) a heart rhythm disorder; (iii) endocrine pathology (e.g., hyperthyroidism, diabetes); (iv) arterial hypertension; (v) current pregnancy or breastfeeding; (vi) ongoing anti-inflammatory treatment; (vii) ongoing treatment that may affect the heart rate (e.g., beta-blockers, calcium channel blockers, alpha-1 agonists); and (viii) psychotropic treatments. Secondary exclusion criteria were: (i) incomplete psychological and cognitive data, and low Cronbach's alpha; (ii) premature termination of the simulation exercise; and (iii) a poor-quality cardiac bio signal (e.g., artifacts, extrasystoles).

2.3 Measures

A 28-item socio-biographical questionnaire was used to collect standard sociodemographic data such as age, health status, and profession.

2.3.1 Psychological measures

The following psychological measures were used.

The 12-item Postural Awareness Scale (PAS) assesses body posture awareness as two sub-factors, “ease/ familiarity with postural awareness” and “need for attention regulation with postural awareness” (Da Costa Silva et al., 2022). The 12-item Scale of Positive and Negative Experience (SPANE) assesses positive and negative affect (Diener et al., 2010). The State Anxiety Inventory (STAI Y-B) assesses the level of situational anxiety (Spielberger et al., 1983).

2.3.2 Cognitive measures

The 6-item NASA Task Load Index was used to assess subjective mental load (Hart and Staveland, 1988).

2.3.3 Heart rate variability

HRV was measured using heartbeat interval data recorded over a 10-min period using an electrocardiogram (EKG), with the BIOPAC system (MP35 Systems; CE; 1 kHz sampling rate) and three electrodes. The HRV analysis followed guidelines (Malik, 1996; Laborde et al., 2017). Circadian variation was accounted for using the PyHRV python library (Gomes et al., 2019). The following data were also recorded: weight, height, BMI, IMG, smoking habits, most recent alcohol intake (>24 h), most recent caffeine (coffee/ tea) consumption (>1 h), most recent meal (>2 h), most recent physical activity (>12 h), and sleep quality on the day of the simulation exercise, and the previous day. Raw EKG data were filtered between 3 Hz and 45 Hz using a finite impulse response bandpass filter. The filter order was set to 300 (0.3 times the sampling rate). R-peaks were automatically detected using the BioSPPy python library (Carreiras et al., 2015). Once the signal had been filtered, a Hamilton segmentation was performed, followed by an R-peak correction with a tolerance set to 0.05. The validity of the R-wave detection was manually examined to ensure correct detection. If an EKG sequence was too noisy when viewing the superposition of all QRS complexes, a time interval was manually removed to improve data quality. RR intervals were detected automatically, with the HRV analysis module using linear interpolation, and corrected manually for artifacts and ectopic beats. In the case of outliers, the RR intervals considered as correct were manually modified.

- *Time domain analysis*: time-domain HRV measurements included: mean RR (the mean interbeat interval); SDNN, which is composed of both sympathetic and parasympathetic activity; RMSSD, which reflects parasympathetic activity; and pNN50.
- *Frequency analysis*: frequency-domain HRV measurements complemented time-domain measurements and included the properties of oscillatory components in heart rate dynamics. Spectral density was estimated according to Welch's method: LF sympathetic activity was in the range 0.04 Hz–0.15 Hz, and HF parasympathetic activity was in the range 0.15 Hz–0.4 Hz.
- *Nonlinear analysis*: non-linear HRV indices reflect dynamic and chaotic internal states that other metrics cannot capture. We used the most representative ones: the Pointcaré plot (a graphical representation of the correlation between successive

interbeat intervals); SD1 is associated with a parasympathetic activity; SD2 is associated with sympathetic activity; α_1 (the self-similarity parameter that represents short-term fluctuations); α_2 (the time-series self-similarity parameter that represents long-term fluctuations); and sample entropy (the regularity and complexity of the time series).

2.4 Data collection

The study was presented to participants. They signed the clinical consent form, inclusion and exclusion criteria were checked.

Data were collected at 3 different times:

- *HRV baseline data* were collected a day before the simulation training: HRV data were recorded for 10 min, participants were asked to sit with their knees bent and their palms pointing upwards at rest. The HRV recording took place in the afternoon, 2 h after lunch.
- *Simulation training data* were collected:
 - (i) *Pre-simulation data* were collected just before the three simulation trainings: body awareness (PAS), emotions (SPANE), anxiety (STAI-Y B) and cognitive load (NASA TLX) questionnaires were collected via WEPI with an internet link sent to the participants. HRV data were recorded for 10 min without the PPE and the respiratory protection. Participants were asked to sit with their knees bent and their palms pointing upwards at rest.
 - (ii) *In between simulation 1 data* (i.e., S1) and in between simulation 2 data (i.e., S2) were collected respectively after the first simulation and the second simulation: body awareness posture (PAS), anxiety (STAI-Y B) and cognitive load (NASA TLX) questionnaires were collected via WEPI with an internet link sent to the participants.
 - (iii) *Post-simulation data* were collected at the end of the three-simulation training: body awareness posture (PAS), anxiety (STAI-Y B), emotions (SPANE) and cognitive load (NASA TLX) questionnaires were collected via WEPI with an internet link sent to the participants. HRV data were recorded 15 min after the end of the last simulation, for 10 min without the PPE and the respiratory protection. Participants were asked to sit with their knees bent and their palms pointing upwards at rest.
- *Recovery data* were collected the morning after the simulation training: body awareness (PAS) questionnaire was collected via WEPI with an internet link sent to the participants.

2.5 Data analysis

On the basis of data from Shaffer and Ginsberg (2017) we can estimate the mean RMSDD score at 42, with a standard deviation

of 10. Given that a 32% reduction in post-simulation would be relevant in view of our study on first responders, with a first-species risk set at 5% and power set at 90%, on a two-sided assumption, the number of subjects required for the study was 26 (Shaffer and Ginsberg, 2017).

Data were analyzed using Python (Python Software Foundation, Wilmington, v3.8) and JASP (JASP, Amsterdam, v 0.16.2) with respect to the stress response, the homoscedasticity of variance and the normality of the distribution were confirmed, justifying the use of parametric ANOVA. When these criteria were not met, non-parametric tests were used. For all comparisons, a p -value of ≤ 0.05 was considered statistically significant. A trend was considered when $0.05 < p \leq 0.1$.

3 Results

Twenty-nine members of the ALS ambulance team were volunteers to participate to the study. All were in good health. One participant was excluded, for medical reasons, during the experiment, leaving 28 participants (six women and 22 men, $Age = 32.62 \pm 6.7$ years, range 21–53). Ten people (35.71%) were driver operators, seven (25%) were nurses, and 12 (42.85%) were emergency physicians. Of the six women, four (14.81%) were using contraception (i.e., the pill, a copper intrauterine device). None were taking any medication. Five (17.85%) were smokers, and one (3.57%) had suffered a pneumothorax. Nine (33.33%) declared having previous experience of a major stressful life event. Ten (37.03%) reported occasional use of a stress management technique (i.e., meditation, self-hypnosis, cardiac coherence, autonomous sensory meridian response). Mean height = 175.00 ± 0.00 meters, and Mean weight $t = 75.51 \pm 13.85$ kilos. Due to operational constraints, only 17 participants took part in all three simulations, while the remaining nine took part in two simulations.

3.1 Impact of the simulations on physiological, psychological, and cognitive

Physiological data: HRV data are showed in Table 1.

There was no significant difference on RMSDD between baseline, pre- and post-simulation ($p = 0.36$; $F = 1.02$) (primary outcome).

There was a significant decrease in mean RR between baseline, pre- and post-simulation ($p = 0.009$; $F = 5.11$) as showed in Figure 1A; an increase in $\alpha 1$ between baseline, pre- and post-simulation ($p = 0.008$; $F = 5.2$) as showed in Figure 1B; and an increase in $\alpha 2$ between baseline and pre-simulation followed by a decrease between pre- and post-simulation ($p = 0.03$; $F = 3.45$) as showed in Figure 1C.

The rest of the HRV analysis were non-significant between times.

3.1.1 Psychological measures

State anxiety (STAI Y-B): there was a significant decrease in state anxiety between pre- and post-simulation measures in subjects who took part in all three simulations as showed in Figure 2 [pre-simulation: 51.3 ± 2.7 ($M \pm SD$); in between simulation 1: $48.4 \pm$

4.3 ($M \pm SD$); in between simulation 2: 49 ± 3.95 ($M \pm SD$); post-simulation: 49.1 ± 4.6 ($M \pm SD$); $p = 0.04$; $F = 2.93$]. However, this difference was not observed in subjects who only completed two simulations ($p = 0.25$; $F = 1$).

Positive and negative affect (SPANE): there was a significant decrease in negative affect between pre- and post-simulation measures (pre-simulation: 1.8 ± 0.5 ($M \pm SD$); post-simulation 1.7 ± 0.42 ($M \pm SD$); $p = 0.03$). There was no significant effect on positive feeling between pre- and post-simulation ($p = 0.5$)

3.1.2 Cognitive measures

There was no significant difference in cognitive load between pre- and post-simulation, measures, either in subjects who participated in two ($p = 0.5$), or three simulations ($p = 0.3$; $F = 1.07$).

3.1.3 Body awareness (PAS)

A significative time effect was observed with a decrease observed for ease and body awareness between pre- and post-simulation, along with a return to the initial level between post-simulation and recovery [pre-simulation: 22.4 ± 7.1 ($M \pm SD$); post simulation: 20.6 ± 7.5 ($M \pm SD$); recovery: 22.2 ± 7.8 ($M \pm SD$); $p = 0.038$; $F = 3.48$] as shown in Figure 3.

4 Discussion

Our results confirm that CRN hazard casualties' simulation have an impact on psychological and physiological first responders' capacities, particularly prior the simulation. Indeed, state anxiety (measured using the STAI-Y scale), decreased significantly between pre-simulation and the first simulation, before stabilizing during the following simulations, and negative feelings decreased significantly between pre- and post-simulation. These psychological findings seem to be confirmed by the HRV, as mean RR decreased significantly between baseline, pre- and post-simulation. The time prior the simulation training seems to be a vulnerable moment that may generate anticipatory anxiety in participants. Anticipatory anxiety is frequently observed in simulation trainings, as participants may feel that they will be observed and judged by their peers, generating additional stress (Schlatter et al., 2022). The phenomenon has also been described in skydivers, with an increase anxiety before a skydive (Clemente-Suárez et al., 2017).

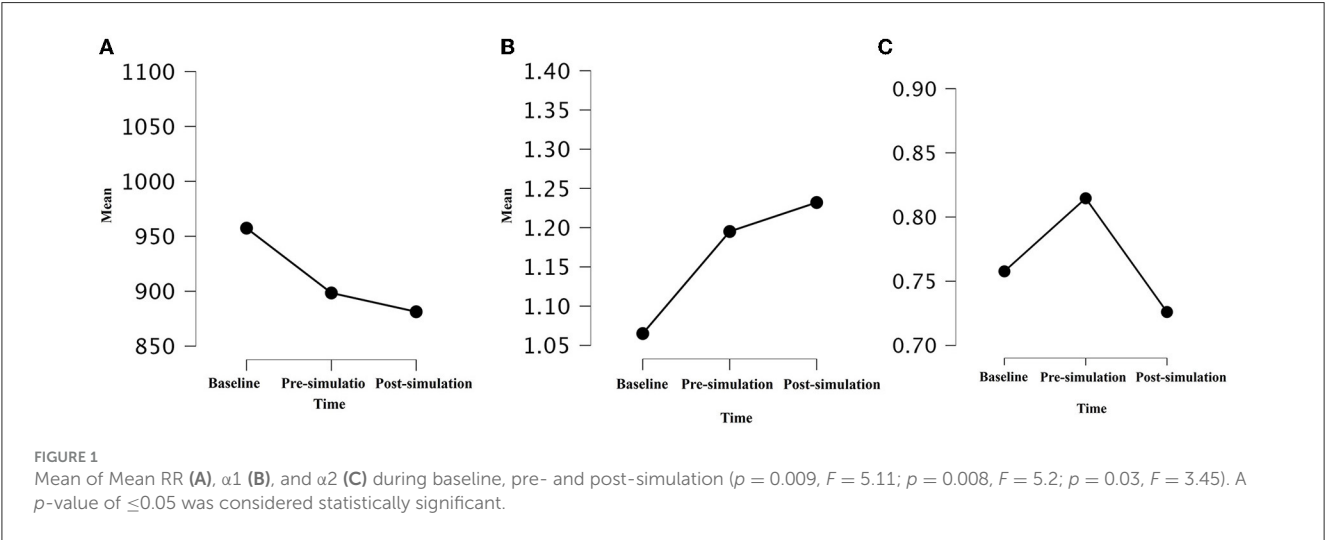
In terms of subjective proprioception, we observed a significant decrease on body awareness between pre- and post-simulation, that return to the initial level at recovery, 24 h later. Thus, this alteration seems reversible and subject to further exploration, it is reasonable to think that a prolonged exercise may have an impact on body postural awareness and on its recovery and to suggest that proprioceptive functioning may be decreased. Emerging reviews show evidence that the SNA, the sympathetic division in particular, routinely participates in postural control (Sibley et al., 2014).

Given all these observations and the experimental context with the wear of CBRN PPE, we were surprised to find no other significant modification on HRV variables, and especially on

TABLE 1 HRV data on baseline, pre-simulation, and post simulation.

HRV data (<i>Mean ± SD</i>)	Baseline	Pre-simulation	Post-simulation	<i>p</i>	<i>F</i>
Time domain analysis					
RMSSD (ms)	51.8 ± 28.8	47.4 ± 25.4	45.8 ± 26.3	0.36	1.02
Mean RR	957.4 ± 147	898.4 ± 119	881.3 ± 129	0.009	5.11
SDDN (ms)	73.9 ± 31.4	75.5 ± 29.9	68.9 ± 25.9	0.39	0.95
pNN50 (%)	31 ± 23.3	24.8 ± 20.6	24.3 ± 21.4	0.2	1.65
Frequency analysis					
LF (ms)	2931.4 ± 2948.9	3160.7 ± 3206	3004 ± 3539	0.88	0.12
HF (ms)	1165.4 ± 1383.1	928.1 ± 1041	845 ± 975.2	0.26	1.3
Non-linear analysis					
SD1	36.6 ± 20.3	33.5 ± 17.9	32.4 ± 18.6	0.3	1.02
SD2	97 ± 40.9	100.5 ± 40	90.88 ± 3.9	0.34	1.07
α1	1.06 ± 0.3	1.19 ± 0.3	1.2 ± 0.3	0.008	5.2
α2	0.75 ± 0.26	0.81 ± 0.31	0.72 ± 0.28	0.03	3.45
Sample entropy	1.32 ± 0.31	1.26 ± 0.34	1.27 ± 0.38	0.4	0.75

A $p \leq 0.05$ was considered statistically significant. SD, standard deviation.



RMSSD between baseline, pre- and post-simulation. Furthermore, the non-linear HRV variables did not change, except the $\alpha 1$ and $\alpha 2$. Short terms fluctuations increased during baseline and pre-simulation whereas long terms fluctuations increased during pre- and post-simulation. This suggests that self-similarity HRV was impact by the simulation.

Studies suggest that human adaptation to a stressful environment may rely heavily on the functioning of the interoceptive network, which provides moment-by-moment awareness (Pinna and Edwards, 2020). Regardless of how exteroception and interoception interact to guide adaptation, the individual's interoceptive capacity is thought to shape their ability to respond to external stimuli in the long term by orchestrating regulatory responses at both the conscious level, through emotions and feelings, and the autonomic level (Chen et al., 2021). Moreover, the link between HRV and interoceptive awareness is becoming

increasingly evident (De Witte et al., 2016). Higher HRV, measured as RMSSD, and better interoception have been associated with better emotional regulation, and better-adjusted behavioral responses. Increased anxiety, rumination, and difficulties in controlling emotions are associated with a decrease HRV (Thayer et al., 2012).

We were also surprised to observe no significant differences in the cognitive load between the three CBRN hazard casualties' scenarios, while their complexity increased.

Based on these findings, we expected to observe changes in HRV, especially in RMSSD, between baseline and simulation like we observed with the psychological and proprioceptive measures. This lack of consistency between physiological, cognitive and psychological measures could indicate that these variables do not capture the same concept. Multiple levels of stress response may explain this finding. In practice, self-reported stress measures, and

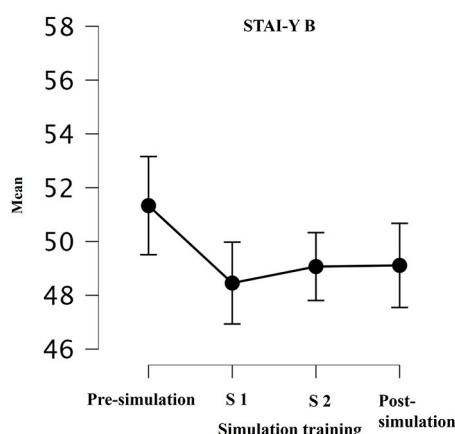


FIGURE 2
Mean of STAI-I during simulation training: pre-training; in between simulation 1 (S1); in between simulation 2 (S2); post-training ($p = 0.02$; $p = 0.04$). A p -value of ≤ 0.05 was considered statistically significant.

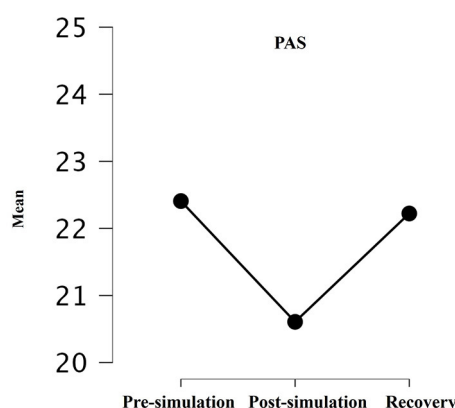


FIGURE 3
Mean of PAS pre-training, post-training, and recovery $p = 0.06$; $p = 0.07$. A p -value of ≤ 0.05 was considered statistically significant; A trend was considered when $0.05 < p \leq 0.1$.

physiological stress outcomes are measured using two different assessment scales: self-administered questionnaires use a Likert-type scale with discrete intervals, while physiological outcomes are monitored continuously, and, most often, non-linearly (Epel et al., 2018).

5 Limitations

Our study shows several limitations. First, our small sample (28 subjects) lacks statistical power, which could explain the lack of significant results regarding psychological and cognitive measures.

Secondly, we did not compare our results with a control group. A control group would have enabled us to distinguish whether the physiological and psychological disturbances were linked to wearing the PPE. With the resources available, a control group

was either an ethical or an experimental issue to us. If we set up a control group under the same training conditions (CBRN hazards casualties) without CBRN PPE, we risked training first responders without the right clinical habits. If we had set up a control group in another hazard casualties that did not require the wear of PPE, the experimental context would have been too different from the specificity of a CBRN hazard casualties. Our operational resources did not allow us to carry out several training sessions with and without the mask, and the goal of our institution is to train first responders correctly according to the guidelines of CBRN hazards casualties.

Another limitation relates to the experimental settings. The chemical and radiological environment was reproduced by scenarios where participants wear CBRN PPE and were exposed to hypothetical radiological and chemical agents and not odorants or real CBRN agents. This implies that first our experimental settings might underestimate the results that we would have been observed with real chemical or radiological agents. With real CBRN agents, we might observe higher score of anxiety in first responders that would have a significant effect on their behavioral and physiological stress response. And, secondly, we did not verify the airtightness of the respiratory protection. Therefore, the participants might not comply respect the strict PPE instructions wearing.

Also, the duration of the simulation trainings (i.e., one morning), might also not be insufficient to observe any significant effects. During the COVID-19 pandemic, the literature report that prolonged duration of PPE use improve the risk of device-related pressure injury (De Coelho et al., 2020; Jiang et al., 2020; Aksoy and Büyükbayram, 2022).

Also, we did not evaluate performance during the simulations, we cannot assess any operational repercussions.

Finally, we did not conduct a longitudinal study due to operational constraints. After training, most participants return to their operational shift and follow-up is complicated. Indeed, recovery HRV measures could have been relevant for better describe impacts on simulation training on HRV stress response as suggest in the vagal tank theory (Laborde et al., 2017).

However, we did not find any difference in terms of HRV, the anxiety level experienced by the participants before and during the simulation may have an impact on the learning process and the effectiveness of training in simulation (Foronda et al., 2013) according to the participants' psychological profiles (Stein, 2022).

It is important to take this stress into account to adapt the learning process so that participants can benefit as much as possible from simulation trainings. Practitioners generally show higher performance when they practice regularly (Lund-Kordahl et al., 2019). The lack of CBRN experience of first responders is likely to generate additional anticipatory anxiety to the anxiety classically generated by other hazard casualty situations (Kako et al., 2018). If the CBRN hazard casualties lasted longer, anticipatory anxiety could have a deleterious effect on the first responders' physiological and cognitive capacities. This additional component of the CBRN environment needs to be considered in the training. Simulation training based on critical situations or hazard casualties seems to have positive and rapid effects on stress and anxiety, and should be practiced regularly by first responders to reduce anticipatory anxiety (Couarraze et al., 2023).

During the EBOLA epidemic, and then the COVID-19 pandemic, healthcare worker (HCW) caring for infected patients in high risk-clinical setting have been obliged to wear PPE to limit the risk of exposure to toxic agents (Fischer et al., 2015; Tabah et al., 2020). On the mental wellbeing impact of wearing during these pandemics, studies report high score of somnolence, anxiety, insomnia, depression and fear of contracting the virus (Swaminathan et al., 2022; Vivion et al., 2023). At a time when the world is talking about the possibility of facing new CBRN attacks or new pandemics (Frieden et al., 2021), it seems essential to take into account the physiological, psychological and cognitive costs for the HCW.

6 Conclusion

Our preliminary findings offer a better understanding of the psychological, cognitive, and physiological functioning of first responders under “*in vivo* stress” conditions, and demonstrates that prior to CBRN hazards casualties’ simulation training, participants experienced anticipatory anxiety. If the CBRN hazard casualties lasted longer, anticipatory anxiety could have a deleterious effect on the first responders’ physiological and cognitive capacities that could increase the risk of errors with consequence for both victims and first responders. Further studies recorded over a longer period, with strict control of CBRN PPE tightness, and with real CBRN agents should be pursued to better understand the impact of anticipatory anxiety in the stress response during CBRN simulation trainings. First responders should practice simulations training regularly to combat anticipatory anxiety.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Committee of the Protection of Person Ile de France XI RIPH2; ID-2021-A03057–34. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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LG: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft. BL: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Writing – review & editing. YD: Validation, Writing – review & editing. HL: Funding acquisition, Investigation, Writing – review & editing. DJ: Project administration, Validation, Writing – review & editing. ST: Validation, Writing – review & editing. MT: Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1336701/full#supplementary-material>

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Good reasons for bad behavior: a randomized controlled experiment on the impact of narrative reading and writing on empathic concern, perspective-taking, and attitude

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Background: Empathic concern and perspective-taking may contribute to avoiding stigmatization of adverse health behavior. Narrative writing has been shown to be effective in promoting perspective-taking and empathy. But since narrative writing is time consuming, we tested in the present study narrative reading as an alternative, more parsimonious approach.

Methods: In a randomized controlled experiment, we compared writing a narrative text about a fictitious person who displays disapproved of health behavior to reading such a text and to a control condition in which participants wrote about an unrelated topic. With a sample of $n = 194$ participants, we investigated the impact of writing and reading a narrative text on promoting empathic concern and perspective-taking as well as on attitude change.

Results: We found that both writing and reading a narrative text about the fictitious character increased empathic concern, $F_{(1, 191)} = 32.85$, $p < 0.001$, part. $\eta^2 = 0.15$, and perspective-taking, $F_{(1, 191)} = 24.76$, $p < 0.001$, part. $\eta^2 = 0.12$, more strongly than writing about an unrelated topic. Writing and reading a narrative text also resulted in a more positive attitude toward this person, $F_{(1, 191)} = 17.63$, $p < 0.001$, part. $\eta^2 = 0.08$. Simply reading a narrative text was equally efficient as narrative writing with respect to empathic concern, $p = 0.581$, perspective-taking, $p = 0.629$, and attitude, $p = 0.197$.

Conclusion: The finding that narrative reading is as effective as narrative writing suggests that the readers appear to be able to comprehend and engage with the story being told. When narrative reading is as effective as narrative writing, it can succeed with reduced effort in increasing empathic concern, perspective-taking, and attitude. We discuss the benefits of this approach for reducing stigmatization of adverse health behavior.

KEYWORDS

narrative writing, narrative reading, perspective-taking, empathic concern, attitude, stigmatization

1 Introduction

Many health campaigns aim to reduce negative health behavior in people like drinking too much alcohol, eating sugary food, driving too fast, or smoking while being pregnant (1–3). Nevertheless, a lot of people exhibit negative health behavior at some point in their lives. Observing this behavior can be disturbing to observers and lead to negative attitudes toward the person who is exhibiting this behavior. It is well known that negative attitudes toward other people have far-reaching consequences in many life situations, like the interaction with peers, colleagues, or family members (4); it has been shown that the attitude of employers can be a barrier to employment (5). Since negative health behavior often results in medical treatment, the impact of negative attitude of health care providers toward patients is especially important (6–9). “There is great concern that the attitudes and beliefs of providers will influence the practice of health care and contribute to the documented health disparities” [(10); p. 2]. Therefore, interventions are required facilitating that people are treated without stigmatization in the immediate personal and wider social environment as well as in the health care system.

Empathic concern and perspective-taking may be important for avoiding stigmatization. Empathic concern is an other-oriented emotion that includes a positive worry over another person, whereas perspective-taking comprises the adoption of other people’s point of view and seeing things from their perspectives (11). Empathic concern and perspective-taking could mitigate stigmatization because they foster understanding, combat stereotypes, promote social inclusion, reduce discrimination, and build empathic communities (12–14) [even though empathy has also a downside (15) and has been connected to selfishness (16) and the manipulation and deception of others (17)]. By empathizing with individuals who face stigmatization, people can challenge prejudice, advocate for equality, and create environments where everyone is treated with dignity and respect. There is evidence that narrative writing may be an effective intervention to promote perspective-taking and empathic concern as two basic capabilities for a good communication basis and for fair behavior (10, 18). Even in the context of strong political opinions, narrative writing strategies have the power to improve attitudes toward the outgroup and reduce political polarization (19). Based on the cognitive processing theory of writing (20), the writing process helps writers to make sense, organize their thoughts, and come to sensible conclusions. However, narrative writing is very time consuming and demanding, and thus not suitable for the busy and stressful daily schedule in the health care system. One potentially promising approach more suitable for everyday life is the idea of simply reading fictional narratives. Reading narratives may help people to develop empathic concern for the persons described in the story who show stigmatized behavior. Also, when reading, the readers may imagine the circumstances and specific stressors of people who show negative health behavior (10, 21, 22).

There is preliminary evidence that reading narratives can have an impact on perspective-taking, empathy, and attitude. A previous study has shown that medical experts who read a patient narrative were more willing to engage in shared decision making and to plan more time for medical conversation than medical experts who

have read only factual information about the patient (23). Narrative writing and narrative reading are assumed to promote perspective-taking and empathic concern through several mechanisms (10, 12, 23). These mechanisms include facilitating identification with the characters depicted in a narrative text and eliciting emotional engagement as people may vicariously experience the joys, sorrows, and hardships encountered by these characters. Perspective-shifting may also be encouraged, enabling individuals to adopt alternative viewpoints and consider the world from different perspectives (12). Through these mechanisms, individuals may develop a deeper understanding of others’ perspectives and experiences, enhancing their capacity for empathic concern and compassionate engagement. In the present study, we aimed to directly compare reading narrative texts as a less time consuming and demanding strategy with the well-studied strategy of narrative writing.

We conducted an experimental study to examine whether writing a fictional narrative text about a person who engages in a stigmatized health-related behavior (smoking while pregnant) vs. reading such a narrative text vs. writing about something different (control group) affects people’s empathic concern, perspective-taking, attitude toward this person, and attribution of the stigmatized behavior. Given the theoretical background described above, we stated and pre-registered the following hypotheses:

Hypothesis 1. We hypothesized that writing or reading a fictional narrative text would increase empathic concern (H1a) and perspective-taking (H1b), improve the attitude toward this person (H1c), and make participants attribute that behavior more strongly to the role of external factors of influence (H1d) compared to the control condition.

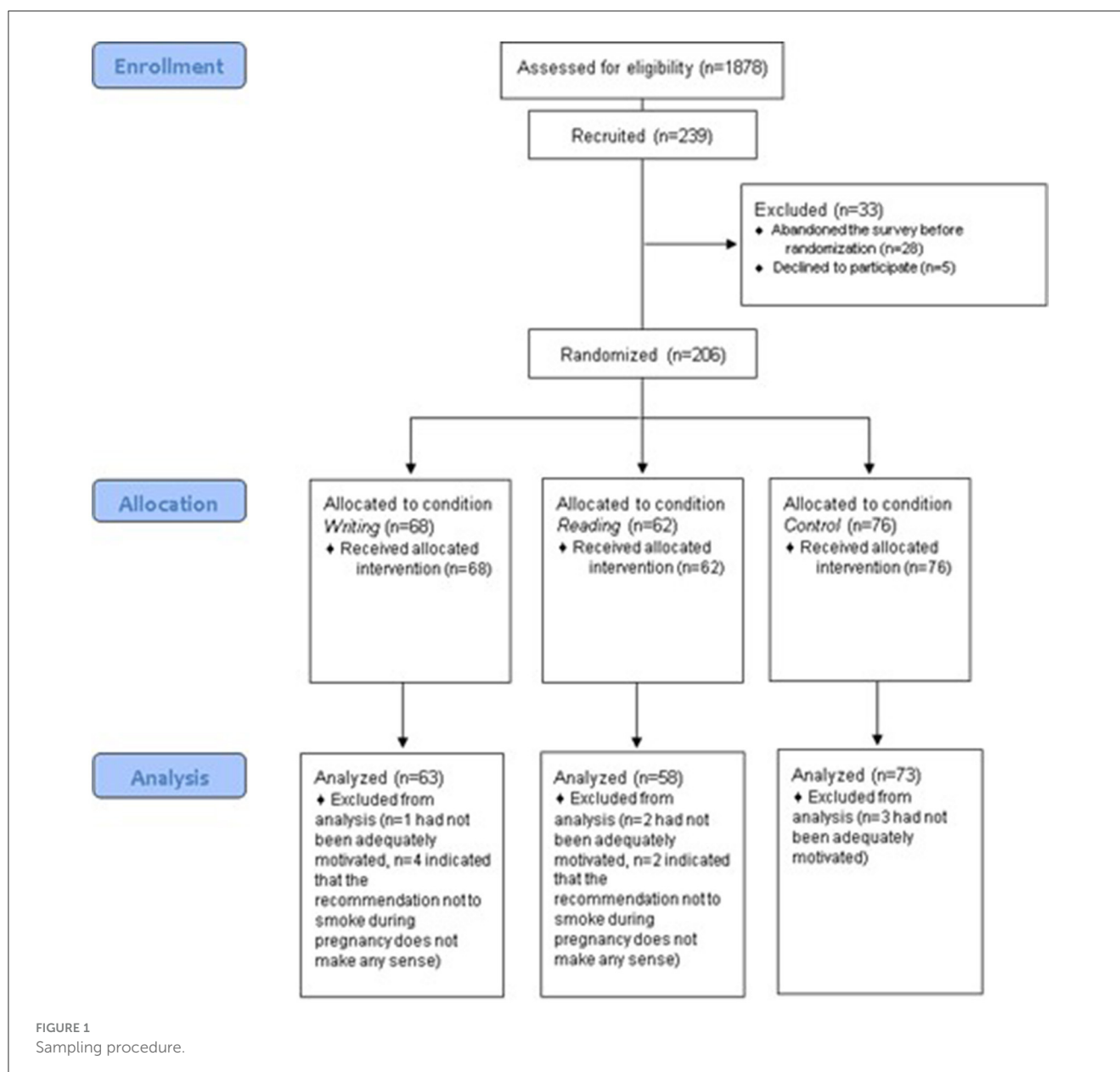
Hypothesis 2. Because writing requires a more active and mindful engagement with the subject matters than reading, we also hypothesized that writing a narrative text would show stronger effects than reading a narrative text, again regarding empathic concern (H2a), perspective-taking (H2b), attitude (H2c), and attribution (H2d).

2 Materials and methods

The experiment that is presented here was part of a larger research project that was approved by the Ethics Committee of the Leibniz-Institut für Wissensmedien (approval number: LEK 2020/032). The study presented in this article was preregistered on the preregistration platform AsPredicted (aspredicted.org) before we began data collection; registration number: #44755; <https://aspredicted.org/fq3ek.pdf>.

2.1 Sample

A power analysis for ANOVAs with $\alpha = 0.05$, an intended power of 95%, and an assumed medium effect size of $f = 0.25$ indicated a required sample size of 189 participants (for main effects of condition). We also indicated that we would exclude those participants (1) who implied that they were not sufficiently motivated during their participation in the study, (2) who did not have suitable German language skills, or (3) who suggested that the



recommendation not to smoke during pregnancy would not make sense to them (i.e., did not recognize smoking during pregnancy as adverse health behavior). We did not at all invite people who were younger than 18 years old or who did not speak German fluently.

We used the online participant recruitment platform Prolific (<https://www.prolific.com/>) to recruit the participants for this study. There were 1,878 potential participants who fulfilled the inclusion criteria and were thus invited to participate in our study. Two hundred and nine people started participation in the study; 45 participants had to be excluded from the data analysis as they did not provide their written informed consent ($n = 5$), canceled the survey before being allocated to the manipulation procedure ($n = 28$), indicated that they had not been sufficiently motivated to participate ($n = 6$), or that the recommendation not to smoke during pregnancy would not make sense ($n = 6$). After these exclusions, the data from the remaining $N = 194$ participants were analyzed (writing condition: $n = 63$ participants; reading condition:

$n = 58$; control condition: $n = 73$ participants). A detailed overview of the sampling procedure can be seen in Figure 1.

Across the entire sample, there were 84 females, 109 males, and one non-binary person. On average, participants were $M = 29.69$ years old ($SD = 10.07$; age range: 18–68 years). There were no group differences regarding gender ($\chi^2 = 2.303$, $p = 0.680$) or age [$F_{(2, 191)} = 0.228$, $p = 0.796$] among the three experimental conditions. Since it is conceivable that smokers would judge the health-related behavior (smoking while pregnant) differently than non-smokers, we asked the participants as control variables whether they were smokers themselves and whether their mothers were smokers at any point during the participants' childhood. There were no group differences regarding these control variables (smoker themselves: $\chi^2 = 1.791$, $p = 0.408$; mother smoker: $\chi^2 = 2.433$, $p = 0.657$) among the three conditions. A detailed overview of demographics and smoking status in the study sample is shown in Table 1.

TABLE 1 Demographics and smoking status in the study sample.

Measures	Writing condition (<i>n</i> = 63)	Reading condition (<i>n</i> = 58)	Control condition (<i>n</i> = 73)
Gender	Male: <i>n</i> = 37	Male: <i>n</i> = 34	Male: <i>n</i> = 38
	Female: <i>n</i> = 26	Female: <i>n</i> = 24	Female: <i>n</i> = 34
	Non-binary: <i>n</i> = 0	Non-binary: <i>n</i> = 0	Non-binary: <i>n</i> = 1
Age	<i>M</i> = 29.27, <i>SD</i> = 9.14	<i>M</i> = 30.43, <i>SD</i> = 10.72	<i>M</i> = 29.47, <i>SD</i> = 10.41
	Range: 18–57	Range: 18–68	Range: 18–63
Smoking status	Smoker: <i>n</i> = 5	Smoker: <i>n</i> = 9	Smoker: <i>n</i> = 10
	Non-smoker: <i>n</i> = 58	Non-smoker: <i>n</i> = 49	Non-smoker: <i>n</i> = 63
Mothers' smoking status	Smoker: <i>n</i> = 21	Smoker: <i>n</i> = 15	Smoker: <i>n</i> = 23
	Non-smoker: <i>n</i> = 40	Non-smoker: <i>n</i> = 42	Non-smoker: <i>n</i> = 46
	Not known: <i>n</i> = 2	Not known: <i>n</i> = 1	Not known: <i>n</i> = 4

2.2 Procedure

The study procedure, instructions, and measures were adopted from studies by Shaffer et al. (10) as well as Bientzle et al. (18). As an extension to these previous studies, the study design presented here was refined by the addition of a reading condition. To conduct the study online, we used the participant recruitment platform Prolific and the online tool Qualtrics Survey Software (Provo, Utah, USA). The randomization procedure was conducted by the Qualtrics Survey Software's random generator with no humans being involved in the allocation. Before starting the survey, participants provided their written informed consent. Then we presented the fictional scenario of seeing a pregnant woman who is smoking a cigarette in a parking lot in front of a supermarket. Then participants answered questions regarding empathic concern, perspective-taking, attitude, and attribution of causes regarding this fictitious person's behavior. After that, the participants were randomly assigned to one of the three conditions.

In the *writing condition*, they received the instructions to compose a narrative text about the pregnant woman. The participants were instructed to imagine this person in a concrete way and to think about possible information about her (such as her name, age, living situation, etc.). The only constraint was that the pregnant woman should be considered to be at least as intelligent as the participants themselves. Then we asked participants to dedicate at least 10 min to write down their text. An automatic timer in the survey prevented them from continuing to the next page sooner than after 5 min. Participants spent *M* = 23.80 min (*SD* = 8.79, range: 9.25–48.15 min) on the task in this condition. Participants' texts had a length of *M* = 217.45 words (*SD* = 75.77, range: 87–348 words).

In the *reading condition*, they received the following instruction: "Earlier we asked you to imagine that you are leaving a grocery store and see a pregnant woman smoking a

cigarette in the parking lot. Please think about this woman. Next, you will receive a fictional text written by another person. The scene is about the woman you saw in the parking lot. Please read the text and try to put yourself in the position of the main character of the text." Then participants read a narrative text about the woman, which was presented on a computer screen (an English translation of this text can be found in [Supplementary material 1](#)). Participants spent *M* = 12.29 min (*SD* = 4.73, range: 6.87–32.65 min) on the task in this condition.

In the *control condition*, participants received the instructions to write a text about the room they were staying in during the study. They also were requested to dedicate at least 10 min to write this text. An automatic timer prevented them from continuing before 5 min of the writing time had passed. Participants spent *M* = 19.47 min (*SD* = 15.15, range: 9.26–126.63 min) on the task in this condition. Participants' texts had a length of *M* = 182.63 words (*SD* = 68.98, range: 82–326 words).

After completing the respective tasks, participants in all of the three conditions answered again the same questions regarding empathic concern, perspective-taking, and attitude. Unfortunately, we made a mistake when creating the study material, with the result that the items regarding attribution were not identical in the pre- and the posttests. Due to this lack of comparability, we had to exclude the attribution items from further analysis. In addition, participants were asked if the recommendation not to smoke during pregnancy would make sense to them, about their motivation while taking part in the study, their demographic data (age and gender), as well as the smoker status of themselves and their mother.

2.3 Material

We used the fictional scenario developed by Shaffer et al. (10). This scenario described the situation of seeing a pregnant woman smoking a cigarette in a parking lot in front of a supermarket. The current study aimed at replicating and extending the findings by Shaffer and colleagues by using an additional study condition (i.e., the reading condition).

2.4 Measures

All dependent variables were assessed twice; initially after participants read the description of the situation (t1) and again after they wrote (writing condition; control condition) or read (reading condition) a text (t2).

Empathic concern and perspective-taking were measured by a German language adaptation (24) of the Interpersonal Reactivity Index (25). It consists of four subscales: perspective-taking, empathic concern, fantasy, and personal distress. In line with the study by Shaffer et al. (10), we used the two subscales perspective-taking and empathic concern in the present study. The four perspective-taking items measured people's capability to put themselves in someone else's place in terms of a cognitive ability. The four items on empathic concern captured people's involvement in someone else's feelings in terms of an emotional capability (11).

TABLE 2 Measurement of perspective-taking and empathic concern.

Perspective-taking		Empathic concern	
Wording used in the present experiment	Original item wording (25)	Wording used in the present experiment	Original item wording (25)
1). I tried to imagine her perspective of the problem.	I sometimes try to understand my friends better by imagining how things look from their perspective.	1). I felt the need to protect the woman.	When I see someone being taken advantage of, I feel kind of protective toward them.
2). I tried to look at the woman's perspective in addition to my own.	I believe that there are two sides to every question and try to look at them both.	2). Just imagining the situation has emotionally touched me.*	I am often quite touched by things that I see happen.
3). Before I criticized the woman, I tried to imagine how I would feel if I were in her place.	Before criticizing somebody, I try to imagine how I would feel if I were in their place.	3). I would consider myself a pretty soft-hearted person, based on how I felt when I imagined the scene.	I would describe myself as a pretty soft-hearted person.
4). When the woman's behavior seemed strange to me, I tried to put myself in her shoes.	When I'm upset at someone, I usually try to "put myself in his shoes" for a while.	4). I had tender feelings for the woman.	I often have tender, concerned feelings for people less fortunate than me.

*not used for analysis because of low internal consistency.

The items were adapted to the fictional situation of the pregnant woman (the original items (25) can be seen in Table 2).

Participants indicated their agreement to the items on a scale ranging from “I don’t agree at all” (0) to “I fully agree” (100). For the perspective-taking sub-scale, the internal consistencies were excellent (Cronbach alpha $\alpha = 0.90$ at t1 and $\alpha = 0.91$ at t2). Internal consistencies for the empathic concern sub-scale at t1 was insufficient (Cronbach alpha $\alpha = 0.55$ at t1); without item 2 the internal consistencies were acceptable to good, however (Cronbach alpha at t1: $\alpha = 0.65$ and t2: $\alpha = 0.75$). Consequently, for the following analysis, the empathic concern score was calculated only from items 1, 3, and 4. All items are shown in Table 2.

We used a feeling thermometer to capture participants’ attitude (26). With this measure people rank their attitude toward the fictitious character on a scale ranging from 0 (negative attitude/“cold”) to 10 (positive attitude/“warm”), with a score of 5 indicating a neutral attitude (see Figure 2).

We conducted the data analysis employing IBM SPSS 25 statistics for Windows. Most variables were not normally distributed. Since simulation studies have disclosed that ANOVAs are robust to normal distribution violations (27, 28), we completed analyses of variance (ANOVA)—with repeated measure analysis, pairwise comparisons, and contrast analyses—to test our hypotheses. In the following results section, we present means (M) and standard deviations (SD); F -values, p -values, and partial eta-squared (part. η^2) as an effect size metric.

3 Results

3.1 Empathic concern and perspective-taking

We found a significant increase in empathic concern for the participants across the conditions; $F_{(1, 191)} = 90.67, p < 0.001$, part. $\eta^2 = 0.32$). At t1, participants indicated less empathic concern for the fictitious pregnant woman ($M = 27.48, SD = 19.71$) than at t2 ($M = 37.92, SD = 22.49$). There was also a significant interaction effect between time of measurement and condition, $F_{(2, 191)} = 16.67, p < 0.001$, part.

$\eta^2 = 0.15$). In Hypothesis 1a, we had assumed that writing or reading a narrative text about the pregnant woman would increase empathic concern more strongly than writing about an unrelated topic. The result of a contrast analysis for this interaction effect with the contrast coefficients [0.5 0.5 -1] supported this hypothesis (H1a), $F_{(1, 191)} = 32.85, p < 0.001$, part. $\eta^2 = 0.15$. The means and standard deviations for all dependent measures split by condition and time can be seen in Table 3.

We also found an increase in participants’ perspective-taking across the conditions; $F_{(1, 191)} = 114.77, p < 0.001$, part. $\eta^2 = 0.38$. At t1, they scored lower on perspective-taking ($M = 40.93, SD = 27.76$) than at t2 ($M = 57.19, SD = 25.58$). Again, there was a significant interaction effect between time of measurement and condition, $F_{(2, 191)} = 12.56, p < 0.001$, part. $\eta^2 = 0.12$). In Hypothesis 1b, we had stated that writing or reading a narrative text about a fictitious pregnant woman would increase perspective-taking more strongly than writing about an unrelated topic. The result of a contrast analysis for this interaction effect with the contrast coefficients [0.5 0.5 -1] supported this hypothesis (H1b), $F_{(1, 191)} = 24.76, p < 0.001$, part. $\eta^2 = 0.12$.

3.2 Attitude

There was a significant effect of time; $F_{(1, 191)} = 95.86, p < 0.001$, part. $\eta^2 = 0.33$. At t1, the attitude was more negative ($M = 1.44, SD = 1.64$) than at t2 ($M = 2.57, SD = 2.13$) across the conditions. In addition, there was a significant interaction effect between time of measurement and condition, $F_{(2, 191)} = 9.80, p < 0.001$, part. $\eta^2 = 0.09$. We had stated in Hypothesis 1c that writing or reading a narrative text about a pregnant woman would result in a more positive attitude toward this person than writing about an unrelated topic. Again, the result of a contrast analysis for this interaction effect with the contrast coefficients [0.5 0.5 -1] supported this hypothesis (H1c), $F_{(1, 191)} = 17.63, p < 0.001$, part. $\eta^2 = 0.08$.

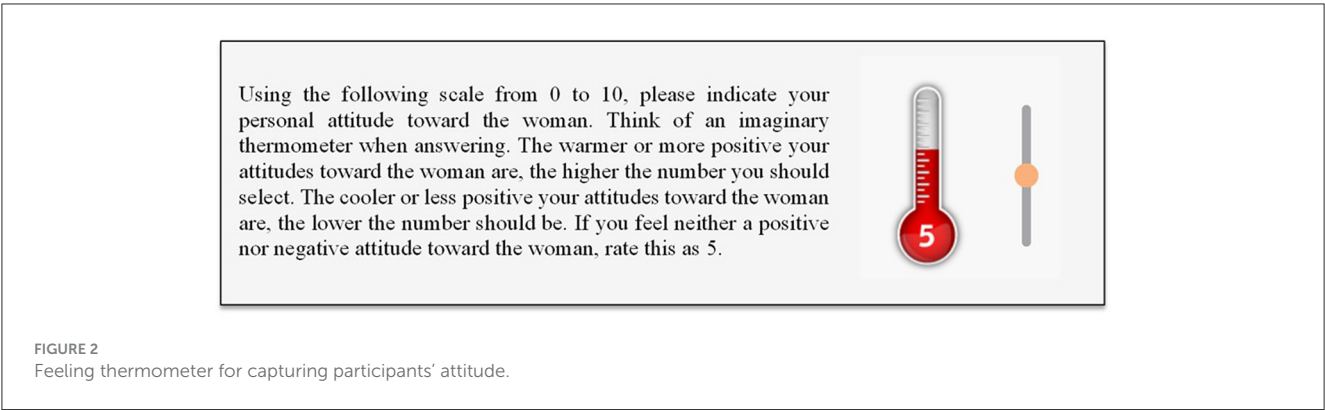


TABLE 3 Means (*M*) and standard deviations (*SD*) for the dependent measures split by condition and time.

			<i>M</i>	<i>SD</i>
Empathic concern	Writing condition	t1	25.93	20.42
		t2	42.28	23.24
	Reading condition	t1	27.53	18.92
		t2	42.26	20.68
	Control condition	t1	28.79	19.86
		t2	30.71	21.63
Perspective-taking	Writing condition	t1	39.76	25.39
		t2	63.03	18.62
	Reading condition	t1	42.26	29.15
		t2	63.61	22.23
	Control condition	t1	40.89	28.91
		t2	47.04	29.94
Attitudes toward the fictitious person	Writing condition	t1	1.35	1.44
		t2	3.05	1.83
	Reading condition	t1	1.47	1.79
		t2	2.78	2.59
	Control condition	t1	1.51	1.70
		t2	1.99	1.83

3.3 Impact of writing vs. reading

We hypothesized that writing a narrative text would show stronger effects than reading a narrative text. The result of a contrast analysis with the contrast coefficients [1 −1 0], however, did not supported this assumption regarding empathic concern (H2a), $F_{(1, 191)} = 0.31, p = 0.581$, perspective-taking (H2b), $F_{(1, 191)} = 0.23, p = 0.629$, or attitude (H2c), $F_{(1, 191)} = 1.68, p =$

0.197. Writing a narrative text did not have any stronger effects on empathic concern, perspective-taking, or attitude than simply reading a narrative text.

4 Discussion

The experiment presented here studied the impact of narrative writing and narrative reading interventions on people’s empathic concern, perspective-taking, and attitude. In line with our preregistered hypotheses, empathic concern, perspective-taking, and attitude toward the fictitious character were modified more strongly in the narrative reading and writing groups than in the control condition. The impact of the reading and writing intervention on perspective-taking and attitude had a medium effect size, the impact on empathic concern even had a large effect. Contrary to our hypotheses, we found no statistically significant differences between the narrative reading and writing interventions. The finding that narrative writing supports empathic concern, perspective-taking, and attitude is in line with previous research (10, 12, 18); the finding that narrative reading is equally supportive extends previous insights in an important way. As the study had a good statistical power, we cautiously interpret this result as an actual non-existent difference between reading and writing a narrative text. Of course, it would be important to confirm this non-existing difference in future research. Until then, it can only be considered as a preliminary finding.

The finding that narrative reading is as effective as narrative writing suggests that the readers appear to be able to comprehend and engage with the story being told, in the same way as if they were the ones creating it themselves. This can be considered as beneficial since narrative reading allows readers to step into the shoes of the characters described and experience their emotions and perspectives. Previous research has already shown that it can be helpful to deal with the personal experiences and emotions of others in the health context (29, 30). This also applies to doctor-patient communication (31). Since the willingness to engage emotionally with other people can lead to increased empathic concern and understanding of others, it may reduce the risk of stigmatizing adverse health behavior. When readers are fully engaged with a story, they are also more likely to analyze and evaluate it critically. This can lead to enhanced critical thinking skills and the ability to identify themes and motifs. Overall, when narrative reading is as

effective as narrative writing, it can succeed with reduced effort in increasing empathic concern, perspective-taking, and attitude.

This approach is particularly beneficial when it avoids stigmatizing adverse health behavior since such stigmatization can have several negative consequences (5, 6). Stigmatization can discourage people from seeking help. When certain behaviors are being stigmatized, it can create a sense of shame and guilt in people who engage in them (32). This can make it less likely that they will seek help or treatment for their health issues, for fear of being judged or stigmatized. Stigmatizing certain behaviors can also reinforce negative stereotypes and contribute to discrimination against certain groups of people (33). Moreover, stigmatization can create barriers to effective care. The stigmatization of certain behaviors can make it more difficult for people to access the care they need. This can happen when health professionals are reluctant to provide care to people who engage in stigmatized behaviors, or when policies and systems are designed in ways that make it difficult for these individuals to access care. Finally, stigmatization can worsen health outcomes by creating stress and other negative emotions, which can in turn lead to poor mental and physical health. This can create a vicious cycle where stigmatized behaviors lead to poor health outcomes, which then lead to further stigmatization. Overall, stigmatizing adverse health behavior is counterproductive and can have serious negative consequences. Instead, it is important to approach these issues with compassion and understanding, and to focus on providing effective care and support to those who need it. In this report, we have presented a relatively simple way to support these processes.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the Leibniz-Institut für Wissensmedien. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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MB: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. ME: Conceptualization, Methodology, Writing – review & editing. JK: Conceptualization, Funding acquisition, Methodology, Project administration, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Health literacy and self-management among middle-aged and young hypertensive patients: a parallel mediation effect of illness perception and self-efficacy

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Background: Hypertension is increasingly prevalent among young and middle-aged populations in rural China, accompanied by suboptimal self-management. Given that this population forms the backbone of the labor force, enhancing their self-management capabilities is crucial for improving overall population health. Studies indicate that individuals with good health literacy are more likely to effectively manage their health.

Methods: Grounded in the health literacy skills framework, a model was constructed in this study to examine the impact of health literacy on self-management among young and middle-aged hypertensive patients in rural China. Meanwhile, the mediating roles of illness perception and self-efficacy were also verified. Using a multi-stage stratified random sampling method, 338 patients were recruited to participate in the study. Structural equation modeling was utilized to establish the relationship model, and bootstrap tests were carried out to examine the mediating effects.

Results: The average self-management score was 70.45 ± 11.36 . Health literacy exhibited a positive correlation with self-management (standardized $\beta = 0.372$, $p < 0.001$). The mediating effects through illness perception and self-efficacy were 0.040 and 0.236, constituting 6.68 and 39.31% of the total effect, respectively.

Conclusion: Illness perception and self-efficacy serve as parallel mediators amid the association between health literacy and self-management. Implementing psychological counseling and health education is imperative for augmenting self-management competence and cultivating an adaptive coping mentality.

KEYWORDS

health literacy, self-management, illness perception, self-efficacy, middle-aged and young hypertensive patients

1 Introduction

As accentuated in the “China Cardiovascular Health and Disease Report 2021,” hypertension constitutes a salient risk factor precipitating cerebrovascular disease (Report on Cardiovascular Health and Diseases in China 2021, 2022). The hypertensive population has burgeoned to an overwhelming 245 million in China, with a ceaselessly elevating prevalence, especially conspicuous in rural locales. To compound concerns, hypertension is now more prevalent among young and middle-aged demographics, culminating in a significant increase in incidence (Zhang et al., 2021).

Self-management is defined as the individual’s ability to manage the symptoms, treatment, physical and psychosocial consequences, and lifestyle changes inherent in living with a chronic condition (Lorig and Holman, 2003). Self-management in hypertensive patients can cover multiple aspects, including but not limited to: blood pressure monitoring, medication adherence, lifestyle management, and symptom management (Glynn et al., 2010). Research consistently reveals that enhancing self-management abilities among chronic disease patients significantly boosts overall health (Allegante et al., 2019). Effective self-management positively influences hypertension treatment and control, lowering the probability of poor blood pressure regulation (Qu et al., 2019), diminishing complication rates (Dickinson et al., 2006), easing disease burden (Long et al., 2017), and even enhancing quality of life (Stuart-Shor et al., 2012). However, young and middle-aged hypertensive patients in China often fall short in self-management proficiency (Wang and Liu, 2018). Early in hypertension symptomatology, patients frequently underestimate condition severity, leading to inadequate treatment (Wang et al., 2017). Proactive self-management typically arises only upon awareness of severe complications, such as stroke (van Bussel et al., 2019). Given the pivotal role of young and middle-aged adults in the labor force and the profound impact of their health on national well-being, research attention has increasingly focused on understanding self-management levels in hypertensive patients within this age bracket. Thus, comprehensive examination of self-management status among young and middle-aged hypertensive patients in rural communities is imperative.

1.1 Literature review

The effectiveness of self-management is contingent upon an array of determinants, encompassing individual health literacy, illness perception, and self-efficacy, among other factors.

1.1.1 Health literacy

Health literacy, a term introduced in the 1970s, embodies the understanding of one’s own health, as well as that of their family and community, encompassing awareness of the factors impinging upon it and the knowledge of how to address these issues effectively. An individual possessing an adequate level of health literacy demonstrates the capacity for assuming responsibility not only for their personal well-being but also for the health of their household and the broader communal environment (McQueen et al., 2007; Sørensen et al., 2012). Numerous studies have consistently shown that individuals with good health literacy are more likely to effectively manage their own health. Shaw et al. (2012) and Murphy et al. (2015) conducted studies that

revealed how a lack of health literacy poses a barrier for hypertensive patients seeking to improve their self-management skills. Additionally, Rimando (2015) highlighted the influence of health literacy on patients’ decision-making abilities in self-management (Ishikawa and Yano, 2011). In a study focusing on uncontrolled hypertensive patients, Persell et al. (2020) discovered a significant correlation between lower health literacy and poor self-management across multiple aspects of medication management. The findings collectively underscore the importance of health literacy in shaping the health behaviors and outcomes of individuals with chronic diseases, particularly hypertensive patients. However, it is worth noting that current research has primarily relied on correlational studies. It is crucial to delve into the underlying mechanisms through which health literacy influences self-management.

1.1.2 Illness perception

Illness perception refers to an individual’s subjective experience and understanding of their own health status and illness, making it a vital variable in the realm of chronic disease management (Leysen et al., 2015). Research has indicated that illness perception can influence patients’ coping behaviors (Liu et al., 2021), and addressing negative illness perception can effectively enhance patients’ ability to self-manage their condition (Xiong et al., 2023). Illness perception plays a crucial role in the self-management of hypertension, with strong associations observed between favorable disease control perception and adherence to medication usage, as well as self-monitoring (Lu et al., 2022); treatment control, risk factors, and psychological attributions, among other factors, can influence compliance with self-management recommendations (Chen et al., 2009). Moreover, a significant correlation has been established between health literacy and illness perception (Pérez, 2015; Shiyanbola et al., 2018). Higher levels of health literacy facilitate enhanced understanding of disease prevention, diagnosis, and treatment, thereby fostering a more objective and rational illness perception. Such accurate disease cognition serves to mitigate misconceptions and anxiety surrounding the condition, fostering active patient engagement and bolstering both the willingness and capacity for self-management.

1.1.3 Self-efficacy

Self-efficacy refers to an individual’s belief in their capability to perform a specific behavior and achieve desired outcomes (Xie et al., 2020). High self-efficacy has emerged as a proven facilitator of patients’ self-management. Extensive research suggests a close relationship between self-efficacy, treatment adherence, and health outcomes among hypertensive patients, making it a crucial factor influencing patients’ commitment to self-management (Zimbudzi et al., 2017). Simultaneously, health literacy empowers patients to attain a deeper understanding of their disease and corresponding treatment regimens, thereby augmenting their sense of self-efficacy, the belief in their capacity to effectively manage their condition. Patients with a robust sense of self-efficacy are more inclined to engage in proactive self-management behaviors, such as regular blood pressure monitoring, adhering to prescribed medication regimens, and maintaining a healthy lifestyle. Consequently, enhancing health literacy and self-efficacy fosters improved self-management practices, ultimately contributing to more favorable health outcomes (Warren-Findlow et al., 2012; Dinh and Bonner, 2023).

1.1.4 Health literacy skills framework

Health Literacy Skills Framework, proposed by Squiers et al. (2012), is a comprehensive model that delineates how individuals access, evaluate, and apply health information. The framework comprises four main components: factors influencing the development and utilization of health literacy skills; health-related stimuli; health literacy skills required to comprehend stimuli and perform tasks; and the intermediary relationship between health literacy and health outcomes. The HLS theory integrates individual and environmental factors with health outcomes, with a primary focus on understanding the direct and indirect effects of health literacy on health outcomes. Based on the successful research experience of this model in the field of chronic diseases (Wong et al., 2018; Rueda-Medina et al., 2020), this particular investigation defines hypertension as a health-related stimulus, illness perception as the comprehension of stimuli, self-efficacy as an intermediary factor, and self-management as a critical health behavior linked to positive health outcomes. Through the application of structural equation modeling, the study further examines how health literacy, illness perception, and self-efficacy influence self-management among young and middle-aged rural individuals diagnosed with hypertension.

Building on HLS model and existing research findings, we put forward the following hypotheses.

The first hypothesis suggests that health literacy directly influences an individual's ability to self-manage their health. The second hypothesis proposes that health literacy indirectly affects self-management by influencing how individuals perceive their illness. The third hypothesis suggests that health literacy indirectly influences self-management through its impact on individuals' self-efficacy. Treating self-efficacy and illness perception as parallel mediators illuminates how two distinct, empirically validated established psychological pathways, independently influence the association between health literacy and self-management, even if the effect of one variable is weaker or nonsignificant, the other may still exert a significant impact through its unique pathway.

Lastly, the fourth hypothesis posits that health literacy indirectly impacts self-management through both illness perception and self-efficacy. In this pathway, it is hypothesized that illness perception impacts self-efficacy. If patients view their illness as an insurmountable adversity, it may lead to emotional distress which undermines self-efficacy. Conversely, regarding disease in a more positive, adaptive manner as a manageable life challenge could promote an affective state more conducive towards bolstering self-efficacy. This would reinforce patients' conviction in their own ability to adhere to healthcare professionals' recommended prescription regimens and lifestyle modifications. This hypothesis finds empirical corroboration in extant research findings (Lau-Walker, 2004; Lau-Walker, 2006; Knowles et al., 2020).

Overall, we have developed an initial theoretical model (Figure 1).

2 Methods

2.1 Data sources

A multi-stage, stratified random sampling strategy was employed within Sichuan Province to select the study sample. Notably, Chengdu City, characterized by relatively favorable economic conditions, and

three ethnic autonomous prefectures exhibiting relatively impoverished economic circumstances were intentionally excluded from the sampling frame. Among the remaining 17 cities, four were randomly selected: Zigong, Yibin, Mianyang, and Bazhong. Within each of these chosen cities, two villages were randomly picked for questionnaire distribution.

Eligibility for inclusion in the sample was determined according to the following criteria: participants aged between 18 and 59 years, with a clinical diagnosis of hypertension, voluntarily consenting to participate in the study, and providing written informed consent by signing the designated consent form.

Exclusion criteria for the sample comprised the following: individuals suffering from severe mental disorders, confusion, impaired communication, or uncooperative behavior; those with malignant tumors, severe cardiac pathologies, or other grave comorbidities; and patients with secondary hypertension stemming from alternative etiologies.

Data on hypertensive patients were gathered from the family physicians serving each of the sampled villages. These healthcare professionals also played a crucial role in identifying and excluding individuals who failed to meet the established inclusion criteria. A total of 352 questionnaires were administered, out of which 338 were deemed valid, whereas 14 were deemed invalid. This yielded an effective response rate of 96.02%.

2.2 Measurement

2.2.1 Health literacy

The measurement of health literacy in this study utilized the Health Literacy Management Scale (HeLMS) (Jordan et al., 2013), which was translated and culturally adapted. It consists of 24 items distributed across four dimensions. Each item is rated on a 5-point Likert scale, with a maximum score of 120. Individuals obtaining higher scores are regarded as possessing higher levels of health literacy, with those scoring above 96 are considered to have a high level. The internal consistency reliability of the scale was assessed using Cronbach's alpha coefficient, resulting in a value of 0.896.

2.2.2 Illness perception

The measurement of illness perception utilized the Brief Illness Perception Questionnaire (BIPQ) developed by Broadbent et al. (2006). It consists of 9 items distributed across 3 dimensions. The scoring for the first 8 items ranges from 0 to 10, with a maximum total score of 80. Higher scores in patients indicate a greater perceived disease burden. The 9th item is an open-ended question. In this study, the standardized Cronbach's alpha coefficient for the scale was calculated to be 0.807.

2.2.3 Self-efficacy

The self-efficacy scale used in this study was the Chinese Hypertension Self-Efficacy Scale developed by Ji Shaorong in 2015 (Shaorong, 2018). It includes 4 dimensions and 11 items. Each item is rated on a 0–4 scale, with a maximum total score of 44. An individual's higher score represents a greater level of confidence in their ability to achieve desired outcomes through their actions. The Cronbach's alpha coefficient for the self-efficacy scale was calculated as 0.862.

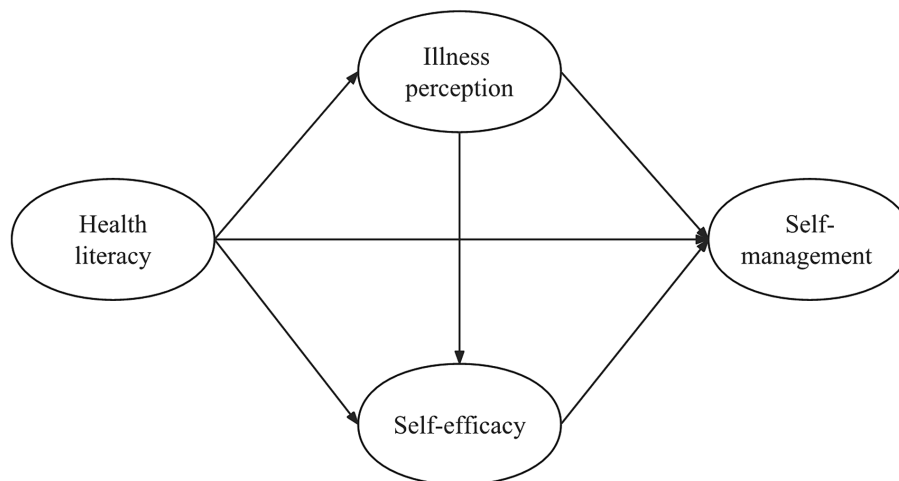


FIGURE 1
Hypothesized structural equation model.

2.2.4 Self-management

The self-management scale utilized in this study was the Chinese Hypertension Self-Management Scale developed by Ning et al. (2015). The scale comprises 21 items distributed across 4 dimensions. Each item is assessed using a 5-point Likert scale, with a maximum score of 105. Individuals with higher scores are considered to possess a higher level of self-management ability. The reliability analysis demonstrated a Cronbach's alpha coefficient of 0.884.

2.3 Statistical analysis

Survey data were entered into IBM Corp's SPSS 26.0, with thorough error correction and missing value resolution to ensure accuracy. Comprehensive statistical analysis followed, employing SPSS 26.0, AMOS 26.0, and the processv34 plugin. A structural equation model (SEM) was first established in alignment with the theoretical model in Figure 1, subsequently refined by eliminating insignificant correlations. The bootstrap method was used to validate mediating effects. Model fit was evaluated using multiple indices: Root Mean Square Error of Approximation (RMSEA) < 0.10, Comparative Fit Index (CFI) > 0.90, Goodness-of-Fit Index (GFI) > 0.90, Normed Fit Index (NFI) > 0.90, Incremental Fit Index (IFI) > 0.90, and Tucker-Lewis Index (TLI) > 0.90 (Browne and Cudeck, 1993).

3 Results

3.1 Patient demographics

This study analyzed a total of 338 valid samples. The age range was 32 to 59 years, with an average age of (51.8 ± 5.9) years. Of the patients, 54.73% were male and 45.27% were female. Among the surveyed samples, the majority (94.67%) were married, 56.21% of the patients had an elementary school education or below, while 39.05% had a junior high school education, indicating a generally low educational level. In terms of residential status, 71.89% of the patients lived

together with their spouses, and 13.91% lived with both their spouse and children. More than half of the patients had a course of hypertension of 3–5 years, and 69.82% of the patients had grade 1 hypertension. The self-management score of the sample was 70.45 ± 11.36 . Additional details can be found in Table 1.

3.2 Correlation analyses

The correlations among health literacy, illness perception, self-efficacy, and self-management were presented in Table 2. As the results demonstrate, significant correlations exist among all four variables, with health literacy showing positive associations with self-efficacy ($r = 0.534$, $p < 0.01$) and self-management ($r = 0.561$, $p < 0.01$). Self-efficacy, in turn, is also positively correlated with self-management ($r = 0.594$, $p < 0.01$). Conversely, illness perception exhibits negative correlations with health literacy ($r = -0.193$, $p < 0.01$), self-efficacy ($r = -0.208$, $p < 0.01$), and self-management ($r = -0.295$, $p < 0.01$).

3.3 Structural equation modeling

A structural equation model was preliminarily established based on the theoretical framework. After confirmatory factor analysis, the model fit indices were as follows: GFI = 0.90, NFI = 0.90, IFI = 0.92, TLI = 0.89, CFI = 0.92, RMSEA = 0.10. However, the path from illness perception to self-efficacy was not significant ($p = 0.38$) and was subsequently removed from the model. The final model, shown in Figure 2, had improved fit indices: GFI = 0.91, NFI = 0.91, IFI = 0.93, TLI = 0.91, CFI = 0.93, RMSEA = 0.095. This indicated a good fit between the model and the data, where all path coefficients and factor loadings were significant in the model.

According to the final model results shown in Table 3, both health literacy and self-efficacy demonstrated a positive association with self-management (std. $\beta = 0.372$, $p < 0.001$; std. $\beta = 0.344$, $p < 0.001$). Conversely, there was a negative correlation between illness perception and self-management (std. $\beta = -0.146$, $p < 0.01$). Moreover, health

TABLE 1 Basic demographics of rural young and middle-aged patients with hypertension.

Variable	Overall (<i>n</i> = 338)
	$\bar{x} \pm \text{SD}/n$ (%)
Age, Mean	51.8 ± 5.9
Age	
Aged 18–45	77(22.78)
Aged 46–59	261(77.22)
Gender	
Male	185(54.73)
Female	153(45.27)
Marital status	
Married	320(94.67)
Single	9(2.66)
Widowed	9(2.66)
Education	
Elementary school and below	190(56.21)
Junior high school	132(39.05)
Technical school or high school	13(3.85)
College or above	3(0.89)
Residential status	
Living alone	36(10.65)
Living with spouse	243(71.89)
Living with children	6(1.78)
Living with spouse and children	47(13.91)
Other	6(1.78)
Course of hypertension	
Less than 3 years	107(31.66)
3–5 years	184(54.44)
6–10 years	29(8.58)
More than 10 years	18(5.33)
Classification of hypertension	
Grade 1 (140–159 mmHg/90–99 mmHg)	236(69.82)
Grade 2 (160–170 mmHg/100–109 mmHg)	85(25.15)
Grade 3 (180 mmHg or higher/110 mmHg or higher)	17(5.03)
Health literacy score	84.44 ± 0.59
Illness perception score	42.32 ± 11.62
Self-efficacy score	28.49 ± 6.95
Self-management score	70.45 ± 11.36

SD, standard deviation.

literacy was found to be negatively associated with illness perception (std. $\beta = -0.291$, $p < 0.001$) while positively associated with self-efficacy (std. $\beta = 0.717$, $p < 0.001$).

3.4 Mediation analysis

The analysis in Table 4 examined the mediating effect of illness perception and self-efficacy on the relationship between health literacy

and self-management, using the Bootstrap method. The results indicate that when considering illness perception as a mediator, the direct effect of health literacy on self-management is 0.561 (SE = 0.048, 95% CI [0.467, 0.656], $p < 0.01$), accounting for 93.32% of the total effect. Its indirect effect is 0.040 (SE = 0.014, 95% CI [0.016, 0.069], $p < 0.01$), accounting for 6.68% of the total effect. In the pathway where self-efficacy serves as a mediator, the direct effect of health literacy on self-management is 0.365 (SE = 0.052, 95% CI [0.263, 0.467], $p < 0.01$), making up 60.69% of the total effect, while its indirect effect is 0.236 (SE = 0.037, 95% CI [0.169, 0.313], $p < 0.01$), contributing 39.31% of the total effect. The overall indirect effect is 0.276, and the total effect through both mediators were identical at 0.602 (illness perception: SE = 0.049, 95% CI [0.506, 0.697], $p < 0.01$; self-efficacy: SE = 0.048, 95% CI [0.506, 0.697], $p < 0.01$).

4 Discussion

The present investigation confirms that health literacy and self-efficacy are critical predictors of improved self-management, whereas illness perception is negatively associated with self-management. Additionally, illness perception and self-efficacy partially mediate the relationship between health literacy and self-management. These findings highlight the importance of mitigating negative illness perceptions and enhancing health literacy and self-efficacy to foster effective self-management among hypertensive populations.

This study examined young and middle-aged hypertensive patients in rural areas and discovered that their self-management scores (70.45 ± 11.36) were inferior to those reported for young and middle-aged hypertensive patients (74.94 ± 3.12) in prior research encompassing both urban and rural inhabitants (Hongchun, 2021). The scores were also marginally below those documented previously among community-dwelling elderly hypertension patients (71.52 ± 8.1) in a study concentrated on urban seniors (Yuan et al., 2019). There could be several reasons for this: Firstly, 56.21% of the patients in this study had an education level of elementary school or below, indicating a lower educational background and limited understanding of health-related knowledge regarding chronic diseases such as hypertension, resulting in weaker self-management awareness. Secondly, rural areas often suffer from a lack of medical resources, incomplete chronic disease management teams, and an inadequate social support system, which contributes to a lack of attention and support for patients. Lastly, the natural environment and infrastructure in rural areas differ from urban areas, with a lack of exercise facilities and a conducive health atmosphere, which limits the improvement of patients' self-management levels.

The results of the structural equation modeling and mediation analysis further validate the theoretical model within the Health Literacy Skills Framework. Specifically, this study examines the intricate relationships between health literacy skills, stimulus comprehension, mediating factors, and health behaviors. Firstly, in alignment with previous research findings (Ishikawa and Yano, 2011; Rimando, 2015; Persell et al., 2020), rural young and middle-aged adults with robust health literacy skills and high blood pressure demonstrate active engagement in self-management practices. A heightened level of health literacy equips individuals with essential tools and knowledge, enabling them to proactively manage their health. These individuals possess a comprehensive understanding of health-related information and resources, including the ability to

TABLE 2 Correlation matrix of health literacy, illness perception, self-efficacy, and self-management.

Variables	Health literacy	Illness perception	Self-efficacy	Self-management
Health literacy	–			
Illness perception	–0.193**	–		
Self-efficacy	0.534**	–0.208**	–	
Self-management	0.561**	–0.295**	0.594**	–

** $p < 0.01$.

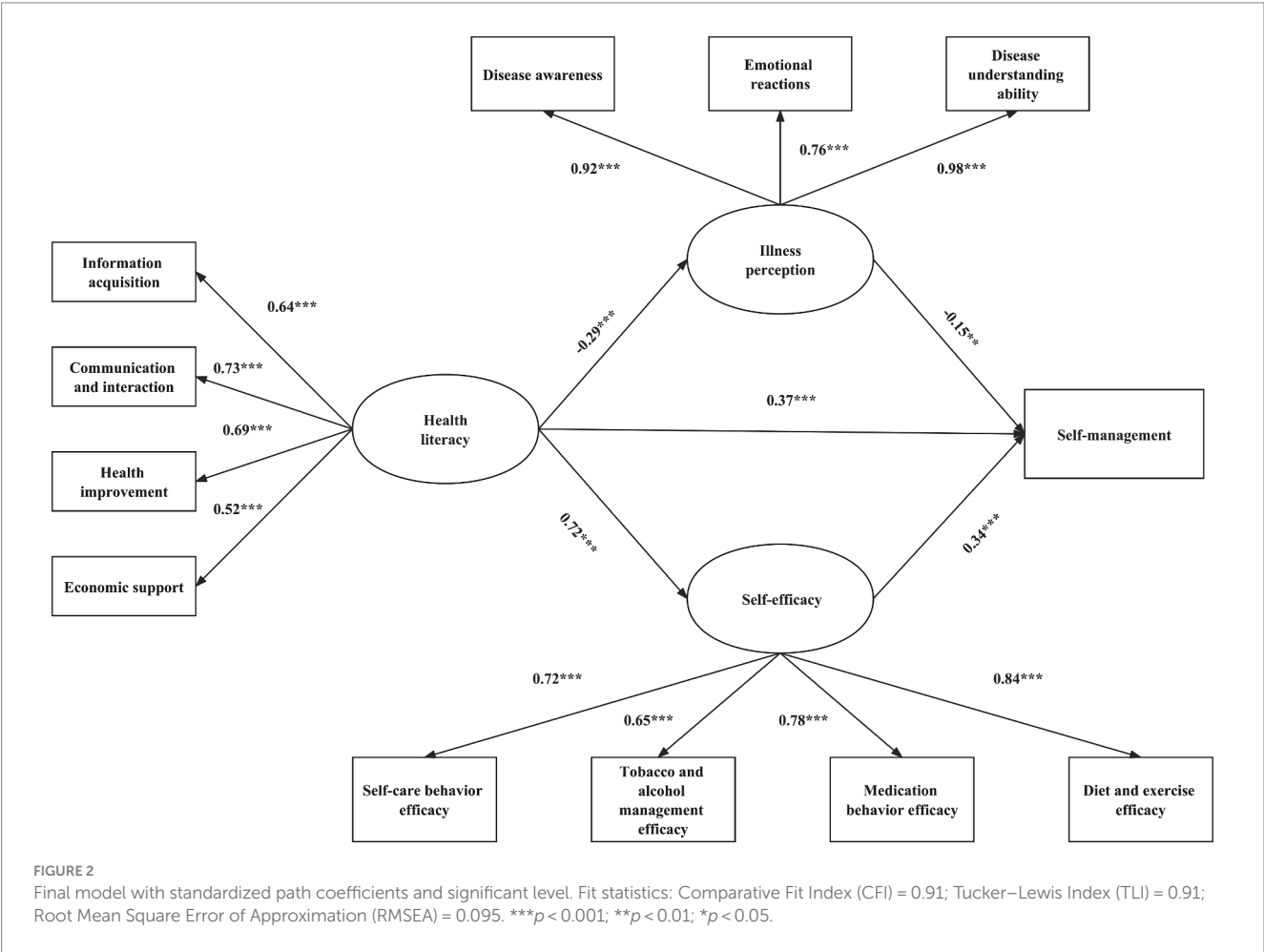


TABLE 3 Path coefficient test for the final SEM model.

Independent variable	Dependent variable	β	S.E.	C.R.
Health literacy	Illness perception	–0.291***	0.686	–4.261
Health literacy	Self-efficacy	0.717***	0.272	7.703
Health literacy	Self-management	0.372***	1.504	4.158
Illness perception	Self-management	–0.146**	0.074	–3.305
Self-efficacy	Self-management	0.344***	0.470	4.197

β , standardized path coefficient; S.E., standard error; C.R., critical ratio. *** $P < 0.001$; ** $P < 0.01$.

comprehend medical instructions, navigate complex healthcare systems, make informed lifestyle choices, and effectively communicate with healthcare professionals (Nutbeam and Lloyd, 2021).

Consequently, they are empowered to make informed decisions and take appropriate actions to safeguard their well-being.

Additionally, patients exhibiting superior health literacy skills demonstrate greater attentiveness and sense of importance towards their health status. They are more likely to accurately perceive and interpret symptoms, signs, and information relevant to their condition, comprehend potential risks and consequences, and possess the knowledge and capabilities to take appropriate actions to manage and mitigate these risks. Thereby, they can better cope with the negative emotional responses triggered by disease stimuli and form positive cognition, alongside adopting proactive self-management measures. These findings provide further support to prior evidence that both health literacy and illness perception play a role in impacting self-management behaviors (Pérez, 2015; Ajuwon and Insel, 2022).

TABLE 4 Mediation effect with illness perception/self-efficacy as the mediating variable.

Mediating variable	Path (Health literacy → Self-management)	Effect value	S.E.	LLCI	ULCI	P-value	Effect percentage (%)
Illness perception	Total effect	0.602	0.049	0.506	0.697	<0.01	–
	Direct effect	0.561	0.048	0.467	0.656	<0.01	93.32%
	Indirect effect	0.040	0.014	0.016	0.069	<0.01	6.68%
Self-efficacy	Total effect	0.602	0.048	0.506	0.697	<0.01	–
	Direct effect	0.365	0.052	0.263	0.467	<0.01	60.69%
	Indirect effect	0.236	0.037	0.169	0.313	<0.01	39.31%

S.E., standard error; LLCI, lower limit of confidence interval; ULCI, upper limit of confidence interval.

On the other hand, individuals possessing competent health literacy have a clearer recognition of their health condition and a more profound grasp and mastery of health knowledge and skills. This enhances their confidence to execute appropriate behaviors and regulate disease progression, thereby amplifying their self-efficacy. This encourages patients to better implement health management know-how in practice, hence strengthening self-management capabilities, alleviating negative impacts, harnessing health risks, and ameliorating blood pressure control (Suarilah and Lin, 2022). Parallely, research has exhibited self-efficacy mediating the association between eHealth literacy and self-care to some degree among chronic disease populations (Wu et al., 2022).

This study furnishes valuable policy insights for the prevention and management of hypertension among young and middle-aged populations residing in rural contexts. Primarily, there is a pressing need to fortify their self-management capabilities. One strategic avenue to accomplish this is through the widespread promotion and adoption of intelligent blood pressure monitoring devices, thereby augmenting the frequency with which patients monitor their blood pressure. Secondly, a holistic approach should be adopted to elevate their health literacy levels. This multifaceted effort may encompass intensified health education initiatives, the promotion of healthful lifestyle habits, and advocacy for the utilization of innovative health monitoring technologies. Thirdly, concerted efforts should be directed towards mitigating negative disease perceptions held by this population. This can be effectively achieved by disseminating relevant health knowledge and evidence-based treatment modalities, thereby bolstering their confidence in the efficacy of therapeutic interventions. Lastly, targeted support should be provided to enhance their self-efficacy. For instance, proactively showcasing success stories of hypertension control among peers can serve to reinforce their capacity for autonomous decision-making and self-regulation, ultimately fostering a heightened sense of self-efficacy in managing their condition.

However, it is important to acknowledge the limitations of this study. Firstly, the survey focused only on young and middle-aged individuals with hypertension in eight rural villages from four prefecture-level cities in Sichuan province. It is possible that there are regional variations in terms of cultural, economic, and other factors that could influence the findings. To obtain more comprehensive results, future research should include a larger geographic area to ensure a more representative sample. Additionally, this study was cross-sectional in nature, which means that it captured a snapshot of

the participants' health literacy, illness perception, self-efficacy, and self-management at a specific point in time. It is unclear whether these relationships will remain constant or change over time. Therefore, conducting longitudinal studies in the future would be beneficial to better understand the long-term dynamics of these variables. Finally, this study was unable to conduct a meticulous subgroup analysis on different age groups in the application of structural equation modeling. Future researchers should develop more targeted study schemes and ensure sufficient sample sizes, in order to realize independent and in-depth discussions on subgroups of different ages, thus making up for this deficiency.

5 Conclusion

Young and middle-aged individuals with hypertension in rural areas exhibit a relatively low level of self-management. Health literacy emerges as a potent positive driver of self-management, with illness perception and self-efficacy functioning as parallel mediators between health literacy and self-management. It is of paramount importance to intensify attention on fostering self-management behaviors among this demographic, augment their health literacy, mitigate negative illness perceptions, and bolster their self-efficacy.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Methods in this study were reviewed and approved by the Institutional Review Board (IRB) of Huazhong University of Science and Technology Tongji Medical College (No. 2023S104) and were in accordance with the 1964 Helsinki declaration and its later amendments, or comparable ethical standards. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

YL: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. FJ: Data curation, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MZ: Formal analysis, Methodology, Project administration, Software, Supervision, Validation, Writing – original draft, Writing – review & editing. HN: Methodology, Software, Supervision, Writing – review & editing. JC: Methodology, Software, Supervision, Writing – review & editing. SD: Methodology, Software, Supervision, Writing – review & editing. HC: Methodology, Software, Supervision, Writing – review & editing. HWa: Methodology, Software, Supervision, Writing – review & editing. LG: Methodology, Software, Supervision, Writing – review & editing. FR: Methodology, Software, Supervision, Writing – review & editing. HWu: Methodology, Software, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Multi-dimensional impact of COVID-19 on active mobility in urban China: a scoping review of empirical knowledge

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Active mobility, such as cycling and walking, is assuming a growing significance in the daily lives of urban residents in China due to its positive impact on health and the environment. The impact of the COVID-19 epidemic has elicited significant changes in behaviors, perceptions, and intellectual viewpoints in this domain, potentially altering residents' physical activities in the long-term. This scoping review seeks to delve into the multi-dimensional influence of the epidemic on active mobility in urban China. A thorough investigation of English and Chinese studies up to January 2024 was conducted, drawing from articles in Web of Science and the Chinese National Knowledge Infrastructure. Only empirical studies providing knowledge into this subject were selected in the review, which comprised 20 studies in total. This review indicates that the influence of COVID-19 on active urban mobility in China has exhibited contradictory outcomes in terms of behavior. Besides, the experiences during the epidemic have significantly shaped citizens' attitudes and understanding of active mobility. The repercussions of the epidemic and the ensuing restrictions exacerbate the existing challenges faced by women, particularly those who are married, the older adult, and individuals with low incomes. The results exhibit both resemblances and idiosyncrasies when juxtaposed with prior research conducted in different nations. This analysis also offers valuable insights for improving active mobility across individual, organizational, and socio-political realms. The current state of empirical understanding in this field underscores the need for further research endeavors employing diverse methodological approaches and increased emphasis on the transformations anticipated in the post-epidemic era.

KEYWORDS

active mobility, physical activity, COVID-19, post-epidemic era, China

1 Introduction

Active mobility, or saying active transportation, is the transport of people or goods, through non-motorized means, based on human physical activity (1), and its best-known forms are walking and cycling. Because of its healthy and environmental benefits, it is an important component of sustainable mobilities (2, 3). In recent years, active mobility has attracted increasing concern all over the world, especially in cities suffering from increasingly serious transportation, health, and environmental issues (4, 5). Urban China is facing an obesity and chronic disease epidemic along with traffic congestion and air pollution due to rapid urbanization, population

aging, and unhealthy lifestyles (6). That's why promoting active mobility is becoming a common governmental response in pursuing sustainable urban development. This is reflected in the implementation of a series of measures represented by urban greenways, pedestrian streets, bicycle-friendly streets, and various kinds of shared bicycles in many cities (7–9).

The outbreak of COVID-19 and its associated constraints have had notable repercussions on the everyday travel patterns of affected citizens (10). This transformation is particularly pronounced within urban areas of China. Leveraging insights gained from the SARS outbreak of 2002–2003, the Chinese authorities have enforced rigorous protocols to limit the movement of their populace in light of COVID-19. Chinese residents witnessed some of the most pronounced and significant alterations in their daily travel routines amidst the epidemic (11–13). A series of empirical studies have discovered the negative relationship between COVID-19, encompassing anti-epidemic policies and measures, and the physical activity levels as well as physical health of Chinese citizens (14–16). Studies in the realm of daily active mobility have revealed that the epidemic has a direct negative impact on the quantity, regularity, distance, and inclination of individuals to engage in active transportation (17–19).

Underlying diminished levels of active mobility, however, some other studies have unveiled a multitude of circumstances. One such instance pertains to the adoption of alternative means of transportation, notably bike sharing, by individuals faced with disruptions in public transit and taxi services during the epidemic. This shift has opened a window of opportunity to encourage more individuals to embrace active travel and to promote greater awareness of the health advantages associated with active transportation (20). Besides, the epidemic has prompted numerous individuals to contemplate the health and environmental advantages of increasing their walking or cycling activities. This alteration in perspective may influence their attitudes toward everyday commuting practices (21, 22). Additionally, the impact of the epidemic on active travel, which entails daily mobility undertaken by diverse individuals for multifaceted reasons, is intricately shaped by sociodemographic variables such as gender, age, income, and other related factors (23, 24). The epidemic might also bring new variations in travel inequalities in affected cities (25, 26). To the best of our understanding, however, a comprehensive evaluation of existing empirical knowledge about how and in what dimensions that COVID-19 impacted Chinese citizens' daily active mobility is currently lacking in scholarly literature.

The void requiring attention arises from the enduring impact of COVID-19, which represents an extraordinary lived encounter for all individuals impacted over an extended duration. This shared collective experience is poised to exert a profound influence on the resurgence and advancement of urban active mobility in the aftermath of the epidemic (27). Consequently, a comprehensive evaluation of the diverse impacts of COVID-19 on active mobility in Chinese cities is vital for advancing sustainable and healthy urban mobility practices in the aftermath of the health crisis. To address this research need, we conducted a scoping review to explore the existing empirical evidence regarding the multi-dimensional impact of COVID-19 on urban active mobility in China.

2 Method

The primary objective of this paper is to examine the empirical knowledge available on the impact of COVID-19 on urban active

transportation in China. To this end, we have utilized the scoping review approach as our methodology. A scoping review is considered an apt tool when the studies being reviewed are heterogeneous, making it impossible to conduct a systematic review or meta-analysis on specific research questions (28). Through the scoping review approach, we aim to provide a comprehensive overview of the research scope, results, and gaps in existing studies (29, 30). Specifically, the study examines the following research questions: (1) What behavioral, attitudinal, intellectual, and situational changes have been discovered and analyzed in relation to Chinese urban active transportation? (2) How were these changes discovered and analyzed? (3) How did they emerge and evolve? (4) What insights do current findings provide for our understanding of Chinese active transportation in the post-epidemic era?

2.1 Data sources and search strategy

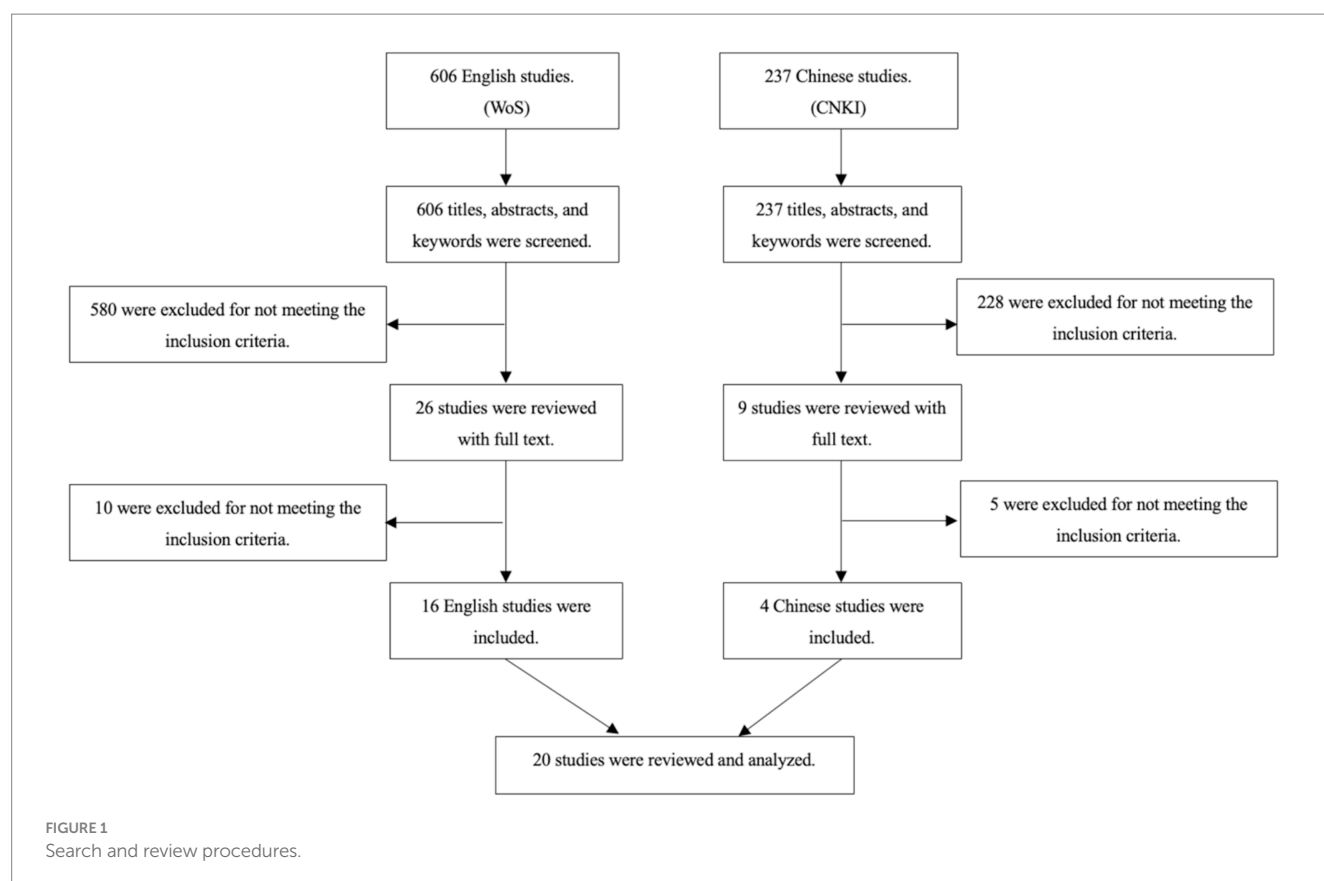
Our inquiry included an extensive review of studies pertaining to the effects of COVID-19 and associated anti-epidemic measures on active transportation in China. Our research scope encompassed empirical studies published in both English and Chinese. On January 29, 2024, we conducted our search for studies published prior to this date.

We conducted a thorough investigation of English language research by utilizing Web of Science (WoS), a comprehensive database that incorporates a variety of indexes such as Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Emerging Sources Citation Index journals and so on. It includes all the concerned disciplines of this review, like public health, transportation, urban studies, environmental science and so on. Our search was constrained to peer-reviewed empirical studies that were relevant to our topic. To limit our search further, we used an array of keywords, including COVID-19 and terms related to active transportation, such as active mobilities, active transportation, active travel, cycling, bike, bicycle, walking, pedestrian, and location (China). We specifically focused on walking and cycling, as these two modes are basic constitutions of active transportation in current China. To ensure an exhaustive search, we did not restrict the categories of studied participants.

Our investigation consisted of conducting a thorough exploration within the Chinese National Knowledge Infrastructure (CNKI) database for empirical studies written in the Chinese language. CNKI is the most widely used and the most authoritative academic database in China (31). Our initial search of relevant keywords translated into Chinese yielded much fewer studies than those available in the English language. Consequently, we adopted a more inclusive approach to our Chinese retrieval to enhance our search results. We incorporated all relevant studies from a search of COVID-19 (“*Yiqing*” / “*Xinguan*”) accompanied by bike/bicycle/cycling (“*Zixingche*”), or walking/pedestrians (“*Buxing*”). Since most of the articles in CNKI were location-specific to China, we refrained from utilizing any location-based keywords. The search and review procedures show in Figure 1.

2.2 Inclusion and exclusion criteria

This review incorporated empirical studies examining active mobilities in China following the emergence of COVID-19. These



modifications included changes in Chinese residents' travel behavior, perceptions, and awareness, as well as modifications in transport-linked infrastructures and built environments, both movable and immovable. Qualitative, quantitative, or hybrid empirical data collection and analysis methods were employed in these studies, with study subjects consisting of Chinese residents with some sort of visible or hidden travel alterations. Given the considerable economic and socio-political disparities between mainland China and Taiwan, Hong Kong, and Macao, this review excluded research carried out in these areas. Master's theses, doctoral dissertations, and conference papers were also omitted from the review because most of them were not peer-reviewed, and it was challenging to assess their research quality.

2.3 Review process

Initially, the authors conducted a thorough review of the titles, keywords, and abstracts of the articles that were selected. Only studies that met the criteria for inclusion received further screening. The authors then undertook a full-text review of the selected studies to establish the final list of included and excluded studies, a process that was conducted independently by two of the authors. If any disagreement between the authors arose, a discussion ensued until a consensus was reached. A detailed depiction of the review procedures was provided in [Figure 1](#). The search yielded a total of 606 research articles in English, of which 580 studies were excluded based on the inclusion criteria after the title, abstract, and keywords screening. A further 10 studies were rejected after the full-text review as they did not meet the required

eligibility criteria. Therefore, 16 studies in English qualified for inclusion after the full-text review. Additionally, a total of 237 articles in Chinese were initially identified, of which 228 studies were excluded after the title, abstract, and keywords screening. After a full-text review, four studies in Chinese met the eligibility criteria for inclusion while five studies were excluded. Thus, a total of 20 studies (16 in English and four in Chinese) were included in this scoping review.

We conducted a coding analysis on the selected articles. Studied travel mode (cycling and/or walking), research subject population, study location, research method, covered pandemic period (for the case city/cities), socioeconomic indicators, and active transportation-relevant behavior, attitude, knowledge, and material/facilities changes were coded. Three authors conducted independent coding, with any discrepancies being thoroughly discussed and resolved through consensus after consultation.

2.4 Limitation of method

The research relies on data sources from SSCI and CNKI. While prior studies have validated the relative representativeness and reliability of these databases for conducting systematic reviews in each language ([31, 32](#)), it is acknowledged that they do not encompass all studies pertinent to the field of active mobility. Consequently, this research overlooks studies published in journals not indexed by these databases. Furthermore, the study's emphasis on credibility is restricted to published peer-reviewed research, excluding other forms such as academic dissertations, working papers, and research reports.

These methodological constraints represent areas for improvement in future research endeavors.

3 Results

3.1 Characteristics of existing research

Of all the 20 studies, six studies focused on walking only (18, 21, 33–36), eight focused on cycling only (17, 22, 24, 37–41), and another six studies included both cycling and walking (23, 42–46). Bike-sharing is a concerned research topic that five studies focused only on it (17, 22, 24, 37, 41), three of which were about dock-less bike-sharing (DBS) (17, 22, 37), one about station-based bike-sharing (SBBS) (24), and one about both kinds (41). 13 studies focused on general urban residents (17, 22–24, 37–45), while another of seven studied specific research populations, like youths (33, 35, 36, 46), middle-aged and older adult people (18, 21) and disabled people (34). The earliest study was published in October 2020.

A survey by questionnaire was the most used method as 13 studies adopted this method (18, 22, 23, 33–36, 38, 40, 43–46), with the sample size range from 127 (22) to 10,082 (35). Secondary analysis of existing data is another commonly used research method based on data collected from relevant companies ($n=4$) (17, 24, 37, 41). There was one study that collected and analyzed citizens' daily steps via a smartphone application (18). Only one research study utilized a qualitative research approach through the execution of in-person interviews (21).

Regarding the location of the studies, of the 20 studies, three were national surveys that did not focus on a certain case city (23, 35, 46), while the other 17 were conducted each in a single city (Figure 2). There were 11 studies that were conducted in cities in the eastern region with well-developed economies, such as Beijing ($n=4$) (36, 38, 43, 45), Shanghai ($n=1$) (37), Nanjing ($n=3$) (22, 24, 41), Zhongshan ($n=1$) (44), Guangzhou ($n=1$) (39) and Shenzhen ($n=1$) (40). Wuhan, the city in the middle region that endured the initial outbreak of the epidemic in China, attracted two studies' attention (17, 42). Changsha and Taiyuan are another two middle region cities that each got one study's attention (18, 34). There was one study conducted in Kunming, a city located in the western region (21). Another one study was implemented in Dalian (33), which was in the northeast region.

In terms of covered epidemic phases of the empirical studies, due to different cities experiencing different periods and durations of the epidemic, we did not adopt a unified time division. Relatively, we divide the epidemic experience of each into three basic phases: pre-pandemic (before the outbreak of COVID-19, generally before the end of 2019), outbreak phase (the initial and most severe stage of the epidemic in the case city, which was also the most strict stage of epidemic control; for national studies, from January 20th to March 10th, 2020 as defined by State Council of China), and the recovery phase (the "new normal" period after the outbreak). In fact, there should be a post-epidemic era that regards the period after the actual cancelation of epidemic control in China on December 7th, 2022, marked by the release of the "New Ten Rules" of COVID-19. But as all current studies were empirically conducted before this phase, we mainly divided all studies into the above three categories. As changes caused by the epidemic were the key concern, 17 out of 20 studies covered more than one period to conduct certain comparisons.

Of the 17 studies, seven covered both pre-epidemic and outbreak phases (18, 22–24, 36, 38, 41), three covered outbreak and recovery phases (42, 44, 45), two compared pre-epidemic and recovery phases (34, 37), and five covered all pre-epidemic, outbreak, and recovery phases (17, 35, 39, 40, 46).

Of the 20 studies, 16 involved findings and explorations on unequal active mobilities among different populations in the context of the epidemic. The two most concerned demographic factors were gender ($n=13$) (18, 21–24, 33, 35, 36, 40, 41, 44–46) and age ($n=9$) (18, 21–24, 40, 41, 44, 45), followed by income ($n=3$) (23, 40, 42), and one study focused on visually impaired people (34). Regarding the language, four were published in Chinese. The other 16 were in English. The characteristics of the reviewed empirical studies were shown in Table 1.

3.2 Studies on behavioral changes in active mobility

The scholarly investigation revealed distinct behavioral shifts in active transportation within China across various phases of the epidemic, as evidenced by all 20 studies. These scholarly inquiries unveiled a paradoxical phenomenon in the realm of Chinese urban active mobility induced by the COVID-19 outbreak. While a reduction in the overall volume, distance, and frequency of active travel among citizens was commonly observed due to apprehensions surrounding the epidemic and implementation of lockdown measures, there was a simultaneous elevation in the utilization and prominence of active mobility during this crisis period.

Of all the 20 studies eight analyzed the changes in walking behaviors in the outbreak period. At the national level, citizens saying they never walked during the epidemic increased by 15.5% (23). Daily steps of Changsha residents aged ≥ 40 years dropped significantly, as their mean daily steps dropped from 8,097 to 5,440 and the prevalence of low daily steps increased from 3 to 18.5% (18). In Zhongshan, residents mainly travel short distances during the outbreak, with walking being the main mode of transportation (44). For the youths, significant decreases were also generally observed in their daily walking behaviors (35, 46). For university students in Beijing, the epidemic produced a 24.36% reduction in total weekly minutes of walking (36). Nevertheless, for university students in Dalian, no correlation was found between the impact of the COVID-19 pandemic and walking behavior (33), which is contrary to the finding in Beijing.

Regarding cycling behavioral change in the outbreak period, seven studies brought us interesting findings under the travel decline preface. On the one hand, it is obvious that cycling decrease significantly because of the epidemic. For instance, in Nanjing, the number of station-based bike-sharing (SBBS) users have been hit hard by the outbreak (22, 24), and SBBS trips in this city fell by 72% (41). SBBS trips at all stations declined, and most stations experienced a drop of around 70%. The trips of another kind of sharing bicycle – dock-less bike-sharing (DBS) – in this city even fell by 82% (41). In Wuhan, a significant decrease in bike-sharing trips also emerged during the outbreak (17).

On the other hand, studies also pointed out the positive functions of cycling and its relative increase in the proportion of daily travel during the epidemic. During the epidemic, especially in the outbreak phase, cycling played a key role in replacing bus and subway (40).

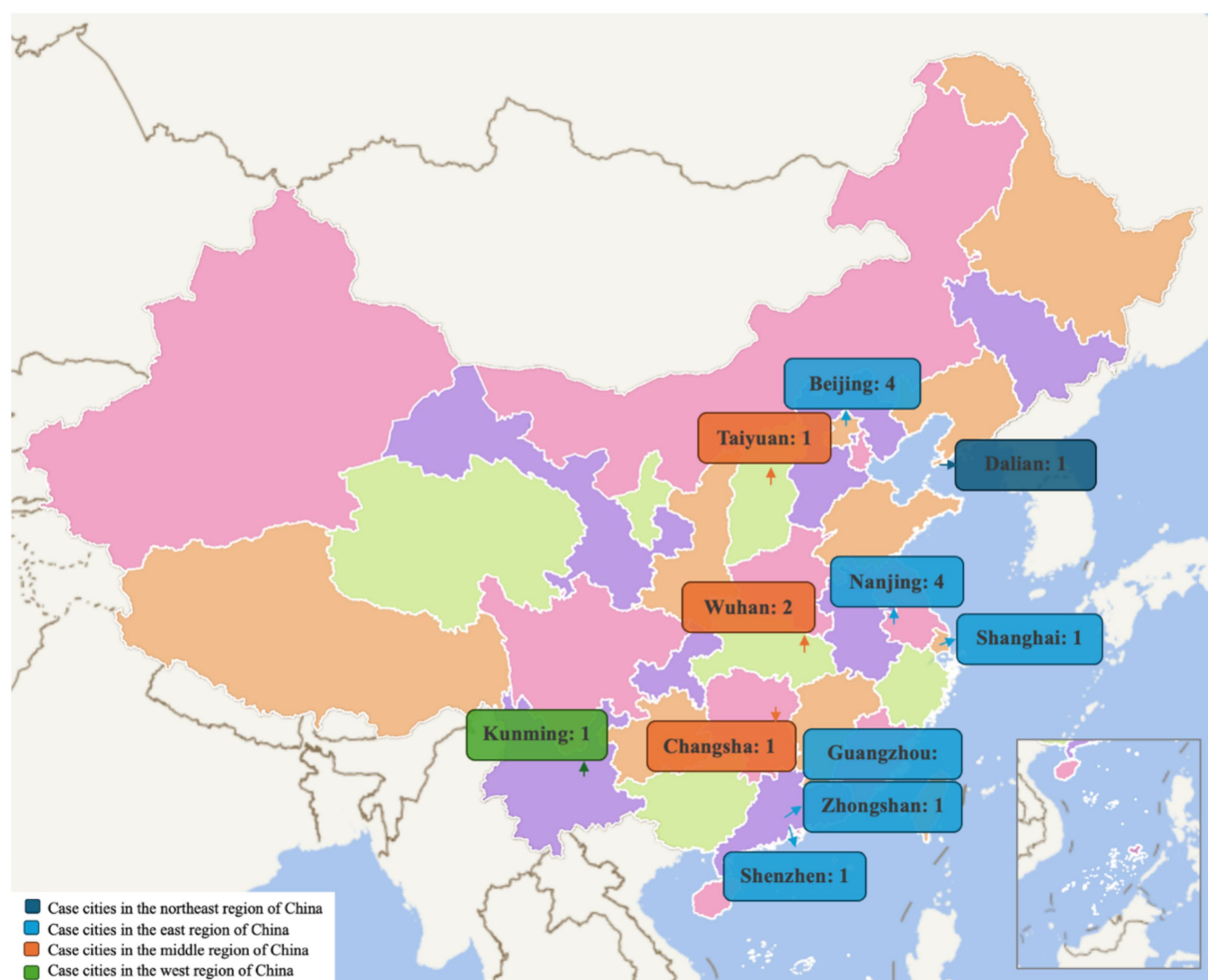


FIGURE 2

Locations of the studied case cities. This figure is made by the authors based on the open-source map provided by National Database for Geographical Names of China. The division of four regions (west, east, middle, northeast) was based on the classification standard promulgated by the government (https://www.stats.gov.cn/zt_18555/ztthd/sjtr/dejtkfr/tjkp/202302/t20230216_1909741.htm, accessed 2 April 2024).

Before the epidemic, the complementary role of cycling was more important than its substitutive role, but during the epidemic, the substitution role of cycling for public transit was enhanced. For instance, the daily trips of Nanjing Metro fell by 95%, which is much more than the drop in bike-sharing trips in this city. The average travel distance of SBBS increased by 32%, and the average travel distance of DBS increased by 16% (41). Furthermore, while the overall travel duration and travel distance of DBS users decreased after the epidemic, the trip frequency of them increased as the travel duration increased (22). And no evident decline in the proportion of commuters in this city was found (from 36.6 to 34.8%) (24). In Beijing, the proportion of bike-sharing increased by 0.89% (38). The user base of DBS in Shanghai increased during the epidemic (37).

The function of cycling also changed during the epidemic. Before the outbreak, the main function of cycling is commuting. It could be proved by obvious morning and evening cycling peaks between 7 am–9 am and 5 pm–7 pm in cities before the epidemic in Wuhan, which, however, were replaced by a unimodal structure with cycling activities concentrated between 11 am and 2 pm during the outbreak phase (17). This change indicated that the purposes of cycling were

more diverse, and cycling played a more important role in residents' daily life and travel. This can also be supported by the relatively low decrease in independent cycling trips compared with cycling and public transit cooperation trips in Nanjing, which reflected that the major role of cycling changed from cooperating with public transport for commuting to independently providing more categories of mobility services (41). Cycling was more adopted for shopping, scenery, health care, and other travel demands (17, 24, 41).

Regarding active transportation changes in the recovery phase, two studies explored walking changes in this stage: one study pointed out that the proportion of walking in all travel within a district in Beijing was 19% (43); another one study pointed out that for the visually impaired people in Taiyuan, despite the absolute amount of walking decreased, the proportion of walking in their daily travel increased from 35.6% (pre-epidemic) to 42.8% (during the epidemic). There were five studies analyzing cycling changes in this period. In general, due to the advantage of cycling in allowing for social distance and being more useful for relatively long-distance travel, the recovery of it is significant and quick. For instance, in Wuhan, the recovery rate of passenger volume reached 39.80% by

TABLE 1 Characteristics of empirical studies about the impact of COVID-19 on urban active transportation in China.

Author	Analyzed active mobility mode	Studied group of population	Data collection method	Location	Covered epidemic phases (in the studied city/area)	Inequality dimension	Language
Wang et al. (2022)	Walking and cycling	General urban residents	A survey by questionnaire (N = 9,010)	Wuhuan, Hubei (Middle)	Outbreak and recovery phases	Income	English
Li and Xu (2022)	Cycling (DBS)	General urban residents	The dataset was provided by Meituan Bike Company	Wuhuan, Hubei (Middle)	Pre-epidemic, outbreak, and recovery phases	Residential area	English
Chen et al. (2022)	Cycling (SBBS)	General urban residents	SBBS smart card data in Nanjing, China provided by Nanjing Public Bike Company	Nanjing, Jiangsu (East)	Pre-epidemic and outbreak phases	Gender and age	English
Barbieri et al. (2021)	Walking and cycling	General urban residents	Online survey (N = 9,394) in 10 countries, including China	China (a national study)	Pre-epidemic and outbreak phases	Gender, age, and income	English
Hua et al. (2021)	Cycling (both kinds)	General urban residents	(1) SBBS trip data were provided by Nanjing Public Bike Company; (2) DBS trip data were provided by Nanjing Transportation Bureau	Nanjing, Jiangsu (East)	Pre-epidemic and outbreak phases	Gender and age	English
Zhou et al. (2022)	Cycling (DBS)	General urban residents	The riding records were provided by Meituan Bike Company	Shanghai (East)	Pre-epidemic and recovery phases	\	English
Liu et al. (2022)	Walking	University students	A survey by questionnaire (N = 429)	Dalian, Liaoning (NorthEast)	Outbreak phase	Gender	English
Zhang et al. (2022)	Cycling (including bike-sharing)	General urban residents	A survey by questionnaire (N = 1,007)	Beijing (Esat)	Pre-epidemic and outbreak phases	\	English
Wang et al. (2020)	Walking	Middle-aged and older people (age ≥ 40)	Daily steps were collected via a smartphone linked to WeChat (N = 3,544)	Changsha, Hunan (Middle)	Pre-epidemic and outbreak phases	Gender, age, and education	English
Yu et al. (2022)	Walking	University students	A survey by questionnaire (N = 1,460)	Beijing (Esat)	Pre-epidemic and outbreak phases	Gender	English
Yang et al. (2023)	Walking	Youths (aged 19.8 ± 2.3 years)	A survey by questionnaire (N = 10,082)	China (a national study)	Pre-epidemic, outbreak, and recovery phases	Gender	English
Liu et al. (2021)	Walking	Older adult people (older than 65)	A qualitative exploration (186 families with a total of 248 older adult people)	Kunming, Yunnan (West)	Outbreak phase	Gender and age	English

(Continued)

TABLE 1 (Continued)

Author	Analyzed active mobility mode	Studied group of population	Data collection method	Location	Covered epidemic phases (in the studied city/area)	Inequality dimension	Language
Shu et al. (2022)	Walking and cycling	General urban residents	A survey by questionnaire (N was not introduced) + field observation	Beijing (Esat)	Recovery phase	\	English
Zhang et al. (2024)	Walking	Visually impaired people	A survey by questionnaire (N = 218)	Taiyuan, Shanxi (Middle)	Pre-epidemic and recovery phases	Disabled people	English
Zhou et al. (2021)	Walking & cycling	Youths (at post-mandatory education level)	A survey by questionnaire (N = 8,115)	China (a national study)	Pre-epidemic, outbreak, and recovery phases	gender	English
Xie et al. (2023)	Cycling (DBS)	DBS users in Nanjing	A survey by questionnaire (N = 127)	Nanjing, Jiangsu (East)	Pre-epidemic and outbreak phases	Gender, age, and occupation	English
Xiang et al. (2023)	Cycling, (including bike-sharing)	Adult commuters	A survey by questionnaire (N = 600)	Shenzhen, Guangdong (East)	Pre-epidemic, outbreak, and recovery phases	Gender, age, and income	English
Hu et al. (2021)	Walking and cycling	General urban residents	A survey by questionnaire (N = 318)	Zhongshan, Guangdong (East)	Outbreak and recovery phases	Gender, age, and occupation	Chinese
Wei and Liu (2022)	Walking and cycling	General urban residents	A survey by questionnaire (N = 1,290)	Beijing (Esat)	Outbreak and recovery phases	Gender and age	Chinese
Ma (2022)	Cycling	General urban residents	Secondary analysis of existing statistical data from previous studies	Guangzhou, Guangdong (East)	Pre-epidemic, outbreak, and recovery phases	\	Chinese

June 2020, while the recovery rate of sharing bicycles came to 104.31%, which returned to the level before the epidemic. And by October 2020, the recovery rate of total passenger volume reached 71.40%, while the recovery rate of sharing bicycles became 260.64% year on year (17). In Shanghai, by June 2020, the number of rush-hours sharing bicycle users increased by 2%, and the number of rush-hour rides increased by 4%, compared with those in October 2019 (37). In Guangzhou, the share of trips by owned bicycles in all urban daily travels in 2021 is 11.7%, higher than that (9.18%) in 2019 before the outbreak, and for sharing bicycles, the change is from 3.43% in 2019 to 6.01% in 2021 (39). The substantiation function of cycling for relatively short distance travel was also experienced by many citizens in Shenzhen (40), which may bring in more cycling in the post-epidemic era. Therefore, it seems that urban cycling might enjoy an increase in the recovery phase and even in the post-epidemic era. Nevertheless, this prediction may not be applicable to SBBS. As in Nanjing, the monthly usage of SBBS continued to decline and did not return to pre-epidemic volumes, and scholars inferred that people may become less willing to use shared modes of transportation in the post-pandemic era (24). The brief summary of behavioral changes in active mobility during the epidemic shows in Table 2.

3.3 Studies on changes in attitudinal and knowledge-based dimensions of active mobility

Exploring the shifts in public perception and understanding of active transportation in light of the COVID-19 epidemic can yield valuable insights into the latent and enduring impacts of the outbreak. Among the 20 studies reviewed, half specifically examined this aspect. While an inherent negative correlation exists between pandemics and travel patterns, it is noteworthy that enhanced awareness of the epidemic tended to foster a more favorable attitude toward walking and cycling among residents.

As COVID-19 is mainly transmitted through the air, most citizens believed that keeping a safe distance from others is an effective means to avoid infection (22), which made active travel modes more favored during the epidemic period. At the national level, walking and cycling were perceived as low probability of contracting COVID-19 by Chinese citizens in the outbreak and recovery phases (23). In Wuhan, after the outbreak, citizens tended to make various preparations for non-motorized travel, and with the upgrading of epidemic control measures, citizens' walking and riding maximum willingness distances were both continuously increasing (42). In Shanghai, after

TABLE 2 Summary of behavioral changes in active mobility during the epidemic.

Location	Active mobility amount (the number of trips, distance, and frequency, compared with the pre-epidemic phase)		Active mobility function (the purpose of active travel)	Reference
	Outbreak Phase (compared with the pre-epidemic phase)	Recovery Phase (compared with the outbreak phase)		
Wuhuan	Decrease	Increase	More diverse	(17, 42)
Nanjing	Decrease (But the proportion of bike-sharing increased.)	Decrease (SBBS)	More diverse	(22, 24, 41)
Shanghai	Decline	Increase	\	(37)
Dalian	No change	\	\	(33)
Beijing	Decrease	Increase	\	(8, 33, 36, 43, 45)
Changsha	Decrease	\	\	(18)
Kunming	Decrease	\	\	(21)
Taiyuan	\	Increase	\	(8)
Shenzhen	\	\	More diverse	(40)
Zhongshan	Decrease	Increase	More diverse	(44)
Guangzhou	\	Increase (compared with the pre-epidemic phase)	More diverse	(39)
National level	Decrease	\	\	(3, 23, 35)

experiencing the outbreak of the epidemic, the enhanced user base improves people's confidence about the long survival of the bike-sharing industry, and citizens showed increasing positive value of bike-sharing as a complement to public transit in the upcoming post-epidemic era (37). But the epidemic also brought certain negative experience in the active travel of some groups of people, which affected their attitude regarding active travel. For instance, for visually impaired people in Tainyuan, the unwillingness to travel using blind track increased from 26% (pre-epidemic) to 41.8% (during the epidemic). This may partially because that visually impaired people need assistance or support from others while walking crossing the road, and the lockdown during COVID-19 caused their dissatisfaction (34).

It is significant that the relationship between attitude, knowledge, and behavior regarding active travel was moderated by the severity of the epidemic. For instance, during the outbreak phase in Beijing, the more citizens understood epidemic prevention policies, the greater the likelihood of choosing to walk, but this kind of positive relation appeared to weaken in the recovery phase (45). Similarly, for the university students in Dalian, although there was a generally positive attitude among them, the impact of the epidemic was negatively correlated with the walking attitude, which had a significant impact on students' walking behavior on weekends (33). In Beijing, among all kinds of sharing mobilities, bike sharing was perceived as the second safe but the second to last comfort by citizens, and when the perceived epidemic severity was relatively low, citizens' preference for cycling significantly increased (38).

For some citizens, especially the older adult, the role of active mobility as an activity by itself was more important during the epidemic. After the outbreak, because all public spaces were closed, walking almost offered the only opportunity for many older citizens to interact with non-family members (21). Active mobility served as

an important, if not the only, part of social life for many older adult citizens, so it's understandable that they show resistance to travel restrictions.

3.4 Inequalities in active mobility during the epidemic

A series of studies explored transportation-related social equity among different demographic groups due to the COVID-19 epidemic (Figure 3). Gender is the most concerned dimension of existing studies in exploring the inequalities in active transportation during the epidemic. Out of 20 studies, 13 found changes in this dimension. In general, the outbreak accelerated more decline in the daily active travel of females compared with males, which was reflected in various behavioral changes. In Nanjing, before the outbreak, the SBBS trips of females and males are roughly equal, but the female trip proportion fell from 47 to 43% after the outbreak (41), and there was also a significant decline in the proportion of female SBBS commuters (24). In Changsha, females were associated with a higher prevalence of frequent low daily steps, which were more pronounced during the epidemic period (18). In both Beijing and Zhongshan, after the outbreak, males were more willing to conduct cycling compared with females (44, 45).

The reason that females were more likely to be affected by the epidemic might not be because they were more afraid of the epidemic, as gender had no significant impact on their attitudes regarding active travel (33). It might be because during the epidemic more females had to stay at home to care for the children who studied at home as schools were closed (41). This was partially proved from the reverse side as that for those young and unmarried females, like university students, the epidemic caused less decrease in physical

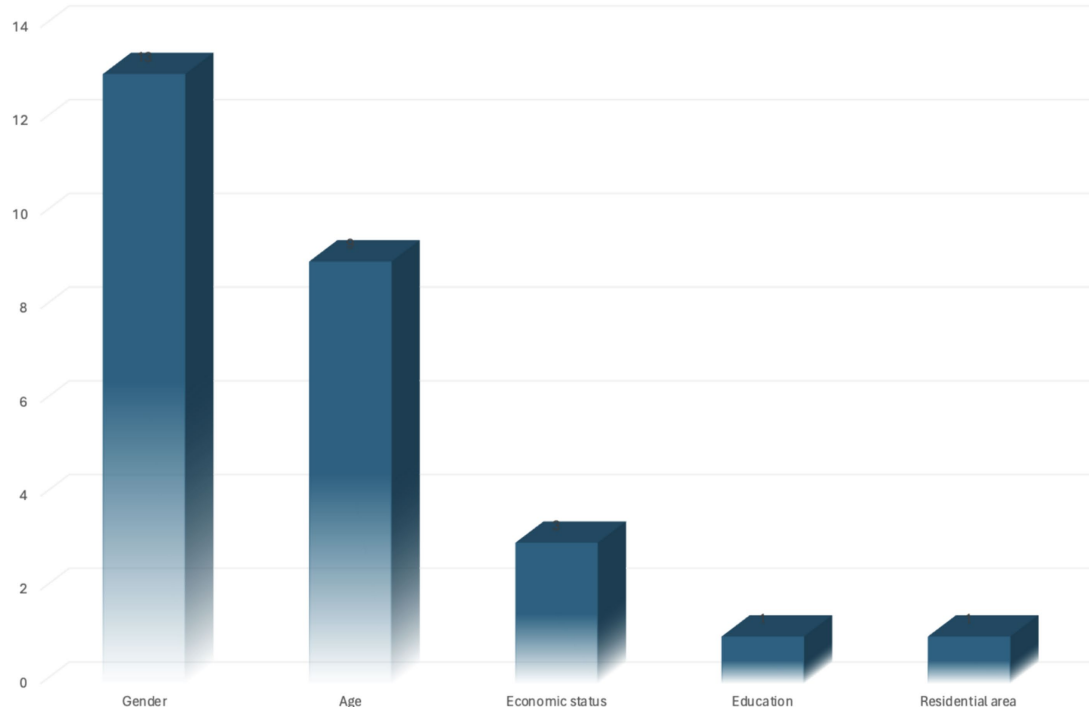


FIGURE 3
Analyzed inequality dimensions in active mobility in urban China during the epidemic.

activity compared with males (36), although the young females even conducted more moderate-/vigorous-intensity housework during the epidemic (35). Besides, as females generally had relatively low participation in cycling and used it more as the complement of public transport (22), the huge decline in public transportation travel during the epidemic may also contribute to the low active mobility of females.

Age is another important dimension regarding the active travel inequality issue, as nine out of 20 studies explored this dimension. The relationship between age and daily active travel is a little complex. For the youths, as schools were all closed during the epidemic, it is understandable that their daily travel dropped significantly and heavily (24, 41). For the older adult, however, the impact of the epidemic was multi-dimensional. On the one hand, for the health concern, the absolute daily active travel of the older adult decreased, which is consistent with the overall situation of the whole society. For instance, in Changsha, the daily steps of Changsha elder residents dropped significantly during the outbreak (18). Nevertheless, some studies discovered that the aged depended more on active mobility and conducted relatively more active travel compared with the young citizens. For instance, during the outbreak in Nanjing, the proportion of SBBS trips of older adult users increased, and their trip amount was least affected by the pandemic (41). Similarly, in Zhongshan, older citizens were more likely to choose walking for travel after the outbreak (44). In Kunming, most of the older citizens routinely performed outdoor physical activities in the first month of the outbreak, whilst only much fewer young people went out regularly during that time (21). However, there are other studies with different findings. For instance, for the users of DBS in Nanjing, the variable of age had a significantly negative effect on cycling after the epidemic, as

the older adult were more sensitive to the possibility of infection risk (22).

This phenomenon reflected the dual dilemma of the older adult in modern digital society as a partial result of the digital divide (47). First, as the older adult were generally less technology-savvy and were less engaged in Cyber-society, the fill of their various material and emotional needs relied more on offline face-to-face interactions. So, during the epidemic, unlike the young people who could conduct shop, work, socialize, and entertainment at home, the older adult had to go out. Especially those elder people who did not live with their children. Second, the epidemic greatly promoted the “digital reform” of the Chinese urban transportation system, and a smartphone is a necessary device for using various transportation modes, especially public transit (21). Therefore, for most elder residents, it was very inconvenient and even unfeasible to use other travel modes besides walking and cycling.

There were three studies exploring the differences in active travel between groups of different economic statuses. There was a significant positive correlation between monthly income and the choice of active mobility during the epidemic. For instance, a study in Beijing found that after the outbreak, the higher the monthly income of travelers, the stronger their willingness to conduct cycling for daily travel (45). In Zhongshan, during the outbreak period, citizens with higher economic status showed more willingness to choose walking rather than electric bicycles (44). Similarly, in Shenzhen, those citizens who tend to ride bicycles for commuting during the epidemic have less income than average (40). It might be because the upper-middle income groups could work from home and enjoy higher economic resilience to stop working, so they mainly conducted short daily travel during the epidemic (42). This is partly

proved by the fact that coming into the recovery phase, the relationship between economic conditions and the conduct of active mobility turned negative (44).

Besides the above three dimensions, other dimensions like education and residential area were also concerned by some studies. For instance, a research investigation revealed that individuals possessing a university degree or higher exhibit a reduced incidence of consistently low daily step counts in the period preceding an epidemic, in contrast to those with a high school education or less. However, this disparity was not observed during the epidemic phase (18). Cycling in the urban area of Nanjing was less impacted by COVID-19, and the suburban area was relatively more impacted (41). In the recovery phase in Wuhan, however, more cycling neighborhoods emerged in suburban areas, and the percentage of ridership in denser areas tends to decrease, which showed a trend toward decentralization and localization (33).

4 Discussion and applications to further research

The onset and persistence of the COVID-19 outbreak have had a profound impact on the daily routines and engagements of Chinese citizens. Among the various aspects affected, physical activity stands out as one of the most significantly influenced areas (36, 46). Research has revealed a marked reduction in physical activity levels among Chinese individuals due to the outbreak, leading to adverse effects on their overall well-being (12, 14). Unlike indoor exercises focused on health benefits (16), active mobility involves outdoor movements for diverse purposes and has been particularly impacted by the outbreak compared to other forms of physical activity. A comprehensive examination of the shifts in Chinese citizens' active mobility patterns during the outbreak not only enables a deeper understanding of the societal repercussions of the crisis but also offers valuable insights on promoting sustainable active mobility practices in the post-epidemic era. Based on this concern, this systematic scoping review addresses the impact of COVID-19 on active mobility in China through an empirical lens. Following rigorous screening procedures, 20 empirical studies were meticulously chosen from a pool of 606 English articles and 237 Chinese articles. A comprehensive analysis of these studies reveals significant insights into the subject matter.

First, the impact of COVID-19 on Chinese urban activity exhibited paradoxical effects on the behavioral dimension, which is consistent with scholars' analysis of the complexity of the epidemic impact (19, 27, 48). While the epidemic led to a decrease in active mobility in urban areas, with reduced frequencies and distances covered in walking and cycling trips, there was also an observed increase in the adoption of active mobility practices among Chinese citizens. The proportion of active mobility in daily travel rose during the outbreak phase, with individuals engaging in active travel for a variety of purposes more frequently than before the epidemic. Bike-sharing, as a form of active mobility in the digital age, emerged as a significant mode of urban transportation during the epidemic, with an increase in the proportion of bike-sharing trips, distance traveled per trip, and diversity of trip purposes. The recovery rate of bike-sharing trips surpassed that of other transportation modes, hinting at a potential rise in the acceptance and use of bike-sharing among Chinese citizens in the post-epidemic era.

Second, the experience amid the epidemic significantly influenced Chinese citizens' attitudes and understanding of active mobility. Throughout this period, citizens in China not only acknowledged the practical significance (49, 50) of active mobility, but also recognized it as a form of physical and social engagement. Active travel transcended its traditional role of transporting individuals and goods from one point to another, providing travellers with physical, social, and emotional benefits, particularly benefiting certain demographics like the older adult. This suggests that the epidemic presented an opportunity to transition toward the "new mobilities paradigm" and foster a more supportive environment for active mobility development. However, it is important to note that negative connotations toward mobility emerged during the epidemic, particularly regarding "non-essential travel" (a term commonly used in China by the government during the epidemic). The evolving attitudes and knowledge pertaining to active mobility among Chinese citizens may have enduring and profound implications, surpassing short-term behavioral changes.

Third, the influences of the epidemic and associated restrictions tend to compound and exacerbate the existing disadvantages faced by (married) women, the older adult, and low-income individuals in daily active transportation. Women, especially the married ones may experience reduced mobility due to the uneven distribution of childcare duties within couples. The older adult, on the other hand, encounter challenges related to the digital divide and transportation disparities, leading to increased active travel during the epidemic phase but inconvenience and exclusion during the recovery period. Low-income groups, with limited economic resilience, are compelled to undertake medium to long-distance travels even amidst the outbreak, resulting in comparatively lower levels of active transportation compared to their higher-income counterparts. Therefore, a nuanced understanding of active travel patterns during the pandemic and beyond is crucial, rather than simply advocating for increased active mobility as a solution. It is essential to recognize that the promotion of active travel does not automatically translate to enhanced travel equality across different socioeconomic groups.

The extant literature on active mobility in urban China exhibits both similarities and distinctions when compared to related studies in other nations. Notably, the research conducted in urban China has confirmed the simultaneous effects of COVID-19 on active mobility observed in other countries, like in the US (51–53), Iran (54), Greece (55), Australia (56), Bangladesh (57), Serbia (58), South Korea (59), and so on. This is evidenced by a reduction in the total amount of active travel, coupled with an increase in the proportion of active travel utilized in citizens' daily travel patterns. The observation underscores a second commonality, namely the emergence of a potential window of opportunity to advocate for increased active mobility due to the epidemic as discovered by studies in Europe (60, 61), the US (62) and Latin America (63, 64). This situation may prompt citizens to acknowledge and prioritize the health and environmental advantages associated with active mobility. Furthermore, research conducted in urban China validates the altered landscape of active mobility equality resulting from the epidemic, particularly affecting vulnerable demographics such as females, the older adult, and individuals with lower incomes (56, 64–66).

The review also identifies unique characteristics in urban China that have not been observed in other nations. First, due to enduring stringent measures over an extended period, Chinese residents have

demonstrated a notably more substantial and favorable shift in their perception toward active mobility. This is evidenced by the swift resurgence in active mobility levels and the wider range of purposes for active transportation during the epidemic, a trend distinct from the developments seen in South Korea (59), Hungary (67), Canada (66) and Latin America countries (63). Second, the significance of cycling, particularly the utilization of shared bicycles like DBS, stands out in China amidst the epidemic. Unlike the limited impact observed on SBBS as noted in studies across different nations (24, 67), the epidemic has had a predominantly positive and enduring effect on DBS (17, 41). This underscores the considerable promise of such forms of active mobility in the global landscape post-epidemic. Third, the impact of epidemics on gender dynamics in active mobility in China underscores the precarious position of married women with children. This is different with the reduction in the gender gap discovered in France (65) and Canada (66). It may reveal the disparities in the allocation of family duties within dual-income households in contemporary urban China, necessitating further empirical investigations. Finally, studies conducted in other countries have underscored that the significance of the enduring favorable impact for active mobility provided by the epidemic-induced opportunity window can yield, contingent upon the provision of suitable preconditions (60, 61, 67). This underscores the necessity for the implementation of policies, regulations, and infrastructures that promote active mobility even amidst the epidemic (62, 64). Nevertheless, there has been a notable dearth of such initiatives in urban China, even during the epidemic recovery phase. Consequently, it is imperative to undertake additional active mobility initiatives across various levels in the contemporary post-epidemic period to capitalize on the opportunity window before it eludes.

This analysis enriches our understanding of the collective experience of Chinese residents throughout the epidemic period and presents valuable perspectives for advancing active mobility in the post-epidemic era. On an individual level, the first-hand encounters during the epidemic serve as tangible assets for advocating and sustaining increased mobility in the future. Many individuals are likely to consider walking and cycling as viable and health-conscious options for their daily commuting needs. Additionally, the increased integration of smart technology with active mobility can be attributed in part to the impact of COVID-19. The utilization of shared bicycles, health-related mobile applications, and virtual reality tools within the realm of physical activity have assumed a growing significance in the daily routines of Chinese citizens amid the epidemic (13, 15). As we transition into the post-pandemic digital age, individuals can explore a variety of innovative technologies for enhancing their active mobility practices, such as utilizing smartphones for route planning, monitoring health metrics, and assessing traffic conditions to enhance the efficiency and safety of their travel experiences. At the organizational level, businesses and entities have the capacity to facilitate active mobility by implementing strategies such as flexible work hours and telecommuting policies. Moreover, organizations can enhance active transportation by offering amenities like bicycle parking facilities and financial assistance.

On a socio-political front, urban administrators should prioritize the development of bicycle lanes and pedestrian pathways to establish a secure and accessible environment for active transport. Additionally,

drawing from past health crises, government bodies and academic institutions are encouraged to advocate for the advantages of active transportation through various channels such as media campaigns and community engagements to bolster public engagement and awareness. Through incentives like tax benefits, financial aid, and other supportive measures, governmental bodies can motivate individuals to adopt eco-friendly modes of travel. Lastly, it is imperative for policymakers and stakeholders to address the needs of marginalized demographics including the older adult, women, individuals with disabilities, and low-income populations by implementing structural reforms to mitigate disparities in the realm of active mobility.

The analysis of contemporary scholarly literature also provides valuable insights into potential directions for future research endeavors. Initially, the predominance of quantitative methodologies in existing studies suggests the potential for more comprehensive qualitative research to enhance our comprehension of various transformations and their enduring consequences within this domain. Subsequently, the prevalence of single-case studies underscores the need for further validation and enhancement of their findings through comparative analyses. Additionally, the examination of a broader range of social variables is warranted to address disparities in active travel during the post-epidemic period. Notably, the absence of studies focusing on the genuine “post-epidemic” era in China, commencing in late 2022, highlights a critical gap in the literature. The purported “post-epidemic” periods in current studies pertain to the recovery period, characterized by the persistence of certain anti-epidemic measures. Encouraging subsequent investigations that can shed light on emerging developments and transformations following the complete relaxation of restrictions will be instrumental in advancing our understanding of promoting active, healthy, and sustainable mobilities in the forthcoming era.

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Survey of public knowledge, attitudes, and practices regarding personal protection against COVID-19 in the post-pandemic era

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In the emerging post-pandemic era (the 'wavelet' era), humans must coexist with viruses for the foreseeable future, and personal protective behaviors will largely replace national-level preventive measures. In this new normal, encouraging the public to implement proper personal protective behaviors against the coronavirus disease (COVID-19) is vital to the sustainable development of cities and communities. This knowledge–attitude–practice (KAP) survey conducted in Chengdu ($N = 900$) narrowed the knowledge gap regarding post-pandemic public practices of protective behavior. Findings show that: (1) approximately 1/3 of the respondents are currently not concerned about COVID-19 at all; (2) respondents with different demographics and individual COVID-19-related factors showed significant differences in practice behaviors indoors and outdoors; (3) vulnerable groups performed better in practice behavior indoors/outdoors; (4) because the public may relax their vigilance outdoors, public places may become a transmission threat in the next outbreak; (5) attitudes are important, but limited incentives for practice; and (6) when knowledge increases beyond a threshold (68.75–75% in this study), protective behaviors decrease. Our results suggest that authorities must continue to educate and motivate the public, extending measures to cover personal protective practices, and have targeted policies for specific demographics to ensure equity in healthcare in the event of another pandemic (COVID-19 and alike crisis). Besides, comparing the results of the current study with similar studies conducted in other parts of the world can provide insights into how different populations respond to and adopt COVID-19 protective behaviors. The epidemiologists can use the data collected by this and other KAP surveys to refine epidemiologic models, which can help predict the spread of the virus and the impact of interventions in different settings.

KEYWORDS

COVID-19, KAP survey, post-pandemic era, risk management, vulnerable populations, non-pharmaceutical interventions

1 Introduction

On 31 December 2019, a case of “viral pneumonia” was first reported in Wuhan, Hubei Province of China (National Health Commission of the People's Republic of China, 2020). Thereafter, the coronavirus disease 2019 (COVID-19) raged across the world for three years until 5 May 2023, when the World Health Organization (WHO) declared the end of the emergency phase of COVID-19 (Lenharo, 2023). The COVID-19 pandemic has revolutionized the daily lives of people worldwide (like the interruptions to work schedules, insecure food supplies, Diotaiuti et al., 2023), resulting in record numbers of cases and deaths (Wang et al., 2022; Chow et al., 2023), and creating a huge healthcare burden globally (Figure 1).

During the pandemic, non-pharmaceutical interventions (NPI) were introduced by governments as the first public health response to impede the spread of infection and reduce the healthcare burden (Chow et al., 2023; Santos et al., 2023), for example, in Sri Lanka (Jayaweera et al., 2021), Sweden (Sjödin et al., 2020), China (Lai et al., 2020), UK (Davies et al., 2020), and Saudi Arabia (Bisanzio et al., 2022). According to the European Centre for Disease Prevention and Control (2023), NPI involves three main levels: individual (hand washing, wearing a mask), environmental (ventilation of indoor spaces), and population (physical distancing and movement restriction). Some countries have incorporated additional levels such as ‘community’ (e.g., shutting facilities, canceling gatherings, stay-at-home; Chow et al., 2023). These measures aimed to control the spread of the virus by delaying the peak of the outbreak and reducing its magnitude, thus allowing time for preparing the healthcare system (Lai et al., 2020). However, despite the rollout of the COVID-19 vaccine and its initial success, its efficacy is being challenged by the evolution of SARS-CoV-2 and emergence of viral variants (Jacobs et al., 2023). Moreover, some potential drugs for the treatment of COVID-19, such as Lopinavir-ritonavir, and Nafamostat, have been reported to have

side effects (Cao et al., 2020; Sonawane et al., 2020). Consequently, many countries continue to utilize NPI as effective measures against COVID-19 (Santos et al., 2023).

The COVID-19 pandemic has been effectively contained, with a significant decrease in the number of cases and deaths as a result of global efforts (Lenharo, 2023). Today, three years after the start of the pandemic, SARS-CoV-2 shows no signs of a seasonal pattern similar to that of influenza (Callaway, 2023). However, infections are still on the rise in some countries due to new variants (e.g., XBB.1.16) and diminished vaccine efficacy, leading to a new normal in the post-epidemic era—the ‘wavelet’ era (Callaway, 2023). This phase is characterized by frequent, less deadly waves and a higher proportion of mild infections (Callaway, 2023). The world will remain in the midst of the pandemic for a prolonged period, and this new status does not mean that countries can be incautious. There is an urgent need for countries to bolster their preparedness for future pandemics (Lenharo, 2023). In addition, as of 5 May 2023, many countries have eliminated strict polymerase chain reaction (PCR) testing, quarantine, and movement restrictions. In some countries, citizens can decide whether to implement government-recommended NPI measures such as wearing masks (Joshi and Wende, 2023; The Japan Times, 2023). Therefore, it is important to acknowledge that personal protective behaviors in the post-pandemic era will replace national-level precautionary measures (Figure 2). Moreover, it is essential for individuals to adopt NPI (e.g., washing hands, wearing a mask, maintaining physical distance) to reduce their own risk of infection, because these guidelines are easy, inexpensive, and effective.

Although wavelets do not always cause spikes in hospitalizations and deaths, their health impact varies across countries (Callaway, 2023), suggesting that the world could still encounter another COVID-19 outbreak, although the probability is currently low. Moreover, it is difficult to completely eliminate this threat in a short time, and humans must coexist with COVID-19 (Rudan et al., 2022; Song et al., 2022; Su et al., 2022). Studies

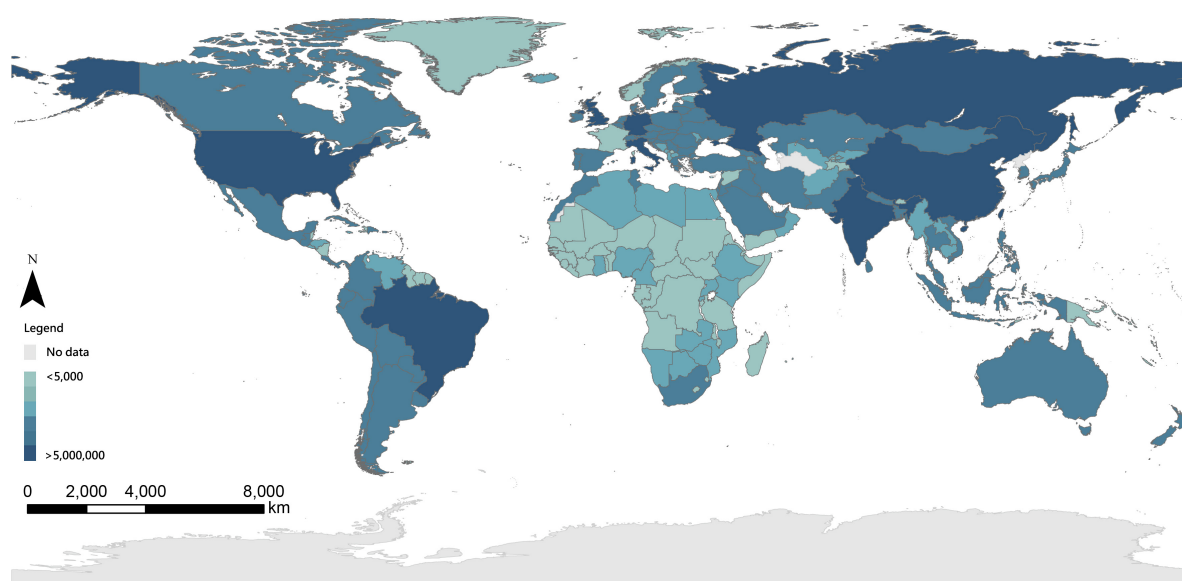
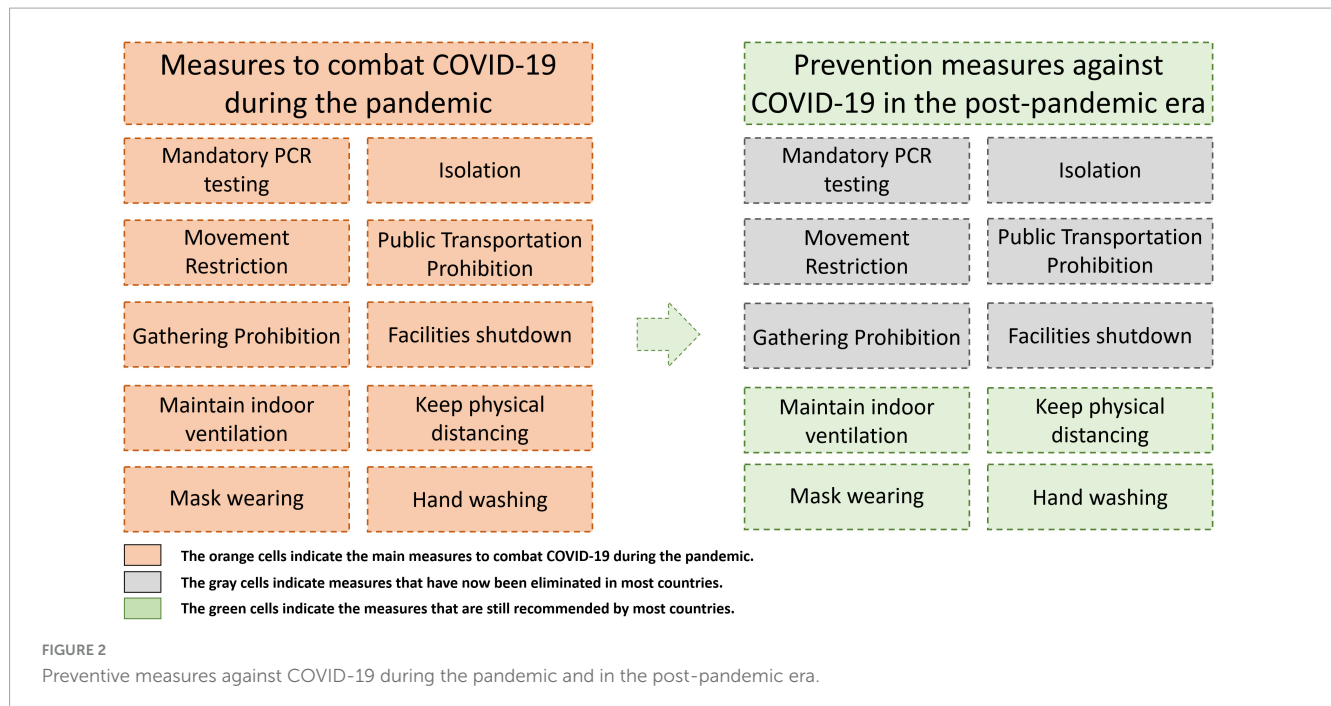


FIGURE 1
Global reported cases as of May 10, 2023 (data resource: World Health Organization, 2023).



on previous outbreaks suggest that public awareness plays an important role in curtailing the infection spread (Lau et al., 2003; Yap et al., 2010), and inadequate knowledge often leads to careless attitudes and inappropriate practices, exacerbating risk (Sujarwoto et al., 2022). Therefore, in the post-pandemic era, it is important for managers and policymakers to promote knowledge of personal prevention and encourage attitudes and practices that reduce the risk of COVID-19 spreading.

To date, several knowledge–attitudes–practices (KAP) surveys on COVID-19 have been conducted, such as Zhong et al. (2020), Feldman et al. (2021), Chai et al. (2022), Sujarwoto et al. (2022), Qalati et al. (2023). KAP surveys aim to determine what the public knows (knowledge), believes (attitudes), and does (practices) with regard to a particular topic of interest. Attitudes reveal the survey respondents' propensity to act on the topic, and practices refer to the measures/behaviors adopted in response to it (Chai et al., 2022). Thus, KAP intervention is considered a key public health strategy for controlling diseases by changing citizens' health behavior (Sujarwoto et al., 2022). However, KAP investigations were conducted during the COVID-19 pandemic, and none have examined the post-pandemic era. Furthermore, these studies mainly dealt with general knowledge regarding COVID-19, such as the incubation period (Qalati et al., 2023), clinical symptoms (Feldman et al., 2021), route of infection (Zhong et al., 2020), and isolation measures (Chai et al., 2022). Although the value of this information is undeniable, its usefulness is limited in the post-pandemic era context, as the public needs to know more about proper personal protection; also, the KAP survey can be used to assess the public's strategies to protect themselves from specific disasters (Rahman et al., 2023).

Therefore, this KAP survey on personal protection in the post-pandemic era is relevant in reducing infection risk and developing public health policies. Moreover, the items in this survey were informed by the most recent literature and policy documents, rendering it useful as a reference for future studies. Last but

not least, in line with United Nations Sustainable Development Goal 11, by 2030, to significantly reduce the number of deaths and the number of people affected, to significantly reduce the negative impacts of disasters and to focus on the protection of the poor and the vulnerable; and, furthermore, to make cities and human settlements inclusive, safe, resilient and sustainable. Therefore, another potential value of this KAP survey is to provide recommendations to city managers on pandemic control related education/training to meet the needs of resilient cities for a healthy population. In summary, the specific objectives of this study are to:

- (1) To investigate whether public KAP behaviors regarding COVID-19 personal protection are adequate in the post-pandemic era;
- (2) To discuss the sociodemographic characteristics that influence the three dimensions of KAP;
- (3) To discuss the influence of individual status on the three dimensions of KAP, such as whether one has been infected with COVID-19, current concerns about the pandemic, and perceived risk of infection;
- (4) To analyze how the three KAP dimensions relate to each other.

2 Methodology

2.1 Study area

A cross-sectional survey was conducted in Chengdu (alternatively romanized as Chengtu), the capital of Sichuan Province, located on the western edge of the Sichuan Basin, with an area of 14,335 km² and a population of over 20 million (Figure 3; Chengdu Statistical Yearbook, 2021). It is the political, industrial, cultural, logistical, and scientific center of the province,

and an important economic center for the entire southwest region (Qin, 2015). Chengdu is a megacity and the core of the Chengdu–Chongqing Urban Agglomeration, identified by the Chinese State Council as an important central city in western China (Yang L. et al., 2022). Another important reason for choosing Chengdu as the study area is that it is one of the most affected by the COVID-19 pandemic and representative of cities in southwest China (Shi et al., 2023). On 7 December 2020, several areas in the city were upgraded to intermediate risk due to local transmission. In order to control the epidemic, the Chengdu city government quickly took decisive and strict action to effectively block further spread of COVID-19, clearing all the intermediate risk areas by December 31 (Jiang et al., 2022). Communities in Chengdu were strictly managed according to the WHO and China's prevention and control management measures until April 2021 to prevent the spread of the infection (Yang K. et al., 2022). From December 2022, the National Health Commission of the People's Republic of China announced the rollout of new prevention and control standards: no health code checks, no quarantine, and no strict management measures, such as movement restrictions, within the country, and residents' lives began to return to normal (National Health Commission of the People's Republic of China, 2023). Thus, Chengdu has entered the post-pandemic era (Jin et al., 2023).

2.2 Study population and data collection

Questionnaire responses were collected from Chengdu residents between 20th to 30th April 2023, using the Credamo online questionnaire platform.¹ Credamo is a professional online questionnaire service with over 3 million Chinese adults registered across all provinces in China (all users have been authenticated by Credamo) and has proven to be a reliable for collecting valid data in several prior studies (He et al., 2023; Xiao et al., 2023). The Credamo platform was used to send job advertisements to participants who met the study requirements (residing in Chengdu, 18 years of age or older), and those interested completed an online survey. Informed consent was obtained before the participants answered the online questionnaire. To avoid invalid and duplicate responses, two screening procedures were implemented: (1) platform-provided "CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart)" questions were used, which are easy for humans but extremely difficult for bots or scripts. Based on the "CAPTCHA" results, the online survey of participants who did not pass was automatically terminated by the platform; (2) the same IP address could not access the survey more than once. Ultimately, 993 responses were submitted; however, 93 were removed due to abnormal response times (< 120 s or > 600 s), leaving a sample of 900 (90.6%) for subsequent analysis. The minimum sample size required was calculated using the formula in Fecso et al. (1996).

$$n = \frac{z^2(p)(1-p)}{c^2} \quad (1)$$

Where n = sample size;

z = Z-value (e.g., 1.96 for 95% confidence level);

p = percentage of choosing an option; when $p = 0.5$, the sample size n is maximized;

c = confidence interval (also error tolerance), expressed as decimal (e.g., $0.05 = \pm 5\%$).

According to Equation (1), the minimum sample size required is 385 when the confidence level is 95.0% ($z = 1.96$), $p = 0.5$, and $c = 5\%$ (Fecso et al., 1996). Therefore, the sample size of 900 used in this study was adequate. The study was approved by the academic committee of the first author's institution, and the ethical review was waived because the study was non-invasive and all participants remained anonymous.

2.3 Survey instruments

The online questionnaire comprised three sections. The first consisted of respondents' sociodemographic characteristics (gender, age, marital status, type of residential area, education level, occupation, and monthly income), which have been previously shown to influence all three dimensions of KAP (Chai et al., 2022; Sujarwoto et al., 2022; Qalati et al., 2023; Rahman et al., 2023). The second section enquired about individual status in the post-pandemic era, such as whether one had been previously infected with COVID-19, current concerns about the pandemic, and perceived risk of infection. Similar to Rahman et al. (2023), this section is supplemental to KAP; however, we argue that these factors may influence the three dimensions of KAP and included them as independent variables in the subsequent analysis. The third section examines KAP related to COVID-19 personal protection and was devised with reference to the latest literature and policy documents (Cone Health, 2020; de Bruin and Bennett, 2020; Bagheri et al., 2021; Feldman et al., 2021; Nordsiek et al., 2021; Andrejko et al., 2022; Arefi et al., 2022; Chai et al., 2022; Eyre et al., 2022; Qalati et al., 2023; TravelHealthPro, 2023; WHO, 2023), and comprises a total of 33 items (16 knowledge, 7 attitude, 10 practice), with responses selected from "yes," "no," and "I don't know." In another similarity to Rahman et al. (2023), correct responses were assigned a value of 1, and incorrect responses and "I don't know" were valued at 0, because "I don't know" usually indicates that the person has suboptimal knowledge or does not know the answer (Luskin and Bullock, 2011). Detailed questions for the three sections of the questionnaire are presented in Sections "3.3 Personal protection knowledge for COVID-19," "3.4 Personal protection attitudes regarding COVID-19," and "3.5 Personal protection practices against COVID-19."

Prior to data collection, the first author recruited a small group of volunteers (covering all age groups) on their own social media (WeChat) to complete the questionnaire and suggest improvements; these data were not included in subsequent analysis. To measure the reliability of the three KAP dimensions in the final version of the questionnaire, the Kuder-Richardson Formula 20 (KR-20) coefficient was calculated for each dimension, wherein the measure was considered reliable if the internal consistency value was greater than 0.70 (Sentandreu-Mañó et al., 2021). Cronbach's alpha coefficients were not adopted because the responses were identified as "correct" and "incorrect" as a binary variable, and the KR-20 coefficient is more appropriate for dealing with this type

¹ <https://www.credamo.world/>

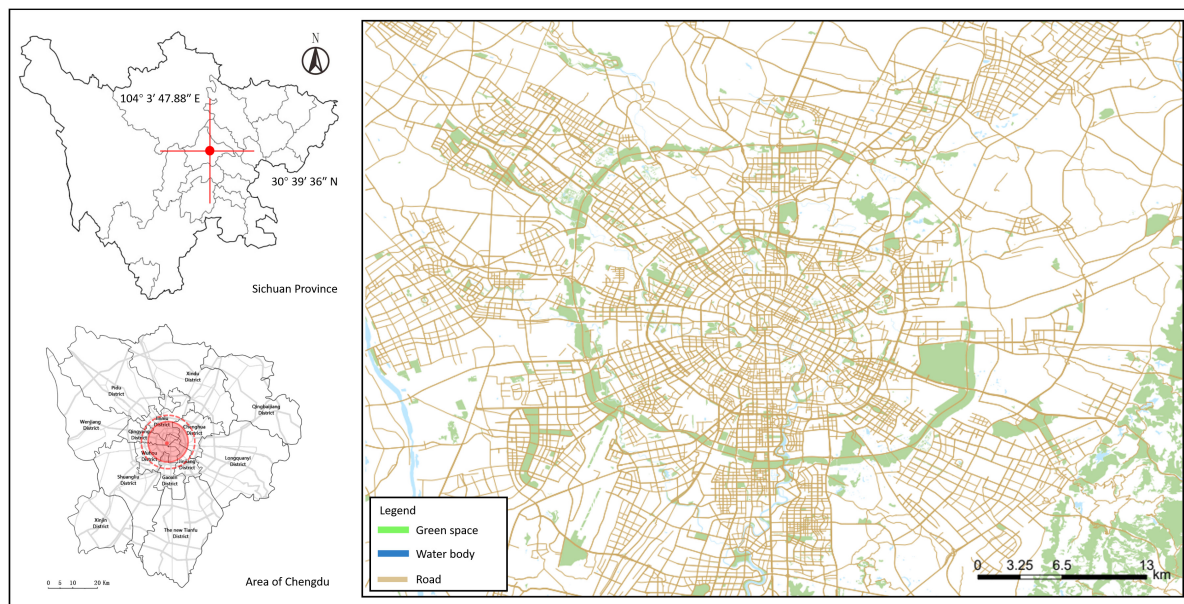


FIGURE 3

The study area.

of variable. The formula for calculating the KR-20 coefficient is as follows (Equation 2):

$$KR-20 = (k/(k-1)) * (1 - \sum p_j q_j / \sigma^2) \quad (2)$$

where:

- k: Total number of items;
- p_j: Proportion of individuals who answered item j correctly;
- q_j: Proportion of individuals who answered item j incorrectly;
- σ²: Variance of scores for all individuals.

The results showed high internal consistency for the three dimensions, with KR-20 coefficients of 0.779 (knowledge), 0.721 (attitude), and 0.897 (practice).

2.4 Data analysis

Microsoft Excel and IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY; IBM Corp) were used to compile and statistically analyze the questionnaire data, with the significance level at $p < 0.05$. Where appropriate, descriptive statistics were calculated. The means of the 900 sample scores on each of the three KAP dimensions (Equations 3–5) were calculated.

$$\text{Average Knowledge} = \frac{\sum_1^n k_i}{n} \quad (3)$$

$$\text{Average Attitude} = \frac{\sum_1^n A_i}{n} \quad (4)$$

$$\text{Average Practice} = \frac{\sum_1^n P_i}{n} \quad (5)$$

Where n = sample number;

The K_i , A_i , and P_i are the total scores of the i th sample for the knowledge, attitude, and practice dimensions, respectively.

Furthermore, an ordinal generalized linear model (OGLM) was implemented using SPSS to analyze the influence of

sociodemographic characteristics and individual status on the KAP dimensions, wherein the former two items were the independent variables and the latter, the dependent variables. OGLM was chosen for its interpretable model parameters that describe the relationship between predictors and the ordinal response, and fit heterogeneous choice and related models better than ordered logit models that often violate the assumption of proportional odds (Zhang et al., 2021). In addition, OGLM is robust to deviations from normality and can handle skewed or non-normal data distributions, commonly encountered in real-world scenarios, thereby maximizing the use of available data by utilizing the full ordinal nature of the response variable. It avoids collapsing ordinal data into binary outcomes that may result in loss of information (Lyles et al., 2007), such as loss of granularity, variability, and statistical power. All results were reported as odds ratios (OR) and 95% confidence intervals (95% CI). The ggplot2 package of the R program (version 4.3.0) was used to make forest plots.

3 Results and discussion

3.1 Sample profile

Table 1 presents the demographic information of the participants. The sample was predominantly female ($n = 546$, 60.7%) and married ($n = 564$, 62.7%). More than half of the respondents were young ($n = 312$, 34.7%) and middle-aged ($n = 360$, 40%). Over 90% of participants lived in urban areas ($n = 822$, 91.3%). Only 15 participants reported that they had received only basic education. Most were retired ($n = 207$, 23%) or employed in the private sector ($n = 162$, 18%). The largest proportion were from the low-income group ($n = 309$, 34.3%), followed by those having average income ($n = 300$, 33.3%).

TABLE 1 Participants' demographic information.

Items	Categories	Number	Percentage (%)
Gender	Male	354	39.3
	Female	546	60.7
Age	18–30 (youth)	312	34.7
	31–40 (young adult)	135	15.0
	41–60 (middle age)	360	40.0
	> 60 (old age)	93	10.3
Marital status	Married	564	62.7
	Unmarried or single	336	37.3
Location	Rural area or suburban	78	8.7
	Urban area	822	91.3
Education	Primary	15	1.7
	Secondary	309	34.3
	Undergraduate/college	321	35.7
	Graduate	255	28.3
Occupation	Unemployed	117	13.0
	Student	153	17.0
	Retired	207	23.0
	Self-employed	60	6.7
	Private sector	162	18.0
	Public sector	138	15.3
	Government sector	63	7.0
Monthly income (RMB)	< 3,000 (low income)	309	34.3
	3,000–6,000 (average income)	300	33.3
	6,000–15,000 (above average income)	243	27.0
	> 15,000 (high income)	48	5.3

3.2 Individual status regarding the COVID-19 pandemic

As shown in **Table 2**, 83.7% of respondents reported having been infected with COVID-19, and 95% had family or friends who were infected, corroborating recently reported trends. The number of infections increased significantly after China ceased strict control and quarantine measures in December 2022. From 3 January 2020 to 17 May 2023, at 5:43 pm CEST, China reported 99,256,991 confirmed COVID-19 cases to the WHO, with a total of 77,077,630 confirmed cases nationwide from 12 to 26 December 2022, accounting for 77.65% of the total reported cases ([World Health Organization, 2023](#); [Figure 4](#)). Zhong Nanshan, a leading Chinese respiratory physician, said the December outbreak infected at least 85% of the population ([Ye, 2023](#)). Our questionnaire was conducted in April, at the point in time when all respondents had already experienced the heaviest wave of the pandemic, which

may be a potential reason why respondents reported such a high rate of infection.

Approximately 1/3 of respondents reported no concern at all about COVID-19 at present, 61.3% were somewhat concerned, and only 8% reported a high level of concern. Additionally, more than 70% considered the current pandemic threat to be very low, with only six participants (0.7%) considering it a high risk. This may be due to the fact that the survey was conducted in April 2023, when the pandemic has been fully controlled and cases of infection have decreased significantly. Thus, the low-risk perception of the public has led to reduced concern about COVID-19. Furthermore, individuals may not recognize the threats they face, and the low-risk perception stems from trust in scientific experts and authorities, and confidence in protective measures ([Wachinger et al., 2013](#)). However, this trust may lead people in areas lacking in protective measures tend to these natural risks, thus reducing their willingness and preparedness to act ([Botzen et al., 2009](#)). Therefore, despite the removal of strict regulatory measures, it is still recommended that authorities continue to engage and inform the public regarding personal NPI to avoid neglecting or underestimating the potential threat of the current pandemic. In terms of education on COVID-19 personal protection, more than half of the respondents indicated that they had received relevant training and 85% of the sample self-assessed that they were knowledgeable about personal protection, mostly from national and local authorities (67.0%), and Internet media (78.7%). This is consistent with previous findings in China, where the Internet was the most common source of information accessed by the public for COVID-19 knowledge ([Wang H. et al., 2021](#)). Moreover, the promotion of COVID-19 knowledge by the authorities also plays an important role, since the Chengdu city government, after December 2020, took great effort in promoting and educating people regarding COVID-19, specifically by organizing science education lectures, and showing promotional videos at community and street levels ([The People's Government of Sichuan Province, 2020](#)). In the future, this initiative should continue and extend to COVID-19 personal protection, to reduce the potential risk.

3.3 Personal protection knowledge for COVID-19

Responses regarding COVID-19 personal protection knowledge were collated (**Table 3**), and the mean score for this dimension was calculated (**Figure 5**). Overall, although a high standard of knowledge was not achieved (approximately 80% of questions were answered correctly; [Rahman et al., 2023](#)), the average of 76.6% correct ($M = 12.25 \pm 3.27$) represents that participants have considerable knowledge related to COVID-19 personal protection. For example, the majority clearly knew how to wear masks properly (96%), to wear masks when entering public places (89.7%), to wash their hands regularly (89.3%), wash their hands after touching objects outdoors (83.3%), reduce the use of public transportation (82.7%), disinfect items at home regularly (88.3%), and wash their hands before rubbing their eyes and eating (90.3%). However, misunderstandings and uncertainties remain regarding some issues. For example, only half of the sample knew

TABLE 2 Individual status regarding the COVID-19 pandemic.

Items	Responses	Number	Percentage (%)
1. Have you been infected with COVID-19?	Yes	753	83.7
	No	147	16.3
2. Have your family or friends been infected with COVID-19?	Yes	855	95.0
	No	21	2.3
	I don't know	24	2.7
3. To what extent have you paid attention to COVID-19 recently?	Not concerned at all	276	30.7
	Somewhat concerned	552	61.3
	Greatly concerned	72	8.0
4. At what level do you think the area you live in is currently threatened by the pandemic?	Low risk	699	77.7
	Moderate risk	195	21.7
	High risk	6	0.7
5. Have you received any relevant training or education on COVID-19 prevention?	Yes	501	55.7
	No	399	44.3
6. Where did you learn about COVID-19 prevention? ^a	National and local authority	603	67.0
	Internet Media	708	78.7
	TV and radio	489	54.3
	Family or friends	507	56.3
	Poster	108	12.0
	Others	54	6.0
7. How would you rate your knowledge regarding COVID-19 prevention	Not at all	48	5.3
	Fairly well informed	765	85.0
	Very well informed	87	9.7

^aMultiple answers could be selected.

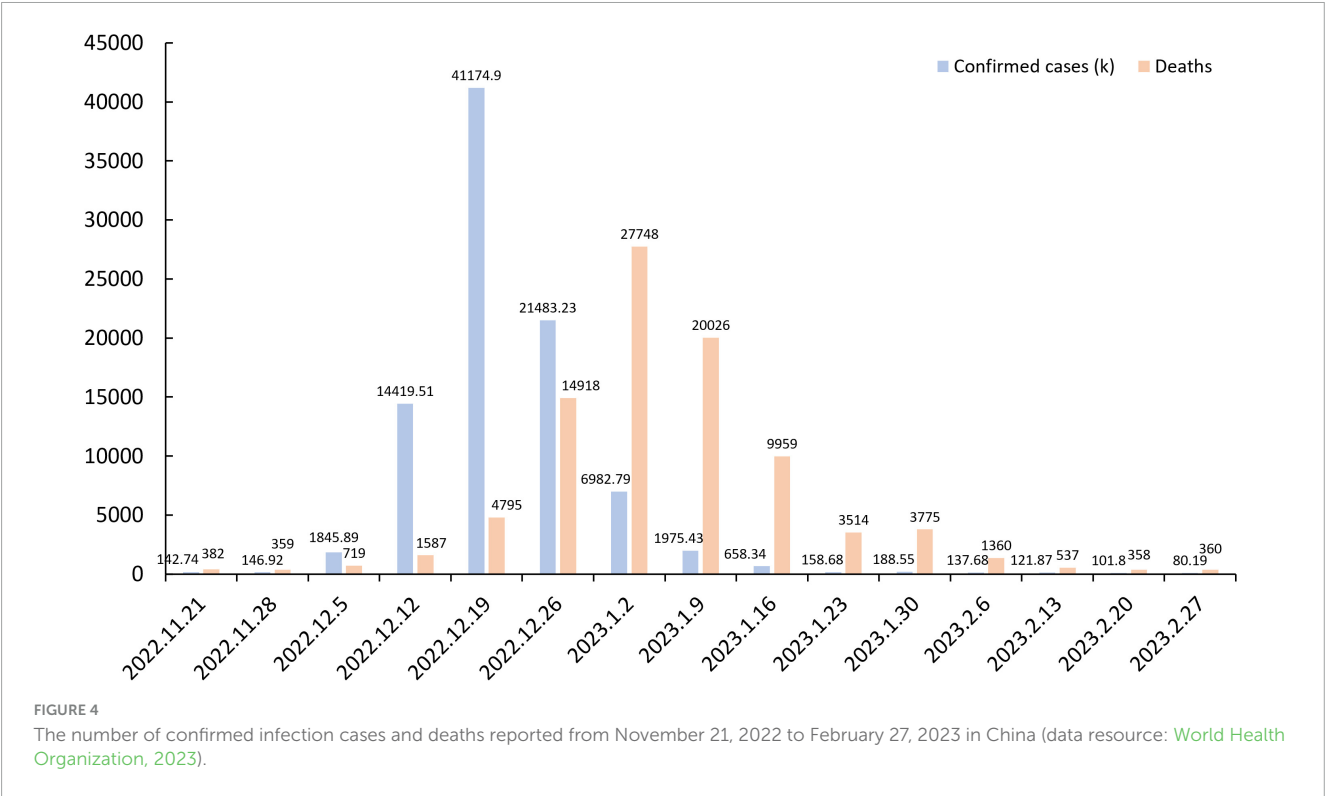


TABLE 3 Responses toward knowledge of personal protection for COVID-19.

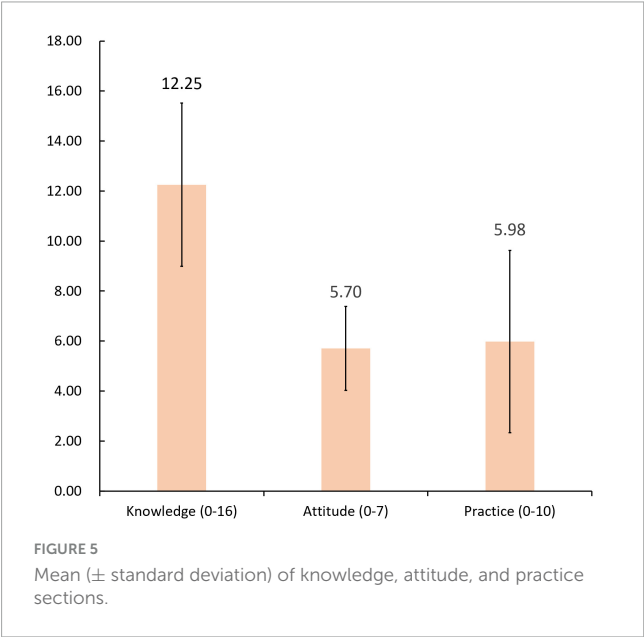
Items	Responses	Number (%)	Sources
1. The correct way to wear a mask is to make sure it covers your nose, mouth, and chin.	Yes	864 (96.0)	WHO, 2023
	No	21 (2.3)	
	I don't know	15 (1.7)	
2. If the mask is worn correctly, you will not get COVID-19.	Yes	105 (11.7)	Andrejko et al., 2022; Qalati et al., 2023; WHO, 2023
	No	447 (49.7)	
	I don't know	348 (38.6)	
3. You cannot be infected if you are vaccinated.	Yes	42 (4.7)	Eyre et al., 2022; WHO, 2022
	No	492 (54.7)	
	I don't know	366 (40.6)	
4. A mask should be worn properly when entering public places to reduce the risk of infection.	Yes	807 (89.7)	Chai et al., 2022; WHO, 2023
	No	21 (2.3)	
	I don't know	72 (8.0)	
5. Hands should be washed regularly and thoroughly with alcohol-based hand rub or soap and water to reduce the risk of infection.	Yes	804 (89.3)	WHO, 2023
	No	33 (3.7)	
	I don't know	63 (7.0)	
6. If the mask is worn correctly, there is no risk of infection even when in contact with others.	Yes	108 (12.0)	Chai et al., 2022; WHO, 2023
	No	498 (55.3)	
	I don't know	294 (32.7)	
7. If you touch anything outdoors, you should clean your hands thoroughly and immediately with alcohol-based hand rub or soap and water to reduce the risk of infection.	Yes	750 (83.3)	Feldman et al., 2021; WHO, 2023
	No	54 (6.0)	
	I don't know	96 (10.7)	
8. When it is not possible to maintain a physical distance of at least 1 meter from others, or in poorly ventilated settings, it is necessary to wear a mask properly to reduce the risk.	Yes	801 (89.0)	Qalati et al., 2023; WHO, 2023
	No	21 (2.3)	
	I don't know	78 (8.7)	
9. Reducing the usage of public transportation (e.g., buses, subways) can reduce the risk of infection.	Yes	744 (82.7)	Chai et al., 2022; Qalati et al., 2023; WHO, 2023
	No	24 (2.7)	
	I don't know	132 (14.6)	
10. Hands need to be cleaned before you put your mask on, before and after you take it off, and after you touch it at any time.	Yes	774 (86.0)	WHO, 2023
	No	33 (3.7)	
	I don't know	93 (10.3)	
11. Door handles, faucets, and phones in your home should be cleaned and disinfected regularly.	Yes	795 (88.3)	WHO, 2023
	No	51 (5.7)	
	I don't know	54 (6.0)	
12. If vaccinated, it is safe to be in public without wearing a mask.	Yes	45 (5.0)	Chai et al., 2022; Qalati et al., 2023; WHO, 2023
	No	630 (70.0)	
	I don't know	225 (25.0)	
13. Cleaning your hands immediately before rubbing your eyes and before eating reduces the risk of infection.	Yes	813 (90.3)	Qalati et al., 2023
	No	27 (3.0)	
	I don't know	60 (6.7)	
14. For short stays in enclosed public places, it is safe not to wear a mask.	Yes	114 (12.7)	Qalati et al., 2023; WHO, 2023
	No	642 (71.3)	
	I don't know	144 (16.0)	

(Continued)

TABLE 3 (Continued)

Items	Responses	Number (%)	Sources
15. In a public place, if everyone else is wearing a mask, it's okay for me to not wear one.	Yes	66 (7.3)	Bagheri et al., 2021; WHO, 2023
	No	690 (76.7)	
	I don't know	144 (16.0)	
16. Outdoor gatherings are safer (lower likelihood of infection) than indoor gatherings.	Yes	474 (52.6)	Nordsiek et al., 2021; WHO, 2023
	No	213 (23.7)	
	I don't know	213 (23.7)	

Bold indicates the correct answer.



that they could get infected even while wearing a mask properly (49.7%), because masks merely reduce the risk of infection (Andrejko et al., 2022), and also because COVID-19 can enter the eye through respiratory droplets (Qalati et al., 2023; WHO, 2023). A significant proportion of respondents were also uncertain about the vaccine; for example, 40.6% did not know whether they could still get infected after vaccination, and 25% were unsure whether vaccinations allow a person to be in public without wearing a mask. Studies have shown that vaccines are not effective in the long term because of the emergence of viral variants (Jacobs et al., 2023), and that there is still a risk of contracting COVID-19 and transmitting it to others after vaccination; thus, WHO recommends that every effort should be made to maintain NPI even after vaccination (WHO, 2022). When it comes to wearing a mask in public, more than 70% of the respondents understood that they should ensure that they wear a mask regardless of the situation (e.g., length of stay, whether others are wearing masks or not). However, only 52.6% knew that outdoor gatherings are safer than indoor ones. Studies have shown that COVID-19 is an airborne disease that can be transmitted through particles (also known as aerosols) exhaled by an infected person that remain suspended in the air for a period rather than immediately falling to the ground, thereby increasing the probability of infection with increased infectious aerosol

concentrations (Nordsiek et al., 2021). Thus, outdoor gatherings provide a lower infection risk.

To examine the demographic characteristics and individual status that influence knowledge, OGLM was applied (Figure 6 and Supplementary Appendix Table 1). Regarding demographic characteristics, older (OR = 0.517 [0.418, 0.640], $p < 0.001$) respondents possessed less correct knowledge. The result is inconsistent with those of previous studies; Cotten and Gupta (2004) found that older people have more health needs than younger people and are, therefore, more likely to seek and find accurate health information, with studies in Saudi Arabia, Indonesia, and Malaysia supporting this conclusion (Azlan et al., 2020; Alnasser et al., 2021; Muslih et al., 2021). However, our findings suggest that younger populations are more likely to know about proper protection in the post-pandemic era, which is reasonable because previous studies have generally been conducted in the pre-pandemic and mid-pandemic periods, where there was a strong motivation to learn about protection due to higher mortality risk in middle-aged and older populations (Ioannidis et al., 2020), however, with the increasing number of infections across all age groups, it is likely that younger populations have also learned from the pandemic. In addition, younger populations are often more adept at using the Internet and have access to more accurate knowledge (Abdel Wahed et al., 2020). Furthermore, compared to the unemployed, retired, and self-employed groups, students (OR = 2.299 [1.298, 4.070], $p = 0.004$), private sector (OR = 1.961 [1.138, 3.380], $p = 0.015$), public sector (OR = 2.015 [1.156, 3.514], $p = 0.013$), and government employees (OR = 1.524 [0.819, 2.836], $p = 0.041$) held more accurate knowledge. The type of employment, usually related to socioeconomic status, potentially influences the level of knowledge acquired (Sujarwoto et al., 2022); thus, the retired, unemployed and non-stable employed groups were least knowledgeable among the respondents. The university students have a higher level of education, are usually young and, therefore, more likely to have accurate knowledge (Abdel Wahed et al., 2020). In terms of individual status, those who had not been previously infected with COVID-19 (OR = 1.819 [1.273, 2.600], $p = 0.001$), their family/friends got infected (OR = 0.361 [0.204, 0.637], $p < 0.001$), assessed themselves as having more knowledge of COVID-19 personal protection (OR = 1.510 [1.096, 2.081], $p = 0.012$), and perceived lower risk (OR = 0.647 [0.492, 0.850], $p = 0.002$) had more accurate knowledge. These results are reasonable since, because of their greater knowledge of personal protection, these respondents were not infected. Further, the results suggest that the self-assessment is consistent with the actual measurement, demonstrating that the items on the scale

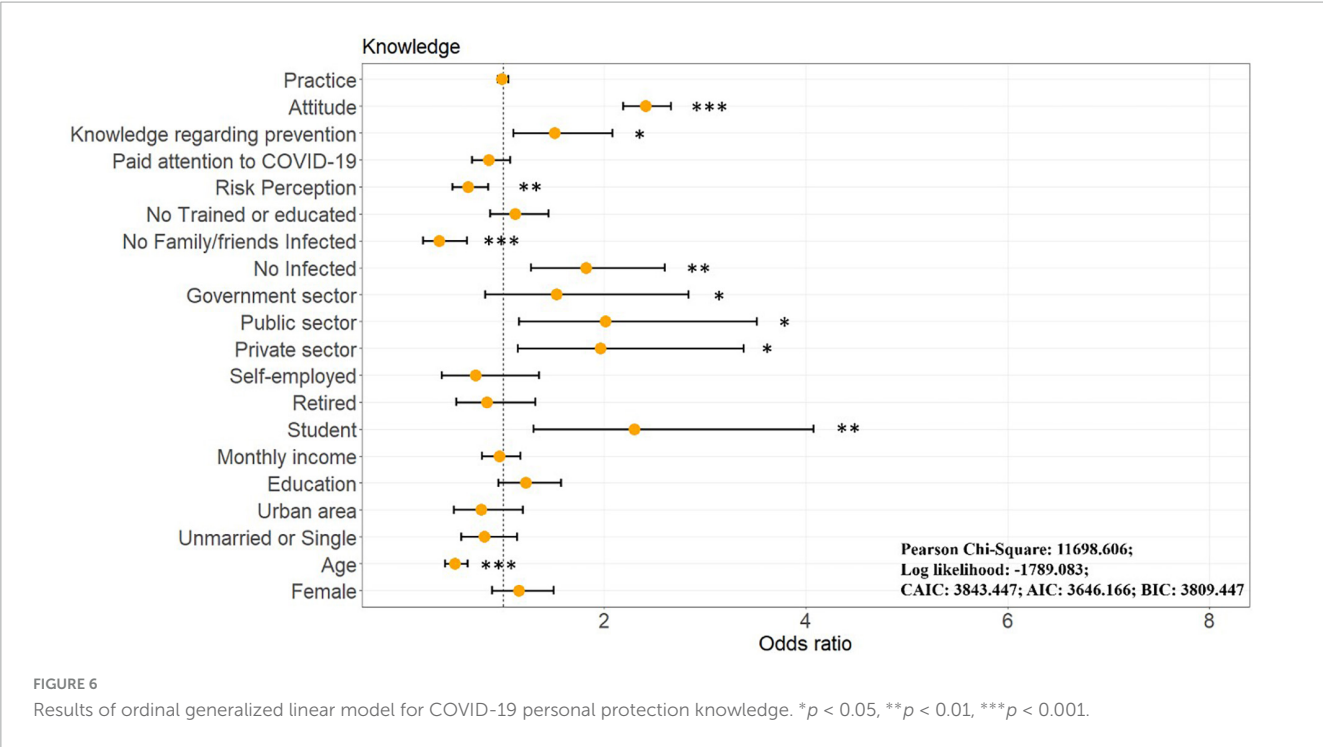


TABLE 4 Responses regarding attitudes toward personal protection against COVID-19.

Items	Responses	Number (%)	Sources
1. I should inform my family and friends about personal protection against COVID-19.	Yes	768 (85.3)	de Bruin and Bennett, 2020; Arefi et al., 2022
	No	33 (3.7)	
	I don't know	99 (11.0)	
2. I should carefully consider the level of infection risk at the destination before making travel or trip plans.	Yes	810 (90.0)	TravelHealthPro, 2023
	No	39 (4.3)	
	I don't know	51 (5.7)	
3. I support activities or training regarding COVID-19 prevention in the community where I live.	Yes	747 (83.0)	de Bruin and Bennett, 2020; Arefi et al., 2022
	No	60 (6.7)	
	I don't know	93 (10.3)	
4. I agree that proper mask wearing and regular hand washing can be effective in preventing the spread of COVID-19.	Yes	834 (92.7)	WHO, 2023
	No	18 (2.0)	
	I don't know	48 (5.3)	
5. I can take off my mask at any time in public if I feel uncomfortable.	Yes	177 (19.7)	WHO, 2023
	No	567 (63.0)	
	I don't know	156 (17.3)	
6. I think everyone should try to avoid unnecessarily remaining and gathering in public places.	Yes	687 (76.3)	Cone Health, 2020
	No	90 (10.0)	
	I don't know	123 (13.7)	
7. I agree that it is necessary to maintain a physical distance of at least 1 meter from others in public places.	Yes	720 (80.0)	WHO, 2023
	No	72 (8.0)	
	I don't know	108 (12.0)	

Bold indicates the correct answer.

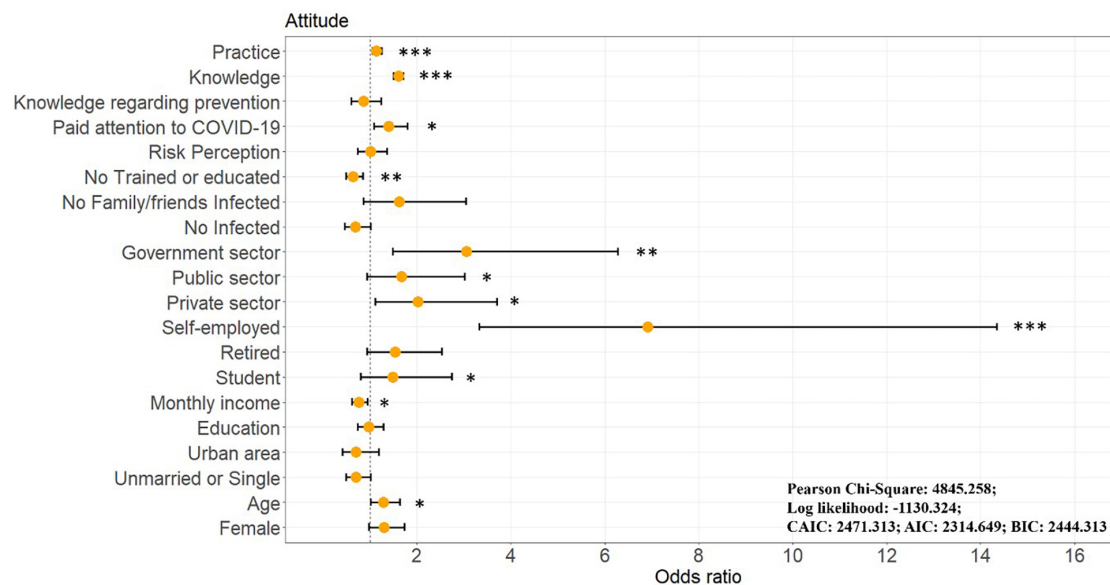


FIGURE 7

Results of ordinal generalized linear model for attitudes toward COVID-19 personal protection. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

are useful knowledge that residents apply to their daily lives. Reporting that a family member had been infected is a reasonable result that led to higher levels of knowledge among respondents, and there are two potential reasons for this: (1) infection of a family member leads to a heightened sense of protection and vigilance among other members, which leads to stronger motivation to learn about personal protection; and (2) during the pandemic in China, if a family member becomes infected, it is often necessary to have other healthy family members to care for them (provide food, water, and medicines), and thus this requires those healthy family members to be more attentive to their personal protection. Also, higher subjective knowledge is associated with lower perceived risk (Jaccard et al., 2005), as individuals who perceive themselves to be well informed may believe that their knowledge counteracts hazards, thus reducing subjective perceptions of risk (Buratti and Allwood, 2019). Finally, respondents with higher attitude scores they also had higher levels of knowledge, which is consistent with the findings of previous studies that attitude is closely related to knowledge, as positive attitudes promote individuals to learn more relevant knowledge (Rahman et al., 2023).

3.4 Personal protection attitudes regarding COVID-19

The responses of personal protection attitudes are shown in Table 4. Compared to knowledge and practice, the participants surveyed in this study had highly positive attitudes toward personal protective behavior, $M = 5.70 \pm 1.68$ (mean correct rate 81.4%; Figure 5). Specifically, 85.3% agreed that they should spread knowledge about personal protective measures to their family and friends, 90% believed that the level of pandemic risk at the destination should be carefully considered before traveling, 83% supported activities or training on COVID-19 prevention in their

community, 92.7% agreed that proper mask wearing and regular hand washing are effective in preventing transmission, and 80% agreed that physical distance should be maintained in public places. However, only 63% of participants insisted on wearing masks in public when they felt uncomfortable. Leung et al. (2020) show that one of the most effective preventive behaviors is wearing a mask that is effective against airborne transmission of viruses; however, the discomfort factor (e.g., thermal sensation) may still reduce people's willingness to wear them (Milošević et al., 2022). Therefore, the development of thermally regulated masks and respirators is important to encouraging daily mask-wearing behavior in the post-pandemic era (O'Dowd et al., 2020), and new comfortable mask materials may greatly reduce the probability of removing masks in public places. Furthermore, only 76.3% agreed that unnecessary gatherings and visits to public places should be avoided as much as possible. Although strict movement restrictions have been removed, there is a potential risk of disease transmission wherever large numbers gather. Therefore, unnecessary excursions to public places, such as dining out and store visits, should be avoided as far as possible.

OGLM was applied to examine whether demographic characteristics and individual states influenced attitudes (Figure 7 and Supplementary Appendix Table 1). Those who was older ($OR = 1.288 [1.015, 1.635]$, $p = 0.038$), and had a low income ($OR = 0.762 [0.616, 0.944]$, $p = 0.013$) had more positive attitudes. First, unlike the knowledge outcome that more correct knowledge among younger people, the older age groups had more positive attitudes toward COVID-19 personal protection. Although, young people can have more access to correct knowledge, the older people, as a vulnerable group in a pandemic, have more health needs than younger groups, which leads to a higher likelihood of higher positive attitudes (Cotten and Gupta, 2004). Besides, in line with the results of a previous study (Sujarwoto et al., 2022), low-income populations are more likely to have more positive attitudes, due to the fact that low-income groups have less ability to afford

TABLE 5 Responses regarding the practice of personal protection against COVID-19.

Items	Responses	Number (%)	Sources
1. In the recent week, I wore my mask properly to reduce the risk of infection when I was in the outdoor public places (e.g., parks, squares).	Yes	540 (60.0)	WHO, 2023
	No	237 (26.3)	
	I am not sure	123 (13.7)	
2. In the recent week, I washed my hands regularly even when I was in outdoor public places.	Yes	675 (75.0)	WHO, 2023
	No	138 (15.3)	
	I am not sure	87 (9.7)	
3. In the recent week, I tried to avoid going to outdoor public places where many people are present.	Yes	492 (54.7)	Qalati et al., 2023; WHO, 2023
	No	285 (31.7)	
	I am not sure	123 (13.6)	
4. In the recent week, I tried to keep a physical distance of at least 1 meter when meeting with others at outdoor public places.	Yes	510 (56.7)	Chai et al., 2022; Qalati et al., 2023; WHO, 2023
	No	255 (28.3)	
	I am not sure	135 (15.0)	
5. In the recent week, I always made sure to wear my mask properly when talking to others at outdoor public places.	Yes	483 (53.7)	WHO, 2023
	No	288 (32.0)	
	I am not sure	129 (14.3)	
6. In the recent week, I wore my mask properly to reduce the risk of infection when I was in the indoor public places (e.g., stores, shopping malls).	Yes	549 (61.0)	WHO, 2023
	No	243 (27.0)	
	I am not sure	108 (12.0)	
7. In the recent week, I washed my hands regularly when I was in indoor public places.	Yes	660 (73.3)	WHO, 2023
	No	165 (18.3)	
	I am not sure	75 (8.3)	
8. In the recent week, I tried to avoid going to indoor public places where many people are present.	Yes	507 (56.3)	Qalati et al., 2023; WHO, 2023
	No	267 (29.7)	
	I am not sure	126 (14.0)	
9. In the recent week, I tried to keep a physical distance of at least 1 meter when meeting with others in indoor public places.	Yes	483 (53.7)	Chai et al., 2022; Qalati et al., 2023; WHO, 2023
	No	282 (31.3)	
	I am not sure	135 (15.0)	
10. In the recent week, I always made sure to wear my mask properly when talking to others at indoor public places.	Yes	480 (53.3)	WHO, 2023
	No	273 (30.3)	
	I am not sure	147 (16.3)	

Bold indicates the correct answer.

healthcare and therefore show stronger positive attitudes toward protecting their own and their family's health, as well as a greater willingness to learn and share relevant information about COVID-19 personal protection. Further, compared to the unemployed population, students ($OR = 1.483 [0.801, 2.743]$, $p = 0.036$), self-employed ($OR = 6.906 [3.325, 14.345]$, $p < 0.001$), private sector ($OR = 2.026 [1.110, 3.698]$, $p = 0.021$), public sector ($OR = 1.678 [0.932, 3.021]$, $p = 0.034$), and government employees ($OR = 3.051 [1.482, 6.283]$, $p = 0.002$) had more positive attitudes. Since students and employed persons are more likely to be in frequent contact with other people (passively or actively, sometimes by necessity), the need for knowledge and positive attitudes toward personal protection is more strongly experienced. In terms of individual status, those who received training ($OR = 0.642 [0.485, 0.852]$, $p = 0.002$) and were more concerned about the COVID-19

pandemic ($OR = 1.394 [1.084, 1.791]$, $p = 0.010$) had stronger positive attitudes. The Chengdu government considers community units to be an important gateway for outbreak prevention and control and has, therefore, has set up a "micro-network" of grassroots governance mechanisms, with family doctors and counselors in each community unit, and regular community education and training (Sichuan View News, 2023). This supports previous research showing that disaster management training can be effective in enhancing positive attitudes toward disaster response behavior (Mirzaei et al., 2019). Moreover, increased attention to disasters has been found to positively influence attitudes toward the event; greater (and easier) access to news that allows the public to be well informed about the details of a disaster, likely enhances their positive attitude (Zhu and Zhang, 2017). Finally, respondents with higher knowledge scores were

more likely to have positive attitudes ($OR = 1.608 [1.523, 1.698]$, $p < 0.001$), which is consistent with finding as for whether or not they received training. In addition, this result demonstrates the role that knowledge plays in shaping attitudes, i.e., knowledge can lead to more positive attitudes toward COVID-19 protection.

3.5 Personal protection practices against COVID-19

The responses of personal protection practices are shown in [Table 5](#). Despite the high level of positive attitudes and the acceptable level of knowledge, the current average of 59.8% ($M = 5.98 \pm 3.65$) correct responses indicates that practical behavior is inadequate in the surveyed sample ([Figure 5](#)). First, only half of the respondents indicated that they would avoid crowded public places (outdoors: 54.7%; indoors: 56.3%). As mentioned earlier, because masks and vaccines provide only limited protection, crowded places are more likely to spread infection (both indoors and outdoors). Therefore, proper practice entails avoid unnecessary visits to these crowded public places to reduce the risk of infection. Second, less than 60% of the respondents reported that they try to maintain more than 1 meter of physical distance from others (outdoors: 56.7%; indoors: 53.7%). A prior meta-analysis of 172 observational studies indicated that virus transmission was lower at physical distances of 1 m or greater, with protection increasing with distance ([Chu et al., 2020](#)). Finally, approximately 53% of respondents said that they would ensure they wore a mask when talking to others (outdoors: 53.7%; indoors: 53.3%). A systematic study showed that various exhalation activities can produce respiratory droplets and aerosols that, when produced by infected individuals, may contain infectious viruses. Additional precautions must be taken to reduce short- and long-range droplet/aerosol transmission, particularly ventilation, air filtration, and mask fit, to prevent future outbreaks ([Wang C. C. et al., 2021](#)).

[Figure 8](#) and [Supplementary Appendix Table 1](#) show the OGLM results for demographic characteristics and individual status that influence overall practice behavior. Unexpectedly, no demographic characteristics other than age ($OR = 1.390 [1.109, 1.744]$, $p = 0.004$) significantly influenced people's practices ($p > 0.05$). In terms of personal status, those with training ($OR = 0.746 [0.573, 0.970]$, $p = 0.029$), higher COVID-19 risk perception ($OR = 1.454 [1.091, 1.938]$, $p = 0.011$), and those who were more concerned about the COVID-19 pandemic ($OR = 2.252 [1.797, 2.824]$, $p < 0.001$) scored higher in overall practice. In addition, people with positive attitudes are more likely to follow personal protective practice behaviors in their daily lives ($OR = 1.395 [1.264, 1.540]$, $p < 0.001$).

To examine whether there were differences in practice behaviors between different populations indoors (e.g., stores, shopping malls, items 6–10) and outdoors (e.g., parks, squares, items 1–5), OGLM was executed twice, and the scores of indoor and outdoor practices were set as dependent variables ([Figure 9](#) and [Supplementary Appendix Table 2](#)). Notably, when we divided overall practice behavior into indoor and outdoor, different sociodemographic characteristics and individual status significantly influenced both scores.

Specifically, in indoor environments, older ($OR = 1.479 [1.171, 1.867]$, $p = 0.001$), living in the urban area ($OR = 1.701 [1.050,$

$2.755]$, $p = 0.031$), and low-income participants ($OR = 0.867 [0.714, 1.054]$, $p = 0.038$) showed better practice behavior. This may be because the public recognizes the greater risk of infection in indoor public places and vulnerable populations (here the elderly, low-income populations) tend to follow personal protective behaviors more appropriately to reduce the risk of infection. In addition, respondents in urban environments scored higher on protective behaviors in indoor environments, which is due to the fact that for people living in urban areas are more likely to visit and use indoor public places (e.g., offices, stores, shopping malls), and therefore pay more attention to personal protection in indoor environments. On the other hand, according to previous reports given that the higher urban infection rates due to population density ([Hamidi et al., 2020](#)), and many infections occur indoors ([Moritz et al., 2021](#)), which potentially increases the alertness of indoor visitors. In outdoor settings, those with low education ($OR = 0.766 [0.596, 0.985]$, $p = 0.037$), and older people ($OR = 1.360 [1.083, 1.707]$, $p = 0.008$) performed better. The low-education population and the old performed better regarding outdoor settings, which may be explained as the same as in indoor settings. Educational status is usually correlated with income ([Sujarwoto et al., 2022](#)), and the lower-educated and the old population, as a vulnerable group, have less access to healthcare and are, therefore, more aware of personal protective behavior practice, even outdoors.

In terms of individual status, those with training ($OR = 0.722 [0.551, 0.947]$, $p = 0.019$), more concerned about the pandemic ($OR = 2.284 [1.814, 2.877]$, $p < 0.001$), and with higher risk perception ($OR = 1.499 [1.109, 2.027]$, $p = 0.009$) scored higher on practice in indoor settings, whereas only those who were more concerned about the pandemic scored higher on practice in outdoor environments ($OR = 1.976 [1.575, 2.480]$, $p < 0.001$). In addition, those who maintained positive attitudes toward COVID-19 personal protection were more likely to adhere to protective behaviors both indoors ($OR = 1.338 [1.209, 1.482]$, $p < 0.001$) and outdoors ($OR = 1.451 [1.311, 1.605]$, $p < 0.001$). As previously discussed, disaster management training can be effective in enhancing positive attitudes toward disaster response behaviors ([Mirzaei et al., 2019](#)) and greater attention to disasters also positively influences attitudes toward the event ([Zhu and Zhang, 2017](#)), and, finally, positive attitudes lead to higher practice outcomes ([Sujarwoto et al., 2022](#)). However, most of the variables did not have a significant effect on practice scores for outdoor environments, even the trained or with higher risk perception population did not show significant differences in practice behaviors in the outdoor environment, which probably because the surrounding population density is lower in most outdoor situations, causing the public to unconsciously relax their vigilance.

Overall, the vulnerable groups (like the elderly, low-income populations) are more aware of personal protective behaviors than non-vulnerable groups, indicating that the latter are more exposed to the risk of COVID-19. However, in general, non-vulnerable groups have easier access to healthcare, medications, and treatments than vulnerable groups, which will undoubtedly exacerbate the pressure on healthcare resources in the next outbreak, thus leading to the possibility of inequitable healthcare access. Additionally, outdoor public spaces (often low-population-density environments) potentially allow visitors to let their guard down and thus reduce the practice of protective

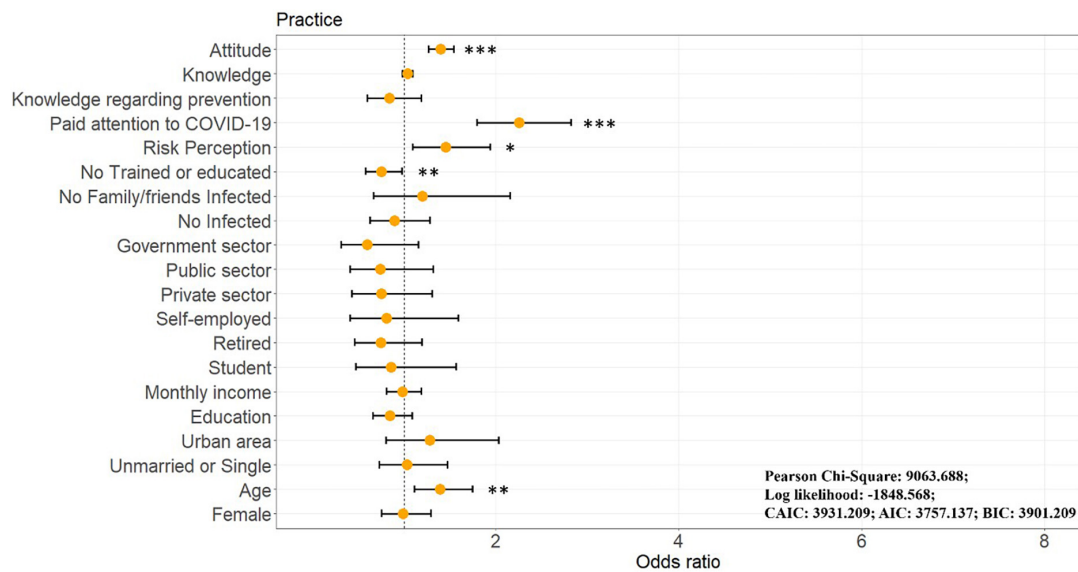


FIGURE 8

Results of ordinal generalized linear model for COVID-19 personal protection practice. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

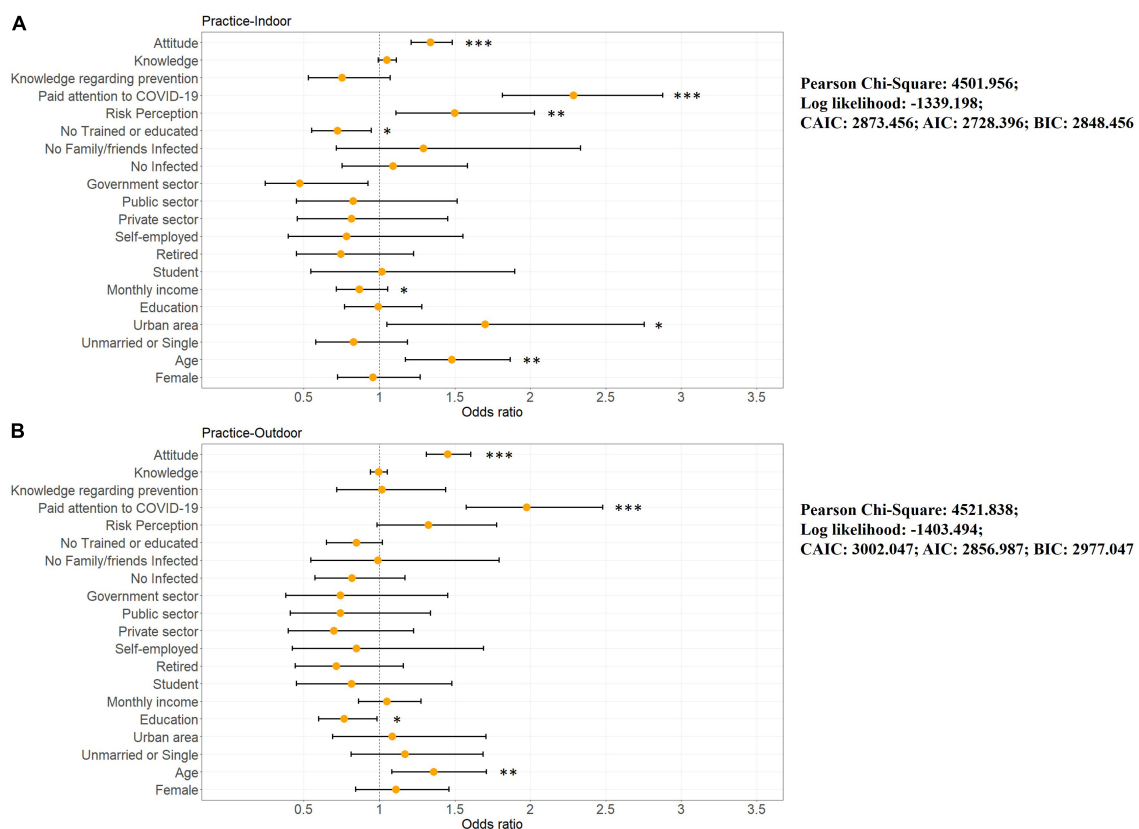


FIGURE 9

Results of ordinal generalized linear model for COVID-19 personal protection indoor and outdoor practice; (A) indoor practice, (B) outdoor practice. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

behaviors, which affects even trained populations as well as those with a higher perceived risk level. Third, only those who maintained positive attitudes toward COVID-19 personal protection were more likely to maintain practice behaviors in both

indoor and outdoor environments, and the amount of knowledge did not significantly contribute to respondents' actual protection behaviors, unlike the previous emphasis on knowledge (see Bagheri et al., 2021; Andrejko et al., 2022; Arefi et al., 2022; Sujarwoto et al.,

2022). These findings are important for developing future urban health policies.

3.6 Non-linear relationships among the three dimensions of KAP

A polynomial regression by R program was executed to examine the nonlinear relationship between the three dimensions of KAP (Figure 10). Overall, respondents' knowledge and practice behaviors increased with positive attitudes (Figures 10A, B). First, the public knowledge was positively correlated with attitudes, which is consistent with previous studies (Alnasser et al., 2021; Reuben et al., 2021; Sujarwoto et al., 2022). Then, practice scores increased with attitude scores, but the tendency to increase decreased when the attitudes scores increased beyond a point, indicating that individuals' attitudes have limited incentives for actual behavior. Particularly, if people become aware that these practices may be unnecessary (e.g., it may be safe to not wear a mask outdoors if there is a low density of people around) or non-mandatory (the current Chinese government no longer requires citizens to strictly implement NPI measures), the propensity to practice may decrease, even if individuals have strong attitudes. Finally, it is worth noting that the relationship between knowledge and practice is an inverted U-shaped (Figure 10C), suggesting that while knowledge increases to a threshold (in this study, 68.75–75% of the correctness rate), the associated protective behavior then begins to decrease, which the result may explain why the relationship between knowledge and practice is insignificant in all OGLM models. Besides, this directly supports previous findings that as populations acquire more knowledge, they are more likely to overestimate the ability of the knowledge they

possess to protect against risk and underestimate the negative effects of risk (Buratti and Allwood, 2019). This result is paradoxical for city managers because on the one hand they want the public to learn more to protect themselves against COVID-19 risks, but on the other hand too much knowledge may lead to complacency and reduce their actual protective behaviors. Therefore, we recommend that, in the future, managers should deliver education about personal protection from COVID-19 which emphasizes the importance of adopting protective behaviors and the potential risks of ignoring them, to increase the public's positive attitude toward personal protection and their tendency to protect themselves.

3.7 Limitations

First, this study used a web-based questionnaire to collect data; therefore, there may be some bias in the sample distribution, such as a smaller proportion of older adults who likely less adept at using cell phones or computers. These biases may limit the external validity of this study and the extent to which the results can be applied to other settings or populations. In addition, people who were not interested or did not want to discuss the topic of this study may have been excluded. Second, cost constraints limited the data collection to the city level, and future studies could consider a deeper survey at the neighborhood or street level to provide a clear picture of the residents in different areas of the city. Third, this was a cross-sectional survey. City managers and policymakers may want to conduct more surveys at different time points as the new normal evolves. Also, comparative analyses with data from earlier time periods are meaningful, therefore more works need to do by comparing the data from this study

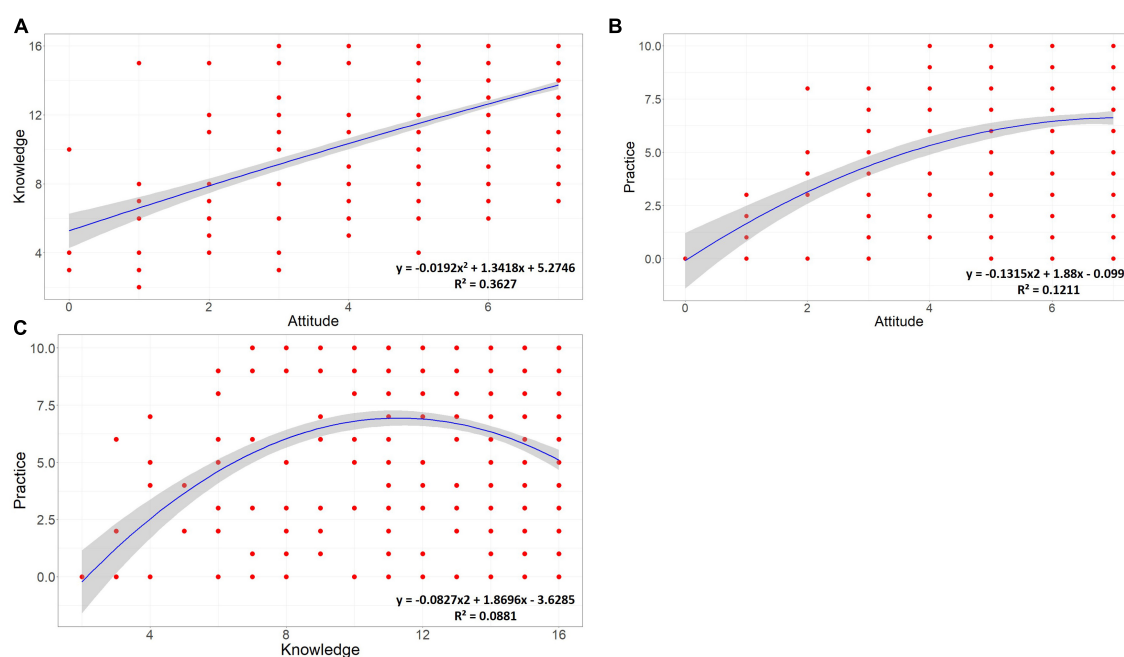


FIGURE 10 Relationships among the three KAP dimensions. (A) Attitude-knowledge; (B) attitude-practice; (C) knowledge-practice.

with previous KAP data from the Chengdu area in the future. Moreover, studies from other cities and countries are required to monitor the extent of KAP in each region, which is important for global preparedness against the next pandemic. Fourth, although the most recent literature and policy documents were referenced to formulate the survey questions, as new technologies and conditions emerge, the current questionnaire would need to be accordingly adapted. Finally, this study innovatively included the individual status dimension, and these items were found to influence public KAP levels. Therefore, more variables that may potentially influence public KAP levels need to be explored and discussed in the future.

4 Study implications and contributions

4.1 Potential international relevance and impacts

At the first, comparing the results of the current study with similar studies conducted in other parts of the world can provide insights into how different populations respond to and adopt COVID-19 protective behaviors. This can help identify trends and variations in knowledge, attitudes, and practices across cultures and regions. Second, according to the United Nations Sustainable Development Goals (SDGs), healthy populations are key to building resilient cities. The survey reveals knowledge gaps or negative attitudes toward certain personal protection behaviors, which can inform targeted educational activities or public health strategies in other region and countries. As such, this study is one of the key pieces of the puzzle for a global KAP survey in the post-pandemic era. Third, epidemiologists can use the data collected by this and other KAP surveys to refine epidemiologic models, which can help predict the spread of the virus and the impact of interventions in different settings.

4.2 Contributions for sustainability of urban cities regarding COVID-19/alike crisis control

More than half of the world's population lives in cities, and the 11th of the UN Sustainable Development Goals aims to "make cities and human settlements inclusive, safe, resilient and sustainable" by 2030, the people therefore form the basis of sustainable cities. Espey (2019) stated that the Sustainable Development Goals without data will inevitably fail. A recent study from Japan has begun to discuss the progress of SDG 11 indicators in the local cities, yet the need for healthy populations or socio-ecological aspects of resilient cities is still not addressed (Yamasaki and Yamada, 2022). Thus, this study demonstrates that the KAP survey can be a reliable indicators data collection tool for COVID-19/alike crisis risk knowledge/protection behaviors. Second, humans will continue to coexist with the virus for a long time to come. Variations, diminishing vaccine efficacy, and the emergence of new infectious diseases (e.g., monkeypox, Matsee et al., 2023) demonstrate that NPI will be a more implementable

and sustainable means of protection for future cities. Therefore, in the post-pandemic era, based on the related KAP surveys managers and policymakers could promote knowledge of personal prevention and encourage attitudes and practices that reduce the risk of COVID-19/alike crisis spreading; also, the KAP surveys can be used to assess the public's strategies to protect themselves from specific disasters. These contributions are valuable for sustainable urban development regarding COVID-19/alike crisis control.

4.3 Control measures, solutions, and policy implications

First and foremost, in contrast to the previous emphasis on the importance of knowledge, our study found that positive attitudes toward personal protection are more important in the post-pandemic era, as this directly and significantly influences residents' practice behaviors. Besides, despite the withdrawal of strict management measures, it is still recommended that authorities encourage and educate on personal NPI while emphasizing the importance of associated protective behaviors and the potential risks of ignoring them, thus enhancing positive attitudes toward personal protection and the propensity for practice to prevent the public from underestimating the potential threat of the current pandemic. Second, the potential casualties from a pandemic can be reduced through early intervention based on sociodemographic information. Using demographic data, infection risk assessment can focus on the populations most at-risk. Third, although WHO has lowered the risk level of COVID-19, humans must coexist with the pandemic for an extended period; thus, understanding changes in public KAP regarding personal protective behaviors in the post-pandemic era is important for the sustainability of cities and communities. In addition, this study reveals that the public's personal protective behaviors in the post-pandemic era are inadequate, specifically maintaining physical distance, avoiding visits to crowded public places, and wearing masks. These findings can inform targeted education and encouragement policies by city managers. Fourth, the development and use of new mask materials that enhance comfort (e.g., decrease thermal sensation) can effectively reduce the probability of removing masks in public places, thereby reducing the risk of outbreaks. Fifth, ensuring that the public is informed about the pandemic from a variety of sources can enhance positive attitudes toward personal protection. Moreover, outdoor public spaces (squares, parks, and public green spaces) in cities may be potential transmission areas for the next outbreak due to the public lets its guard down. Therefore, focus on these areas needs to be strengthened to emphasize and advise on personal protective behaviors. In particular, persuasion of non-vulnerable populations to practice NPI could reduce the potential pressure on urban medical resources. Finally, the KAP survey can help identify potential risk areas in the city (such as the outdoor public spaces surveyed in this study), as well as high infect risk populations (such as the non-vulnerable groups in this study). The results of the study can therefore help city authorities to allocate resources such as medical supplies, testing facilities and public health activities more efficiently based on the specific knowledge, attitudes and practices of the city population.

5 Conclusion

The United Nations 2030 Agenda for Sustainable Development recognizes and reaffirms the urgent need for disaster risk reduction to promote the resilience and sustainability of cities and human settlements. With the advent of the post-pandemic era, national-level preparedness measures will be largely replaced by personal protective behaviors. Therefore, in the context of the new normal, encouraging the public to implement proper COVID-19 personal protection behaviors is of great significance for the sustainable development of cities and communities. To the best of our knowledge, there are few studies that address public protective behaviors in the post-pandemic era, and this baseline survey closes this knowledge gap, yielding many valuable findings: (1) approximately 1/3 of the respondents in this study indicated that they are currently not concerned about COVID-19 at all, which needs to be brought to the attention of the authorities because the pandemic is still not over and excessive public laxity could pose a great risk to urban public health; (2) more than half of the respondents indicated that they had received relevant training and 85% of the sample self-assessed as being knowledgeable about personal protection, indicating that the promotion and education (lectures and training) measures should be continued in the future; (3) although the participants possessed fairly accurate knowledge related to COVID-19 personal protection and had highly positive attitudes, their practice behaviors were inadequate; (4) knowledge scores were higher in younger and employed participants; (5) attitude scores were higher in older, low-income, and employed participants; (6) individual status dimensions (such as whether previously infected, trained, and concerned about the pandemic) were found to significantly influence the three KAP dimensions, making this data valuable; (7) respondents with different sociodemographic characteristics and individual statuses show significant differences in their indoor and outdoor safety practices; (8) disaster training and higher concern with regard to the pandemic positively influenced the public's scores on COVID-19 attitudes toward personal protective behaviors, leading to higher practice behaviors; (9) vulnerable groups (older people, people with low education levels, and low-income groups) performed better in indoor/outdoor practices. Further, most people relaxed their vigilance in outdoor environments, thus reducing practice behaviors; (10) attitudes offer limited incentive for practice when people realize that practice behaviors may be unnecessary or non-mandatory; the propensity to practice may be low even when individuals have strong attitudes; (11) when knowledge increases to a threshold level (68.75–75% in this study), individuals' protective behaviors start to decrease because they may overestimate the risk resistance potential of the knowledge they possess. Finally, a series of measures are also proposed based on these results and findings, as well as recommendations to help cities deal with potential future COVID-19 and alike crisis.

Data availability statement

The original contributions presented in this study are included in this article/**Supplementary material**, further inquiries can be directed to the corresponding author.

Author contributions

SL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. JX: Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. JC: Investigation, Methodology, Visualization, Writing – review & editing. HL: Investigation, Writing – review & editing. SZ: Investigation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1411055/full#supplementary-material>

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A cross-sectional study of predictive factors of health literacy among rheumatoid arthritis patients in China

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Objective: To investigate the factors that influence health literacy (HL) among Chinese patients with rheumatoid arthritis (RA) and furnish theoretical underpinnings for the development of intervention strategies aimed at enhancing patients' quality of life.

Methods: From May 2022 to December 2022, a comprehensive survey was conducted among both outpatients and inpatients diagnosed with (RA) in a tertiary hospital in China. The survey utilized various instruments, including a general information questionnaire, a chronic disease patient health literacy scale, the Health Assessment Questionnaire-Disability Index (HAQ-DI), the Chinese-translated Rheumatoid Arthritis Self-Efficacy Scale, the Chinese-translated Rheumatoid Arthritis Stigma Scale, and the Chinese-translated Compliance Questionnaire for Rheumatology Treatments.

Results: The average scores of HL, self-efficacy, medication adherence, and disability index were 83.54 ± 17.43 , 84.91 ± 14.37 , 70.16 ± 11.24 , and 0.26 ± 0.44 , respectively. HL in Chinese RA patients was negatively correlated with age, erythrocyte sedimentation rate (ESR), number of tender joints, number of swollen joints, and disease activity, while positively correlated with self-efficacy and medication adherence. Age, disease activity, disability index, self-efficacy, and medication adherence are predictive factors of HL, and a predictive model has been initially constructed.

Conclusion: In the management of RA, healthcare professionals should develop and implement effective intervention measures by focusing on improving medication adherence, enhancing patients' self-efficacy, improving patients' physical function, and reducing disease activity. This will help enhance the health literacy and promote clinical outcomes in RA patients.

KEYWORDS

rheumatoid arthritis, health literacy, self-efficacy, medication adherence, disability index

Introduction

Rheumatoid arthritis (RA) is a chronic autoimmune disease characterized by inflammatory arthritis. In China, the prevalence of RA ranges from 0.35 to 0.45%, with an estimated total RA patient count of approximately 5 million, exhibiting a significant male-to-female ratio of 1:4 (Yu et al., 2023). Extensive research has revealed that joint diseases constitute one of the primary sources of physical disability, with RA occupying the topmost position in terms of disability rates (Bai et al., 2020). This high disability rate is attributed to the unclear etiology of RA and the absence of effective curative measures (Brown et al., 2024). Moreover, the scarcity of preventive research and delayed interventions serve as significant factors that contribute to the unfavorable prognosis of RA (Abbasi, 2017).

Health literacy (HL) is a cognitive and social skill that determines an individual's motivation and ability to access, understand, and apply information to promote and maintain health (Nutbeam, 2008). Research has shown that HL is a crucial factor in health outcomes (Stormacq et al., 2020). Low HL among RA patients can lead to poor medication adherence and an increased risk of misinterpretation of medical advice (Nakayama et al., 2015). HL is not merely a lack of knowledge and skills; it also involves making correct health decisions through self-awareness (Zhuang et al., 2023). Studies have found that the proportion of HL in RA patients ranges from 7 to 42% (Loke et al., 2012). Many factors contribute to low HL in RA patients, including low education levels, a lack of reading habits, as well as race, income, and age-related factors (Martin et al., 2013). A study conducted in a nursing outpatient clinic in Germany revealed a significant association between high HL and low disease activity as well as high quality of life across various dimensions (Hirsh et al., 2019). A cross-sectional study of 110 RA patients found that low HL was associated with joint dysfunction (Caplan et al., 2014). A study in Ontario, Canada, showed that poor HL can lead to poor medication adherence (Gong et al., 2015).

In the early stages, most domestic and international scholars investigated the influencing factors of HL primarily from demographic characteristics. As cross-sectional studies have progressed, social and psychological factors have become hot topics of discussion (Stoll et al., 2024). However, correlation research remains comparatively scarce, and comprehensive, large-scale cross-sectional studies encompassing multiple factors are still pending. The consequence of low HL is suboptimal clinical outcomes, which ultimately impedes the progression toward high-quality healthcare. Therefore, the focus of research has shifted to how to identify the influencing factors of low HL in RA patients from multiple dimensions and perspectives. In terms of psychological factors, a higher level of HL has been linked to patient confidence (Jang et al., 2024). Hence, this study includes the self-efficacy of RA patients in a cross-sectional study on HL. Additionally, patients' symptoms, disease activity, physical function, and self-management capabilities have also become areas of our focus. Meanwhile, as the commonly used functional HL scales have not undergone reliability and validity testing in the Chinese RA population, this study employs a chronic disease HL scale that is suitable for the Chinese population. The aim of this study is to explore factors significantly associated with HL in RA patients, reveal potential predictors of HL in Chinese RA patients, and initially develop a predictive model. This will provide theoretical support for medical professionals to accurately identify RA patients with low HL levels, develop targeted intervention measures, and improve health outcomes.

Methods

Demographic survey and questionnaire

A convenience sampling method was adopted to recruit RA patients from the outpatient and inpatient departments of the rheumatology and immunology division in Changzhou, China, from May 2022 to December 2022. Inclusion criteria were: ages ranging from 18 to 79; diagnosed with RA according to the 1987 American College of Rheumatology (ACR) classification criteria; normal cognitive ability and clear expression skills; disease duration greater than 6 months. Exclusion criteria were: severe personal or family changes affecting the patient's emotional well-being during the survey period; presence of severe diseases (such as heart failure, renal insufficiency, respiratory failure, severe infection, etc.) and extra-articular manifestations of RA; and the presence of other autoimmune diseases. The survey was conducted by a nurse from the Chronic Rheumatic Disease Management Center. After obtaining the patients' informed consent, all questionnaires were distributed to the patients, and uniform instructions were provided for any issues encountered during completion. The questionnaires were collected on the spot, and strict confidentiality measures were implemented to protect the participants' privacy. A total of 172 participants were surveyed in this study, and 172 valid questionnaires were recovered, with a 100% response rate. This study was approved by the Ethics Committee of our hospital with the approval number [2021] KY025-01.

Chronic disease HL Management Scale

The HL Management Scale (HeLMS), which was developed by Australian scholars, was translated and revised by Sun (2012) in China. The scale comprises 24 items and is divided into 4 dimensions. The total score is 120 points, and a higher score indicates a higher level of HL. Patients scoring 80% or above are defined as having high HL. The Cronbach's alpha coefficient of this scale ranges from 0.857 to 0.947, indicating good internal consistency of the scale.

Chinese Compliance Questionnaire for Rheumatology (CCQR)

This scale was translated into Chinese by Zhu et al. (2013). It comprises 19 items, utilizing a 4-point scoring method. The CCQR score is calculated using the formula: (sum of scores for each item-19)/0.57. A score of 80 or above indicates good compliance. The intra-class correlation coefficient for the CCQR score is 0.994 (95% confidence interval: 0.990, 0.997).

Chinese version of Rheumatoid Arthritis Self-Efficacy Scale (C-RASE)

This scale was adapted into Chinese by Chinese scholars Li et al. (2019). It consists of 25 items, with scores ranging from 1 to 5, and a total score ranging from 25 to 125. A higher score indicates a stronger sense of self-efficacy. The Cronbach's α coefficient for this scale is 0.751.

Chinese version of the Rheumatoid Arthritis Stigma Scale (C-ISMI-RA)

This scale was revised by Geng et al. (2022). It uses a 4-point Likert scale, with a total score ranging from 20 to 80. A higher score indicates a more severe stigma. The Cronbach's α coefficient for this scale is 0.90. The confirmatory factor analysis showed RMSEA = 0.09, CFI = 0.94, and TLI = 0.93.

Health Assessment Questionnaire-Disability Index (HAQ-DI)

Consisting of 20 items, this scale is used to assess the physical function of RA patients. Scores are categorized as mild (total score ≤ 1), moderate ($1 < \text{total score} \leq 2$), and severe ($2 < \text{total score} \leq 3$). The scale exhibits good reliability and validity, making it suitable for evaluating physical function limitations in RA patients (Fries et al., 1980).

Statistical analysis

Data analysis was conducted using SPSS 19.0 software. Descriptive statistical analysis was performed using means, standard deviations (SDs), medians, quartiles, absolute frequencies, and relative frequencies. Pearson's correlation coefficient was used to explore the relationship between quantitative variables. Due to the inability to determine normal distribution previously, the Kruskal-Wallis test was used to determine the effect of variables on HL. Linear regression analysis was used to explore predictive associations among variables. A p -value of <0.05 indicates statistical significance.

Results

Common method deviation test

The Harman single-factor test was used to assess the common method deviation in the samples. The results indicate that the interpretation rate of the first factor is 15.5%, which is significantly below the critical threshold of 40% (Podsakoff et al., 2003), thus suggesting that there is no significant common methodological bias in the data from this sample.

Patient characteristics

A total of 172 RA patients who met the inclusion criteria were surveyed, and 172 valid questionnaires were returned (response rate of 100%). The majority of RA patients were female, 72.67% were urban residents, and their ages ranged from 46 to 59 years, with a median age of 53 years. Most patients had a morning stiffness level of 1 (69.19%). Specific information on the patients is presented in Table 1.

Scores on related scales for RA patients

The average scores for health literacy, stigma of illness, medication adherence, self-efficacy, and disability index were (83.54 ± 17.43),

(54.51 ± 9.68), (70.16 ± 11.24), (84.91 ± 14.37), and (0.26 ± 0.44) respectively. Table 2 presents the detailed results.

The relationship between demographic, clinical variables, related scale scores, and HL

As shown in Figure 1, The Spearman's rank correlation coefficient was calculated to determine the relationship between HL (represented by HL_T) of RA patients and demographic and clinical variables. The results revealed that HL had a significant negative correlation with age ($r = -0.63$, $p < 0.001$), ESR ($r = -0.19$, $p < 0.05$), joint pain score ($r = -0.16$, $p < 0.05$), joint swelling score ($r = -0.22$, $p < 0.01$), and DAS28 ($r = -0.21$, $p < 0.01$), while it had a significant positive correlation with Total_SEFF ($r = 0.45$, $p < 0.001$) and CCQRT ($r = 0.37$, $p < 0.001$). The disease duration, pain score (VAS), PGA, and stigma score showed no significant correlation with HL and were not included in subsequent analyses.

Univariate analysis of HL in RA patients

The results of the univariate analysis indicated that there were statistically significant differences in HL among patients with respect to age, disease activity (DAS28), self-efficacy, and treatment compliance ($p < 0.05$). Although HAQ did not have a significant correlation with HL ($F = 1.44$, $p = 0.15$), it was still included in the subsequent analysis for clinical consideration, as shown in Table 3.

Predictors of HL in RA patients

To determine which factors best predict HL, a stepwise multiple linear regression analysis was performed (Table 4). Spearman's rank correlation coefficient was calculated to distinguish the relationships between these factors and HL (represented by HL_T score). Age, DAS28, HAQ_DI, self-efficacy, and CCQRT values were identified as predictors of HL. These predictors yielded a statistically significant model ($F = 48.96$, $p \leq 0.001$), explaining 77% of the variation in the dependent variable (adjusted $R^2 = 0.765$). The final equation is: $HL = 64.67 - 0.82 * \text{Age} - 4.20 * \text{DAS28} + 12.29 * \text{HAQ_DI} + 0.46 * \text{TOTAL_SEFF} + 0.51 * \text{CCQRT}$.

Discussion

The average HL score for RA patients in China is (83.54 ± 17.43), indicating a moderate level. Although it is still lower than the diabetic patients (Qin and Xu, 2016), significant progress has been made in the "Healthy China 2030" strategy. An effective way to improve HL among RA patients is to implement chronic disease management. China started relatively late in this regard, but China's still actively exploring a chronic rheumatic disease management model that suits its national conditions. HL emphasizes active acquisition, critical thinking, and ultimately using the obtained information to make healthy decisions and solve problems. Foreign studies (Hirsh, 2016) have shown that low education levels can affect HL levels. In this study, 75% of the participants had an education level below high school, which created

TABLE 1 Characteristics of RA patients.

Variable	Mean ± SD or N (%)	Median (Q1,Q3)
Gender		
Male	22 (12.79)	
Female	150 (87.21)	
Age	52.62 ± 12.25	53.00 (46.00,59.00)
Illness duration	8.67 ± 8.06	5.65 (3.00,10.50)
District		
Urban	125 (72.67)	
Rural	47 (27.33)	
Education		
Primary school and below	51 (29.65)	
Junior school or technical school	78 (45.35)	
High school and above	43 (25.00)	
Occupation		
Employed	111 (64.53)	
Unemployed	61 (35.47)	
Income		
<3,000	88 (51.16)	
3,000–5,000	60 (34.88)	
>5,000	24 (13.95)	
Insurance		
Self-paid	11 (6.40)	
NCMS	37 (21.51)	
Basic medical insurance	124 (72.09)	
Family history		
Yes	17 (9.88)	
No	155 (90.12)	
Morning stiffness		
Level one	119 (69.19)	
Level two	35 (20.35)	
Level three	18 (10.47)	
Regular medication		
Level one	12 (6.98)	
Level two	45 (26.16)	
Level three	115 (66.86)	
ESR	33.44 ± 23.96	28.00 (16.50,45.00)
VAS	4.13 ± 2.09	4 (3,6)
PGA	3.89 ± 1.92	4 (3,5)
Joint pain	4.62 ± 5.02	3 (2,6)
joint swelling	3.09 ± 3.22	2 (1,5)
DAS28	4.48 ± 1.59	4.55 (3.06,5.62)

ESR, erythrocyte sedimentation rate; VAS, visual analog scale of pain; PGA, patient global assessment; DAS28, disease activity index.

certain obstacles in accessing and utilizing health information, and may be a reason why the HL score of RA patients is at a moderate level. Self-efficacy refers to individuals' confidence or belief in their ability to achieve specific behavioral goals in a particular domain

(Cepukiene and Puzeriene, 2024). The average score of self-efficacy for RA patients in this study was (84.91 $\pm$ 14.37), indicating that it is consistent with a cross-sectional study in Spain (Cantero-Tellez et al., 2023). The results of the multivariate analysis show that self-efficacy

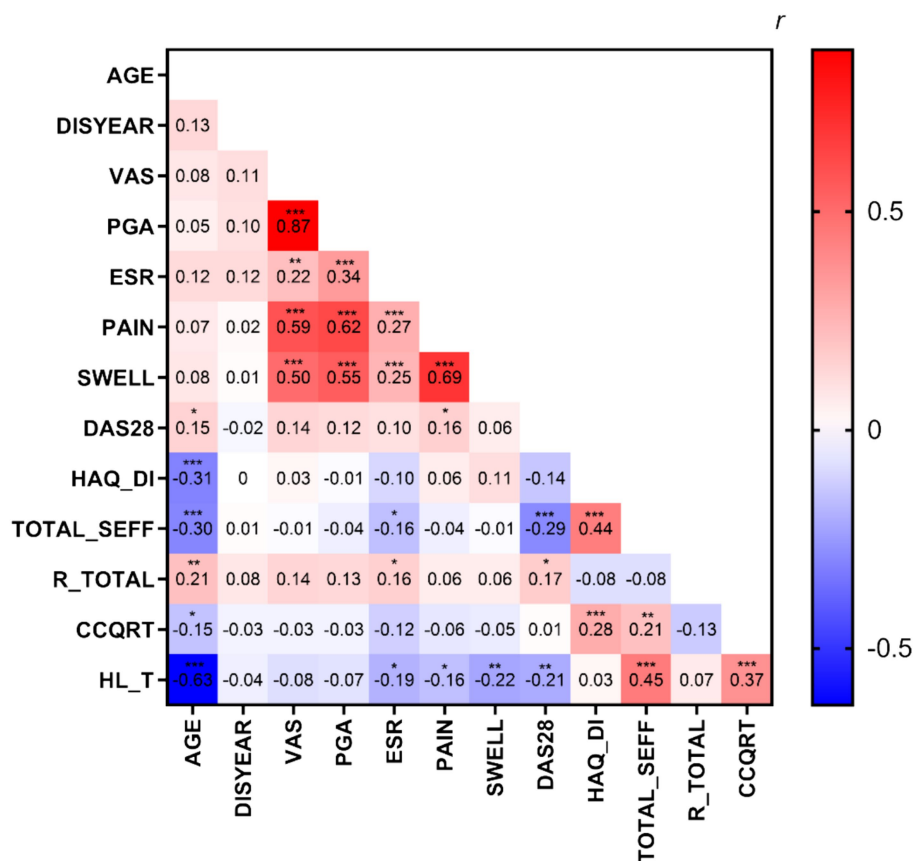


FIGURE 1
The heatmap of correlations between variables. DISYEAR, illness duration (month); ESR, erythrocyte sedimentation rate; pain, the total joint pain count; SWELL, the total joint swelling count; DAS28,disease activity index; HAQ-DI, total score of HAQ-DI; TOTAL_SEFF, total score of C-RASE; R_TOTAL, total score of C-ISMI-RA; CCQRT, total score of CCQR; HL_T, total score of HL Scale for chronic patients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE 2 Descriptive statistics of related scales.

Variables	Mean (SD)	Median (Q1,Q3)
Health literacy (Health Literacy Scale for chronic patients)	83.54 (17.43)	81.00 (67.00,98.5)
Stigma (C-ISMI-RA)	54.51 (9.68)	55.00 (48.50,61.00)
Chinese Compliance Questionnaire for Rheumatology(CCQR)	70.16 (11.24)	66.67 (61.40,78.95)
Self-efficacy (C-RASE)	84.91 (14.37)	87.00 (76.00,94.50)
Health assessment Questionnaire-Disability index (HAQ-DI)	0.26 (0.44)	0.05 (0.0,35)

TABLE 3 Univariable linear regression analysis between associated variables and HL.

Variables	F	p
Age	111.73	<0.001
DAS28	9.53	<0.001
TOTAL_SEFF	43.22	<0.001
CCQRT	28.79	<0.001

is a predictor of HL among RA patients. RA patients with higher HL levels are more likely to be aware of the relationship between current behaviors and health outcomes, which plays an important role in adopting and maintaining healthy behaviors (Liu et al., 2024). The

study by Cantero-Tellez et al. has proven that individuals with high self-efficacy are more likely to adopt positive health behaviors (Cantero-Tellez et al., 2023). HL, self-efficacy, and their levels are closely related to health outcomes and quality of life. Enhancing self-efficacy and improving HL among RA patients, as well as changing unhealthy lifestyles, can contribute significantly to improving their quality of life.

The proportion of medication adherence among RA patients ranges from 30 to 93% (Omair et al., 2022). Some studies have shown that low HL in RA patients is associated with poor medication adherence (Contreras-Yanez et al., 2021). In this study, there was a positive correlation between self-efficacy and medication adherence ($p < 0.01$), which is consistent with the findings of Lavsa's research (Lavsa et al., 2011). Simultaneously, there was also a positive

TABLE 4 Multiple linear regression analysis explaining the variance of HL in RA patients (n = 172).

Variable	β	SE	Beta	t	p	R ²	Adjusted R ²	F
Intercept	64.67	7.63	0.00	8.47	<0.001	0.774	0.765	48.96
Age	−0.82	0.05	−0.58	−15.34	<0.001			
DAS28	−4.20	0.53	−0.33	−7.99	<0.001			
HAQ_DI	12.29	1.66	0.31	7.39	<0.001			
TOTAL_SEFF	0.46	0.05	0.38	10.26	<0.001			
CCQRT	0.51	0.06	0.33	8.86	<0.001			

DAS28, disease activity index; HAQ-DI, total score of HAQ-DI; TOTAL_SEFF, total score of C-RASE; R_TOTAL, total score of C-ISMI-RA; CCQRT, total score of CCQR; HL_T, total score of Health Literacy Scale for chronic patients.

correlation between disability index and medication adherence ($p < 0.001$), in line with Nagafusa’s study (Nagafusa et al., 2023). Multivariate analysis revealed that medication adherence is a predictor of HL. Gomez-Galicia and colleagues reported that low HL is associated with poor self-reported medication adherence among RA patients (Gomez-Galicia et al., 2022). Hirsh et al. (2020) pointed out that patients with low HL encounter difficulties in reading medication labels and prescriptions. Additional research has shown that patients with low levels of light physical activity and self-efficacy tend to have severe joint deformities and more functional limitations (Contreras-Yanez et al., 2021; Park et al., 2024). In this study, medication adherence and self-efficacy both affect HL among RA patients, but we do not know whether these two factors directly impact HL or if one factor indirectly affects HL through the other. This remains to be further explored in the future. However, it is certain that interventions targeting HL can improve patients’ long-term medication adherence, increase treatment engagement, and enhance skills in medication management.

In this study, the mean value of the Health Assessment Questionnaire Disability Index (HAQ-DI) was 0.26 ± 0.44 , indicating mild functional disability. Univariate regression analysis showed no significant correlation between HAQ-DI and HL. However, based on clinical judgment, HAQ-DI was included in the multiple regression analysis, suggesting its potential as a predictor of HL. This may be related to the data sources, since most of the data came from chronic rheumatic disease management centers. Domestic experts believe that to address physical dysfunction among RA patients in China, more attention should be paid to elderly patients and those with high disease activity (Zhou et al., 2018). Currently, there are few studies on the relationship between physical dysfunction and HL, but some research has shown a close relationship between low HL and cognitive impairment (Han et al., 2015). Therefore, we hypothesize that the disability index may predict HL among RA patients, and that there may be an underlying relationship with cognitive impairment, which requires further validation.

Age (52.62 ± 12.25) and the average DAS28 score (4.48 ± 1.59) were also significant negative factors for HL. Among the recruited age range, older age was associated with lower HL. These findings are similar to previous studies (Buchbinder et al., 2006), which suggest that reading, writing, and cognitive abilities decline as patients age (Fraenkel et al., 2006). HL emphasizes the ability to read, write, access information, communicate, and understand. In terms of disease activity, higher DAS28 scores were associated with lower HL, possibly because patients experience recurrent disease episodes and poor control, leading to a complete loss of confidence in self-management. They may perceive the disease as an incurable cancer and shut themselves off from all

disease-related information. Therefore, controlling the disease in a stable state is of utmost importance to improve HL.

Conclusion

This study shows that in Chinese RA patients, HL is negatively correlated with age, ESR, the number of tender joints, the number of swollen joints, and disease activity score (DAS28), while positively correlated with self-efficacy and medication adherence. A preliminary prediction model for HL has been established, providing a theoretical basis for healthcare professionals to develop targeted strategies to effectively enhance functional, critical, and interactive HL levels, strengthen patients’ ability to access self-disease management information, and improve their quality of life (Nutbeam and Lloyd, 2021). However, there are some limitations to this study. Although our research initially established a prediction model for HL in RA patients, covering a broad range, we still need to expand the sample size and conduct a multi-center study to validate the model in the future. Moreover, a longer follow-up time would be beneficial to further validate the model.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Ethics Committee of Changzhou Second People’s Hospital. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TL: Writing – original draft, Writing – review & editing, Data curation. WM: Conceptualization, Data curation, Writing – original draft, Writing – review & editing. WW: Formal analysis, Project administration, Writing – original draft, Writing – review & editing.

GS: Data curation, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. XC: Data curation, Investigation, Resources, Writing – original draft, Writing – review & editing. YL: Supervision, Visualization, Writing – original draft, Writing – review & editing. WQ: Writing – original draft, Writing – review & editing, Investigation. YW: Data curation, Resources, Supervision, Writing – original draft, Writing – review & editing. LZ: Formal analysis, Investigation, Writing – original draft, Writing – review & editing. SZ: Supervision, Validation, Writing – review & editing, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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How health seeking behavior develops in patients with type 2 diabetes: a qualitative study based on health belief model in China

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Background: Type 2 diabetes (T2DM) is a global health problem which is accompanied with multi-systemic complications, and associated with long-term health burden and economic burden. Effective health seeking behavior (HSB) refers to reasonably utilize health resources, effectively prevent and treat diseases, and maintain health. Effective health seeking behavior (HSB) is vital to mitigate the risk of T2DM complications. However, health seeking behavior for T2DM patients remains sub-optimal worldwide.

Objective: The study aimed to explore the internal logic of how health seeking behavior of T2DM patients develops and the influencing factors of health seeking behavior. With a view to provide a reference basis for improving the health seeking behavior situation of T2DM patients.

Methods: This study was conducted at an integrated tertiary hospital in China. People who were diagnosed with T2DM, capable of expressing clearly and had no mental illness, were approached based on a purposive sampling. The experience of T2DM and health seeking behavior were collected via in-depth interviews. A theory-driven thematic analysis based on *Health Belief Model (HBM)* was applied for data analysis. Inductive reasoning was used to identify emerging themes which were not included in HBM.

Results: 26 patients with T2DM were included in the current study. Seven themes were identified, including: (1) T2DM diagnosis and severity; (2) T2DM treatment and management; (3) Perceived susceptibility of diabetes progression; (4) Perceived severity of diabetes progression; (5) Perceived benefits of health seeking behavior; (6) Perceived barriers of health seeking behavior; (7) Perception of behavioral cues. Generally, patients with T2DM lacked reliable sources of information, considered T2DM to be slow-progressing and without posing an immediate threat to life. Consequently, they did not fully grasp the long-term risks associated with T2DM or the protective effects of health seeking behavior.

Conclusion: This study highlighted the challenges in health seeking behavior for patients with T2DM. It suggested that future interventions and strategies should involve multi-faceted approaches, targeting healthcare providers (HCPs), patients with T2DM, and their support networks. This comprehensive strategy can help patients better understand their condition and the importance of effective health seeking behavior. Ultimately, enhancing their capacity for adopting appropriate health-seeking practices.

KEYWORDS

type 2 diabetes mellitus (T2MD), health seeking behavior, health belief model, qualitative design, China

Introduction

Type 2 diabetes Mellitus (T2DM) is the most prevalent form of diabetes, accounting for 90–95% of all diabetic cases, and it poses a significant global health and socioeconomic challenge (1). The global prevalence of diabetes in adults (aged 20–79) was estimated to be 10.5% in 2021, and this figure is projected to rise to 12.2% by 2045 (2). As a result, the global health expenditures related to diabetes were estimated to be 966 billion USD in 2021 and are expected to reach 1,054 billion USD by 2045 (2). The high prevalence and rapid increase in diabetes make it one of the most critical public health challenges of the 21st century. The World Health Organization (WHO) has identified diabetes as one of the five priority noncommunicable diseases in its action plan to address the health challenges (3).

Globally, 240 million people estimated to be undiagnosed. And in China, approximately 50.5% of the adults (aged 20–79) with diabetes remaining undiagnosed (4). According to epidemiological surveys in China, the treatment rate of diabetes is only 32.2% (5). This lack of diagnosis, coupled with a low treatment rate, promotes the development of diabetes complications, which can be disabled and even fatal to those affected.

Research in 2023 by Liu et al. (6) revealed that over two-thirds of T2DM patients in China had at least one complication, and the percentage of patients with three or more complications had risen from 12% in 2014 to 50% in 2019. Diabetes complications, such as nontraumatic lower limb amputation and blindness have severely impacted the quality of life for T2DM patients, leading to disability. These complications have also been identified as the primary cause of death among diabetic patients (7). Moreover, patients with complications from diabetes incur significantly higher health seeking expenses, approximately 3.36 times higher than those without complications (8).

The insidious and progressive nature of diabetes highlights the importance of early detection, prompt diagnosis and ongoing care with regular evaluation to mitigate the growing burden of this condition (7). While there is strong evidence that access to good care, education and medication can control diabetes and its complications, it is essential to understand the health seeking behavior of T2DM patients, as it plays a crucial role in determining whether they receive appropriate care and treatment. This understanding can shed light on the existing under-utilization of healthcare services despite increased access (9).

Previous research has found that health seeking behavior in diabetes is complex, influenced by various factors including economic and cultural (10, 11), cognitive (12, 13), disease attitude (14), health seeking attitude (15), self-efficacy (16), healthcare system factors (17), social support (18) and so on. However, previous studies always adopted quantitative research methods to explore the influencing factors of diabetes patients' health seeking behavior. Few studies adopted qualitative research methods to deeply understand the formation and experience of diabetes patients' health seeking behavior. Qualitative research adopted open questions allowed us to fully consider the influence of social psychological factors on behavior, to understand more potential problems and information, better understand how health seeking behavior develops in patients with type 2 diabetes, so as to draw more accurate, full and comprehensive conclusions.

Health belief model (HBM) was proposed by American psychologists Hochbaum and others, that application of social

psychology methods to explore the formation mechanism and influencing factors of behavior from the perspective of people's health beliefs is an important theoretical model for explaining people's health behavior (19). It has been widely applied to explain and predict individual health behaviors related to disease prevention and management (20), that is why making it a valuable framework to examine why patients with T2DM seek or do not seek health services (21). In this study, a qualitative design was adopted to gather the experiences of T2DM patients from the time of diagnosis to the formation of stable health seeking behavior. The objective was to explore the internal logic of how health seeking behavior of T2DM patients develops and the influencing factors of health seeking behavior based on HBM. With a view to provide a reference basis for improving the health seeking behavior situation of T2DM patients.

Methods

Study design

This qualitative descriptive study utilizes semi-structured in-depth interviews to collect the experiences, perspectives, and attitudes of the research subjects in seeking healthy behaviors through face-to-face semi-structured conversations, as well as to gain a deeper understanding of their underlying thoughts and motivations. Record the entire interview process and transcribe the interview data within 24 h after the interview ends. The subsequent data analysis is based on thematic analysis of the interview content and development of the conceptual framework. The study design and reporting followed the Qualitative Research Comprehensive Reporting Standard (COREQ) checklist.

Settings

The research was conducted in the Endocrine Department of a Hospital in Daqing, China. The Fourth Hospital of Daqing is a national tertiary comprehensive hospital that offers a wide range of medical services and has an annual outpatient volume of nearly 0.5 million people. As a comprehensive hospital, patients seeking health at this hospital have various sociodemographic backgrounds and experiences in seeking health.

Participants

According to "the American diabetes association diabetes diagnostic criteria (2023)," and any result higher than the standard was diagnosed as T2DM. Eligible criteria: (1) Diagnosed as type 2 diabetes (Diagnosed by a physician); (2) Age ≥ 18 years old; (3) Conscious, with stable vital signs, and the ability to communicate normally; (4) Willingness to participate and able to provide informed consent. Exclusion criteria: (1) Patients with cognitive impairment; (2) Patients with mental disorders. (3) Patients with gestational diabetes. Purposive sampling and maximum variation sampling strategies (including occupation and disease duration) was adopted to ensure the inclusion of T2DM patients with diverse characteristics.

Interview guideline

A semi-structured interview guideline was developed and pilot-tested to collect data based on health-seeking behavior. The guideline contained open-ended questions focused on participants' experiences, beliefs regarding diabetes, and how they formed their current health-seeking behavior. According to the HBM (22), individual adoption of a health behavior depends on their belief in its effectiveness and their desire to avoid potential disease progression.

According to HBM (Figure 1), whether the patients with T2DM developed standardized HSB depends mainly on their perceived value of HSB and perceived threat of potential diabetes progression consequences. Among them, perceived value is a systematic assessment of the benefits and obstacles of HSB, and perceived threat is an overall assessment of the susceptibility and severity of the consequences of potential diabetes progression. In addition, the experience of T2DM patients has affected and shaped the HSB of diabetic patients. Based on the above questions, an interview guideline for this study was developed (Table 1). Due to the high prevalence of diabetes in the world, behavioral norms may affect the HSB of diabetic patients. Therefore, we also collected the demographic data of participants.

Data collection

Nurses at the Endocrinology Department of Daqing Fourth Hospital identified potential participants, informed them about the study, and invited them to participate. The interviews were conducted by a pair of authors from July to August 2023 and had a duration of 25 to 48 min each. The interview adopts an open-ended questioning method, during which the interviewer carefully listens, observes and records their facial expressions, emotional changes, and body language, and encourages them to express their true feelings. Flexibly adjust the interview procedure and content based on the specific situation of the interview. All interviews were conducted face-to-face and recorded using digital audio recording devices. The interviewers were then transcribed verbatim by two researchers at the same time. Data saturation was reached after 23 interviews, and an additional three interviews found that the explanatory dimensions of each encoding or topic began to

repeat, and no other explanations were found for the encoding or topic, that confirmed data saturation. In total, 26 interviews were completed.

Data analysis

The data analysis adopts a theoretical driven topic analysis method based on HBM, which includes six steps: data familiarization, generating initial encoding, searching for topics, reviewing topics, defining and naming topics, and writing a manuscript. Two researchers independently and repeatedly read the text, identifying meaningful unites and categorizing keywords and phrases, and used an iterative approach whereby codes were continuously revised and refined throughout the analysis. Any discrepancies during the encoding process were solved by joint discussed with another researcher to ensure that both broader level and emergent sub-themes were exhaustively captured. After the coding process, one researcher used NVIVO Version 12.5.0 software to assist in grouping the codes into themes. These themes were categorized based on the initial coding under the umbrella of health-seeking behavior. The sub-themes that appeared were driven by classification data based on the initial codes within the same main theme. Finally, review all identified themes and sub-themes based on the initial encoded and transcribed text. To ensure credibility, the results were fed back to the participants for further confirmation.

Rigor

This study conducted analysis under the guidance of the Health Belief Model (HBM), ensuring the scientific and objective nature of the study. The data analysis was conducted independently by two researchers, any discrepancies during the encoding process were solved by joint discussed with another researcher to avoid the authors' subjective. We also have adopted an iterative approach in data analysis, which helps us gain a deeper and more accurate understanding of the data and to some extent avoids researcher bias. The research team of this study includes three researchers with associate professor or above titles who have rich qualitative research experience, and three graduate students who have received systematic qualitative research training,

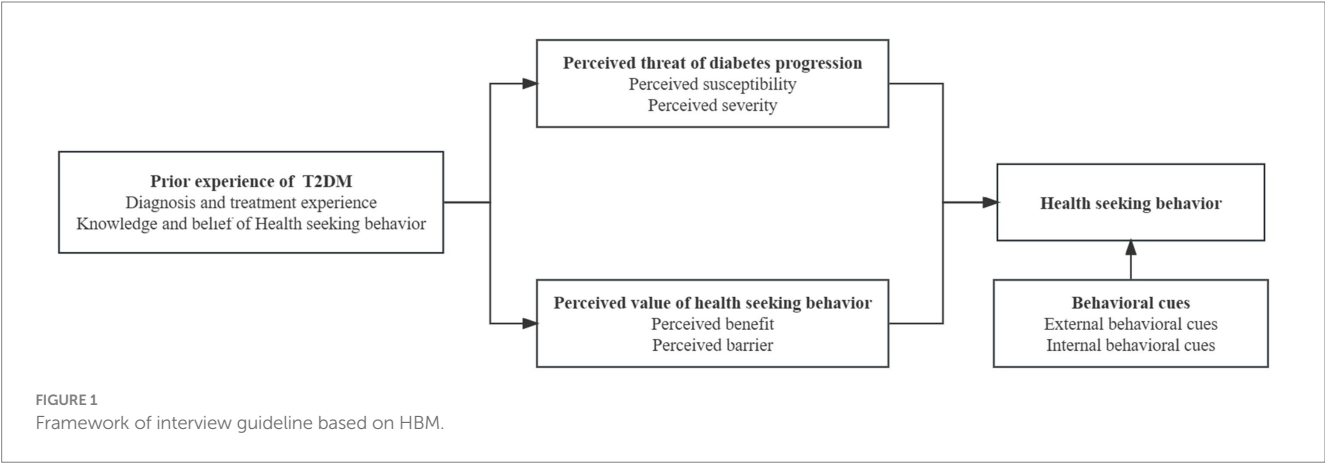


TABLE 1 Interview questions about T2DM patients based on HBM.

Topic one: Experience of T2DM
■ When and how were you diagnosed with diabetes?
■ Please tell me about your experience of diabetes?
Topic Two: Perceived threat of diabetes progression consequence
■ What do you think about the possibility of diabetes progression? Why?
■ What do you think about the progression of diabetes?
Topic Three: Perceived value of health seeking behavior
■ What do you know about the benefit of health seeking behavior?
■ Is any barrier of health seeking behavior? / Why you do not want to seeking health service?
Topic Four: Behavior cues
■ Are you influenced by external factors when you seeking health service?
■ Are you influenced by Internal factors when you seeking health service?

different roles and backgrounds have also contributed to avoiding bias in research results. Finally, we invited three qualitative research experts review all identified themes and sub-themes based on the initial encoded and transcribed text to ensure that the whole text data is well presented and the relationships between themes were not distorted. In order to ensure credibility, the results were fed back to the participants for further confirmation, and they all expressed that the research results were consistent with their ideas.

Results

A total of 26 patients diagnosed with T2DM were recruited for interviews. The demographic composition of the participants was as follows: 38% of the participants were female ($n = 10$); The age range of the participants was between 28 and 82 years; The education level of the participants varied from illiterate to holding a master’s degree; The duration of diabetes ranged from 2 year to 30 years, among them, over half of the participants ($n = 14$) had been living with T2DM for over 10 years, while 5 patients had been diagnosed with T2DM for less than 5 years; Participants came from diverse occupational backgrounds, including clerk, farmers, retirees, businessmen, civil servants, and others. Detailed information is presented in [Table 2](#).

T2DM diagnosis and severity

Question: “When and how were you diagnosed with diabetes? Please tell me about your experience of diabetes?”

Most participants were diagnosed with diabetes when they experienced symptoms related to the condition or its complications. Small number of participants were diagnosed with diabetes when they performed physical examination. When informed of the results, most participants said they were not surprised because they had family history of diabetes and the physical symptoms also made them perceived that something’s wrong.

When I went to the toilet, I found that the urine was sticky, when I stepped on the urine, it stuck to the sole of my shoe. I suspected that I had diabetes, because many people around me had diabetes, so I know it. Later, I checked the blood sugar and diagnosed it. (No. 2).

However, in cases where there were no family history or apparent symptoms, participants often expressed surprise and disbelief regarding their diagnosis. They attributed the condition to irregular diet and rest.

I was surprised at that time. I did not have a family history, and nothing is wrong, I could not believe it! Later, I went to other hospitals for examination, which also said that my blood sugar was high and diabetes was diagnosed. (No.13).

Most participants believe that slightly elevated blood sugar levels that did not significantly disrupt their daily lives, and they perceived diabetes as a common and non-serious ailment. As a result, they did not initially manage their diabetes effectively or go for regular check-ups, as they considered it non-urgent.

Diagnosed diabetes, but I did not pay attention to it, I did not take medicine, and did not check blood sugar. It was more than ten years later that I was hospitalized for the first time in 2009. I did all physical examinations, and the fasting blood sugar was about 12 then. (No.13).

T2DM treatment and management

Some participants initially managed their diabetes effectively through diet control and exercise. This early success sometimes led to overconfidence, causing participants to become less vigilant and stopped regular monitoring of blood sugar. It is worth noting that most participants said they never monitored postprandial blood glucose.

At the beginning, I through exercise and diet to control my blood sugar, the effect was quite good at that time. Originally, I always monitored my fasting blood sugar. Then with confidence in blood sugar control, I occasionally monitored my fasting blood sugar, but I have never monitored my postprandial blood sugar. Nowadays, relying solely on diet and exercise cannot control blood sugar anymore. I always feel like I need to increase the dosage of hypoglycemic drugs after meals, otherwise I will not be able to control it. (No.14).

Diabetes necessitates long-term disease management and control. While some participants could initially adhere to strict control measures, many eventually gave up on such rigorous management.

When I first diagnosed diabetes, I went running at three o’clock every morning. I lost more than 15kg and my blood sugar was well controlled. Later on, I thought it would be too hard to persist, so I gave up. (No.6).

Participants experiences highlight the dynamic nature of T2DM, with individuals often experiencing fluctuations in their level of attention and vigilance toward the condition. When they observed that their blood sugar levels significantly elevated or worsened, they re-evaluated their disease and more active management and treatment. The onset of complications can serve as a powerful wake-up call, urging individuals to take their diabetes more seriously.

I was so busy every day, so I did not pay attention to diabetes. Later, it became worse, and my blood sugar could not be controlled, so I had to go to the hospital to see a doctor. (No. 16).

TABLE 2 Demographic data of the participant.

	Age (years)	Sex	Occupation	Education	Members of family	Complication	Confirmed time (years)
1	58	Female	Clerk	High School	Husband	Exist	15
2	47	Male	Teacher	Middle School	Wife	None	3
3	47	Male	Business man	Middle School	Wife	Exist	10
4	28	Male	Electrician	High School	Wife, daughter	None	2
5	59	Male	Clerk	Vocational school	Wife	Exist	8
6	60	Male	Retiree	Middle School	Wife, son's family	Exist	20
7	52	Male	Functionary	Master	Wife, daughter	Exist	12
8	60	Male	Veterans	High School	Wife	Exist	7
9	51	Female	Labourer	High School	Husband	Exist	10
10	36	Male	Driver	Middle School	Wife, son	None	5
11	59	Male	Conductor	Associate	Wife	Exist	5
12	42	Male	Driver	Primary School	Wife	None	2
13	72	Male	Retiree	High School	Wife	Exist	28
14	63	Female	Retiree	Bachelor	Husband	Exist	10
15	55	Female	Business man	Middle School	Husband, son's family	Exist	20
16	66	Female	Financial staff	Vocational school	Husband, son's family	Exist	20
17	68	Female	Retiree	Associate	Son's family	Exist	23
18	48	Male	Civil servant	Bachelor	Wife	Exist	20
19	52	Male	Business man	Bachelor	Wife	Exist	5
20	47	Female	Teacher	Associate	Husband	Exist	13
21	78	Female	Farmer	illiteracy	Husband	Exist	5
22	72	Female	Farmer	illiteracy	Husband	Exist	18
23	74	Male	Farmer	illiteracy	Live alone	Exist	5
24	68	Male	Farmer	Primary School	Wife	Exist	4
25	60	Male	Village cadre	Middle School	Wife	None	2
26	82	Female	Farmer	illiteracy	Son	Exist	30

Perceived threat of diabetes progression

Perceived susceptibility

Question: “What do you think about the possibility of diabetes progression? Why?”

When asked about the susceptibility of diabetes progression, some participants ($n = 7$) believed that their risk of diabetes complications was high. They based this belief on: family history, course of disease, age, personal physical condition, lifestyle and disease control.

I think I may suffer from complications of diabetes in the future. I think that with the prolongation of the course of disease and the growth of age, the possibility of complications of the decline of physical function will also enhance. (No.5).

A majority of participants ($n = 16$) believed that their risk of diabetes complications was low, there was currently no immediate threat of diabetes progression. Their reasoning included they belief

that diabetes progression is a slow process; controlling blood sugar could prevent complications.

My fasting blood sugar is generally not very high. Diabetes worsens slowly. When my blood sugar is high, I will feel my mouth is dry, at that time, I will monitor my blood sugar and take hypoglycemic drugs. At present, my disease is unlikely to progress. (No. 21).

Three participants expressed that they never imagined the possibility of the progression of diabetes. Because they fear of considering it.

I dare not think about the possibility of complications of diabetes. I am afraid that diabetes complications will drag my family down, so that, when I found that my blood sugar levels were very high, I feel uncertain and afraid. Thus, I have not measured blood sugar for a long time. (No. 6).

Perceived severity

Question: “What do you think about the progression of diabetes?”

More than half of the participants ($n=16$) considered the complications resulting from diabetes progression to be very serious. They expressed concerns about the impact on various aspects of their lives: life threat, organ damage, long-term consequences, psychological burden, possible need for insulin or hospitalization.

I often experience hypoglycemia while sleeping at night, which makes me feel terrible. If I do not wake up during hypoglycemia, I may die. At that time, I wanted to be hospitalized. (No. 15).

A group of participants ($n=10$) felt that the symptoms they experienced were mild and did not impact their daily lives significantly, and they had less understanding of the severity of diabetes complications. They downplayed the seriousness of diabetes based on their current physical condition, and they were less alert to diabetes-related symptoms and potential complications.

The progression of diabetes is not serious for me, I am old now. I feel numb in my hands and feet now, but I do not think it will have much impact on me, so I did not tell the doctor about this symptom when I went to the hospital for treatment, because it was less impact on my daily lives. (No. 21).

Perceived benefits and barriers of health seeking behavior

Perceived benefits

Question: "What do you know about the benefit of health seeking behavior?"

Participants had varied perceptions of the benefits of health seeking behavior, including it could reduce the threat of disease, could effectively control blood sugar and avoid (or delay) the occurrence of complications, could help diabetic patients understand their true health status, could increase their knowledge of diabetes, could reduce their and their families' worries about their health status, it also can promote lifestyle changes and avoid further financial and care burdens on family members due to severe illness in the future.

Health seeking behavior can delay the occurrence of complications, and I can absorb some experience in diabetes management. When blood sugar is well controlled, it also reduces the psychological burden on my family. (No.1).

Some participants believed that diabetes was a condition that they could manage on their own, self-medication and lifestyle adjustments as sufficient and did not see the need for professional healthcare services. The idea that diabetes was incurable led some participants to question the purpose of health seeking behavior, they did not see how seeking healthcare could change their condition.

I feel that diabetes is mainly controlled by myself. When I feel that the blood sugar is high, I will adjust the dosage of drugs. Because diabetes is incurable, there is no need to go to the hospital. (No. 25).

Perceived barriers

Question: "Is any barrier of health seeking behavior?"

When participants were asked about the barriers to health seeking behavior, several common obstacles emerged: the most frequently mentioned barrier was the financial burden of seeking healthcare. Many participants, particularly those in rural areas, cited concerns about spending too much money on medical expenses, the high self-payment expenses due to low insurance reimbursement rates were especially concerning.

The New Rural Cooperative Medical Insurance we purchased has a reimbursement rate of 60% for hospitalization, which is not high and cannot be reimbursed for outpatient services. (No. 26).

Participants noted that being too busy with work or family responsibilities was a significant barrier. They often felt they had no time to seek healthcare. Some participants believed that there was no difference between early and late health seeking behavior for a chronic condition like diabetes.

Because I have children to take care of and I have to work, I usually do not go to the hospital. I only consider going to the hospital when it's serious. (No. 4).

Traffic barriers and cumbersome medical procedures were mentioned as obstacles, particularly by older adults and remote patients. Long travel times, complex registration and payment processes, and inconvenience in reaching healthcare facilities deterred them from seeking medical attention.

I find it troublesome to go to the hospital. I need to take the bus for an hour, waiting in line to register and undergo a check-up. It will take me a whole day and make me very tired. (No. 9).

Question: "Why you do not want to seeking health services?"

A few participants expressed a lack of trust in hospitals and doctors. They doubted the effectiveness of prescribed treatments, which discouraged them from seeking medical care. This skepticism toward the healthcare system was a barrier to engaging in health seeking behavior.

I feel that doctors nowadays always require patients to undergo many tests such as CT, MRI, electrocardiogram, etc., and there is no general practitioner who truly relies on experience and medical skills to treat diseases. Another issue is that different doctors have different views on medication. I think many doctors lack skills and clinical experience. (No.8).

Participants reported that worry about their physical condition and fear of receiving a severe diagnosis contributed to their unwillingness to seek medical care. They worried about the psychological burden and pressure that might result from a diagnosis.

At first, my eyes were uncomfortable, but I did not dare to go to the hospital to see a doctor. I was afraid the doctor would tell me that

my condition was very serious. Later, I had bleeding in the fundus of my eyes, which caused me a lot of psychological pressure. (No. 19).

Concerns about the risk of infection or transmission in a hospital environment deterred some participants from seeking healthcare. They preferred to avoid hospitals to protect themselves from potential infections.

I think there are a lot of bacteria and viruses in the hospital, and there are also many infectious diseases. I try not to come to the hospital as much as possible, which is also a form of self-protection. (No.14).

Some participants expressed reluctance to seek healthcare because they did not want to add financial or care burdens to their families. They were also concerned about causing worry among family members.

I can only go to the hospital with the company of my family because of I am getting older, but I am afraid of troubling my child. (No.26).

The discomfort associated with being hospitalized was mentioned as an obstacle. Participants cited issues like poor sleep quality and discomfort in hospital settings as reasons for their reluctance to seek medical care.

Being hospitalized will also makes me very uncomfortable because I cannot sleep well while someone snores. (No.9).

Perception of behavioral cues

External clues

Question: "Are you influenced by external factors when you seeking health?"

A lot of participants expressed that their belief in health seeking behavior is mainly influenced by their surrounding people, including family, other patients, friends and health care providers (HCPs). The participants feel a strong motivation to seek health services from their family, friends, and health care providers (HCPs), and learn from the indirect experiences of others to influence their own health seeking behavior.

My friend with diabetes who is drinking while taking medicine has no physical problems, so I should also be OK. (No. 11).

National healthcare policies had a significant impact on their decision-making.

The New Rural Cooperative Medical Insurance we purchased has a reimbursement rate of 60% for hospitalization, which is not high and cannot be reimbursed for outpatient services, so I did not easily go to seek health services. (No. 26).

Having a familiar doctor or a satisfactory health seeking behavior experience are also considered important external factors in promoting patients' medical treatment.

The reason why I always go to the People's Hospital to see a doctor is because I am familiar with the doctors there. They have a better understanding of my condition and know what medication to prescribe. After receiving an infusion, I am relieved. (No. 22).

Internal clues

Question: "Are you influenced by Internal factors when you seeking health?"

Participants who had experienced complications due to diabetes were more motivated to seek health services and control their condition, the fear of potential complications drove some participants to seek health services for early prevention.

Before this cerebral infarction, I did not pay much attention to the management of diabetes. I always felt that the complications were far away from me. After the last cerebral infarction, my mind changed. This time, I went to the hospital immediately when I had symptoms. (No.3).

Feeling responsible for their family's well-being encouraged participants to seek health and manage their condition.

I do not want to seek health services, but when I think about my family, my parents are over 80 years old, and my little grandson still needs my care, so I still have to take care of my body to be responsible for my family. (No. 11).

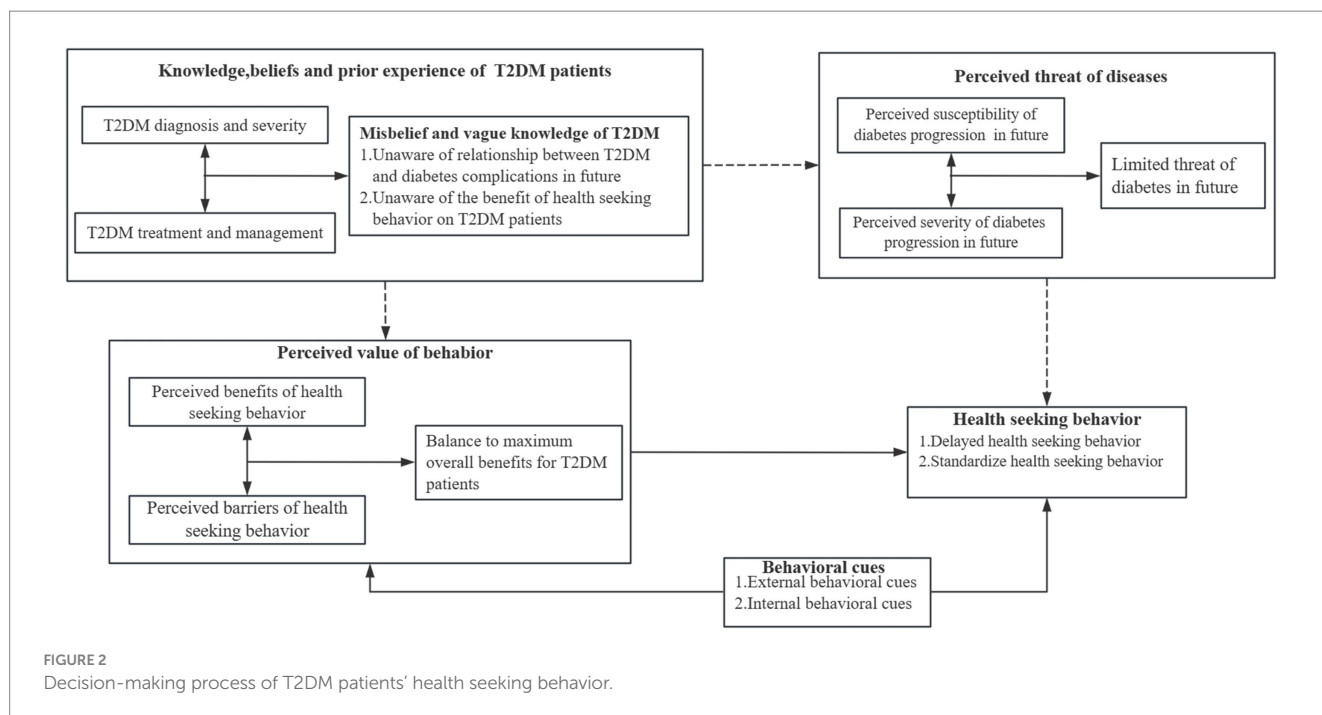
Modified health belief model for T2DM patients' health seeking behavioral decision-making.

Derived from HBM, [Figure 2](#) presents the decision-making process of T2DM patients HSB. The model showed that T2DM patients may have limited understanding of complications and their long-term impact. Misconceptions and vague knowledge about diabetes deter their awareness of the risk of complications and the benefits of health seeking behavior (Black dashed line in [Figure 2](#)). The perception of disease progression risk in T2DM patients plays as a prerequisite role in seeking healthy behavioral decisions. T2DM patients balanced the benefits and barriers of HSB to maximize the overall benefits for themselves that play a decisive role in health seeking behavior decision making. In addition, behavioral cues also facilitate T2DM patients to make reasonable HSB by promoting them to perceive the threat of disease or the benefits of HSB, or by eliminating barriers to medical treatment behaviors. If the perceived benefit of HSB is outweigh than the perceived threat, a T2DM patient is likely to seek health services, while the reverse may be the truth.

Discussion

Main findings

A qualitative design has been adopted to explore how T2DM patients developed their health seeking behavior. Based on HBM, the diagnosis and treatment experience of T2DM, their perceived threats of diabetes progression consequence, perceived values of health



seeking benefits, behavior clues of health seeking behavior and how these factors influence their health seeking behavior decision-making were combined to form an overall understanding of health seeking behavior decision-making process.

Due to lack of awareness about the disease, T2DM patients often have limited understanding of their condition, leading to underestimating the severity and susceptibility of the diabetes progression, generally considering it as a minor illness that will not significantly impact their lives. This situation prevents T2DM from recognizing the potential health threat of diabetes progression and potential protective effects of HSB, this often results in delayed diagnosis and treatment.

Due to lack of awareness about diabetes, T2DM patients questioned whether diabetes need for medical consultations and tests, leading to underestimating the benefit of the HSB. Financial constraints, time constraints, traffic barriers and other obstacles often results in delayed diagnosis and treatment.

Whether T2DM adopted health seeking behavior depends on the evaluation between the benefit and barriers of HSB for them. External and Internal behavioral cues, such as supports from family and health care providers help T2DM patients reduce the barrier or perceive the benefit, which brought about promotion of HSB.

Comparison to existing studies

The diagnosis and treatment experience of T2DM patients is considered as the cornerstone of the formation of diabetic patients' health seeking behavior beliefs (23). T2DM patients typically became aware of their conditions when they experienced symptoms or complications related to diabetes. This also reflects that people generally do not actively pay attention to their own physical health. After diagnosed as diabetes, few people periodic review it, so delayed diagnosis and treatment are common. This is consistent with Jia et al.

(12) reported that more than 60% of rural diabetic patients in China have delayed diagnosis and treatment. T2DM patients' sub-optimal understanding of the disease and poor understanding of HSB were prevalent worldwide, which was also identified in Bangladesh (24), Indonesia (25) and India (26).

Unlike other studies showing that diabetes increases patients' concerns about disease management and access to health care, and patients struggled to cope with the disease (27), most participants in the current study considered that T2DM was not a severe illness, will not threaten their daily work and life, and their management was arbitrary, just when the condition is severe will one go to seek health services. Unstrict diet control, arbitrary monitoring blood sugar, and even non-indication change of drug use were identified, which was associated with severe adverse events of diabetic patients, such as diabetes foot, diabetes nephropathy and diabetes neuropathy (28). Yang et al. (29) also found a similar phenomenon in a qualitative study. In the current study, young patients with T2DM with a short course of disease (especially those diagnosed as diabetes for less than 5 years), due to the short duration of diabetes, it is relatively easy to control blood sugar in this period. Most of these patients are prone to develop blindly optimistic attitudes in diabetes management, which may reduce their awareness of risks and hinder them from seeking health to avoid potential health threats.

The perceived benefits and perceived barriers to HSB of T2DM patients, largely determine the HSB of them. Consistent with many studies, this study also found that T2DM patients generally believed that diabetes was a condition that they could manage on their own, self-medication and lifestyle adjustments as sufficient, and HSB cannot bring more benefits (25, 30). The established fact that diabetes could not be cured also made them underestimate the benefits of HSB (31). Meanwhile, health care providers play a significant role in T2DM patients' decision-making process regarding HSB as well as in the diabetes management. However, some participants expressed a lack of trust in the prescriptions and recommendations provided by doctor,

believing that many doctors lack medical skills and clinical experience. The main reason why doctors are considered untrustworthy is because they believe they are overly reliant on examination. A quantitative study on the doctor-patient relationship in Chinese public hospitals also confirms the existence of distrust and tension between doctors and patients in China (32).

Fear of spending too much money and time is the two main barriers for T2DM patients in seeking health services. For rural patients with T2DM, medical expenses are considered to be the main obstacle. Due to the low income of rural diabetic patients and the high self-payment expenses (because of high reimbursement threshold and low reimbursement ratio of the new rural cooperative medical insurance), leading to rural T2DM patients usually at a severe stage in their diabetes by the time they receive a treatment. A study in Bangladesh (24) also shows that the lack of medical expenses is the main reason that hinders rural diabetic patients from accessing health services. Besides, inconvenient transportation, the belief that the medical process is troublesome, the fear of being diagnosed with a serious disease, and the fear of adding trouble to the family have also caused huge obstacles to the health seeking behavior of patients with type 2 diabetes. For urban patients with T2DM, the inability to spare time for health seeking was expressed by most participants as the main obstacle. Participants expressed that they were too busy with their work or taking care of their families to take care of their own health, but at the same time, some participants also said that the lack of perception of the seriousness of diabetes progression was the main reason why they used the excuse of no time to rationalize their delayed medical treatment.

On the other hand, tips and support from family members, friends, other patients and healthcare providers are particularly important for T2DM patients' health seeking behavioral decision-making. T2DM patients feel strong health seeking motivation from them, and learn indirect experience to influence their own HSB beliefs. According to current research, behavioral cues may facilitate the HSB of diabetic patients by reducing the barriers of seeking health services, consistent with the previous studies in other developing areas (33). However, unqualified behavioral cues sometimes cause additional obstacles. For example, in current study, the poor HSB of nearby may hinder them from seeking health services.

Implication for clinical practices and policy

This study highlighted several factors that should be targeted when formulating intervention measures, and suggested that a multi-facets intervention for health care providers, T2DM patients and their support networks was more likely to promote standardized HSB for diabetic patients.

Firstly, current research has shown that there are disagreements between doctors and patients regarding the examination items, and patients cannot understand the purpose and role of the examination, resulting in a lack of trust in doctors. Encourage joint decision-making between HCPs and patients to enhance trust and understanding can solve this problem. The effectiveness of joint decision-making between doctors and patients in improving the disease perception level of patients with T2DM has been widely confirmed (34, 35). The implementation of doctor-patient joint decision-making is to bring

the individual preferences of patients into the decision-making process, which can not only improve patients' enthusiasm for mastering disease knowledge, but also leading to better compliance and improved the level of health seeking behavior decision-making.

Secondly, HCPs should provide consistent education on diabetes management. Research from the United Kingdom (36) and Sweden (37) shows that experiential education on complications can significantly increase the level of health seeking behavior decision-making by improving the perception of disease threat, and increase T2DM patients likelihood to seeking health services. Due to the fact that HCPs are authorities for public health behavior, both doctors and nurses may play a role.

Strength and limitations

This study is among the first to use a qualitative approach to explore the development of health seeking behavior in T2DM patients. It provides valuable insights into how patients perceive their condition and make decisions about seeking healthcare. The modified Health Belief Model helps clarify the factors influencing patient behavior. However, the current study also has limitations. The study sample is relatively small, and participants were recruited from specific regions in China, which may limit the generalizability of the findings. There is also the potential for social desirability bias, as participants might provide responses, they think researchers want to hear. Similar studies can be conducted in other countries and cities in the future to explore the different characteristics of health seeking behavior in different cultural backgrounds. Meanwhile we suggested that research on the mechanism of diabetes patients' health seeking behavior can be carried out in the future to further explore this important theme.

Conclusion

This study offers a comprehensive understanding of the health-seeking behavior of individuals with T2DM. It explores various aspects related to the diagnosis and treatment experience of T2DM patients and factors that shape their health seeking behavior. Many T2DM patients lack a clear understanding of their condition, often underestimating the severity and susceptibility of the diabetes progression. This situation prevents them from recognizing the potential health threat of diabetes progression and potential protective effects of HSB. The formation of HSB depends on the balance between benefits and barriers of HSB. Therefore, the multi-facets intervention on HCPs, T2DM patients and their networks were of great significance to help T2DM patients form a correct understanding of the disease and standardized health seeking behavior belief.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

This study received ethical approval from the Ethics Committee of Harbin Medical University (HMUDQ20230418001). Prior to conducting the interviews, participants received both oral explanations and written documentation outlining the study's procedures, potential risks, and benefits. They provided written informed consent, signifying their willingness to participate in the study and their permission for the interviews to be recorded. To protect participant's identities and maintain anonymity, their names were replaced with unique identifiers (N01-N26).

Author contributions

Q-hD: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. Z-cZ: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. YY: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. X-xL: Data curation, Formal analysis, Methodology, Supervision, Writing – review & editing. LL: Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing. H-hJ: Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Effects of social support on vision-related quality of life in older adults with dry eye disease: the chain mediating role of illness perception and coping style

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Objective: This study explored the effects of social support, illness perception, coping style, and vision-related quality of life (VRQOL) in older patients with dry eye disease (DED) using a chain mediation model.

Methods: A total of 407 patients with DED from a tertiary hospital in Wuxi, Jiangsu Province, China, between June and December 2023 were selected as participants. A demographic questionnaire, the Social Support Rating Scale, the Brief Illness Perception Questionnaire, the Medical Coping Modes Questionnaire, and the National Eye Institute Visual Functioning questionnaire-25 were all given to them to complete. IBM SPSS (version 27.0) was used for data analysis, and Model 6 of the PROCESS Macro was used to test the predicted chain mediation model.

Results: The positive association between social support and VRQOL demonstrated the mediation role of illness perception and coping style. Social support affected VRQOL via three pathways: illness perception (effect = 0.190), confrontational coping style (effect = 0.103), and a combination of illness perception and confrontational coping style (effect = 0.067), accounted for 23.60%, 12.80%, and 8.32% of the total effect, respectively.

Conclusion: Social support in older patients with DED can significantly and positively predict the VRQOL. In addition to the independent mediating effect of illness perception and confrontational coping style, a chain-mediating effect exists between social support and VRQOL. The study serves as a valuable strategy for healthcare professionals to prevent and intervene in VRQOL for older patients with DED in the future.

KEYWORDS

dry eye disease, vision-related quality of life, social support, illness perception, coping style, chain mediating effect

1 Introduction

Dry eye disease (DED) is the most common chronic ocular surface disease and is caused by inflammation of the ocular surface, tear instability, hyperosmolarity, and disorders related to the nervous system (Hakim and Farooq, 2022). Age-related increases in DED incidence have been observed, with previous research indicating that 34.4% of patients with DED in

China may be older than 60 years (Zhang et al., 2020). As the Chinese population ages and life expectancy rises, DED will remain one of the leading causes of ophthalmic illness (Song et al., 2018; Cai et al., 2022). Patients typically experience various symptoms, such as photophobia, fatigue, itchiness, burning, and visual disturbance, and some may even experience severe visual problems and blindness in the later stages if treatment is delayed (Boboridis et al., 2023). Meanwhile, those with DED must bear a substantial economic burden and develop psychological problems such as anxiety and depression during prolonged therapy, making DED an important public health problem (Chan et al., 2021; Yu et al., 2022). Furthermore, the ongoing deterioration of visual function in older adults leads to inconvenience in daily behaviors and activities, threatening the ocular health and vision-related quality of life (VRQOL) of older patients with DED (Wang et al., 2020).

VRQOL is a multidimensional measure that reflects the impact of ocular diseases and their treatment and care on patients' activities of daily living, mental health status, and social functioning (Morthen et al., 2022). The focus of DED therapy is gradually shifting from treating symptoms of ocular discomfort alone to restoring or at least enhancing VRQOL as health concepts and medical models evolve (Guo and Akpek, 2020). In clinical practice, DED has been found to be associated with significant decreases in multiple dimensions of VRQOL, and its effect on VRQOL is comparable to that of severe fundus illness (Li et al., 2012; Le et al., 2014; Wu et al., 2021). A few population-based research on VRQOL and DED have shown that DED will reduce work efficiency; increase the risk of unemployment; disrupt normal activities such as reading, writing, and cooking; as well as increasing the burden of daily life (Dana et al., 2020; Morthen et al., 2023). It also increases the risk of falls and injuries among older adults (Barabino, 2022). Moreover, a study revealed that patients with DED over 50 years of age had lower VRQOL scores than patients younger than 50 (Paulsen et al., 2014). It can be seen that patients' daily lives are significantly impacted by DED, especially those of older patients. Therefore, health professionals must take reasonable measures to enhance the VRQOL of older patients with DED.

Social support is a useful and effective external resource that provides individuals with the assistance they require while under strain or facing difficulties (Shen et al., 2022). Social support plays an essential role in the physical and mental health of older patients and is a predictor of their healthy outcome (Zheng et al., 2022). According to previous research, higher subjective happiness levels in DED patients are associated with a lower self-reported incidence of dry eye symptoms (Kawashima et al., 2015). Additionally, supportive social relationships can help alleviate negative emotions in the treatment of DED patients, including anxiety and worry (Viet Vu et al., 2019). This may indirectly explain the positive effects of social support on DED patients' mental and physical wellbeing. However, no studies have directly examined the influence of social support on VRQOL in older patients with DED; this is important, as according to social support theory, excellent social support promotes individual health (Hupcey, 1998). Thus, this study proposes:

H1: social support positively predicts the VRQOL of older patients with DED.

Illness perception is a possible mediator in the association between social support and VRQOL in older patients with

DED. Illness perception is a psychological concept based on Leventhal et al. (2016)'s common sense model of self-regulation (CSM), which describes a process in which patients recognize and evaluate diseases and symptoms using their knowledge and experience. Illness perception is an important index for predicting the quality of life of patients with chronic diseases, as many studies have reported. According to a cross-sectional study, those with glaucoma who had a negative illness perception and thought they had more eye-related symptoms were more likely to have poorer VRQOL (Zhang et al., 2022). One study investigating 706 patients with DED from five European nations found that they had severely negative cognition of DED. Indeed, negative illness perception contributes to unfavorable health outcomes (Labetoulle et al., 2017). Furthermore, insufficient social networks in patients with age-related eye disease were independently associated with ongoing psychological problems (e.g., anxiety and depression); we thought that this might negatively affect the patients' perception of their situation (Hernández-Moreno et al., 2021; Zhang et al., 2024). Therefore, this study proposes:

H2: illness perception mediates the relationship between social support and VRQOL.

Coping styles are the cognitive approaches and behavioral strategies that people turn to in the face of stress and frustration and provide another psychological process that may affect VRQOL (Sturrock et al., 2015). Research has demonstrated that coping style predicts individual healthy activities and those who have effective coping styles report having fewer mental and physical impairments and engage in more healthy behaviors (Knowles et al., 2023; Chen et al., 2024). Throughout the treatment and rehabilitation of older patients with DED, a positive coping style can help them confront their illness more proactively and develop long-term resilience. In addition, some studies in health psychology have shown that social support can affect patients' health outcomes and disease prognosis by stimulating them to adopt a corresponding coping style (Tian et al., 2021; Luo et al., 2023). Based on these findings, this study proposes:

H3: coping style mediates the relationship between social support and VRQOL.

Furthermore, according to the CSM, when patients perceive threats to their health, their subjective views may change their coping strategies, which may in turn affect their health outcomes (Leventhal et al., 2016). Several studies have supported the influence of illness perception and coping style on the quality of life of individuals with chronic illnesses (Tu et al., 2022; O'Connor et al., 2023). Thus, this study proposes:

H4: illness perception and coping style play a chain-mediating role between social support and VRQOL.

However, the association among social support, illness perception, coping style, and VRQOL in older patients with DED is unclear. The purpose of this study was to investigate and analyze the correlations between these four variables. The hypothesized conceptual framework is shown in Figure 1, which aims to provide valuable evidence for establishing targeted interventions to improve VRQOL in older patients with DED.

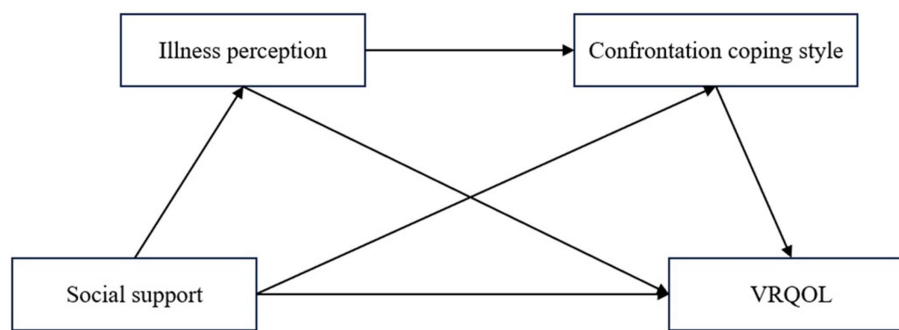


FIGURE 1
Hypothesized model. VRQOL, vision-related quality of life.

2 Methods

2.1 Participants and setting

The survey was conducted at a general tertiary hospital in Wuxi, Jiangsu Province, southern China, between June and December 2023. A total of 410 questionnaires were distributed; three invalid questionnaires were excluded, while 407 valid questionnaires were retained. Thus, the effective response rate was 99.3%. Inclusion criteria: (1) meets the diagnostic criteria reported by TFOS DEWS II (Wolfssohn et al., 2017); (2) is aged 60 years or older; (3) voluntary signing of informed consent; and (4) have clear consciousness and can cooperate with the investigator. Exclusion criteria: (1) presence of any other chronic eye disease that might affect the ocular surface; (2) active eye lesions or eye surgery within the past 3 months; and (3) with severe psychological and mental problems as assessed by a psychiatrist.

2.2 Data collection

The study followed the principles of the Declaration of Helsinki. All procedures were approved by the Ethics Committee of the Affiliated Hospital of Jiangnan University (LS2024031). Participants were informed of the study's purpose and significance, and the questionnaires were completed anonymously after signing informed consent. For anybody who had difficulty reading or writing, the investigators filled out the questionnaire based on the patients' verbal responses. The investigators were nursing staff from the ophthalmology department who had received professional training. To protect the respondents' privacy, each completed questionnaire was gathered and sealed.

2.3 Measures

2.3.1 Demographic and clinical characteristics

The participants' demographic data included age, gender, occupation, marital status, place of residence, educational level, medical insurance type, monthly family income (in Chinese yuan), disease duration, smoking history, and clinical data such as treatment condition, disease health education, and comorbidities.

2.3.2 Questionnaires

2.3.2.1 Social support rating scale (SSRS)

The Social Support Rating Scale (SSRS) was originally developed by the Chinese scholar Xiao (1994). It has three dimensions and 10 items, including objective support, subjective support, and the utilization of support. A 4-point Likert scale was adopted, with a total score between 12 and 66 points; higher scores indicated greater levels of social support. China has made extensive use of the SSRS, with a Cronbach's α of 0.920. The scale's Cronbach's α in this study was 0.878.

2.3.2.2 Brief illness perception questionnaire (BIPQ)

The Brief Illness Perception Questionnaire (BIPQ) was designed by Broadbent et al. (2006). It consists of 9 items across three dimensions: illness comprehensibility, illness cognitive representations, and emotional representations. The scores range from 0 to 80, and the final item is open-ended, so it does not contribute to the overall mark. Patients with higher scores indicate that the illness is perceived as more threatening. In the current study, the Cronbach's α was 0.859.

2.3.2.3 Medical coping modes questionnaire (MCMQ)

The Medical Coping Modes Questionnaire (MCMQ) was designed by Feifel et al. (1987). It has been verified that the Chinese version of the instrument has strong validity and reliability. The questionnaire has 20 items across three dimensions: confrontation (8 items), avoidance (7 items), and resignation (5 items). The total score is 20–80, and the three dimensions range from 8 to 32, 7 to 28, and 5 to 20, respectively. Patients are more likely to use this coping style if they average score better on one dimension, with respective Cronbach's α of 0.838, 0.763, and 0.860 in this study.

2.3.2.4 National eye institute visual functioning questionnaire-25 (NEI-VFQ-25)

The National Eye Institute Visual Functioning Questionnaire-25 (NEI-VFQ-25) was simplified by Mangione et al. based on the NEI-VFQ-51 (Mangione et al., 2001). The scale has 12 dimensions: general health, general vision, ocular pain, near activities, distance activities, social functioning, mental health, role difficulties, dependency, driving, color vision, and peripheral vision. This study evaluated VRQOL using the Chinese version of the NEI-VFQ-25. The

score ranges from 0 to 100; the lower the score, the worse the patients' VRQOL, accompanied by severe visual impairment. In addition, Cronbach's α for the scale in this study was 0.956. Notably, in China and other Asian countries, the missing rate of the driving dimension is high, and its applicability to older adults is low. Therefore, this study removed those dimensions following suggestions for questionnaire usage (Le et al., 2012).

2.4 Statistical analysis

All data were analyzed using SPSS version 27 (IBM, Inc., Armonk, NY, USA). In our study, all continuous variables met the assumptions of normality based on the Shapiro–Wilk test and linearity for path analysis. The demographic measurement data were described using the mean $\pm$ standard deviation ($M \pm SD$), while categorical data were described statistically by frequency (n) and percentage (%). One-way analysis of variance and independent t -tests were used to assess the statistical significance of the various clinical and demographic categories. The association among social support, illness perception, coping style and VRQOL were examined using Pearson's correlation analysis. Harman's single-factor test was used to examine the possible standard deviation before data analysis and further improve the rigor of the research (Podsakoff et al., 2003). Model 6 of the PROCESS Macro was utilized to estimate the chain-mediating effect. Demographic and clinical characteristics, including age, gender, marital status, educational level, medical insurance type, DED duration, smoking history, DED treatment, and DED health education that can significantly affect the dependent variable (Table 1) were included as control variables into the model. Bootstrapping was used to assess the mediating effect's significance using 5,000 random samples. The mediating impact was deemed statistically significant if there was no zero in the matching 95% bias-corrected confidence interval (CI). A p -values <0.05 were considered statistically significant.

3 Results

3.1 Common methods bias test

Applying Harman's single-factor test to identify common methodological deviations. Nine variables with characteristic values larger than one were found in the results. The first component explained 38.07% of the variance, which was lower than the 40% critical criterion. Thus, this study showed no severe common method bias.

3.2 Participant characteristics

The mean age of the 407 patients was 71.63 (± 6.19) years, with a range of 60 to 90 years. Univariate results for the sample population and their demographics are shown in Table 1. Over half of the patients (58.5%) were female, 82.10% were married, and 49.6% resided in urban areas. A total of 34.2% had a high school degree or higher and approximately 53.1% were retired. Over half of the participants (66.1%) had a monthly family income of more than 50,00 yuan, and the majority (83.0%) had health insurance. Among these patients, 51.10% were previously smokers. Over half (50.9%) of the patients had

TABLE 1 Demographic and clinical characteristics by VRQOL and results of the univariate model ($n = 407$).

Variables	VRQOL		t / F	p -value
	N (%)	$M \pm SD$		
Age			11.668	<0.001
60–69	157 (38.57)	65.73 $\pm$ 18.87		
70–79	200 (49.14)	60.04 $\pm$ 15.90		
≥ 80	50 (12.29)	51.10 $\pm$ 19.55		
Gender			10.077	<0.001
Male	169 (41.52)	72.52 $\pm$ 14.59		
Female	238 (58.48)	54.47 $\pm$ 17.43		
Residence			1.947	0.144
Urban	202 (49.63)	62.90 $\pm$ 17.26		
Rural	102 (25.06)	59.75 $\pm$ 19.08		
Town	103 (25.31)	59.05 $\pm$ 18.60		
Marital status			2.220	0.027
Married	334 (82.06)	62.06 $\pm$ 17.72		
Single/Divorced/ Widowed	73 (17.94)	56.89 $\pm$ 19.37		
Education level			18.787	<0.001
Primary and below	159 (39.07)	54.45 $\pm$ 20.24		
Middle school	109 (26.78)	61.09 $\pm$ 15.32		
High school	86 (21.13)	67.25 $\pm$ 14.21		
Junior college or above	53 (13.02)	71.35 $\pm$ 13.94		
Occupation			2.198	0.112
Inservice	110 (27.03)	64.13 $\pm$ 17.14		
Retire	216 (53.07)	60.34 $\pm$ 18.44		
Other	81 (19.90)	59.18 $\pm$ 18.23		
Monthly family income			2.378	0.069
<3,000 yuan	59 (14.50)	56.60 $\pm$ 18.96		
3,000 ~ 5,000 yuan	79 (19.41)	59.73 $\pm$ 18.22		
5,000 ~ 8,000 yuan	130 (31.94)	61.25 $\pm$ 16.80		
>8,000 yuan	139 (34.15)	63.75 $\pm$ 18.60		
Medical insurance			3.506	<0.001
Yes	338 (83.05)	62.55 $\pm$ 17.83		
No	69 (16.95)	54.22 $\pm$ 18.01		
Duration of DED			10.105	<0.001
<3 months	207 (50.86)	64.10 $\pm$ 17.01		
3–6 months	63 (15.48)	62.67 $\pm$ 19.98		
6–12 months	69 (16.95)	61.07 $\pm$ 15.23		
>12 months	68 (16.71)	50.74 $\pm$ 18.81		
Smoking history			–3.706	<0.001
Yes	208 (51.11)	57.93 $\pm$ 18.11		
No	199 (48.89)	64.48 $\pm$ 17.54		
DED related treatment			5.922	<0.001

(Continued)

TABLE 1 (Continued)

Variables	VRQOL		<i>t</i> / <i>F</i>	<i>p</i> -value
	<i>N</i> (%)	<i>M</i> ± <i>SD</i>		
Yes	198 (48.65)	66.38±16.97		
No	209 (51.35)	56.17±17.79		
DED related health education			8.772	<0.001
Yes	191 (46.93)	68.75±15.01		
No	216 (53.07)	54.40±17.98		
Comorbidities			1.595	0.111
No	126 (30.96)	63.27±18.15		
Yes	281 (69.04)	60.18±18.05		

M, mean; *SD*, standard deviation. VRQOL, vision-related quality of life.

DED for less than 3 months at the time of the survey. Approximately 48.7% of patients received suitable therapy, whereas 46.9% received related health education. Two-thirds of the patients had at least one comorbidity (69.0%). Furthermore, residence, occupation, monthly family income, and comorbidities had no statistically significant relationship with VRQOL. Other characteristics were statistically significant with VRQOL ($p < 0.05$) and were included as control variables in the multiple linear regression model.

3.3 Variable information

Table 2 demonstrates the mean and standard deviation of the different variables with a mean score of 61.14 (± 18.11), the VRQOL for the entire study population was classified as moderate. The social support score was 38.53 (± 11.54), indicating a medium level of social support. Patients perceived illness as a threat, as indicated by their mean illness perception score of 50.39 (± 10.73). The scores for the confrontation, avoidance, and resignation coping styles were 18.94 (± 4.54), 16.04 (± 3.85), and 11.98 (± 3.65), while the average scores were 2.37 (± 0.57), 2.29 (± 0.55), and 2.41 (± 0.75), respectively. Based on their average scores, the patients tended to adopt a resignation coping style.

3.4 Correlation analysis

Table 3 indicates a significant positive correlation between VRQOL and both social support ($r = 0.713$, $p < 0.001$) and confrontational coping style ($r = 0.664$, $p < 0.001$). Conversely, VRQOL was found to have a negative relationship with illness perception ($r = -0.703$, $p < 0.001$) and resignation coping style ($r = -0.720$, $p < 0.001$). Additionally, social support was positively correlated with confrontational coping style ($r = 0.562$, $p < 0.001$) and negatively correlated with resignation coping style ($r = -0.581$, $p < 0.001$) and illness perception ($r = -0.707$, $p < 0.001$). Furthermore, illness perception had a positive correlation with resignation coping style ($r = 0.579$, $p < 0.001$) and a negative correlation with confrontational coping style ($r = -0.580$, $p < 0.001$). No correlations were observed between avoidance coping style and the other key variables.

TABLE 2 Mean and standard deviations among the variables ($n = 407$).

Variables	<i>M</i> ± <i>SD</i>
VRQOL	61.14±18.11
Social support	38.53±11.54
Illness perception	50.39±10.73
Confrontation	18.94±4.54
Avoidance	16.04±3.85
Resignation	11.98±3.65

M, mean; *SD*, standard deviation. VRQOL, vision-related quality of life.

3.5 Mediation analysis

This study assessed the chain-mediation impact with the Model 6 of the PROCESS Macro. In the study, social support was examined as the independent variable, while illness perception, confrontational coping style, and resignation coping style were viewed as the intermediary variable, with VRQOL being the outcome variable. Figure 2 and Table 4 show the correlation between illness perception and confrontational coping style on social support and VRQOL after controlling for nine variables (e.g., age, gender, marital status, educational level).

Multiple linear regression analysis revealed that social support had a significant positive total effect on VRQOL ($\beta = 0.513$, $p < 0.001$). It directly affected VRQOL ($\beta = 0.284$, $p < 0.001$), while also negatively predicting illness perception ($\beta = -0.540$, $p < 0.001$) and positively predicting confrontational coping style ($\beta = 0.246$, $p < 0.001$). Meanwhile, illness perception had a negative effect on both VRQOL ($\beta = -0.224$, $p < 0.001$) and confrontational coping style ($\beta = -0.294$, $p < 0.001$). Confrontational coping style positively predicted VRQOL ($\beta = 0.268$, $p < 0.001$). The results for illness perception and resignation coping style as mediating variables were not statistically significant.

3.6 Bootstrap tests

Bootstrap tests were repeated 5,000 times to test the mediation effect. The mediation effect was considered significant because the 95% bootstrap confidence interval of the effect did not reach zero. As Table 5 shows, the direct effect pathway was social support → VRQOL, the effect value is 0.445 (95% CI: 0.310 to 0.581), which accounts for 55.28% of the total effect.

The total indirect effect was 0.360 (95% CI: 0.266 to 0.455), which accounted for 44.72% of the total effect. Three mediatory impact pathways were identified: social support → illness perception → VRQOL, with an indirect effect value of 0.190 (95% CI: 0.106 to 0.277), accounting for 23.60% of the total effect; social support → confrontation → VRQOL, with an indirect effect value of 0.103 (95% CI: 0.054 to 0.157), accounting for 12.80% of the total effect; and social support → illness perception → confrontation → VRQOL, with an indirect effect value of 0.067 (95% CI: 0.033 to 0.106), accounting for 8.32% of the total effect.

4 Discussion

This study concentrated on the mediating effects of social support and VRQOL in older patients with DED. Social support was found to

TABLE 3 Correlation between social support, illness perception, coping style, and VRQOL (*n* = 407).

Variables	VRQOL	Social support	Illness perception	Confrontation	Avoidance	Resignation
VRQOL	1.000	-	-	-	-	-
Social support	0.713*	1.000	-	-	-	-
Illness perception	−0.703*	−0.707*	1.000	-	-	-
Confrontation	0.664*	0.562*	−0.580*	1.000	-	-
Avoidance	−0.044	−0.072	0.011	−0.163*	1.000	-
Resignation	−0.720*	−0.581*	0.579*	−0.589*	−0.029	1.000

**p* < 0.001. VRQOL, vision-related quality of life.

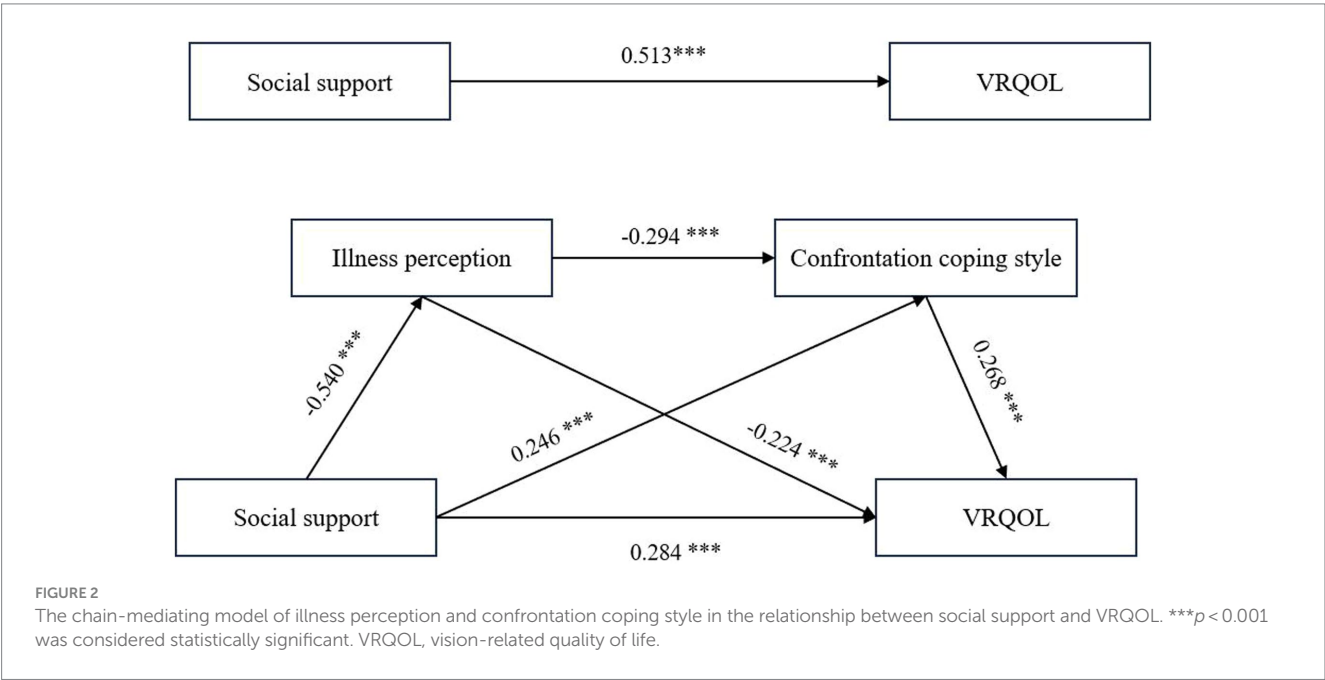


TABLE 4 Regression model of the relationship between factors (*n* = 407).

Variables	VRQOL		Illness perception		Confrontation		VRQOL	
	β	<i>t</i>	β	<i>t</i>	β	<i>t</i>	β	<i>t</i>
Age	−0.082	−2.475*	0.040	1.165	−0.070	−1.757	−0.051	−1.715
Gender	−0.127	−3.545***	0.126	3.373*	−0.018	−0.426	−0.084	−2.576*
Marital status	−0.020	−0.627	0.012	0.349	−0.009	−0.235	−0.014	−0.493
Education level	0.090	2.623**	−0.025	−0.704	0.071	1.733	0.064	2.052*
Duration of DED	−0.083	−2.521*	0.078	2.268*	−0.058	−1.474	−0.044	−1.472
Smoking history	0.087	2.660**	−0.053	−1.548	0.020	0.514	0.065	2.232*
treatment	−0.077	−2.266*	0.080	2.261*	0.029	0.703	−0.060	−1.971*
health education	−0.148	−4.293***	0.113	3.150*	−0.155	−3.734***	−0.072	−2.264*
Medical insurance	−0.021	−0.640	0.078	2.274*	−0.031	−0.787	0.011	0.368
Social support	0.513	12.728***	−0.540	−12.837***	0.246	4.296***	0.284	6.454***
Illness perception					−0.294	−5.118***	−0.224	−5.028***
Confrontation							0.268	7.093***
<i>R</i> ²	0.594		0.557		0.423		0.676	
<i>F</i>	57.982***		49.834***		26.319***		68.521***	

p* < 0.05, *p* < 0.01, ****p* < 0.001. VRQOL, vision-related quality of life.

TABLE 5 Bootstrap analysis of the mediating effect of social support and VRQOL ($n = 407$).

Paths	Effect	Boot SE	Boot LL CI	Boot UL CI	Effect ratio
Total effect	0.805	0.063	0.681	0.930	100.00%
Direct effect	0.445	0.069	0.310	0.581	55.28%
Total indirect effect	0.360	0.048	0.266	0.455	44.72%
Indirect effect 1	0.190	0.044	0.106	0.277	23.60%
Indirect effect 2	0.103	0.026	0.054	0.157	12.80%
Indirect effect 3	0.067	0.019	0.033	0.106	8.32%

Indirect effect 1: Social support → Illness perception → VRQOL; Indirect effect 2: Social support → Confrontation → VRQOL; Indirect effect 3: Social support → Illness perception → Confrontation → VRQOL. VRQOL, vision-related quality of life.

promote VRQOL through the indirect pathways of illness perceptions and confrontational coping style, as well as the chain mediation path of illness perceptions and confrontational coping style.

According to this study's results, the mean VRQOL score of older patients with DED is 61.14 (± 18.11), which is lower than the results of 71.60 (± 12.80) points by Hossain et al. (2021) and 83.0 (± 9.0) points by Erøy et al. (2023). This discrepancy could be clarified by the fact that the studies were conducted at various locations on different dates. Furthermore, the participants in this study were older patients whose visual function was worse than that of the adult patients in previous studies. Older patients with DED generally suffer from the disease for a long time and recover slowly, which leads to increased psychological stress. Additionally, their ocular symptoms result in decreased visual function and, to some extent, limit their independence, which lowers VRQOL.

This study's results showed that social support had a positive predictive effect on the VRQOL of older patients with DED (Hypothesis 1). Older patients with DED have greater health outcome when they have more social support, which agree with the results of several similar studies examining patients with glaucoma (Uruthiramoorthy et al., 2020) and diabetic retinopathy (Zhang et al., 2024). Social support is well-known to be a significant external component. Nevertheless, the mean social support score of older patients with DED in this study was moderate 38.53 (± 11.54). Patients with a sufficiently large social network can receive practical, emotional, and interpersonal support in addition to health assistance, which helps improve their health and lessen the negative effects of illness. For example, a qualitative study revealed that patients with DED are more willing to spend more time socializing with family and friends because it helps them divert their attention and reduce the painful impact of their eye symptoms on their lives (Yeo and Tong, 2018). Therefore, health professionals and families should encourage patients to participate in as many activities as possible to broaden their social network system and obtain appropriate support and assistance to promote good health outcomes and increase their VRQOL.

In addition, this study's results revealed that illness perception mediated the relationship between social support and VRQOL in older patients with DED (Hypothesis 2). The mean illness perception score for participants in this study was high 50.39 (± 10.73). The results align with a previous study (Dunn et al., 2021), which also emphasized that DED patients lack a correct understanding of the disease; more knowledge and education regarding the etiology of DED and therapeutic approaches are essential for changing patients' perceptions. Social support from family, friends, and the external environment can stimulate patients' latent cognitive and psychological attributes and

help them develop an accurate perception of the disease (Segal et al., 2021). Positive illness perception can effectively establish reasonable beliefs and improve physical and mental health, thereby enhancing the overall quality of life for older patients with DED. Sano et al. (2018) discovered that educating participants with DED on how exercise can alleviate eye symptoms and promote health over a 10-week period resulted in improved subjective symptoms of DED. Consequently, healthcare professionals should instruct patients to use the various social resources available to them to obtain appropriate knowledge and skills related to the disease, as well as guide them in developing a positive attitude toward coping with the disease to maintain a good emotional state and, ultimately, improve VRQOL.

Finally, this study's results demonstrated that a confrontational coping style mediated the relationship between social support and VRQOL in older patients with DED (Hypothesis 3). This study found that older patients with DED were more likely to adopt a resignation coping style. DED is a disease that requires long-term and repeated physical therapy and daily eye drops, which reduces patients' self-confidence in recovering from the disease, leads to a pessimistic attitude, and causes them to cope with the disease by succumbing to it. However, when people have more social support, they can fully mobilize social resources in the face of the threat of disease, take the initiative to learn about the disease, and cope with the challenges it presents (Zamanian et al., 2021). Patients with a high level of social support have a rich social network, usually have a constructive attitude toward the illness, a high level of adherence, and good health behaviors (Li et al., 2023; Yang et al., 2024). These actions result in the formation of positive coping strategies and health management behaviors, which, in turn, support patients' physical and psychological recovery and enhance their VRQOL.

Notably, we also discovered that social support can affect VRQOL in older patients with DED through the chain mediation of illness perception and confrontational coping style (Hypothesis 4). Put simply, increasing social support levels for older patients with DED will help them positively perceive and cope with the disease and improve their VRQOL. The indirect effect ratio was 8.32%. With a high degree of social support, patients can obtain sufficient cognitive, emotional, and material motivation, which is not only conducive to improving their illness perception but also helps relieve negative feelings. The positive illness perception motivates patients to use constructive coping styles, improves their ability to handle stressful situations, and increases their VRQOL during the disease period. Overall, these findings offer fresh evidence about CSM in the context of older patients with DED. Our results emphasize how critical it is to better understand the underlying mechanisms to establish effective therapies for older patients with DED.

4.1 Limitations and recommendations

This study had some limitations. First, the samples were collected from a single hospital, more verification is needed to ensure that the study's results are representative. Future research should involve multicenter large-sample analyses to verify our findings. Second, this study was cross-sectional, so we were unable to explain the dynamic development and changes between the variables. The causal relationships among these variables can be further investigated in the future using better methods such as longitudinal studies. Third, self-report questionnaires served as all of the instruments in this investigation; we also did not assess the patients' cognitive level using a structure test (e.g., a mini-mental test); we only assessed it based on the judgment of the psychiatrists, which may be subjective. Thus, relatively objective methods can be combined to improve the study's accuracy in the future. Fourth, considering we did not want to increase the burden on older patients, we did not measure their psychological status. In the future, it is necessary to explore the effects of psychological factors (e.g., anxiety and depression) on the VRQOL of DED patients to provide more evidence for the study of VRQOL. Finally, although this study included only older patients with DED, future studies should include patients of all ages.

5 Conclusion

As far as we are aware, this cross-sectional study is the first to investigate the association among social support, illness perception, coping styles, and VRQOL in older patients with DED. Social support has a positive effect on VRQOL in older patients with DED. Illness perception and confrontational coping style not only mediate the relationship between social support and VRQOL independently but also have chain mediating effects. Thus, this study provides a theoretical basis and reference for healthcare professionals to formulate effective intervention strategies to improve VRQOL in older patients with DED in the future.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Affiliate Hospital of Jiangnan University. The studies were conducted in accordance with

the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

HP: Writing – original draft, Writing – review & editing, Data curation, Investigation. XP: Funding acquisition, Resources, Supervision, Writing – review & editing. DG: Funding acquisition, Methodology, Resources, Supervision, Writing – review & editing. XW: Data curation, Investigation, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Incidence and influencing factors of kinesiophobia in patients with chronic heart failure: a scoping review

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Introduction: Kinesiophobia denotes an excessive and irrational apprehension towards physical activity or exercise among patients, stemming from a perception of susceptibility to painful injury or re-injury. Cardiac rehabilitation stands pivotal in the secondary prevention spectrum for individuals with cardiovascular ailments, with exercise constituting a cornerstone of this regimen. However, the emergence of kinesiophobia poses a formidable challenge, diminishing patient adherence to cardiac rehabilitation protocols, particularly among those grappling with chronic heart failure. To bolster exercise-based rehabilitation initiatives in this cohort, a thorough comprehension of the multifaceted factors precipitating kinesiophobia is imperative. This review endeavors to delineate prevailing evidence and prevalence concerning kinesiophobia triggers in chronic heart failure patients, while pinpointing research lacunae for future exploration.

Methods: Employing a scoping review methodology, our investigation culled data from diverse scholarly databases, including Embase, PubMed, Scopus, CINAHL, Web of Science, Medline, Sinomed, CNKI, Wangfan, and VIP.

Results: After thorough evaluation, 9 studies that met the inclusion criteria were ultimately incorporated.

Discussion: Our findings underscore a notable prevalence of kinesiophobia in chronic heart failure patients, predominantly influenced by socio-demographic factors, psychological and cognitive factors, disease and treatment factors, as well as lifestyle and behavior. Armed with these insights, future interventions can be tailored to mitigate kinesiophobia levels, fostering enhanced engagement in exercise-centric cardiac rehabilitation endeavors among patients grappling with chronic heart failure.

KEYWORDS

Kinesiophobia, chronic heart failure, cardiac rehabilitation, influencing factors, mental health, scoping review

1 Introduction

Cardiovascular disease is a major public health problem worldwide, characterized by high morbidity and high mortality, and is the leading killer of human health (Benjamin et al., 2019), which will increase the heavy burden on individuals and social medical and health service system (Cook et al., 2014; The Writing Committee Of China, 2023). More than 64 million people worldwide suffer from heart failure (Savarese et al., 2023). Cardiac exercise rehabilitation originated in the 1960s (Clausen et al., 1969), which is a comprehensive rehabilitation strategy consisting of five prescriptions including drugs, exercise, nutrition,

psychology (including sleep management), smoking cessation and alcohol restriction. Many guidelines recommend exercise rehabilitation for patients with cardiovascular disease (Ponikowski et al., 2016; Sharma et al., 2021). For example, the ‘Ten Commandments’ for the 2020 ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease clearly state that “All able individuals with cardiovascular disease should engage in at least 150 min of exercise per week divided over 5 days, or 75 min of vigorous exercise divided over 3 days” (Sharma et al., 2021). Kinesiophobia is defined as an excessive, irrational sense of vulnerability to sports or daily activities due to a reduced threshold of the body to pain due to injury such as pain (Vlaeyen et al., 1995), it is also known as fear of movement, and so on. Changes in cardiac structure and decreased cardiac output in heart failure patients contribute to respiratory muscle atrophy, exacerbating dyspnea (Nakagawa et al., 2020). Concurrently, pulmonary congestion and infection further compromise lung function, resulting in symptoms such as coughing and expectoration (Douillet et al., 2023). These combined factors significantly diminish the quality of life for affected patients. Kinesiophobia can exacerbate dyspnea and lead to discomfort such as chest tightness and palpitations. Furthermore, it can increase psychological stress and negative emotions in patients (Qin J.-W. et al., 2022; Tang et al., 2023), reducing treatment compliance and posing a major obstacle to participation in exercise-based cardiac rehabilitation for heart failure patients (Rogerson et al., 2012). Exercise rehabilitation has been proven to be an effective secondary prevention measure for patients with Chronic Heart Failure (CHF). It serves as a cornerstone and crucial component of cardiac rehabilitation, offering numerous benefits to patients, as evidenced by studies (Pelliccia et al., 2021; Youn et al., 2023). Studies have shown that kinesiophobia is one of the key factors for non-adherence to home-based cardiac rehabilitation in patients with chronic heart failure (Yang et al., 2023a,b). Despite the growing body of research on kinesiophobia, there is a lack of systematic reviews that have comprehensively outlined the influencing factors of kinesiophobia in patients with chronic heart failure. Therefore, the aim of this commentary is to delineate the current influencing factors of kinesiophobia in patients with chronic heart failure and identify potential research gaps to address future research needs in this area. Our review addresses two key research questions: (a) What is the prevalence of kinesiophobia in patients with chronic heart failure? (b) What are the factors that influence kinesiophobia in patients with chronic heart failure?

2 Methods

While we applied the scoping review methodology proposed by Arksey and O'Malley (2005) and advanced by Levac et al. (2010), we did not perform the sixth step, i.e., consultation, because we examined the study related to the influencing factors of kinesiophobia in patients with chronic heart failure, we did not address the perspectives of other stakeholders on this issue.

2.1 Identifying the research question

The purpose of this review is to find the existing study on the influencing factors of kinesiophobia in patients with chronic heart

failure and the research gaps in the study. To achieve these goals, we asked the following research questions: (a) What is the incidence of kinesiophobia in patients with chronic heart failure? (b) What are the influencing factors of kinesiophobia in patients with chronic heart failure?

2.2 Identifying relevant studies

Two investigators with extensive evidence-based knowledge participated in the systematic review search, which involved multiple searches of the following databases: PubMed, Scopus, CINAHL, Web of Science, Embase, Medline, Sinomed, CNKI, Wangfan, VIP. The selection of search terms was initially established through consultations with experts and discussions among members of the subject group. Following a trial search, the following search terms were finalized: heart failure/CHF/chronic heart failure/cardiac failure*/heart decompensation/right-side heart failure/myocardial failure/congestive heart failure/left-side heart failure/kinesiophobia/fear of movement/fear of physical activity/risk factors/relative risk/social risk factor*/health correlate*/population at risk/risk score/risk factor score*/cause/protective factor. The search period was from the establishment of the database to December 20, 2023. Languages are limited to English and Chinese. After the search was completed, we read the reference lists of each article and found no new relevant articles. In addition, we discussed and identified 4 common core journals. Keywords in these journals were manually searched to identify missing study, and no new study was found. The search strategy is described in the [Appendix 1](#).

2.3 Study selection

Our study inclusion criteria encompassed studies involving individuals diagnosed with chronic heart failure, focusing on elucidating the factors influencing the development of kinesiophobia within this population. Accepted study designs include qualitative, quantitative, mixed, or multimethod approaches. The exclusion criteria comprised conference abstracts, editorials, letters, studies lacking access to full-text study, and duplicate publications.

2.4 Study screening and data extraction and analysis

The titles of the study retrieved in the database were imported into EndNote 20 software, and after automatic and manual de-duplication, two trained researchers independently read the titles and abstracts of the study according to the inclusion and exclusion criteria of the study for the first screening. After the initial screening, the researchers further obtained the full text for the second screening. In the screening process, if the researchers had differences of opinion and could not reach a consensus, the third researcher was invited to participate in the discussion and resolution. In addition, the data extraction of the included study was also conducted by two researchers independently, and any discrepancies in the extraction process were resolved by discussion between the two researchers or adjudicated by a third researcher. Subsequently, the lead author conducted the study

summary analysis, extracting key information such as author details, publication year, country, research methodology, sample size, incidence of kinesiophobia, influencing factors, and assessment tools. Following information extraction, researchers collaboratively developed data charts using Excel software tailored to the research inquiries. Throughout the study, descriptive statistics and narrative reviews were employed to organize and synthesize research findings (Stang, 2010; Zeng et al., 2012), with thematic analysis (Braun and Clarke, 2006) utilized to categorize influencing factors. See Figure 1 for more details.

3 Results

3.1 Descriptive statistics summary

A total of 143 relevant studies were preliminarily retrieved, and 9 studies were finally included (Hoffmann et al., 2018; Dai et al., 2022;

Qin J. et al., 2022; Qin J.-W. et al., 2022; Chen and Li, 2023; Qin et al., 2023; Sentandreu-Mano et al., 2023; Tang et al., 2023; Zhang et al., 2023), with a total sample size of 1923 cases.

3.2 Current status of kinesiophobia in patients with chronic heart failure

Five studies specifically described the incidence of kinesiophobia in patients with chronic heart failure, ranging from 54.4 to 69.5%, among which Tang (Tang et al., 2023) had the highest incidence, indicating that patients with chronic heart failure had a high incidence of kinesiophobia. In terms of regions, 7 studies (Dai et al., 2022; Qin J. et al., 2022; Qin J.-W. et al., 2022; Chen and Li, 2023; Qin et al., 2023; Tang et al., 2023; Zhang et al., 2023) were from China, to a certain extent, the research on kinesiophobia in patients with chronic heart failure is not enough. The studies are summarized in Table 1.

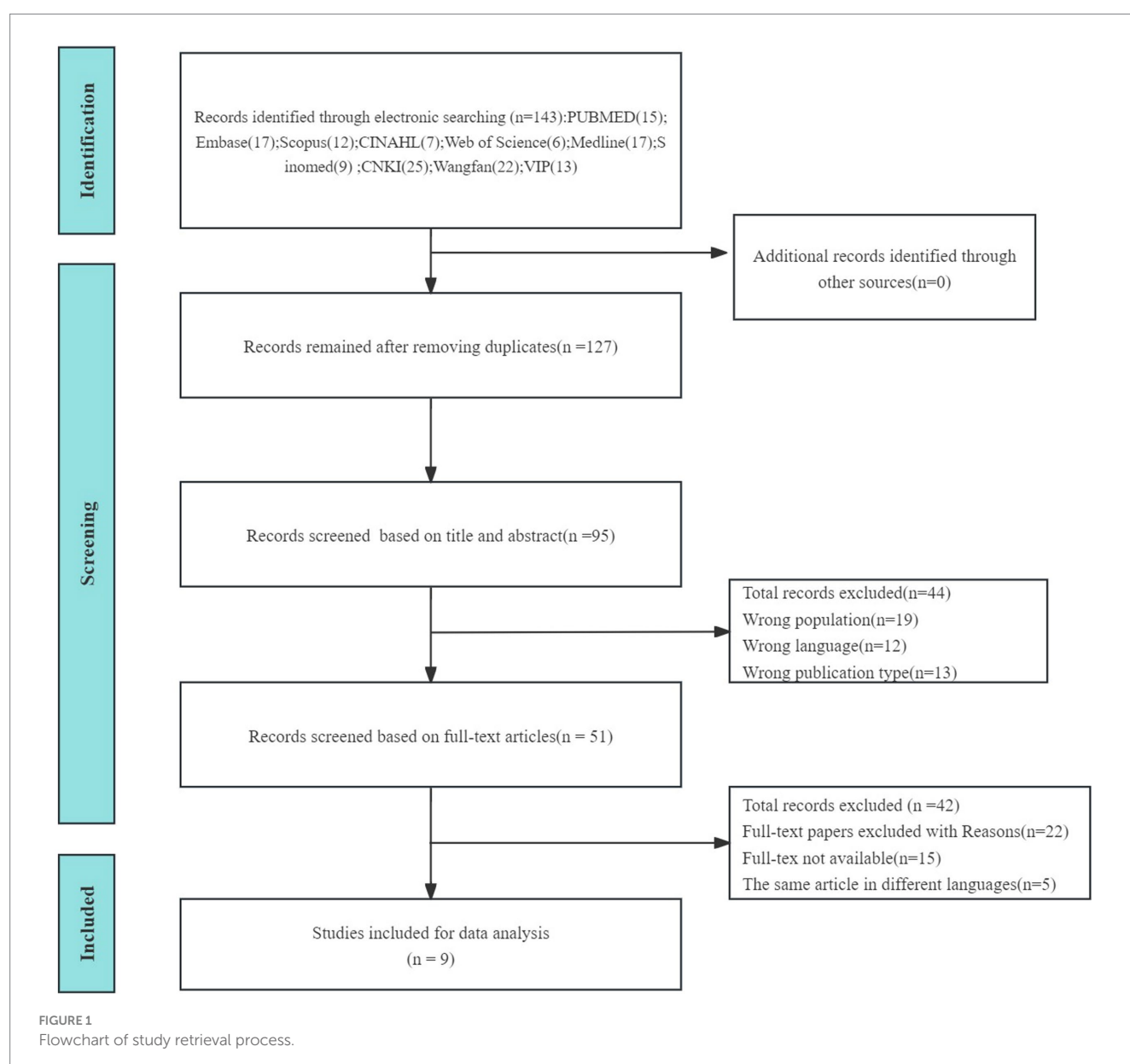


TABLE 1 Basic characteristics of the included studies.

Author/Year	Country	Study type	Sample size	Incidence rate (%)	Age	Evaluation tools	Kinesiophobia score	Influencing factors
Chen and Li (2023)	China	Cohort studies	181	-	61.36 ± 12.57	TSK-Heart-C	(a) On admission: 46.69 ± 7.83; (b) 1 month after discharge: 43.15 ± 9.20; (c) 3 months after discharge: 39.78 ± 7.53; (d) 6 months after discharge: 34.21 ± 5.95	(1) (2) (3) (11) (18)
Dai et al. (2022)	China	Cross-sectional study	188	-	54.66 ± 16.49	TSK-SV Heart	34.88 ± 13.25	(2) (4) (5) (12) (13)
Qin J-. W. et al. (2022)	China	Cross-sectional study	260	65.00	76.80 ± 7.40	TSK-Heart-C	-	(4) (11) (14) (16) (18)
Sentandreu-Mano et al. (2023)	Spain	Cross-sectional study	107	54.40	73.18 ± 12.68	TSK-11	-	(1) (3) (16) (17)
Hoffmann et al. (2018)	Germany	Cross-sectional study	132	-	67.10 ± 12.10	TSK-SV Heart	-	(8) (9) (15) (19)
Qin et al. (2022)	China	Cross-sectional study	236	63.14	>60	TSK-Heart-C	59.31	(4) (5) (11) (17)
Tang et al. (2023)	China	Cross-sectional study	244	69.50	64.45 ± 11.076	TSK-SV Heart	-	(4) (5) (6) (12) (19)
Qin et al. (2023)	China	Cross-sectional study	270	-	76.17 ± 7.96	TSK-SV Heart-C	-	(10) (14) (18)
Zhang et al. (2023)	China	Cross-sectional study	305	58.40	64.41 ± 8.38	TSK-SV Heart	39.45 ± 76.91	(6) (7) (8)

Influencing factors: (1)Gender; (2) Age; (3) Social Support; (4) Educational Attainment; (5) Economic Status; (6) Occupation; (7) Social Status; (8) Anxiety and Depression; (9) Disease Awareness; (10) Coping Mechanisms; (11) Disease Progression; (12) Cardiac Function; (13) Surgical History; (14) Heart Failure Symptoms; (15) Comorbidities; (16) Fatigue; (17) Pain Perception; (18) Self-Efficacy; (19) Physical Exercise. Evaluation tools: (1) TSK-Heart-C: Chinese version of Kinesiophobia of Heart Disease Scale; (2) TSK-SV Heart: Kinesiophobia Scale for patients with heart disease; (3) TSK-11: Kinesiophobia of Heart Disease-11.

TABLE 2 Influencing factors of kinesiophobia in CHF.

Theme	Specific factors
Socio-demographic factors	Gender, Age, Social Support, Educational Attainment, Economic Status, Occupation, Subject Social Status
Psychological and cognitive factors	Anxiety and Depression, Disease Awareness, Coping Mechanisms, Self-Efficacy
Disease and treatment factors	Disease Progression, Cardiac Function, Surgical History, Heart Failure Symptoms, Comorbidities, Fatigue, Pain Perception
Lifestyle and behavior	Physical Exercise

3.3 The influencing factors of kinesiophobia in people with chronic heart failure

After a systematic retrieval process, we meticulously sorted and synthesized the pertinent influencing factors gleaned from the included studies. These factors predominantly fall within four overarching categories, amounting to a total of 19 distinct influencers. See Table 2 for details.

3.3.1 Socio-demographic factors

Existing studies have shown that gender, age and other related socio-demographic factors of patients with chronic heart failure can affect the occurrence of kinesiophobia. In the retrieved studies, Chen and Li (2023) underscored the female gender as a noteworthy risk factor for fostering apprehension towards exercise among CHF patients ($p < 0.05$). Conversely, Acar et al. (2016) observed a higher incidence of exercise-related fear in men compared to women. Despite the contrasting findings, it is evident that gender plays a role in influencing fear of exercise. Age was also a risk factor for kinesiophobia ($p < 0.05$), and the older the age (Dai et al., 2022; Chen and Li, 2023), the higher the level of kinesiophobia. Social support was also an influencing factor of kinesiophobia. Studies (Chen and Li, 2023; Sentandreu-Mano et al., 2023) pointed out that the level of social support was negatively correlated with kinesiophobia, that is, the higher the level of social support, the lower the level of kinesiophobia ($r = -0.48$, $p < 0.01$). Education attainment was closely related to the level of kinesiophobia. Studies (Dai et al., 2022; Qin J. et al., 2022; Qin J.-W. et al., 2022; Tang et al., 2023) pointed out that the lower the education attainment, the higher the level of kinesiophobia, and the patients with junior high school education or below had a higher level of kinesiophobia ($p < 0.05$). Qin et al. (2022) found that educational background had the greatest impact on kinesiophobia [OR = 3.369, 95%CI (1.249–9.091)]. Patients with low economic income had a higher level of kinesiophobia (Dai et al., 2022; Qin J.-W. et al., 2022; Tang et al., 2023) than those with higher income ($p < 0.05$). Occupational status and type of occupation were the influencing factors of the occurrence of kinesiophobia, and two studies (Tang et al., 2023; Zhang et al.,

2023) showed that non-working status (retired, unemployed or unemployed), workers, and farmers had higher levels of kinesiophobia ($p = 0.002$).

3.3.2 Psychological and cognitive factors

Two studies (Hoffmann et al., 2018; Zhang et al., 2023) pointed out that kinesiophobia was related to anxiety ($r = 0.418$, $p < 0.05$) and depression ($r = 0.498$, $p < 0.05$). On the one hand, a high level of kinesiophobia was positively correlated with disability rate and depression in patients with heart disease; on the other hand, the occurrence of kinesiophobia could also lead to anxiety in patients. Patients with CHF frequently experience psychological challenges stemming from the prolonged disease trajectory and escalating physical symptoms (Zhang et al., 2019). In such instances, cardiophobia often surfaces, representing an anxiety disorder characterized by recurrent physical discomfort like chest pain and palpitations, coupled with an intense fear of heart attack and mortality, despite the absence of underlying physical pathology (Eifert, 1992). The level of disease awareness (Hoffmann et al., 2018) and coping mechanisms (Qin et al., 2023) were also risk factors for kinesiophobia ($p < 0.01$). Three studies (Qin J.-W. et al., 2022; Chen and Li, 2023; Qin et al., 2023) pointed out that self-efficacy was related to kinesiophobia ($p < 0.01$). The lower the level of self-efficacy, the higher the level of kinesiophobia.

3.3.3 Disease and treatment factors

Disease progression was positively correlated with the level of kinesiophobia (Qin J. et al., 2022; Qin J.-W. et al., 2022; Chen and Li, 2023), and the longer the disease progression, the greater the likelihood of heightened kinesiophobia levels ($p < 0.05$). Two studies (Dai et al., 2022; Tang et al., 2023) showed that the level of cardiac function classification was also positively correlated with the level of kinesiophobia ($p < 0.01$). Another study pointed out that the history of surgery ($p < 0.05$) (Dai et al., 2022); Heart failure symptoms (Qin J.-W. et al., 2022; Qin et al., 2023) such as dyspnea and activity intolerance ($p < 0.01$). Heart failure symptoms and comorbidities are closely related to kinesiophobia (Hoffmann et al., 2018; Qin J.-W. et al., 2022; Qin et al., 2023; $r = 0.44$, $p < 0.01$). The more serious the symptoms of heart failure and the more the number of comorbidities, the higher the level of kinesiophobia in CHF patients. Studies (Qin J. et al., 2022; Qin J.-W. et al., 2022) showed that fatigue was negatively correlated with kinesiophobia ($r = 0.49$, $p < 0.01$). Fatigue manifests as a persistent subjective sensation affecting the body, emotions, or cognition. Patients typically experience negative moods, diminished energy, and disrupted rest (Bower, 2014). Moreover, heightened levels of fatigue correlate with increased kinesiophobia among patients. One study (Sentandreu-Mano et al., 2023) showed that the location, intensity, and frequency of pain perception were related to kinesiophobia, especially patients with knee and waist pain had higher levels of kinesiophobia ($p < 0.01$). Exercise avoidance due to pain is the primary cause of kinesiophobia (Lethem et al., 1983). Patients who excessively focus on pain and threatening stimuli will develop fear and resistance towards physical activities, leading to exercise avoidance and impeding the rehabilitation process.

3.3.4 Lifestyle and behavior

Studies (Hoffmann et al., 2018; Tang et al., 2023) pointed out that kinesiophobia was related to the physical exercise of patients with heart failure ($p < 0.05$).

3.4 Kinesiophobia assessment tools

In the 9 included studies, a total of 3 kinesiophobia assessment tools were utilized: TSK-Heart-C, TSK-SV Heart, and TSK-11.

3.4.1 The Tampa Scale for Kinesiophobia heart

The scale, adapted and developed by the Bäck (Bäck et al., 2012) from the Tampa Scale for Kinesiophobia (TSK). Is first used to measure the level of kinesiophobia heart patients. The scholars of different countries, respectively, to cross-cultural adaptation and the scale reliability and validity of test. The TSK-SV Heart scale has 17 items and is divided into 4 dimensions: risk perception, kinesiophobia, exercise avoidance and dysfunction. The total score ranged from 17 to 68 points, and >37 points were considered to have kinesiophobia, and the higher the score, the more serious the degree of kinesiophobia.

3.4.2 Tampa Scale for Kinesiophobia

It was originally used to assess fear of exercise-related pain in patients with musculoskeletal pain (Miller et al., 1991). The Cronbach's α coefficient of each version of TSK was between 0.7 and 0.92, and the test-retest reliability was above 0.8, which had good reliability and validity. Kamonseki (Zale and Ditre, 2015) translated the Short Form for Kinesiophobia Assessment (TSK-11) into a Brazilian version and applied it to patients with shoulder pain.

4 Discussion

The current situation of kinesiophobia in patients with chronic heart failure is not optimistic. According to existing studies, the level of kinesiophobia in patients with chronic heart failure reaches 54.40–69.50% (Qin J. et al., 2022; Qin J.-W. et al., 2022; Sentandreu-Mano et al., 2023; Tang et al., 2023; Zhang et al., 2023). The current research in this field is mainly concentrated in China, with less research in other regions, which to some extent reflects the insufficient attention paid to CHF-related anxiety in other regions. Our research shows that the current studies are mostly cross-sectional surveys, lacking comprehensive policy guidance or targeted interventional studies. Our study indicates that the assessment tools for CHF-related anxiety are mostly subjective questionnaires, lacking objective assessment indicators or tools, which highlights the importance of medical and nursing staff assessing the level of CHF-related anxiety in a timely manner and developing suitable objective assessment tools in the future, which will improve the accuracy of assessment and promote the achievement of cardiac rehabilitation for CHF patients.

The study review conducted in this study revealed 19 factors that affect kinesiophobia in patients with CHF, which can be categorized into four thematic categories. Among them, the socio-demographic factors and disease and treatment factors themes contain the most factors, with 7 factors each. It is worth noting that although our study

categorized the factors affecting kinesiophobia in patients with CHF into four themes, each theme is not independent and can interact with each other. The factors of social support in the socio-demographic factors domain and comorbidity factors in the disease and treatment domain are closely associated with mental health. Social support encompasses emotional, informational, and tangible aid from various sources such as family, friends, and the community (Langford et al., 1997). Effective social support can significantly alleviate patients' psychological distress, including depression (Patra et al., 2017). Additionally, an increase in the number of complications can elevate the risk of depression (Wiltink et al., 2011). Social support can also enhance patients' access to medical information. Patients who heavily rely on social support tend to leverage the social resources available to them to acquire disease-related information through various channels (Qiao et al., 2021). Furthermore, social support directly influences self-efficacy (Liu et al., 2023). Patients with high self-efficacy are confident enough to actively engage in postoperative rehabilitation training, thereby establishing and adopting healthy behaviors, enhancing compliance with treatment, and developing skills for health self-management to promote cardiac rehabilitation.

Among all these factors, educational attainment has proven to be the most prevalent influencing factor, indicating a significant effect on kinesiophobia. Patients with higher levels of education demonstrate greater abilities in acquiring disease-related information and self-management skills (Qiao et al., 2021). This, in turn, empowers them to make informed decisions. Conversely, CHF patients with lower educational backgrounds may lack a comprehensive understanding of their condition, potentially leading to fear of early functional exercise and resistance to early rehabilitation training. Consequently, the optimal rehabilitation window may be missed, thereby impacting patient rehabilitation. This underscores the importance of giving increased attention to CHF patients with lower educational backgrounds in clinical settings. Implementing targeted interventions or health education based on the educational level of CHF patients holds significant value.

Low-income CHF patients often face significant financial burdens, worrying that engaging in physical activity may exacerbate their condition and escalate medical costs. Thus, they often resort to avoidance and passive coping strategies in managing daily activities and functional exercises. However, employment not only offers financial stability but also fosters social interaction, structure, and a sense of accomplishment, all of which can alleviate symptoms of kinesiophobia.

Social status is a position within society determined by an individual or group's access to resources, including income, education, occupation, and other factors (Bradley and Corwyn, 2002). It encompasses both objective measures and subjective perceptions, with subjective social status more accurately influencing life attitudes, behaviors, and future expectations (Goodman et al., 2003). Subject social status (Zhang et al., 2023) exhibited a negative correlation with kinesiophobia ($p < 0.05$). Higher social status affords greater resources, social recognition, and influence, thereby enhancing individual well-being and mental health (Adler et al., 2000).

Coping style serves as a cognitive behavioral strategy individuals employ to effectively manage internal and external stressors. Patients adopting a positive coping style are more likely to exhibit psychological resilience to adverse reactions, thereby optimizing health outcomes

and improving quality of life. Conversely, individuals inclined towards negative responses may lack confidence and succumb to ineffective outcomes, exacerbating health consequences. Patients with multiple comorbidities often exhibit reduced tolerance for self-exercise and are prone to avoidant coping, leading to diminished motivation for physical activity. Consequently, patients with lower activity levels are more susceptible to developing kinesiophobia. Despite the myriad benefits regular activity and exercise offer, such as enhanced physical functioning, improved sleep quality, and better management of negative emotions (Chakravarty et al., 2008), individuals grappling with kinesiophobia often fail to fully leverage these advantages. This limitation, in part, presents a challenge to cardiac rehabilitation in CHF patients.

While existing studies have highlighted associations between social status, disease awareness, coping mechanisms, surgical history, comorbidities, and kinesiophobia in CHF patients, further research is needed to deepen our understanding of these factors. Future studies should comprehensively explore these aspects to inform effective intervention measures. Accurate assessment of exercise fear in heart failure patients is pivotal for promoting exercise rehabilitation. Although various versions of exercise fear assessment scales exist and have been applied in diverse populations, researchers must carefully select the most suitable research tool considering regional and population characteristics to accurately gauge the level of exercise fear in future studies.

In general, the 9 studies (Hoffmann et al., 2018; Dai et al., 2022; Qin J. et al., 2022; Qin J.-W. et al., 2022; Chen and Li, 2023; Qin et al., 2023; Sentandreu-Mano et al., 2023; Tang et al., 2023; Zhang et al., 2023) included in this study can reflect the influencing factors of the occurrence of kinesiophobia in patients with chronic heart failure, and provide a basis for the development of clinical targeted nursing measures. However, only part of the studies have conducted follow-up, which may cause bias in the study results. Secondly, on the issue of kinesiophobia, most of the studies included in this study were analyzed from the patients themselves, and there were certain limitations in the perspective of discussion. In addition, kinesiophobia is a dynamic process, and long-term follow-up of patients is needed to evaluate the impact of kinesiophobia on cardiac rehabilitation. To effectively reduce or mitigate the fear of movement in patients with CHF, a comprehensive approach is necessary, encompassing multidisciplinary professional interventions and governmental policy support, particularly for economically disadvantaged patients. Given the chronic nature of CHF and its prolonged treatment process, patients often bear a substantial disease burden, making appropriate medical subsidies or relief crucial. Hence, future research should adopt a multifaceted approach, examining various perspectives, including those factors or populations currently underrepresented. A thorough exploration of targeted interventions for kinesiophobia is paramount. Additionally, further research is warranted to investigate the long-term effects of kinesiophobia on the cardiac rehabilitation outcomes of CHF patients.

5 Limitations

The reviewers encountered challenges related to language barriers, resulting in the consideration of only published Chinese or English. There may also be a certain degree of selection bias

present. The reviewers did not reach out to the researchers involved in this study for additional relevant information, potentially leading to some missing data. Furthermore, the methodological quality of the studies included was not systematically evaluated. Lastly, the assessment instrument utilized in these studies consisted of a self-report questionnaire and lacked objective measures of kinesiophobia, suggesting potential bias in the reported levels.

6 Conclusion

Patients with chronic heart failure have a high incidence of kinesiophobia and many influencing factors, but the current research is not comprehensive. In the future, more clinical interventions can be further carried out based on the results of existing research to reduce the incidence of kinesiophobia in patients with chronic heart failure and promote the realization of cardiac rehabilitation based on exercise rehabilitation.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

QX: Writing – original draft, Writing – review & editing. X-YX: Conceptualization, Funding acquisition, Supervision, Writing – review & editing. M-JZ: Data curation, Formal analysis, Writing – review & editing. SL: Data curation, Formal analysis, Resources, Writing – original draft. HC: Methodology, Supervision, Writing – review & editing. M-DL: Data curation, Formal analysis, Writing – review & editing. YW: Methodology, Resources, Software, Writing – review & editing. YY: Resources, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1395199/full#supplementary-material>

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When end of treatment situations challenge patient-centered care: a discussion paper proposing new theoretical insights

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Introduction: According to the Institute of Medicine patient-centered medicine is one of the six crucial dimensions of health care quality. Although the patient-centered care model is widely recognized for its ethical underpinnings and effectiveness, its practical implementation still raises challenges, especially in end-of-treatment situations. This discussion paper offers an overview of the challenges facing the physician-patient relationship in end-of-treatment situations.

Methods: We developed three clinical vignettes and made some theoretical considerations about ethical issues related to the decision-making process leading to the end of treatment.

Results: We identified two main challenges that end-of-treatment situations pose to patient-centered care: (1) when the patient's autonomy challenges the best clinical treatment; and (2) when the proposed treatment (discontinuation of treatment) challenges the patient's preferences.

Discussions: Patient-centered care supports personalized decision-making, in which the physician's approach varies according to the patient's situation and individuality. The idea of beneficence may change during care, because of acceptance of the patient's principles or a change in the primary goal of care.

KEYWORDS

patient-centered medicine, end-of-treatment, decision-making process, shared decision-making, physician-patient relationship

1 Introduction

The Institute of Medicine defines patient-centered medicine as one of the six crucial dimensions of quality healthcare (Hashim, 2017). In contrast to the traditional disease-centered model, patient-centered medicine is a model of care that integrates the biological dimension with the patient's illness experience and aims to provide care that is tailored to the patient's individuality including the patient's values and needs (Moja and Vegni, 2000). Patient-centered care encompasses several components, such as considering the patient's illness experience, handling the emotions related to the illness, and promoting the patients' active role in the decision-making process (Lamiani et al., 2008; Bertakis and Azari, 2011). Over the last decade, the patient-centered model has become the gold standard for quality care as application of the clinical method has shown several benefits for patients and their care

process, including better health outcomes, greater adherence to treatment, improved patient satisfaction, and better psychosocial adjustment (Bertakis and Azari, 2011; Ekman et al., 2012).

At the ethical level, a core feature of patient-centered care is the importance given to patient autonomy. Autonomy is identified as one of the six values of medical ethics, along with the principles of beneficence, non-maleficence, confidentiality, truth-telling, and distributive justice (Beauchamp and Childress, 2001; Thompson, 1979; Zolkefli, 2018). The value of autonomy encompasses the freedom of an individual to behave in accordance with a plan of their own choosing, act in line with their own desires and ideals, and not being subject to external control (Varelius, 2006). In the health care context, autonomy presupposes that patients should be involved in decision-making regarding their health and express their values and preferences about treatment options. The emphasis on the value of patient's autonomy is in contrast with paternalism (Emanuel and Emanuel, 1992). Paternalism is a medical approach that assumes that physicians should be the primary decision maker because they have the knowledge to make the best decision regarding the patient's health (Beauchamp and Childress, 2001; Chin, 2002). The paternalistic approach entitles physicians to limit the patient's role in the decision-making process and independently make decisions based on what they discern to be in the patient's best interests, even when patients can make decisions for themselves (Murgic et al., 2015). Over the last twenty years, patient-centered medicine has made many critiques of paternalism and promoted a more active role of patients in their care process, emphasizing the value of autonomy (Komrad, 1983). Respect for patient autonomy is currently the dominant ethos in healthcare (Chin, 2002) and is the basic premise of Shared Decision-Making (SDM). SDM is a process in which physicians and patients work together to reach a decision regarding care. Throughout the SDM process, clinicians and patients work together to clarify treatment, sharing information about the risks, benefits, possible consequences of different options and preferred outcomes with the aim of reaching mutual agreement on the best course of action (Coulter and Collins, 2011). Patient-centered care recognizes the value of autonomy and demonstrates the centrality of shared decision-making, during all the phases of the care process, also at the end-of-treatment.

Although the patient-centered care is widely recognized for its ethical foundations and efficacy (Murgic et al., 2015), its practical implementation still raises challenges and can potentially lead to ethical conflicts (Hansson and Fröding, 2021). Ethical conflicts occur when one ethical obligation appears to conflict with another (Davis, 1990). As far we know, several previous studies shed lights on the potential ethical conflicts resulting from the application of patient-centered care (Davis, 1990; Munthe et al., 2012; Hansson, 2018) but more attention is needed for end-of-treatment situations. The end-of-treatment does not necessarily coincide with the end of life but refers to situations in which it is necessary to stop treatment due to medical conditions or patients' needs and choices. End-of-treatment situations force patient-centered care to consider important ethical conflicts and challenges, that needed to be theoretically and practically addressed.

In this paper, we provide a reflective discussion on the challenges that the physician-patient relationship within a framework of patient-centered care undergoes in end-of-treatment situations. Specifically, we propose to discuss the implications on clinical decision-making process and the physicians' role. We identified two main challenges that end-of-treatment situations pose to patient-centered medicine:

(1) when patient's autonomy challenges best clinical treatment; and (2) when proposed (discontinuation of) treatment challenges patient's preferences. We will discuss these challenges adopting a bottom-up approach. First, three clinical scenarios developed from the authors' clinical experience as clinical psychologists will be presented. Then, we will make some theoretical considerations about ethical issues embedded in the decision-making process leading to the end-of-treatment will be specifically discussed.

2 Self-determination in end-of-treatment situations: when patient's autonomy challenges best clinical treatment

Vignette 1 presents an exemplary situation in which the patient's clinical decision is in contrast with the treatment option proposed by the medical team. It is informed refusal, as the patient refused the treatment despite it being suggested by physicians as "best for his health." In this scenario, patient autonomy is demonstrated by his decision to behave in accordance with his own choices and values even when it means declining medically indicated treatment. The patient's preferences were expressed in the Advanced Treatment Directives document and confirmed during hospitalization, resulting in the patient's choice to refuse essential treatments. The patient's choice forced physicians to withhold treatment and consequently witness the patient's death.

When patient autonomy is not aligned with proposed clinical care, a discrepancy occurs between the choice and the physicians' chosen options (e.g., tracheostomy, antibiotic, re-evaluation with rehabilitation purpose). The intervention proposed by the physicians would require treatments, such as tracheostomy, contrary to the patient's preferences and values. The patient's final choice led to the avoidance of treatment: in the doctor-patient relationship the decisional balance hangs toward the patient. Legislation and the ethical value of autonomy required physicians to accept a patient's choice, even in a life-threatening condition that would be reasonably treatable.

Vignette 1 : O.

O. is about 80 years old. He has been admitted to the Intensive Care Unit (ICU); the elective treatment for the patient is endovascular aneurysm repair (EVAR) with endoprosthesis. During the first postoperative day, the patient suffered from axillary bleeding and was treated with surgical hemostasis, but surgery resulted in spinal cord ischemia with paraplegia. The clinical situation has become complicated as the patient has presented with pneumonia. Consulting the patient's medical record, the document related to the patient's advanced treatment directives was found and discussed. The document had been compiled 3 years earlier in the municipality of residence. In consideration of this document, sedation had to be reduced to inform the patient of the onset of disability and the possibility of undergoing tracheostomy. Sedation was reduced until the patient was conscious and communication was possible. He was informed of the outcomes of the hemorrhage and the need for tracheostomy for a pulmonary infection. The patient was able to discern and declared that he wanted to be extubated, refusing a tracheostomy, even though aware that this choice would result in worsening of his condition and death. In a second interview the patient reiterated his preference and consented to sedation only, refusing any other treatment. After a discussion among the intensive care team, surgeons and the medical examiner, the patient was extubated. O. died after a few hours.

Such situations constituted an ethical conflict from the physicians' perspective. The ethical value of beneficence comes up against autonomy and self-determination, which are predominant. Hence, there is tension between the responsibility to act in the patient's best interest and the obligation to respect the patient's autonomy. In other words, in situations like this, respecting patient autonomy requires the physician to renounce the first and most important principle of the Hippocratic Oath, namely, the obligation to act to obtain the patient's good. Respect for the value of autonomy, in this scenario, implies renouncing pursuit of the value of beneficence and entails a moral conflict for physicians. As a result, physicians have changed their role from that of providing care and treatment to that of accompanying patients in a decision leading to the end of life. Although not being able to provide appropriate care may lead physicians to disengagement (Seeman and Seeman, 1983), they should continue patient care, by accompanying the patient through the sequelae determined by his/her choice. The physician's role does not end with the decision but continues by supporting the patient in managing the predictable outcomes of the choice (Rodriguez-Osorio and Dominguez-Cherit, 2008).

Lastly, end-of-treatment situations such as the one described push physicians toward an informative, active, and respectful dialogue with the patient. Physicians must verify that the choice is informed and legitimize patients' decisions, even if they differ from their own or from those that would guarantee clinical benefits.

3 Palliative paternalism in end-of-treatment situations: when proposed (discontinuation of) treatment challenges patient's preferences

Vignette 2 presents the vignette of Ms. A and Mr. G who underwent an Assisted Reproductive Technology (ART) pathway due to infertility. In the ART setting, there is no clear and univocal medical criteria determining the end-of-treatment, but the end-of-treatment occurs or should occur "when the chance of success is so low that it is in the couple's best interest to discontinue the treatment" (Boivin et al.,

2005). The lack of criteria for treatment interruption makes the decision to discontinue ART particularly complex for the physician-patient relationship.

This scenario is exemplary of many complex situations in which there is still the possibility of continuing treatment, but the probability of success is so low that the persistence of treatment only results in an unnecessary physical and psychological burden. In this scenario, patient autonomy is expressed in the choice to continue treatment despite the doctor's perspective and recommendation.

These situations can easily lead to overtreatment during clinical care. For "overtreatment" we intend starting or continuing medical procedures that have no other aim but to prolong the patient's hope (Lepine and Pazos, 2007; Leone et al., 2022). In a condition in which a patient and a physician persist in treatments even though the possibility of a positive impact is significantly doubtful, the decision-making process is particularly complex. Who will finally take the responsibility for ending treatment and how will the process unfold?

Over the past decades, several authors have argued that end-of-treatment situations at risk of excessive persistence may benefit from a new paternalistic style called palliative paternalism (Roeland et al., 2014). Paternalism is a model of traditional medicine. This model allows physicians to intervene and overrule patient's preferences to respect one of the oldest and most essential principles of the medical profession: the value of beneficence (Beauchamp and Childress, 2001; Chin, 2002). Paternalism has been rejected with the rise of patient-centered medicine and the emphasis on personal autonomy. However, Roeland et al. (2014) introduced the concept of "palliative paternalism". Palliative paternalism indicates a medical approach that aims to balance the appropriate level of patient autonomy with the physician's professional judgment to avoid non-beneficial treatments (Roeland et al., 2014). Palliative paternalism differs from traditional paternalism since the physician uses informed options to guide patients in making choice, reduces disinformation, and prevents futile treatment. Furthermore, palliative paternalism includes understanding the likelihood of the patient not making a decision and carrying on the responsibility to recommend the end of unsuccessful treatment (Roeland et al., 2014; deBlois, 1994). Palliative paternalism can be considered essential, particularly in end-of-treatment conditions, as it helps prevent overtreatment situations, when patients persist with futile treatments that offer no benefits. However, several studies have shed lights on its drawbacks, including the risk of undermining patient autonomy by prioritizing the physician's perspective, the risk to impose physicians' values over the patients' preferences, and the risk of conflict between patients/families and physician in case of disagreement on the best course of action (Bailoor et al., 2018).

To date, the concept of palliative paternalism can be revised in accordance with the SDM process. Under end-of-treatment conditions, a partnership is necessary that requires both parties to negotiate a solution that is acceptable to both parties. Physicians should demand a favorable risk-benefit ratio for patients from the intervention. In circumstances such as Ms. A and Mr. G's vignette, there is leeway to continue treatment, but the cost to the patient would be significant. Continuing treatment may meet the patient's preference and autonomy, but it may also involve abandoning the physician's professional obligations related to beneficence and non-maleficence values, with the risk of administering therapies to the patient that are no longer appropriate (Boivin et al., 2005). In the scenario 2, the physician exercises palliative paternalism with negative outcomes.

Vignette 2 : Ms. A. and Mr. G

A. A 42-year-old woman, suffering from endometriosis since the age of 24. She has a degree in veterinary medicine and works at a clinical center. G, 44, an agronomist, manages a facility that produces organic wines. They are an infertile couple who came to the ART center after a series of 6 IVF attempts at first at a public facility, and later at a private, contracted center. The last attempt was done with heterologous (egg donation), but the embryo did not implant. The probability of a new cycle of egg donation being successful is less than 1%. The couple reports that the last 3 years (after a first year and a half before the infertility diagnosis) have been a real strain, and G. is particularly concerned for A. as the last failure took a lot out of her physically and psychologically. They think, however, that "since they are a good couple, one should not give up". Therefore, they requested a new consultation at another center. The consultation with the doctor focused on the choice of assisted reproductive technology (ART) in old age and the difficulties associated with it. G. asked the doctor to be frank and help them with the choice that independently they are unable to make. The doctor then explained the age-related problem, risks, and costs. He emphasized that he does not want to decide for them but does not give willingness to continue with new treatment due to the many difficulties. Given this perspective, the couple decides to go to another ART center to pursue treatment.

Although the physician respects the value of beneficence by not continuing the patients' desired treatment and opposing their preferences, the couple decides to persist elsewhere, demonstrating a lack of understanding of the physician's perspective. Patients may choose to persist with treatment, for example seeking availability from other doctors and starting the "doctor shopping" phenomenon (Kasteler et al., 1976). However, physicians must accompany patients by explaining his/her clinical perspective and verifying that the choice is informed and legitimizing patients' decisions, even if they differ from those that would guarantee clinical benefits.

Another ethical dilemma with a conflict between patient autonomy and beneficence is shown in [Vignette 3](#). In this scenario, the physician exercises palliative paternalism with respect to the value of beneficence. Despite the patient's contrariety stated in the documents, the physician performed the intervention, which was successful. The choice leads to the renunciation of the value of autonomy in the name of values of beneficence and non-maleficence. In such situations, it is important to consider whether the patient is able to choose, and appreciate the consequences of their choices, or whether the emotional suffering is excessive and significantly impedes the patient's capacity to make particular medical decisions. The palliative paternalism led to a positive outcome in that it prevented the patient's death.

Under these circumstances, it is important to maintain a balanced approach that respects patient autonomy while allowing for professional guidance in complex end-of-treatment situations. The physician should guide the patient toward a decision that respects medical responsibilities and patient's values. This balance can enhance patient care and ensure ethical integrity.

4 Discussions

Our aim was to discuss the main practical and theoretical challenges that the physician-patient relationship undergoes in the context of end-of-treatment situations. We discussed the implications of end-of-treatment situations on clinical decision-making process and physicians' role.

Patient-centered care advocates a personalization of the decision-making process, in which the physician's approach varies according to the patient's situation and individuality. However, some end-of-treatment situations, such as those presented, may lead to ethical

conflicts, which become part of the decision-making process. In end-of-treatment situations in which the patient's autonomy challenges proposed treatment, physicians should respect the patient's autonomy and accept the patient's choice to refuse treatment, even if this is deemed best for the patient's health and in contrast with the value of beneficence. Conversely, in end-of-treatment situations where proposed (discontinuation of) treatment challenges the patient's needs and preferences, a form of revised palliative paternalism may help to address the patient's needs and support the decision as the treatment would cause more harm than benefits. The scenarios presented exemplify situations where ethical conflicts make it difficult to apply defined guidelines for best practice. Ethical conflicts must be managed with great attention to prevent them from influencing the decision-making process and leading to outcomes perceived as negative by healthcare professionals and/or patients. [Jonsen et al. \(2010\)](#) introduced the Four-Box Method to improve clinical ethics case analysis. The Four-Box Method is a structured framework for resolving ethical conflicts in end-of-treatment situations. It considers medical indications, patient preferences, quality of life, and contextual features. According to the authors, healthcare providers should systematically evaluate each of these aspects to better manage ethical dilemmas. Thus, physicians should identify the ethical issue. Then, they should gather all relevant information and discuss the benefit that the treatment/the intervention will provide toward the goal. They should identify the likelihood of success, the possible alternatives, and the potential harms of providing or not the treatment. This analysis should be done within the healthcare team and ethical committees so that there is a multidisciplinary and ethical perspective. Then, it is essential to discuss with patients and their family to consider how the clinical alternatives impact the patient's daily life and think about the quality of life with and without treatment. The preferences of patients and their life context can be identified through the exploration of the patient's agenda ([Moja and Vegni, 2000](#)). This exploration may also include the family system, especially in cases where there is direct involvement. Once the clinical situation is fully understood and the viable alternatives have been identified, it is helpful for healthcare professionals to discuss with the patient to ensure accountability and transparency. There are clinical situations in which the intervention of a third actor is needed; offering third-party insight can increase the objectivity of the assessment. At every stage, effective communication is essential, and conflict resolution strategies such as mediation and consensus-building techniques may facilitate the process.

By systematically evaluating each of these aspects, physicians can better manage ethical dilemmas.

The physician's professional actions are always guided by ethical values; however, ethical values may change over time and with cultural progress. One of the most radical consequences of patient-centered care is the transformation of the idea of beneficence. In a disease-centered model, beneficence coincides with the care and treatment that best eradicate the disease and allow a prompt recovery. In contrast, in patient-centered care, beneficence is based on the bio-psycho-social concept of health, and considers medical and psychosocial circumstances, requiring a focus on the disease experience and the patient's values. The principle of beneficence may therefore need to be revised in the patient care process and does not always coincide with biological health and treatment.

The decision-making process is often defined as a cognitive process, but several clinical circumstances make it clear that it also

Vignette 3 : Mr. LP

A 44-year-old man suffering from chronic intestinal pseudo-obstruction (CIPO) for 13 years comes to the hospital in extreme prostration due to an acute episode requiring surgery. The patient is only partially able to interact due to severe distress and ongoing morphine treatment (chronically prescribed). The wife has always participated little in her husband's albeit intense care due to her emotional fragility. She does not object to an emergency intervention that might resolve the situation. On the other hand, there is evidence in the patient's documents of several conversations with the attending physician in which the patient claimed an unwillingness to further intensification of treatment, believing her life to be already very compromised. The physician explains to the patient that the intervention is very limited, emphasizing that there would be no substantial modification of the already extensive medical treatments thereafter (23 prescriptions per day, in addition to periodic bowel washings and intermittent fasting), and brings the patient into the room.

The surgery takes place successfully.

involves ethical and emotional dimensions. The decision-making process is influenced by values and emotions, especially those of patients (Leone et al., 2022). Often patients are not aware of their values and preferences until they enter a disease condition and are faced with difficult decisions. When preferences and principles are not specified in advance, patients may not be able to adopt a position of self-determination. In addition, emotional distress such as fear, angst, anger may significantly hinder patients' ability to make informed decisions (Roeland et al., 2014). At the same time, the physicians' psycho-emotional burden is noteworthy. Accepting a decision leading to the patient's death is emotionally demanding and may lead to moral distress.

A transversal concept in clinical practice is the need for ongoing training for physicians. Adequate communication should characterize all stages of the relationship; however, it is crucial for ethical decision-making. It would therefore be appropriate to implement training courses, workshops, and seminars focused on the relational and ethical dimension of care to improve the healthcare professionals' communication skills with the patient and within the team (Borghi et al., 2021).

Furthermore, due to the current paucity of end-of-treatment data, future studies should devote more attention to this complex phase and provide a better definition of end-of-treatment, especially in those contexts, such as medically assisted reproduction, where there is still a lack of agreement in this regard.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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The impact of stress on sleep quality: a mediation analysis based on longitudinal data

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Objective: This study evaluates the potential mechanisms through which stress affects sleep quality and examines the mediating roles of rumination, social anxiety, emotion-focused coping strategies, and smartphone dependence in the relationship between stress and sleep quality.

Methods: From October 2023 to April 2024, we conducted three surveys with 426 university students and utilized structural equation modeling to explore the mechanisms by which stress impacts sleep quality.

Results: Stress not only significantly predicts sleep quality but also significantly affects sleep quality through rumination, emotion-focused coping strategies, and smartphone dependence as independent mediators. Additionally, stress influences sleep quality through both dual-mediation and triple-mediation paths.

Conclusion: Stress has a significant direct and indirect impact on sleep quality. This study reveals the complex mechanisms through which stress affects sleep quality. Improving individuals' sleep quality requires not only considering the influence of real-life stressors but also examining the intersecting effects between stress and factors such as ruminative thinking, social anxiety, smartphone dependency, and emotion-focused coping strategies. The intense social competition in Chinese society exacerbates the decline in sleep quality, highlighting the need for the government to implement more policies aimed at maintaining the physical and mental health of the population to alleviate the increasingly severe sleep issues and mental health crisis.

KEYWORDS

stress, sleep quality, rumination, social anxiety, Mobile phone addiction, emotion-focused coping strategies

1 Introduction

Sleep quality refers to an individual's self-satisfaction with various aspects of their sleep experience. The assessment of sleep quality mainly includes four indicators: sleep efficiency, sleep latency, sleep duration, and early awakening (Wang X. Y. et al., 2023). Factors affecting sleep quality include physiological factors (such as age, circadian rhythms, body mass index, and rapid eye movement sleep), psychological factors (such as stress, anxiety, and depression), and environmental factors (such as room temperature, use of televisions/electronic devices), as well as family/social commitments. Individuals with poor sleep quality are more likely to experience

fatigue, irritability, daytime functional impairment, slower reactions, and increased caffeine/alcohol consumption (Nelson et al., 2022).

In 2023, the Institute of Sociology of the Chinese Academy of Social Sciences released the report “China Sleep Research Report 2023.” The sleep quality indicator used in this survey was the sleep index, with a score of 60 as the baseline for acceptable sleep quality; higher scores represent better sleep quality. Data showed that the overall sleep index for residents in China was 67.77, slightly above the acceptable threshold of 60. Longitudinal data in the report indicated a general decline in sleep duration and quality with age. Gender comparisons showed little difference in average sleep duration between males and females, though males had slightly higher sleep index scores than females. Higher-educated individuals (with postgraduate education or above) tended to have shorter sleep durations and significantly lower sleep scores compared to those with lower education levels (He et al., 2023). In 2024, the Institute of Sociology of the Chinese Academy of Social Sciences released the results of the 2023 National Resident Sleep Quality Survey, showing that the overall sleep index for residents in China was 62.61, a decrease of 5.16 points from the previous year. This indicates a remarkably rapid decline in the sleep index score in just 1 year (Wang et al., 2024). In fact, in China, short sleep duration and poor sleep quality have become prevalent and increasingly concerning health issues, possibly related to the high stress resulting from rapid economic and social development (Yuan and Xing, 2016).

A large-scale survey of Chinese adults found that over 40% of respondents reported getting less than 7 h of sleep per night, and nearly 60% indicated that they frequently or occasionally experienced poor sleep quality issues, such as difficulty falling asleep, waking up during the night, or waking up early (Li et al., 2018). Additionally, the study discovered that individuals with poor sleep quality often face a range of health problems, including anxiety, depression, decreased cognitive function, and an increased risk of cardiovascular diseases (Xu et al., 2016). These issues not only impact individuals’ physical and mental health but can also negatively affect work efficiency, social functioning, and overall quality of life. Why is sleep quality so poor among Chinese people? Jones and Brighton (2018) suggest that high levels of work-related stress are a significant factor contributing to reduced sleep duration and poor sleep quality.

Stress is a psychological and physiological response that individuals experience when dealing with challenges, demands, or uncertainties from their internal or external environments. This response can include emotional symptoms such as anxiety and tension, as well as physiological changes like increased heart rate and muscle tension (Song et al., 2022). The factors influencing stress are multifaceted, including individual characteristics, environmental factors, and coping strategies. Regarding individual characteristics, factors such as personality traits, coping abilities, and social support can affect how one perceives and manages stress. Environmental factors, such as stressors related to work, education, and family, can also impact individuals (Segerstrom and Smith, 2019; Slavich, 2020). Long-term exposure to stress can lead to psychological health issues such as

anxiety and depression, characterized by emotional instability, negative self-evaluation, and difficulties in coping (Choi S. W. et al., 2019). This, in turn, can trigger physiological stress responses, including the release of hormones like adrenaline and cortisol, potentially affecting physiological functions such as the cardiovascular, immune, and digestive systems. This may increase the risk of cardiovascular diseases, diabetes, and other chronic conditions (Alonso et al., 2021). Individuals who face prolonged stress might engage in unhealthy behaviors such as increased consumption of high-calorie foods, excessive alcohol intake, and smoking. These behaviors may be related to stress-induced emotional dysregulation, psychological health issues, and changes in coping strategies (Choi K. W. et al., 2019). Stress can also impact sleep quality, leading to insomnia or insufficient sleep, which in turn affects physical health and cognitive function (Altena et al., 2020). Additionally, stress can impair cognitive functions such as attention, memory, and decision-making abilities, potentially reducing work and study efficiency (Shields et al., 2016).

The Stress-Sleep Relationship Theory Model posits that stressors can impact sleep quality, with variations depending on the duration and intensity of the stress. Additionally, acute versus chronic and positive versus negative stress can exhibit different characteristics and outcomes. Decreased sleep quality can also become a stressor, creating a feedback loop where sleep quality affects and is affected by stress. Beyond direct impacts, the role of mediating factors such as stress coping and stress responses is also crucial (Yan et al., 2010). Stress can lead to increased release of physiological hormones like adrenaline and cortisol, affecting sleep regulation centers and cognitive functions, which in turn results in reduced sleep quality (Altena et al., 2020). The research tool used in this study to measure sleep quality is the Epworth Sleepiness Scale. A higher score on this scale indicates poorer nighttime sleep quality and greater daytime sleepiness. Therefore, this study proposes the following hypothesis:

Hypothesis 1: Stress can significantly predict sleep quality.

Some researchers argue that the mechanisms through which stress impacts sleep quality are complex and require a comprehensive assessment of factors that may affect sleep. Generally, under long-term stress conditions, individuals may develop various psychological disorders, which further trigger negative emotional experiences (such as social anxiety) (Yan Y. et al., 2013), negative behavioral responses (such as emotion-focused coping strategies) (Zhang Y. et al., 2023), psychological internal conflicts (such as rumination) (Lin H. et al., 2023), and unhealthy addictive behaviors (like Mobile phone addiction) (Wan and Ding, 2024a). Stress can lead individuals to experience rumination, a cognitive pattern where individuals repeatedly recall, ponder, and struggle to break free from issues or dilemmas (Lin J. et al., 2023). This cognitive pattern exacerbates negative emotions (such as social anxiety), causing discomfort in social interactions (Yan H. et al., 2013), increasing emotional stress, and disrupting normal sleep patterns (Tampke E. C. et al., 2019). Additionally, stress often prompts individuals to adopt emotion-focused coping strategies, such as avoidance, denial, or self-blame (Zhang Y. F. et al., 2023). Using smartphones is one way to temporarily escape from real-life stress, as frequent smartphone use seeks psychological comfort (Wan and Ding, 2024b). However, these coping strategies typically fail to effectively resolve problems and may instead worsen the individual’s psychological burden, leading to a decline in

Abbreviations: VSA, Vulnerability-Stress-Adaptation; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders; CFA, Confirmatory factor analysis; CFI, Comparative Fit Index; TLI, Tucker-Lewis Index; RMSEA, Root Mean Square Error of Approximation; SRMR, Standardized Root Mean Square Residual; I-PACE, The Interaction of Person-Affect-Cognition-Execution.

sleep quality (Cedeno D. et al., 2023; Guan L. et al., 2020). Therefore, in this study, we use social anxiety, emotion-focused coping strategies, Mobile phone addiction, and rumination as mediating variables to explore the relationship between stress and sleep quality.

1.1 Mediating effects of rumination, social anxiety, emotion-focused coping strategies, and Mobile phone addiction

1.1.1 Mediating effect of rumination

Rumination is a cognitive process where individuals repeatedly revisit, ponder, and analyze problems or difficulties, finding it challenging to escape this cycle (Li et al., 2022). This type of thinking often manifests as repetitive reflection and deep contemplation of negative events or emotions, leading individuals to experience states of brooding, worry, or depression (Lin H. et al., 2023). The biopsychosocial model emphasizes that an individual's health and well-being are influenced by a combination of biological factors (including genetics, physiology, biochemistry, and any conditions or diseases affecting physical health), psychological factors (including cognitive processes, emotions, personality traits, coping mechanisms, and mental health conditions such as depression or anxiety, as well as beliefs, attitudes, and stress responses that might affect health outcomes), and social factors (including relationships, family dynamics, socioeconomic status, cultural background, community support, access to healthcare, and environmental influences). The complex interplay of these biological, psychological, and social factors often significantly impacts overall health (Ghaemi, 2018). This theory has been further validated in practice, showing significant relationships among stress, rumination, and sleep quality. Specifically, stress is significantly positively correlated with rumination, while stress and rumination are both significantly negatively correlated with sleep quality (Fang et al., 2023; Chen et al., 2022; Zhu et al., 2020). Stress from work and life events can alter physiological hormone levels, leading to psychological states such as anxiety and depression, which negatively impact individuals' physiological, psychological, and social well-being, disrupting normal sleep and reducing sleep quality (Wan and Ding, 2024a; Guan Y. Q. et al., 2020).

Currently, there is relatively limited research on the relationships between stress, sleep quality, and rumination in humans, but we can explore these relationships through related studies in animals. In the field of animal husbandry, researchers have found that stress may indirectly affect rumination behavior in ruminant animals by influencing physiological and behavioral processes, and that the emotions and sleep behaviors of ruminants are often affected by their rumination behavior (Rosenbaum et al., 2018). Therefore, we might infer that stress could affect sleep quality by influencing rumination behavior in ruminants. However, whether these findings in animals apply to humans still requires further validation. Based on this, we propose.

Hypothesis 2: Rumination significantly mediates the relationship between stress and sleep quality.

1.1.2 Mediating effect of social anxiety

Social anxiety is a common psychological disorder in clinical practice, characterized by excessive worry, fear, or discomfort in social

or public situations involving interactions with others or self-presentation (Liu et al., 2024). This anxiety may be related to fears of negative evaluation by others, concerns about one's actions or performance leading to disapproval or ridicule, which often results in individuals avoiding social situations or feeling extremely uncomfortable in them. Social anxiety is frequently accompanied by physical symptoms such as increased heart rate, trembling hands, and sweating, as well as psychological symptoms like feelings of inferiority and self-criticism, causing significant distress and suffering (Richards et al., 2015). The biopsychosocial model posits that social anxiety results from the complex interplay of biological, psychological, and social factors. Biological factors, such as genetic predispositions and neurochemical imbalances, may increase sensitivity to social situations. Psychological factors, including negative self-perceptions and lack of social skills, may heighten the risk of social anxiety. Social factors, such as environmental stress and social experiences, also influence an individual's level of social anxiety (Ghaemi, 2018). Research has found a positive correlation between stress and social anxiety, as well as a significant negative correlation between stress and sleep quality. Specifically, greater interpersonal stress is associated with more severe social anxiety and a notable decline in sleep quality (Chen et al., 2022; Siegel et al., 2018).

Other studies have also identified a significant relationship between social anxiety and sleep quality, suggesting that anxiety-induced cognitive disruptions may impair sleep onset (Yan X. et al., 2013; Tampke D. et al., 2019). Based on this, the present study proposes the following hypothesis:

Hypothesis 3: Social anxiety mediates the relationship between stress and sleep quality.

1.1.3 Mediating effect of emotion-focused coping strategies

Emotion-focused coping strategies refer to behaviors or psychological states where individuals use negative, avoidant, or helpless approaches that are not conducive to problem-solving or emotional regulation when faced with stress, challenges, or difficulties (Everett et al., 2004). These strategies include avoiding problems, denying difficulties, self-blame, and dwelling on negative emotions. Such approaches typically lead to the persistence or worsening of problems and a decline in the individual's mental health (Zhang Y. F. et al., 2023). The Vulnerability-Stress-Adaptation (VSA) Model posits that individuals under constant stress, especially those with poor adaptability, often resort to emotion-focused coping strategies. These are short-term maladaptive strategies such as avoidance, denial, and self-blame (Cedeno A. et al., 2023). A study investigating the stress and emotion-focused coping strategies among 120 tuberculosis patients found that their sources of stress included the disease itself, hospital environment, and societal factors. In terms of coping strategies, these patients primarily used avoidance and resignation, and there was a significant positive correlation between stress and emotion-focused coping strategies (Yang K. Z. et al., 2021).

The stress coping model suggests that individuals exhibit different emotional and behavioral responses when facing stress, which can lead to various types of mental disorders, such as sleep disorders (Morin et al., 2003). Zhang et al. (2018) conducted a study with university nursing students to explore the relationships between sleep quality, coping strategies, and depressive symptoms. The results revealed that individuals using active coping strategies, especially those engaging in active problem-solving and emotional regulation, might mitigate the impact of

declining sleep quality on depressive symptoms to some extent. In contrast, individuals employing emotion-focused coping strategies often experienced a significant decline in sleep quality (Zhang et al., 2018). Based on this, the present study proposes the following hypothesis:

Hypothesis 4: Emotion-focused coping strategies mediate the relationship between stress and sleep quality.

1.1.4 The mediating role of Mobile phone addiction

Mobile phone dependency refers to excessive reliance on smartphones or mobile phones, characterized by overuse, excessive attention, and emotional or behavioral dependence on the device (An and Jiang, 2020). This dependency can lead to ineffective control over phone use in daily life, affecting normal functioning in work, study, social interactions, and even having negative impacts on mental health (Panova and Carbonell, 2018). The Interaction of Person-Affect-Cognition-Execution (I-PACE) model suggests that individuals may engage in addictive behaviors (such as drug addiction, phone dependency, gaming, etc.) as a way to cope with stress from negative experiences. Behavioral addiction can lead to manifestations similar to substance addiction, including cravings, uncontrollable use, and functional impairment due to continued use, and in some cases, the behavior becomes automatic and habitual (Brand et al., 2019; Roberts et al., 2017; Schneider et al., 2017; Starcke et al., 2018).

According to the “Statistical Report on China’s Internet Development,” published by the China Internet Network Information Center, by June 2021, the number of mobile internet users in China had reached 1.16 billion, accounting for 82.0% of the total population. This indicates that the majority of Chinese people are accustomed to accessing the internet via their mobile phones. With the widespread adoption of smartphones, an increasing number of people have developed the habit of using their phones before bedtime. The blue light emitted by phones can affect the secretion of melatonin, disrupt natural sleep rhythms, and the psychological stimulation from phone use can also make it difficult to fall asleep (Wang, 2014). Empirical research supports these findings, showing a significant positive correlation between stress and phone use. When individuals face higher levels of stress, especially when feeling overwhelmed, they tend to unconsciously choose to escape from real-life stress, often through means such as alcohol addiction, phone addiction, or drug addiction (Zhang, 2015). Prolonged phone use is associated with a noticeable decline in sleep quality, with significant negative correlations between phone use and sleep quality, as well as between stress and sleep quality (Li et al., 2016a,b; Zhang B. et al., 2021; Zhang D. et al., 2021). Based on this, the study proposes the following hypothesis:

Hypothesis 5: Mobile phone dependency mediates the relationship between stress and sleep quality.

1.2 Relationships among rumination, social anxiety, emotion-focused coping strategies, and Mobile phone addiction

1.2.1 The relationship between rumination and social anxiety

Rumination and social anxiety are closely related. Cognitive models of social anxiety suggest that social anxiety arises from

individuals’ negative cognitive patterns and thought processes about social situations, such as excessive concern about others’ evaluations, underestimating their own abilities, and over-worrying about negative outcomes. Cognitive theories emphasize the importance of altering these negative cognitive patterns to reduce social anxiety. They view biases in interpreting ambiguous social cues as a key process in maintaining social anxiety. For example, a socially anxious person might interpret someone yawning during a conversation as a sign of boredom rather than fatigue, leading to increased state anxiety (Beard and Amir, 2010).

Rumination is a negative cognitive process where individuals repeatedly revisit and reflect on negative experiences, worries, and self-criticism from social situations, which exacerbates anxiety and fear. This thinking pattern is often closely associated with social anxiety and may be a significant feature of social anxiety disorder. Rumination is considered a crucial influencing factor for symptoms of depression and social anxiety (Kross et al., 2014). It can not only intensify depressive emotions but also impair an individual’s problem-solving abilities, making it difficult to effectively address challenges. This thinking pattern can trap individuals in a cycle of negative emotions, preventing them from finding solutions to their problems (Spinhoven et al., 2018). Research has found a positive correlation between rumination and social anxiety, meaning that greater rumination is associated with higher levels of anxiety in social situations. Reducing rumination can effectively alleviate symptoms of social anxiety disorder and improve quality of life (Nordahl et al., 2016).

1.2.2 The relationship between rumination, Mobile phone addiction, and emotion-focused coping strategies

Compensatory Internet Use Theory posits that if individuals feel discomfort in their real-life environment, they may use mobile phones to escape from real-life difficulties and meet unmet needs, potentially leading to excessive mobile phone dependence or internet addiction (Kardefelt-Winther, 2014). Zhang B. et al. (2021) conducted a survey among Chinese college students and found that female students scored significantly higher than males on mobile phone dependence overall, as well as on the sub-factors of inefficacy and escapism. Mobile phone dependence scores were significantly positively correlated with sleep quality, sleep onset latency, sleep disturbances, and daytime dysfunction scores, and also showed a significant positive correlation with rumination. Higher levels of mobile phone dependence make it easier for individuals to detach from their real-life environment, reducing actual behavioral engagement. Consequently, they are more likely to experience frustration in real life, which can increase psychological stress such as depression and anxiety. Repeated obsessive thinking and reflection on personal experiences during the night can lead to more active thinking and difficulty falling asleep (Zhang B. et al., 2021).

Rumination is a negative cognitive process characterized by repeatedly thinking about, recalling, and emphasizing negative experiences, emotions, and issues. Emotion-focused coping strategies, on the other hand, are a range of unhealthy, ineffective, or avoidant methods used to deal with stress, challenges, or negative emotions. It is easy to understand that individuals engaged in rumination may generate negative emotions (Kross et al., 2014), which can lead them to adopt more emotion-focused coping behaviors, such as avoiding difficulties, denying problems, or indulging in negative emotions. Conversely, emotion-focused coping strategies may also exacerbate

the frequency and intensity of rumination, creating a vicious cycle. This cycle traps individuals in a deeper emotional and psychological distress, gradually worsening their overall well-being.

1.2.3 The relationship between emotion-focused coping strategies, Mobile phone addiction, and social anxiety

Approach–avoidance theory suggests that although emotion-focused coping strategies may temporarily alleviate negative emotions, they do not improve an individual's ability to effectively solve problems or face challenges. Therefore, in the long term, emotion-focused coping strategies may actually exacerbate the severity of the issues (Corr and Krupi, 2017). Mobile phone dependence is a form of escape behavior resulting from stress, where individuals use their phones to avoid or distract themselves from difficult situations in real life (Lin, 2018). A study investigated the relationship between Mobile phone addiction and adolescent mental health, with a focus on the association between Mobile phone addiction and emotion-focused coping strategies. The results showed a significant positive correlation between Mobile phone addiction and emotion-focused coping strategies. Adolescents with higher levels of Mobile phone addiction were more likely to use emotion-focused coping strategies (such as avoidance and denial) to cope with challenges and stress. They might be more prone to escaping real-life problems by immersing themselves in phone use, thereby avoiding negative emotions and challenges, which creates a negative cycle (Choi K. W. et al., 2019). This association not only has the potential to negatively impact adolescents' mental health but may also lead to reduced engagement in important activities such as social interactions, learning, and work, increasing the likelihood that they will adopt emotion-focused coping strategies (Elhai et al., 2017; Hawi and Samaha, 2016).

Cognitive models of social anxiety suggest that individuals tend to use emotion-focused coping strategies to manage stress and discomfort in social situations. However, these coping methods often exacerbate anxiety and make it difficult for individuals to escape the anxious state. For instance, avoiding social situations might lead to a decline in social skills and confidence, which in turn increases social anxiety levels. Research has found a significant positive correlation between emotion-focused coping strategies and social anxiety (Liao et al., 2014; Beard and Amir, 2010). A study assessing 2,695 Chinese college students found that autistic traits and emotion-focused coping strategies were positively correlated with social anxiety, with emotion-focused coping strategies mediating the relationship between autistic traits and social anxiety (Yang T. Y. et al., 2021). Based on this, the following hypotheses are proposed:

Hypothesis 6: Rumination and social anxiety mediate the relationship between stress and sleep quality.

Hypothesis 7: Rumination and mobile phone dependence mediate the relationship between stress and sleep quality.

Hypothesis 8: Emotion-focused coping strategies and mobile phone dependence mediate the relationship between stress and sleep quality.

Hypothesis 9: Rumination – Emotion-focused coping strategies – Mobile phone dependence mediate the relationship between stress and sleep quality.

Hypothesis 10: Rumination – Emotion-focused coping strategies – Social anxiety mediate the relationship between stress and sleep quality.

Hypothesis 11: Rumination – Social anxiety – Mobile phone dependence mediate the relationship between stress and sleep quality.

2 Methods

2.1 Participants

We used a cluster sampling method to select three universities from a total of 20 higher education institutions in Anhui and Zhejiang provinces in China. The selected universities were Tourism College of Zhejiang, Bozhou University, and Zhejiang Police Vocational College. All enrolled students from these institutions who had no classes on the day of the survey participated in the study, with no exclusion criteria applied. We strictly adhered to the relevant provisions of the Helsinki Declaration, and after obtaining approval from the Ethics Committee of Tourism College of Zhejiang, we proceeded with the questionnaire survey. This study required three rounds of longitudinal data collection, with a three-month interval between each survey. The first survey was conducted on October 17, 2023, with 438 questionnaires distributed and collected; the second survey was conducted on January 19, 2024, with 426 questionnaires distributed and collected; and the third survey was conducted on April 22, 2024, with 440 questionnaires distributed and collected.

Due to the fact that a small number of students were absent during the three rounds of the questionnaire surveys, and since this study is longitudinal, we only retained data from participants who completed all three surveys. After excluding invalid responses, we ultimately obtained 426 valid questionnaires. Of these, 77 participants (18.1% of the total) were boys, and 349 participants (81.9% of the total) were girls. Additionally, 326 participants (76.5% of the total) were from rural areas, while 100 participants (23.5% of the total) were from urban areas. We extracted stress data as the independent variable from the first survey, rumination, social anxiety, mobile phone dependence, and emotion-focused coping strategies data as mediating variables from the second survey, and sleep quality data as the dependent variable from the third survey. Prior to the survey, we emphasized the purpose of the study and the voluntary nature of participation, and we obtained written informed consent from the students. No compensation was provided to participants. The questionnaire surveys were conducted in classrooms, with all participants independently completing the demographic variables and the questionnaires on stress, sleep quality, rumination, social anxiety, emotion-focused coping strategies, and mobile phone dependence. After completion, the questionnaires were collected and verified by the examiner.

2.2 Research instruments

2.2.1 College student stress scale

We used the stress scale for Chinese college students developed by Li and Mei (2002) to measure stress levels. This scale consists of 30 items covering three dimensions: academic stress (e.g., “Despite

efforts, my grades in some subjects are still poor”), personal stress (e.g., “Desiring true love but not receiving it”), and negative life events (e.g., “Failing more than two courses”). The scale employs a 4-point Likert scoring method, where participants choose from 0 (no stress) to 3 (severe stress). Higher scores indicate greater perceived stress at the current time (Li and Mei, 2002). The scale in this study demonstrated excellent internal reliability (Cronbach’s $\alpha=0.97$) and structural validity: Comparative Fit Index (CFI)=0.94, Tucker-Lewis Index (TLI)=0.92, Root Mean Square Error of Approximation (RMSEA)=0.07, and Standardized Root Mean Square Residual (SRMR)=0.04.

2.2.2 Epworth sleepiness scale

The Chinese version of the Epworth Sleepiness Scale, developed by Johns, was used. This version was tested among Chinese populations using the scale revised by Chinese scholars Mei et al., which demonstrated good reliability and validity. The scale is primarily used to assess an individual’s sleep quality (Mei et al., 2024). The scale contains only 8 items and employs a 4-point Likert scoring method, where participants are asked to choose from 0 (never) to 3 (high chance). Higher total scores indicate a stronger tendency for daytime sleepiness. The scoring interpretation is as follows: 0–9 points: Normal sleep quality; 10–15 points: Mild decrease in sleep quality, leading to low daytime sleepiness; 16–24 points: Moderate decrease in sleep quality, leading to moderate daytime sleepiness; 25 points and above: Extremely poor sleep quality, leading to severe daytime sleepiness (Scharf, 2022; Johns, 1991). The scale in this study demonstrated good internal reliability (Cronbach’s $\alpha=0.86$) and structural validity: Comparative Fit Index (CFI)=0.93, Tucker-Lewis Index (TLI)=0.90, Root Mean Square Error of Approximation (RMSEA)=0.08, and Standardized Root Mean Square Residual (SRMR)=0.05.

2.2.3 Mobile phone addiction scale

The initial mobile phone dependency scale was developed by Leung based on the diagnostic criteria for addiction outlined in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) to measure the extent of Mobile phone addiction. We used the Chinese version revised by Shi et al. (2016) to ensure the measurement tool is suitable for Chinese students. This scale includes 17 items covering four dimensions: Withdrawal (e.g., “You start to feel anxious about missing calls if you do not check your phone for an extended period”). Loss of Control (e.g., “Your friends and family complain that you always use your phone”). Inefficiency (e.g., “You delay other activities because you are busy using your phone, causing trouble”). Escape (e.g., “You have used your phone to relieve feelings of sadness when you felt down”). The scale uses a 5-point Likert scoring method, where participants are asked to choose from 1 (not at all) to 5 (always). Higher scores indicate higher levels of addiction (Wang, 2022; Leung, 2008). The scale in this study demonstrated good internal reliability (Cronbach’s $\alpha=0.95$) and structural validity: Comparative Fit Index (CFI)=0.93, Tucker-Lewis Index (TLI)=0.92, Root Mean Square Error of Approximation (RMSEA)=0.07, and Standardized Root Mean Square Residual (SRMR)=0.05.

2.2.4 Rumination scale

We used the Rumination Scale developed by Nolen-Hoeksema, which was revised for this study to ensure that the measurement tool

is suitable for the Chinese population. This scale measures the level of rumination and consists of three dimensions with a total of 12 items. These dimensions are: Symptom Rumination Dimension: Includes 3 items (e.g., “I often think about why I feel so unhappy”). Reflective Rumination Dimension: Includes 5 items (e.g., “I often think about what I did that led to this”). Compulsive Reflection Dimension: Includes 4 items (e.g., “I often think alone about why this happened”). The scale uses a 4-point Likert scoring method, where participants are asked to choose from 1 (never think about depressing things) to 4 (always think about depressing things) (Wang H. et al., 2023; Nolen-Hoeksema, 2000). The scale in this study demonstrated good internal reliability (Cronbach’s $\alpha=0.96$) and structural validity: Comparative Fit Index (CFI)=0.96, Tucker-Lewis Index (TLI)=0.95, Root Mean Square Error of Approximation (RMSEA)=0.07, and Standardized Root Mean Square Residual (SRMR)=0.03.

2.2.5 Social anxiety scale

We used the Chinese version of the Social Anxiety Scale initially developed by Fenigstein et al., with revisions completed by You to better suit the measurement of social anxiety levels in the Chinese population (You, 2024). This scale consists of a single factor with a total of 6 items. Item 4, “I find it easy to talk to strangers,” is a reverse-scored item, while the remaining 5 items are scored positively. The scale uses a 4-point Likert scoring method. For example, for item 2, “I find it difficult to work when someone is watching me,” participants are asked to choose from 0 (not at all like me) to 3 (very much like me). A higher score indicates a higher level of social anxiety (Kai and Jin, 2022; Fenigstein et al., 1975). In this study, the scale demonstrated good internal reliability (Cronbach’s $\alpha=0.84$) and structural validity: Comparative Fit Index (CFI)=0.94, Tucker-Lewis Index (TLI)=0.91, Root Mean Square Error of Approximation (RMSEA)=0.08, and Standardized Root Mean Square Residual (SRMR)=0.03.

2.2.6 Emotion-focused coping strategies questionnaire

The original questionnaire on coping strategies was developed by Folkman and Lazarus, and Fang et al. revised it for Chinese adolescents to create the Chinese version of the Coping Strategies Questionnaire (Fang et al., 2018). This scale consists of 20 items across two factors: Positive Coping Strategies and Emotion-Focused Coping Strategies. The Positive Coping dimension (e.g., “seeking advice from relatives, friends, or classmates”) includes 12 items, while the Emotion-Focused Coping Strategies dimension (e.g., “using smoking, drinking, medication, or eating to relieve distress”) includes 8 items. Participants are asked to choose from a scale ranging from 0 (not at all) to 3 (very often) (Ye, 2023; Folkman et al., 1988). In this study, we will use the Emotion-Focused Coping Strategies dimension as the measurement tool for emotion-focused coping strategies. The scale demonstrates good internal reliability (Cronbach’s $\alpha=0.85$) and structural validity: Comparative Fit Index (CFI)=0.90, Tucker-Lewis Index (TLI)=0.92, Root Mean Square Error of Approximation (RMSEA)=0.08, and Standardized Root Mean Square Residual (SRMR)=0.05.

2.3 Data analysis strategy

We utilized SPSS 25.0 software to calculate the mean, standard deviation, and Pearson correlation coefficients for stress, sleep quality,

rumination, social anxiety, Emotion-Focused Coping Strategies, and Mobile phone addiction. Confirmatory factor analysis (CFA) was performed using Mplus 7.0 software to assess the internal structural validity of the survey instruments used in this study. Maximum likelihood estimation was employed to address missing data in the questionnaires. Following the confirmation of adequate fit for the structural validity indicators of the stress, sleep quality, rumination, social anxiety, Emotion-Focused Coping Strategies, and Mobile phone addiction questionnaires, we constructed a structural equation model to evaluate its validity. Model fit indices were assessed based on the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The criteria proposed by Brown (2015) were applied to determine model fit adequacy, with a model considered to have a reasonable fit if RMSEA < 0.1, SRMR < 0.1, TLI > 0.9, and CFI > 0.9 (Ji et al., 2023).

The research was conducted in two phases. First, a direct relationship model was established with stress as the independent variable and sleep quality as the dependent variable. Second, an indirect relationship model was developed where stress serves as the independent variable, and sleep quality is the dependent variable, with rumination, social anxiety, Emotion-Focused Coping Strategies, and Mobile phone addiction acting as mediating variables, as illustrated in Figure 1. To assess the significance of the indirect effects, Bootstrap 95% confidence intervals for bias-corrected bootstrapped tests were employed. Indirect effects were deemed significant if the Bootstrap 95% confidence intervals did not include zero.

3 Results

3.1 Control and verification of common method bias

To address the issue of common method bias, we implemented various measures, including the use of anonymous questionnaires and reverse-scored items. Exploratory factor analysis was conducted using Harman's single-factor method. The results indicated that 11 factors with eigenvalues greater than 1 accounted for 70.45% of the total variance. Additionally, the variance explained by the first principal factor was 39.50%, which is below the 40% threshold (He et al., 2022), suggesting that substantial common method bias is not present.

3.2 Descriptive statistics and correlation analysis

We utilized the independent sample *t*-test method to investigate the variances in demographic variables related to household registration and gender concerning Stress, Sleep quality, rumination, social anxiety, Emotion-Focused Coping Strategies, and Mobile phone addiction. Statistically significant differences were identified between male and female participants in the scores of social anxiety and Mobile phone addiction ($p < 0.05$), whereas no significant distinctions were noted in Stress, Sleep quality, rumination, and Emotion-Focused Coping Strategies scores ($p > 0.05$). Significant differences were observed between participants from urban and rural households regarding Stress, social anxiety, and rumination scores ($p < 0.05$),

whereas no statistically significant variances were evident in Sleep quality and Emotion-Focused Coping Strategies scores ($p > 0.05$) (refer to Table 1). Additionally, significant positive correlations were identified among the six variables—Stress, Sleep quality, rumination, social anxiety, Emotion-Focused Coping Strategies, and Mobile phone addiction—suggesting interrelatedness among them. The means, standard deviations, and correlation coefficients for each variable are detailed in Table 2.

3.3 Direct effect analysis

We constructed a direct relationship model with Stress as the independent variable and Sleep quality as the dependent variable to investigate whether Stress can directly predict Sleep quality. Path analysis demonstrated that Stress significantly and positively predicted Sleep quality ($\beta = 0.53$, $p < 0.001$), thus confirming Hypothesis 1.

3.4 Mediation analysis

Due to the large number of items in the stress scale, rumination scale, and mobile phone dependency scale used in this study, we utilized the item packaging method for modeling (Wu and Wen, 2011). Based on the direct relationship model mentioned above, we inserted four mediators (i.e., rumination, social anxiety, emotion-focused coping strategies, and mobile phone dependency) between stress and sleep quality to establish an indirect relationship model (see Figure 2). The results show that the model fit indices are satisfactory: RMSEA = 0.05, SRMR = 0.04, TLI = 0.96, CFI = 0.97.

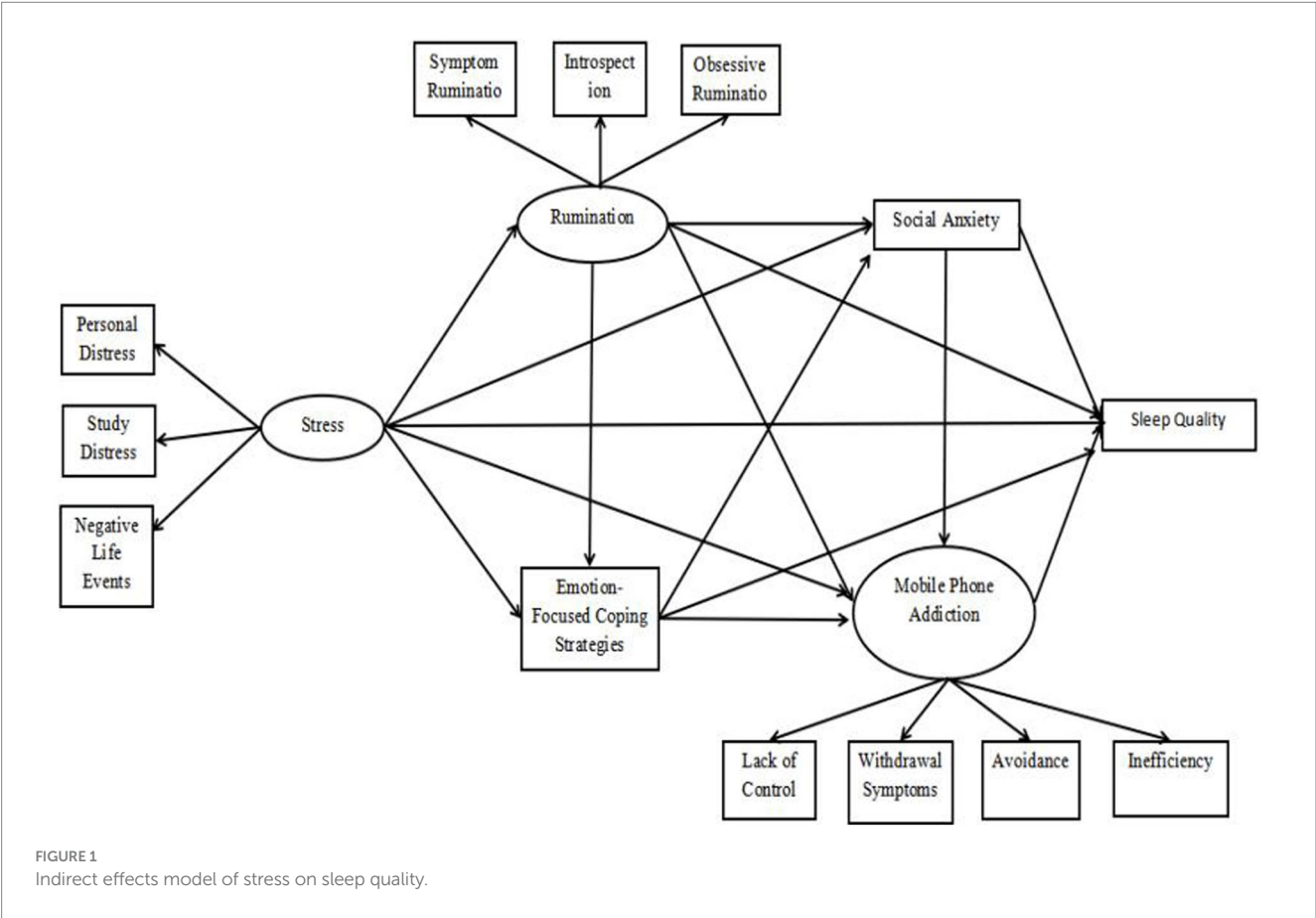
To evaluate the significance levels of the indirect relationships shown in Figure 2, we used Bootstrap resampling with 1,000 iterations to test the chain mediation effects and calculate 95% confidence intervals. The results indicated that among the 10 mediation paths we constructed in the indirect relationship model, 7 paths had Bootstrap 95% confidence intervals that did not include zero, suggesting that these 7 mediation effects were significant. Specifically, Hypotheses 2, 4, 5, 7, 8, and 9 were supported. In contrast, the remaining 3 mediation paths had Bootstrap 95% confidence intervals that included zero, indicating that these 3 mediation effects were not significant (see Table 3). Thus, Hypotheses 3, 6, and 10 were not supported.

4 Discussion

This study found that stress can significantly predict sleep quality. According to social cognitive theory, the interactions among individuals, their environment, and the interplay between individuals and their environment are crucial for behavioral outcomes. The uniqueness of each situation—considering the environment, participants, and their interactions—often leads to different learning, behavioral expressions, and outcomes (Beauchamp et al., 2019). Stress can lead to negative cognitive activities such as worry, anxiety, and rumination, which can interfere with the ability to fall asleep and maintain sleep, thereby affecting sleep quality (Kyle et al., 2015; Pa et al., 2015). In real life, the high-pressure lifestyle in China (including work stress, academic pressure, and social stress) and the competitive

TABLE 1 Differences in stress, sleep quality, rumination, social anxiety, emotion-focused coping strategies, and Mobile phone addiction among different genders and registered residences.

Dependent variable	Independent variable	<i>F</i>	Significance	<i>t</i>	Sig (two-tailed)
Sleep quality	Gender	4.99	0.02	−1.54	0.12
Social anxiety		0.19	0.66	−2.79	0.00
Emotion-focused coping strategies		8.50	0.00	−1.93	0.05
Rumination		9.91	0.00	−0.37	0.70
Stress		12.35	0.00	−0.86	0.38
Mobile phone addiction		6.69	0.01	−3.09	0.00
Sleep quality	Household registration	0.00	0.93	1.10	0.26
Social anxiety		3.58	0.05	2.26	0.02
Emotion-focused coping strategies		0.05	0.81	1.58	0.11
Rumination		1.22	0.26	1.97	0.04
Stress		1.34	0.24	3.09	0.00
Mobile phone addiction		1.55	0.21	1.57	0.11



social environment often result in symptoms of anxiety and depression. The prevalence of stress disorders, obsessive-compulsive disorder, social phobia, anxiety, and depression is increasing annually among the Chinese population, with generally low sleep quality and prevalent sleep issues such as difficulty falling asleep, shallow sleep, and nighttime awakenings. These issues significantly impact individuals' quality of life and health (Li et al., 2018), posing a major challenge to mental health (Wang et al., 2014; Huang et al., 2019). In this study, we also found that ruminative thinking, emotion-focused coping strategies, and smartphone dependency significantly impact

TABLE 2 Means, standard deviations, and correlation coefficients of variables.

	1	2	3	4	5	6	7	8
1. Gender	1							
2. Household registration	0.04	1						
3. Sleep quality	0.07	−0.05	1					
4. Social anxiety	0.13**	−0.10*	0.37**	1				
5. Emotion-focused coping strategies	0.09	−0.07	0.49**	0.50**	1			
6. Rumination	0.01	−0.09*	0.50**	0.52**	0.53**	1		
7. Stress	0.04	−0.14**	0.52**	0.50**	0.54**	0.69**	1	
8. Mobile phone addiction	0.14**	−0.07	0.46**	0.48**	0.54**	0.55**	0.56**	1
Quantity			426	426	426	426	426	426
Minimum value			12.00	0.00	17.00	6.00	0.00	0.00
Maximum value			48.00	90.00	85.00	24.00	24.00	24.0
Mean			21.90	23.67	44.91	13.84	8.37	7.63
Standard deviation			6.51	15.30	13.40	3.66	4.31	4.10

N = 426. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

sleep quality, while social anxiety does not have a direct significant effect on sleep quality. This result suggests that for individuals to achieve sustainable development, it is important to address the pressures and sleep quality issues they face. For example, individuals should learn techniques such as deep breathing, meditation, and progressive muscle relaxation to help them relax before sleep and reduce the negative impacts of stress on their physical and mental well-being.

We found that stress mediates sleep quality through two dual mediation paths. First, stress mediates sleep quality through the mediation path of “emotion-focused coping strategies – mobile phone dependency.” The approach–avoidance theory suggests that when individuals face stress, they may adopt negative coping strategies such as avoidance, denial, or immersing themselves in negative emotions (Corr and Krupi, 2017). Prolonged use of mobile phones, especially before bedtime, can lead to exposure to blue light, which suppresses melatonin production and interferes with falling asleep and sleep quality. Additionally, mobile phone use may also trigger excitement and arousal, making it difficult for individuals to relax and fall asleep. When sleep quality deteriorates, individuals’ coping abilities may weaken, making them more prone to falling into a cycle of emotion-focused coping strategies and mobile phone dependency (Levenson et al., 2016). Secondly, stress mediates sleep quality through the mediation path of “rumination – mobile phone dependency.” Response style theory suggests that when facing negative emotions or stress, individuals may become trapped in a cycle of rumination. Rumination involves the repetitive, deep thinking, and analysis of negative experiences, emotions, or problems. Individuals often attempt to understand, resolve, or escape stress and negative emotions through rumination. However, rumination typically exacerbates emotional discomfort and psychological distress, leading individuals into a cycle of negative emotions, which increases their perception of stress and psychological burden (Black and Plessel, 2015). Individuals may use mobile phones excessively as a means of escaping reality or regulating negative emotions. Mobile phone use provides a way to escape reality and regulate emotions, temporarily

relieving individuals from stress and negative emotions (Elhai et al., 2017). The longer the phone use, the greater the phone dependency, and the worse the sleep quality (Demirci et al., 2015). In today’s Chinese society, people spend a significant portion of their lives using electronic devices (such as smartphones and computers). Although this usage often arises from work-related needs, it can have a substantial negative impact on people’s lives and is detrimental to their overall development.

We found that stress mediates sleep quality through three intermediary paths. First, stress mediates sleep quality via “rumination–emotion-focused coping strategies–smartphone dependence.” When individuals experience high levels of stress, their ability to manage negative emotions may weaken, making them more prone to entering a state of rumination (Smith et al., 2008). This excessive focus on negative emotions leads to a greater tendency to use emotion regulation strategies when facing emotional distress. Such selective attention can hinder effective problem-solving, resulting in coping mechanisms that focus more on emotional management rather than problem resolution (Nolen-Hoeksema, 2000), potentially causing long-term emotional distress (Nolen-Hoeksema, 2001). Over-reliance on short-term emotional relief methods, such as smartphone dependence, social media, or engaging in other highly stimulating activities (like gaming or browsing news), can trigger psychological and physiological arousal, leading to a sustained state of excitement and difficulty relaxing before sleep (Rosen et al., 2013). Secondly, stress mediates sleep quality through the “rumination–social anxiety–smartphone dependence” pathway. In high-stress environments, an individual’s cognitive resources and emotional regulation abilities may be impaired, leading to increased frequency and intensity of rumination (Robinson and Alloy, 2003). Research indicates that this thought pattern causes individuals to constantly recall and amplify their negative experiences in past social situations, increasing anxiety about future social events (Moulds and Wong, 2009). Additionally, rumination may make individuals overly sensitive to their performance in social interactions, further exacerbating symptoms of social anxiety (Rood et al., 2011). Smartphones offer a relatively safe means of communication, allowing

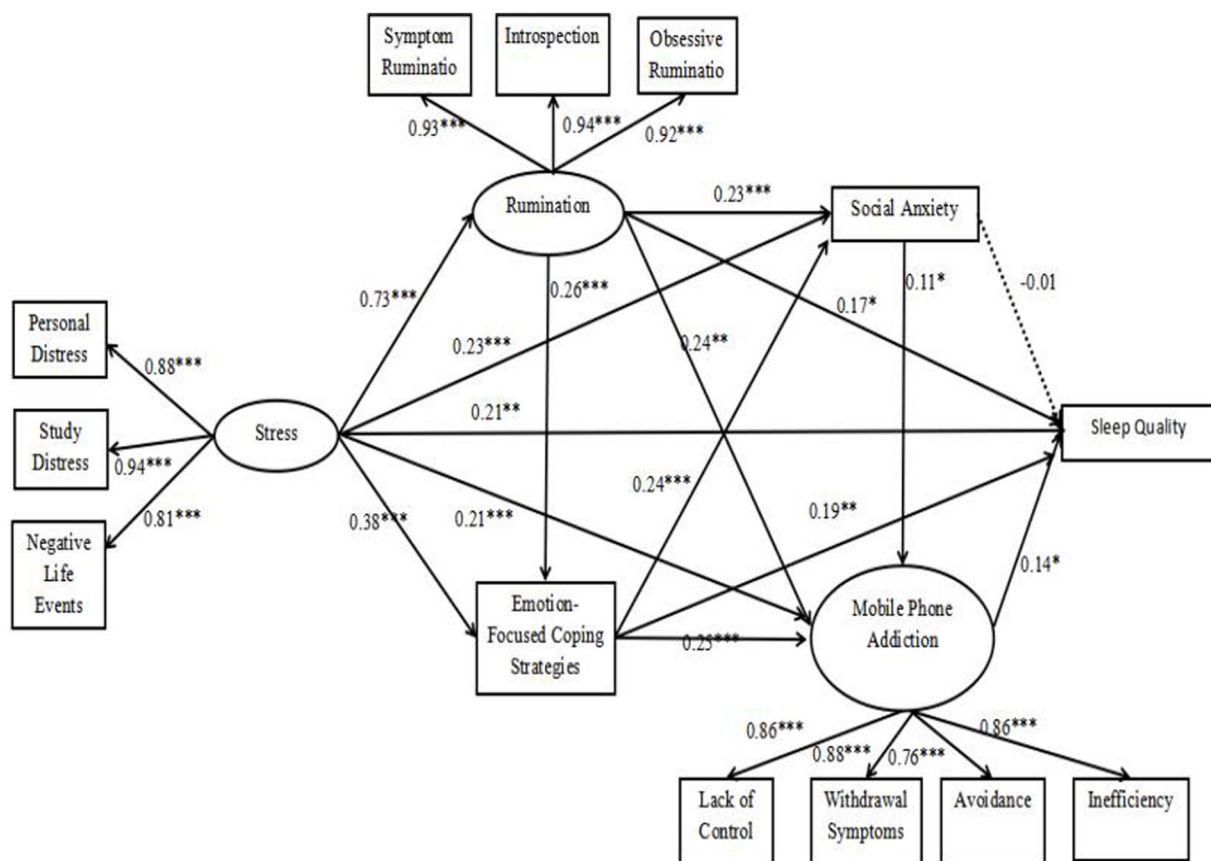


FIGURE 2
Mediation model of the effect of stress on sleep quality.

them to engage socially in a controlled environment and reducing opportunities to confront social anxiety directly (Elhai et al., 2017). This may lead to excessive time spent on smartphones, increasing smartphone dependence. Browsing social media and receiving notifications at night can also disrupt sleep, reducing the amount of deep sleep individuals get (Liu et al., 2017) and causing delays in falling asleep and nighttime awakenings (Demirci et al., 2015). Third, the level of social anxiety is positively correlated with the severity of rumination. Individuals with social anxiety tend to exhibit higher levels of rumination, often repeatedly recalling and analyzing negative experiences or concerns from social interactions (McEvoy and Brans, 2013). The more severe the rumination (Aldao et al., 2014), the more likely these individuals are to adopt negative coping strategies when faced with problems (Aldao et al., 2010), which makes them more susceptible to excessive smartphone use (Elhai et al., 2017). To my knowledge, there is currently limited research in academia on how stress mediates sleep quality through multiple intermediary paths. Based on the findings of this study, we need to recognize that the mechanisms by which stress affects sleep quality are complex. Stress may exert its influence through independent mediating variables, as well as through mediation paths involving two variables (such as “rumination and smartphone dependence” and “emotion-focused coping strategies and smartphone dependence”) or three variables (such as “rumination-emotion-focused coping strategies-smartphone

dependence,” “rumination-social anxiety-smartphone dependence,” and “rumination-emotion-focused coping strategies-social anxiety-smartphone dependence”). Given the numerous factors influencing sleep quality, individuals can effectively improve their sleep by maintaining a regular sleep schedule, increasing moderate physical activity, establishing relaxing pre-sleep habits (such as deep breathing and meditation), and managing stress and anxiety.

5 Limitations and implications

We must acknowledge some limitations in this study. Firstly, with only 426 participants, the sample size is relatively small, which may affect the generalizability of the results to other populations. Secondly, although the self-report scales used in this study demonstrated internal reliability and validity, there remains uncertainty about whether the data accurately reflects the participants' psychological states. Therefore, future research should incorporate multiple methods to ensure the quality of the research.

Despite these limitations, this study not only supports the approach-avoidance theory and social cognitive theory but also empirically validates these theories. Additionally, by collecting longitudinal data, the results of this study are more robust. Furthermore, this research provides a new framework for

TABLE 3 Bootstrap analysis for significance testing of mediation effects.

Mediation pathway	Effect size	95% Confidence interval	
		Lower bound	Upper bound
Stress-rumination-sleep quality	0.07	0.01	0.14
Stress-social anxiety-sleep quality	0.00	−0.02	0.01
Stress-emotion-focused coping strategies-sleep quality	0.04	0.01	0.08
Stress-mobile phone addiction-sleep quality	0.01	0.00	0.05
Stress-rumination-social anxiety-sleep quality	0.00	−0.01	0.01
Stress-rumination-mobile phone addiction-sleep quality	0.01	0.00	0.03
Stress-emotion-focused coping strategies-mobile phone addiction-sleep quality	0.00	0.00	0.01
Stress-rumination-emotion-focused coping strategies-mobile phone addiction-sleep quality	0.00	0.00	0.01
Stress-rumination-emotion-focused coping strategies-social anxiety-sleep quality	0.00	0.00	0.00
Stress-rumination-social anxiety-mobile phone addiction-sleep quality	0.00	0.00	0.00

understanding the relationship between stress and sleep quality, offers new insights for improving sleep quality in psychological health practices, and contributes new knowledge to the theoretical and empirical research on the relationship between stress and sleep quality.

6 Conclusion

Stress not only significantly impacts sleep quality directly but also has a substantial effect on sleep quality through dual and triple mediation paths formed by rumination, social anxiety, emotion-focused coping strategies, and smartphone dependence. Given the severe challenges faced by the sleep quality of individuals in China, it is essential for labor protection departments to promote the formulation and implementation of policies that support healthy sleep, such as providing appropriate rest breaks in the workplace. Additionally, stress management and relaxation techniques, such as deep breathing, meditation, or yoga, can be promoted to help alleviate stress and anxiety, thereby improving sleep quality.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: zhangjunahu@163.com. If you request, I can provide to you.

Ethics statement

The studies involving humans were reviewed and approved by the Ethics Committee of the Tourism College of Zhejiang (Reference Number: ZT3892628) to ensure the full protection of participants' rights. The studies were conducted in accordance with the local

legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JZ: Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. SX: Data curation, Formal analysis, Writing – original draft. XL: Conceptualization, Formal analysis, Investigation, Software, Writing – original draft. YT: Data curation, Formal analysis, Supervision, Validation, Writing – original draft. QH: Data curation, Methodology, Project administration, Supervision, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Nudge theories and strategies influencing adult health behaviors and outcomes in COPD management: a systematic review

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Objective: Chronic obstructive pulmonary disease (COPD) is a chronic respiratory disease with high prevalence and mortality, and self-management is a key component for better outcomes of COPD. Recently, nudging has shown promising potential in COPD management. In the present study, we conducted a systematic review to collate the list of nudges and identified the variables that influence nudging.

Methods: We undertook a systematic review. We employed database searches and snowballing. Data from selected studies were extracted. The risk of bias was assessed using the Cochrane Effective Practice and Organization of Care risk of bias tool. The study is registered with PROSPERO, CRD42023427051.

Results: We retrieved 4,022 studies from database searches and 38 studies were included. By snowballing, 5 additional studies were obtained. Nudges were classified into four types: social influence, gamification, reminder, and feedback. Medication adherence, inhalation technique, physical activity, smoking cessation, vaccination administration, exercise capacity, self-efficacy, pulmonary function, clinical symptoms, and quality of life were analyzed as targeted health behaviors and outcomes. We found medication adherence was significantly improved by reminders via mobile applications or text materials, as well as feedback based on devices. Additionally, reminders through text materials greatly enhance inhalation techniques and vaccination in patients.

Conclusion: This review demonstrates nudging can improve the health behaviors of patients with COPD and shows great potential for certain outcomes, particularly medication adherence, inhalation techniques, and vaccination. Additionally, the delivery modes, the patient characteristics, and the durations and seasons of interventions may influence the successful nudge-based intervention.

Clinical trial registration: This review has been registered in the international Prospective Registry of Systematic Evaluation (PROSPERO) database (identifier number CRD42023427051).

KEYWORDS

chronic obstructive pulmonary disease, health behavior, self-management, nudge, systematic review

1 Introduction

Chronic obstructive pulmonary disease (COPD) is a prevalent and severe chronic respiratory ailment that is characterized by persistent and typically progressive airflow obstruction, leading to an irreversible decline in pulmonary function (1). Globally, COPD has become a prominent public health concern, imposing a considerable burden of mortality and morbidity (2). According to the statistics from the World Health Organization, COPD is regarded as the third most prevalent cause of death internationally (3). Due to its chronic and progressive condition, COPD significantly impacts the lifestyle and quality of life of patients. To enhance health outcomes, quality of life, and long-term prognosis of patients, effective COPD care encompasses a range of behavioral interventions, pharmacological therapies, respiratory therapies, exercise rehabilitation, smoking cessation, and vaccination (1, 4, 5). In addition to professional guidance, the management of COPD necessitates patients' autonomous involvement by implementing effective and sustainable behavioral modifications to attain enduring disease control (6–8).

The new term “nudge,” originally derived from behavioral economics, has recently gained popular attention as an innovative approach for encouraging patients with chronic illnesses to modify their health-related behaviors (9). Nudge was first introduced and defined by economist Thaler and his associate Sunstein, which means the process of assisting individuals in making better judgments on a predictable routine when they are faced with choices, without prohibiting any options or drastically altering the incentives that drive the behaviors (10). In contrast to commands or persuasion, nudging does not restrict patients' freedom of choice (10). It seeks to modify the choice architecture or the environment in which decisions are made (10). Examples of this include rearranging food items to promote healthier eating or laying warning images on cigarette packs to encourage quitting smoking (11, 12). There is evidence supporting the effectiveness of nudges in improving health behaviors among patients with chronic diseases such as heart disease and COPD (13, 14).

Currently, scholars cannot come to a consensus on the definition of nudge yet, and different approaches have been taken to classify nudges, such as the MINDSPACE classification proposed by Dolan et al. (15) and Munscher et al.'s (16) classification by intervention design. Consequently, we are not sure of exactly what type of nudge works effectively to improve the health behaviors and outcomes of patients with COPD. On the other hand, the context of decision-making influences nudges (17). For example, patients with varying characteristics may react differently to the same nudge, and the same nudge may have conflicting effects when delivered in different modes (17–19). In order to implement effective nudges, these contexts also require additional investigation.

The article aims to perform a systematic review that thoroughly assesses the applications of nudge theory and strategies in connection with health behaviors and outcomes among patients with COPD. This review helps to further understand the potential influence of the characteristics on the effectiveness of nudge interventions by presenting scientific supporting data on the use of nudge in the management of COPD. Overall, it provides novel evidence-based practice for researchers, politicians, and medical practitioners to implement nudges for COPD patients.

2 Methods

This review has been registered in the international Prospective Registry of Systematic Evaluation (PROSPERO) database (identifier number CRD42023427051). Registration was open until June 1, 2023.

2.1 Nudge theory and strategies

We referred to the interpretation and classification of nudges by Meske et al. (20) and Munscher et al. (16) to guide us to include the following strategies as the subcategories of nudges in this review.

2.1.1 Social influence

Social influence can be categorized into two basic types. The first type involves information. When a large number of individuals act or think in a certain way, knowledge about what might be beneficial in terms of actions or thoughts is disseminated through their collective behavior and thinking patterns. The second type is peer pressure. In this case, one may choose to conform to societal norms or follow the majority due to concerns about how others, such as family members, perceive them, aiming to gain approval or avoid disapproval (11).

2.1.2 Gamification

Gamification refers to the use of game design elements in non-game contexts, to motivate and engage through fun and enjoyment in a game setting (21).

2.1.3 Reminder

Reminders can make a big difference since they ensure that people can act promptly at the right moment and avoid procrastinating being distracted by other duties or becoming inert (12).

2.1.4 Feedback

Feedback makes own behavior visible. Giving feedback on one's behavior removes many of the attentional and mental barriers that prevent people from accessing this knowledge in their daily lives. Devices and tools that offer feedback include pedometers that count steps and smart electricity meters displaying energy consumption (16).

2.2 Information sources and search strategy

We employed a two-arm search strategy including database searches and snowballing. We searched PubMed, Embase, Web of Science, Cochrane Library, Scopus, PsycINFO, and EconLit for relevant articles. We carefully defined the terms and keywords and determined the search strategy (see [Supplementary Table 1](#)). The search filter was set to English only. The search was performed on June 26, 2023. The references of included studies were also manually checked for appropriate sources. Deduplicates were removed using the reference management software EndNote 20, followed by a meticulous manual deduplication process.

2.3 Inclusion and exclusion criteria

Eligible studies were selected based on specific inclusion and exclusion criteria. The inclusion criteria included adults diagnosed with COPD; interventions based on the theory of behavioral nudges; study designs that featured an appropriate control, such as randomized controlled trials or pre-post studies, where the control group received non-nudges like usual care; reported outcomes that encompassed medication adherence, inhalation technique, physical activity, smoking cessation, vaccine behavior, self-efficacy in health behaviors, as well as pulmonary function, clinical symptoms, and quality of life as health outcomes; and the literature search was limited to studies published in English. Exclusion criteria were as follows: patients with Acute Exacerbation of Chronic Obstructive Pulmonary Disease (AECOPD), conference abstracts, letters, comments, case reports, case series, preclinical studies, review articles, descriptive studies such as case-control studies and cohort studies, other non-relevant studies, and studies with no relevant results. [Table 1](#) lists the PICOS for this systematic review.

2.4 Study selection

The entire screening process was conducted by two independent reviewers (W-QH and Z-RB). Any disagreements were resolved through discussion. If necessary, a third reviewer (ZM) performed assistance and reached a consensus with all investigators. Based on the inclusion and exclusion criteria, a two-round screening process was implemented. Initially, screening involved reading the titles and abstracts, followed by a comprehensive examination of the full texts.

2.5 Data extraction

The data was extracted independently by two review authors using a pre-designed data extraction form. Information extracted included publication information (e.g., title, first author, year of publication, study design, country), patient characteristics (e.g., mean age, sex, sample size), intervention or control characteristics

(e.g., nudge intervention and control description, duration of intervention) and targeted behaviors and health outcomes, and limitations.

2.6 Quality assessment

The risk of bias in each study was assessed using the Cochrane Effective Practice and Organization of Care risk of bias tool ([22](#)), which has nine standard criteria for the study with a separate control group and seven standard criteria for the interpreted time series study. Each study was independently assessed by two reviewers against each of the criteria assessing a score of either low risk, high risk, or unclear risk of bias according to the Cochrane Effective Practice and Organization of Care risk of bias tool ([22](#)).

2.7 Data synthesis

Due to the heterogeneity of interventions, outcome measurements, and study designs in the included studies, it would not have been possible to provide substantial results by performing a meta-analysis. Instead, to confirm the effective context of nudge interventions, we reported statistical significance based on the type of nudge and included outcome measures, and used a vote counting approach for narrative synthesis.

3 Results

3.1 Study selection

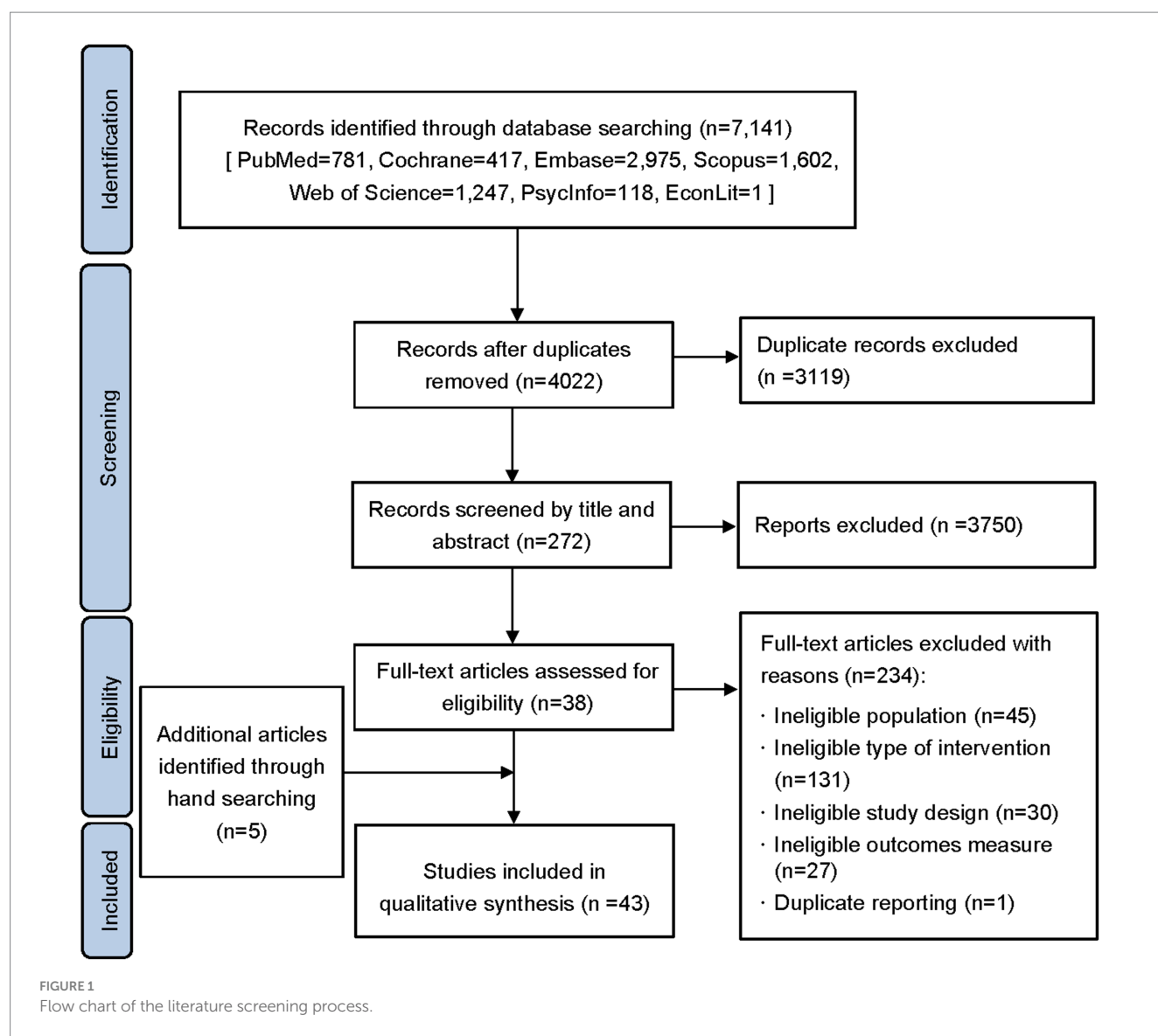
A total of 4,022 articles were identified in the initial search from the database after the exclusion of 3,119 duplicates. After screening the titles and abstracts, 3,750 articles were excluded because they did not meet the inclusion criteria. 272 articles in total were selected for full-text screening. After that, 234 articles were disqualified ([Figure 1](#)). Five additional articles were added after manual searching. Finally, 43 studies were included in the review ([Figure 1](#)). The features of the study were shown in [Table 2](#). Among them, three studies were lacking in the information on gender and one study only indicated age range without mean age. The sample sizes in most studies were less than 50. Thirty studies were randomized controlled studies, and ten studies were performed in the United States. [Supplementary Tables 2, 3](#) provide specifics regarding the study's characteristics and nudge strategies.

3.2 Quality assessment

The results from the methodological risk of bias assessment of the included studies using the Cochrane Effective Practice and Organization of Care (EPOC) risk of bias tool are reported in [Supplementary Table 4](#). Fifteen studies in all were classified as high risk: four for selection bias, six for dissimilar baseline outcomes or characteristics, five for high dropout rates leading to incomplete outcome data, and 3 for absence of blind assessment.

TABLE 1 PICOS for this systematic review.

Elements	Contents
P (Population)	Adults diagnosed with COPD
I (Intervention)	Interventions based on the theory of behavioral nudges
C (Comparison)	Non-nudged interventions, like usual care
O (Outcome)	Health behaviors and outcomes such as medication adherence, inhalation technique, physical activity, smoking cessation, vaccine behavior, self-efficacy, pulmonary function, clinical symptoms, and quality of life
S (Study design)	An appropriate control, such as randomized control or pre-post control



3.3 Characteristics of nudge interventions

As shown in Table 3, this study included a total of four different types of nudge interventions, including social influence ($n=5$), gamification ($n=7$), reminder ($n=6$), and feedback ($n=25$). Twenty-one of the 43 trials used multi-component interventions, meaning that in addition to nudging, they contained interventions including training, education, rehabilitation activities, general encouragement, and health outcome monitoring.

The most popular intervention was feedback nudges, and the most frequently used delivery modes ($n=24$) were pedometers or other devices (23–46), along with mobile applications (47). Among the five studies employing social influence, two used group sessions (14, 48), and three utilized mobile applications (49–51) as the delivery modes. Of the seven gamification

interventions, five involved devices such as consoles and headsets (52–56), one was web-based (57), and one used mobile applications (58). The interventions utilized various reminder devices, including wearable ones (59), while two others employed mobile applications (60, 61). Three other interventions employed text materials, including labels (62), cards (63), and written materials (64).

The nudge intervention of social influence primarily targeted exercise capacity, physical activity, and self-efficacy (14, 48–51). Exercise capacity and physical activity were the primary concerns of gamification (12, 52, 54–58). The main points of the reminder were self-efficacy, exercise capacity, vaccine behavior, inhalation technique, and medication adherence (59–64). The primary goals of the 25 studies that included feedback were self-efficacy, exercise capacity, and physical activity (23–47). Each kind of intervention looked into how it affected quality of life.

TABLE 2 Characteristics of studies.

Population selection	Number of studies
Mean age (years)	
[40,50)	2
[50,60)	2
[60,70)	29
≥70	9
Age provided as a range	1
Male (%)	
<30	1
[30,60)	15
[60,90)	19
≥90	5
Gender not reported	3
Sample size	
<50	21
[50,100)	7
[100,200)	10
≥200	5
Country/region	
North America	
USA	10
Europe	
UK	4
Other European countries ^a	17
Asia-Pacific countries ^b	12
Study design	
RCT	31
Non-RCT	12

^aOther European countries include Germany, France, Switzerland, Portugal, Netherlands, Norway, Italy, Poland, Spain and Turkey.

^bAsia-Pacific countries include Australia, Chile, China, Indonesia, Vietnam, Korea and Japan.

3.4 Characteristics of effective nudging measured

The results and health behavior data from the included studies are displayed in Table 4. Table 5 outlines the characteristics of effective nudge interventions. Variations in the targeted outcomes and method of delivering nudging interventions resulted in different intervention effects.

In social influence interventions, exercise capacity, self-efficacy, and quality of life were significantly enhanced through mobile applications, while physical activity was ineffective. Using group sessions had inconsistent effects on quality of life and was ineffective for increasing exercise capacity or physical activity. Gamification intervention based on the web effectively increased exercise capacity. Physical activity was unaffected by gamification through mobile applications. Gamification using devices was beneficial for clinical symptoms but ineffective for lung function and quality of life, with conflicting results on exercise capacity.

Though they did not influence exercise capacity, reminders based on text materials were an excellent way to promote medication adherence, inhalation technique, influenza vaccination rates, self-efficacy, and quality of life. Mobile applications and devices that served as reminders had little effect on quality of life. Reminders via devices greatly increased medication adherence. However, mobile applications did not affect pulmonary function.

Through the chronolog, studies that employed feedback as a nudge to enhance medication adherence were effective. Pedometers and other devices had inconsistent impacts on quality of life, clinical symptoms, exercise capacity, self-efficacy, and physical activity, but had no effect on smoking cessation behavior or pulmonary function. Feedback via mobile applications did not influence the quality of life, clinical symptoms, or physical activity.

4 Discussion

To our best knowledge, this study is the first to summarize the evidence regarding the effectiveness of nudge in modifying patients with COPD and improving their health behaviors and outcomes. Prior research by Möllenkamp et al. (9) examined the effectiveness of nudges in enhancing patients' ability to manage their chronic illnesses, including a subgroup of patients with COPD. However, this study only comprised two trials (14, 44) that were specifically focused on COPD and did not yield substantial conclusions. We included five different types of nudges for investigating the effects of various nudge types on the health behaviors and outcomes of patients with COPD, without restricting RCT studies. The health outcomes also exhibited considerable heterogeneity, including medication adherence, inhalation technique, smoking cessation, influenza vaccination, physical activity, self-efficacy, exercise capacity, pulmonary function, clinical symptoms, and quality of life. Owing to these variabilities, a qualitative synthesis that was consistent with the research by Möllenkamp et al. (9) and Kwan et al. (17) was carried out instead of a meta-analysis. Furthermore, many studies that used nudges might not have mentioned the term “nudge” explicitly because it was just introduced in 2008 (11). In order to expand the scope of inclusion and incorporate as much research on the nudging approach as feasible, our study included terms like social norm, social support, persuasion, and feedback in the search strategy.

Our systematic review found significant effects of nudging on medication adherence, inhalation technique, and vaccination behavior. Medication adherence was significantly improved by reminders via mobile applications or text materials, as well as feedback based on devices. Additionally, reminders through text materials greatly enhance inhalation techniques and vaccination behaviors in patients. The most recent *Global Initiative for Chronic Obstructive Lung Disease: 2023 Report* (1), emphasizes the importance that it is to promote medication adherence, inhalation techniques, vaccination, and other health-related behaviors to further enhance the health outcomes of patients with COPD. On the other hand, low-cost, simple nudging interventions—like using a simple mobile application, equipped with devices such as the chronolog, offering text materials or cards, or simply labeling on inhalation devices—can significantly improve health behaviors and benefit patients with COPD.

Comparisons of intervention types revealed that feedback was the most frequently investigated nudge, followed by gamification,

TABLE 3 Characteristics of nudge interventions.

Intervention	Social influence (<i>n</i> = 5)	Gamification (<i>n</i> = 7)	Reminder (<i>n</i> = 6)	Feedback (<i>n</i> = 25)
Multi-component	3	1	3	14
Single-component	2	6	3	11
Delivery mode				
Mobile applications	3	1	2	1
Web-based		1		
Pedometer/devices		5	1	24
Group sessions	2			
Text materials			3	
Targeted health behavior				
Physical activity	2	1		18
Exercise capacity	3	5	1	17
Smoking cessation				1
Influenza vaccination			1	
Medication adherence			3	3
Inhalation technique			1	
Self-efficacy	2		1	6
Pulmonary function		1	1	2
Clinical symptom		1		12
Quality of life	3	2	3	20
Duration of intervention				
<3 months	1	7	4	8
[3,6) months	3			8
[6,12) months			1	4
≥12 months	1		1	5

reminders, and social influence. According to our review, nudge-based interventions were found to increase medication adherence, inhalation technique, and vaccine behavior, but not lung function or smoking cessation behavior. It is evident from other outcomes that the type of nudging and the delivery modes have an impact on the results. For instance, social influence had a strong impact, but reminders and feedback were ineffective when mobile applications were utilized as delivery modes to affect the quality of life (47, 49, 61). Reminders sent via text materials significantly improved quality of life (64), whereas no discernible effects were observed with mobile applications or devices (59, 61), suggesting that delivery modes might have a significant impact on the effectiveness given the parallels in study design and patient variables. We were unable to make reliable conclusions regarding the relationship between modes of delivery and health outcomes due to the small number of studies. Hence, more research is required to confirm the impact of different types of nudging on the health behavior outcomes of patients with COPD.

Conflicting outcomes in studies investigating interventions for COPD may be attributable to variations in patient characteristics, such as baseline disease severity and levels of physical activity. For example, Mendoza et al. (37) reported that 80% of participants in their study

had mild to moderate COPD, and the use of pedometers was associated with improvements in quality of life, clinical symptoms, exercise capacity, and physical activity. In contrast, a similar intervention yielded no significant effects on physical activity, exercise endurance, or clinical symptoms among patients with severe to very severe COPD (35). Furthermore, Geidl et al. (45) found that patients with high baseline levels of physical activity did not benefit from the intervention in terms of increasing physical activity or improving clinical symptoms. Armstrong et al. (27), however, observed notable improvements in physical activity and clinical symptoms in patients using pedometers as part of their intervention. Interestingly, in the study by Moy et al. (25), more than half of the patients exhibited good baseline health and minimal dyspnea, and the intervention failed to produce significant changes in clinical symptoms or quality of life.

In addition, the duration and season of the interventions may also affect intervention effectiveness. Due to the short intervention period of some studies, statistical significance was not observed for some outcome measures that could only measure significant changes after long-term intervention, such as lung function (29, 42, 56, 59). Since the study by de Blok et al. (41) was carried out in autumn and wintertime, the physical activity of patients did not improve during

TABLE 4 Results of outcome measures of interest in the included studies.

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
Medication adherence						
Tashkin (1991) (24)	I	112	NA	The percent of patients actually used the inhaler two or more times daily according to the chronolog record: 78%	NA	<i>p</i> < 0.001
	C	85	NA	The percent of patients actually used the inhaler two or more times daily according to the chronolog record: 52%	NA	
Simmons (1996) (43)	I	129	Not reported	Mean sets per day: Month 4: 1.93 ± 0.69 Month 8: 1.76 ± 0.83 Month 12: 1.74 ± 0.89 Month 16: 1.70 ± 0.89 Month 20: 1.56 ± 0.87 Month 24: 1.65 ± 0.89	Not reported	Month 4: <i>p</i> = 0.0035 Month 8: <i>p</i> = 0.0003 Month 12: <i>p</i> = 0.0007 Month 16: <i>p</i> = 0.0018 Month 20: <i>p</i> = 0.0190 Month 24: <i>p</i> = 0.0006
	C	102	Not reported	Mean sets per day: Month 4: 1.60 ± 0.83 Month 8: 1.31 ± 0.89 Month 12: 1.29 ± 0.91 Month 16: 1.27 ± 0.92 Month 20: 1.22 ± 0.97 Month 24: 1.16 ± 0.95	Not reported	
Song (2014) (64)	I	20	Medication adherence: 30.4 ± 4.8	Medication adherence: 33.0 ± 3.2	Not reported	<i>p</i> = 0.047
	C	20	Medication adherence: 31.6 ± 3.4	Medication adherence: 31.9 ± 4.8	Not reported	
Jolly (2018) (38)	I	Baseline: 273 Month 6: 219 Month 12: 218	Medication adherence score: 1[0–2]*	Medication adherence score: Month 6: 1[0–2]* Month 12: 1[0–1]*	Not reported	Month 6: <i>p</i> = 0.008
	C	Baseline: 265 Month 6: 255 Month 12: 255	Medication adherence score: 1[0–2]*	Medication adherence score: Month 6: 1[0–2]* Month 12: 1[0–2]*	Not reported	
Criner (2021) (61)	I	67	NA	The mean number of adherent sets of puffs/day: 1.61 ± 0.389	NA	<i>p</i> < 0.001

(Continued)

TABLE 4 (Continued)

First author (year)	Group (intervention/control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	70	NA	The mean number of adherent sets of puffs/day: 1.33 ± 0.509	NA	
Morfaw (2023) (60)	I	30	MMAS-8: 4.4 ± 1.591	MMAS-8: 6.4 ± 1.453	$p < 0.05$	NA
Inhalation technique						
Nguyen (2018) (62)	I	Baseline: 211 Month 1:163 Month 3:163 Month 6:139 Month12:102	Inhaler technique score: MDI:6.09 Turbuhaler*: 6.68	Inhaler technique score: MDI: Month 1 = 6.97; Month 3 = 7.49; Month 6 = 7.49; Month 12 = 6.93 Turbuhaler*: Month 1 = 7.24; Month 3 = 7.56; Month 6 = 7.56; Month 12 = 7.24	MDI: all points: $p < 0.001$ Turbuhaler*: Month 3: $p = 0.001$ Month 6: $p < 0.001$	NA
Smoking cessation						
Jolly (2018) (38)	I	Baseline: 289 Month 6: 267 Month12: 247	Smoking cessation rate: 26%	Smoking cessation rate: Month 6: 22% Month 12: 13%	Not reported	NS
	C	Baseline: 288 Month 6: 287 Month12: 226	Smoking cessation rate: 19%	Smoking cessation rate: Month 6: 18% Month 12: 25%	Not reported	
Influenza vaccination						
Vayisoglu (2019) (63)	I	44	NA	Influenza vaccination rate: 63.6%	NA	$p = 0.001$
	C	44	NA	Influenza vaccination rate: 29.5%	NA	
Physical activity						
de Blok (2006) (41)	I	8	Daily steps: 2082	Daily steps: 3512	Not reported	NS
	C	8	Daily steps: 2377	Daily steps: 2832	Not reported	
Wewel (2008) (23)	I	21	Activity per hour of monitoring (counts/h): 1061 ± 636	Activity per hour of monitoring (counts/h): 1330 ± 726	$p = 0.007$	NA
Hospes (2009) (32)	I	18	Daily steps: $7087 \pm 4,058$	Daily steps: $7872 \pm 3,962$	Not reported	$p = 0.01$
	C	17	Daily steps: $7539 \pm 3,945$	Daily steps: $6172 \pm 3,194$	Not reported	

(Continued)

TABLE 4 (Continued)

First author (year)	Group (intervention/control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
Berry (2010) (14)	I	Baseline: 87 End: 61	Physical activity levels (kcal/week): Reported in diagram format	Physical activity levels (kcal/week): Reported in diagram format	Month 3: $p = 0.004$ Month 6: $p = 0.005$ Month12: $p = 0.048$	NS
	C	Baseline: 89 End: 69	Physical activity levels (kcal/week): Reported in diagram format	Physical activity levels (kcal/week): Reported in diagram format	Month 3: $p = 0.002$ Month 6: $p = 0.039$	
Moy (2012) (25)	I	24	Daily steps: $2908 \pm 2,416$	Daily steps: $4171 \pm 2,970$	$p = 0.0054$	NA
Cruz (2014) (34)	I	16	Daily steps (W1): 8638.23 ± 2408.14	Daily steps: W7: 10002.27 ± 2798.13 W12: 8858.43 ± 1641.80	W1 to W12: $p = 0.026$ W1 to W7: $p = 0.050$; W7 to W12: $p = 0.048$	NA
Tabak (2014) (47)	I	13	Daily steps: 5766 ± 965	Daily steps: 5603 ± 964	NS	Not reported
	C	16	Daily steps: 5256 ± 865	Daily steps: 4617 ± 865	NS	
Altenburg (2015) (39)	I	Baseline: 78 Month 3: 65 Month15: 50	Daily steps: $4292[2182-6,596]^*$	Daily steps: Changes after 3 months: $618[-137-1771]^*$ Changes after 15 months: $218[-1,423-1863]^*$	Not reported	Changes after 3 months: $p = 0.001$
	C	Baseline: 77 Month 3: 55 Month15: 51	Daily steps: $4132[2979-6,030]^*$	Daily steps: Changes after 3 months: $-185[-1,425-969]^*$ Changes after 15 months: $-201[1809-1,006]^*$	Not reported	
Kawagoshi (2015) (31)	I	12	The time spent walking (mins/day): Reported in diagram format	Changes after 12 months: 51.3 ± 63.7	$p < 0.05$	$p = 0.036$
	C	15	The time spent walking (mins/day): Reported in diagram format	Changes after 12 months: 12.3 ± 25.5	$p < 0.05$	
Mendoza (2015) (37)	I	Baseline: 52 End: 50	Daily steps: $4008 \pm 2,253$	Daily steps: Changes after 3 months: 3080 ± 3254.8	Not reported	$p < 0.001$
	C	Baseline: 50 End: 47	Daily steps: $3956 \pm 2,723$	Daily steps: Changes after 3 months: 138.3 ± 1950.4	Not reported	

(Continued)

TABLE 4 (Continued)

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
Cruz (2016) (44)	I	13	Daily steps: 7161.5 ± 1708.1	Daily steps: Month 3: 10440.0 ± 4012.9 Month 6: 9747.9 ± 3511.8	<i>p</i> = 0.001	Month 3: <i>p</i> = 0.006 Month 6: <i>p</i> = 0.025
	C	13	Daily steps: 6617.1 ± 2914.2	Daily steps: Month 3: 6430.0 ± 2613.1 Month 6: 6481.3 ± 3454.4	<i>p</i> = 0.001	
Arbillaga-Etxarri (2018) (46)	I	132	Daily steps: 8069 ± 4,554	Daily steps: 8002 ± 4,635	NS	NS
	C	148	Daily steps: 7783 ± 3,847	Daily steps: 7825 ± 3,850	NS	
Burkow (2018) (51)	I	10	The average number of physical activity sessions per week (mean): 2.9	The average number of physical activity sessions per week (mean): 5.9	Not reported	Not reported
Jolly (2018) (38)	I	Baseline: 230 Month 6: 202 Month12: 191	Total MET minutes/week: 3242.2 ± 3284.2	Total MET minutes/week: Month 6: 3786.0 ± 3685.7 Month 12: 3214.3 ± 3578.4	Not reported	Month 6: <i>p</i> = 0.003
	C	Baseline: 236 Month 6: 237 Month12: 223	Total MET minutes/week: 3265.8 ± 3480.6	Total MET minutes/week: Month 6: 2920.6 ± 3195.0 Month 12: 2738.1 ± 3249.9	Not reported	
O'Neill (2018) (28)	I	Baseline:17 End: 14	Daily steps: 3305.6 ± 1960.2	Daily steps: 5332.0 ± 3070.7	Not reported	Not reported
	C	Baseline:23 End: 12	Daily steps: 3946.2 ± 2263.1	Daily steps: 4984.6 ± 3598.0	Not reported	
Kohlbrenner (2020) (35)	I	Baseline: 37 End: 29	Daily steps: 3708 ± 3,601	Daily steps: Changes after 3 months: 694 ± 1709 Changes after 12 months: −108 ± 1,057	Not reported	NS
	C	Baseline: 37 End: 31	Daily steps: 2451 ± 1819	Daily steps: Changes after 3 months: 423 ± 2,258 Changes after 12 months: −480 ± 1703	Not reported	
Park (2020) (33)	I	22	Daily steps: 5223.68 ± 2899.61	Daily steps: 6546.77 ± 2354.43	<i>p</i> < 0.05	NS
	C	20	Daily steps: 6756.26 ± 2978.77	Daily steps: 6890.39 ± 2967.73	NS	
Armstrong (2021) (27)	I	24	Daily steps: 3450 ± 2,168	Daily steps: 4426 ± 2,577	<i>p</i> = 0.001	<i>p</i> = 0.001

(Continued)

TABLE 4 (Continued)

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	24	Daily steps: 3446 ± 2,342	Daily steps: 3406 ± 2095	NS	
Geidl (2021) (45)	I	167	Daily steps: 5722.4 ± 2948.6	Daily steps: Week 6: 6875.0 ± 3229.5 Month 6: 6517.7 ± 3427.8	<i>p</i> < 0.05	NS
	C	160	Daily steps: 5934.5 ± 3101.0	Daily steps: Week 6: 6679.5 ± 3337.4 Month 6: 6234.0 ± 3357.6	<i>p</i> < 0.05	
Robinson (2021) (26)	I	75	Daily steps: 3176.6 ± 2211.6	Changes after 3 months: 645.95 ± 3394.6 Changes after 6 months: 672.90 ± 3399.0	Changes after 3/6 months: Not reported	Month 3: <i>p</i> = 0.005 Month 6: <i>p</i> < 0.001
	C	78	Daily steps: 3210.2 ± 2247.9	Changes after 3 months: −385.78 ± 3633.8 Changes after 6 months: −639.38 ± 3667.9	Changes after 3/6 months: Not reported	
Simmich (2021) (58)	I	9	Daily steps: 4730 ± 1959	Daily steps: 4649 ± 2,357	Not reported	Not reported
	C	9	Daily steps: 6394 ± 4,306	Daily steps: 5593 ± 4,277	Not reported	
Exercise capacity						
Giardino (2004) (29)	I	20	6MWD(m): 249 ± 97	6MWD(m): 432 ± 133	<i>p</i> < 0.01	NA
de Blok (2006) (41)	I	8	2MST: 36.6	2MST: 57.4	Not reported	NS
	C	8	2MST: 49.3	2MST: 55.1	Not reported	
Woo (2006) (48)	I	33	6MWD(m): 285 ± 96	6MWD(m): 303 ± 98	NS	NA
Wewel (2008) (23)	I	21	6MWD(m): 379.6 ± 115.3	6MWD(m): 411.4 ± 100.5	<i>p</i> = 0.030	NA
Hospes (2009) (32)	I	18	6MWD(m): 364.9 ± 45.1	6MWD(m): 387.4 ± 46.6	Not reported	NS
	C	17	6MWD(m): 351.4 ± 54.5	6MWD(m): 361.4 ± 66.6	Not reported	
Berry (2010) (14)	I	Baseline: 87 End: 61	6MWD(m): 410.7	6MWD(m): Month 3: 434.8 ± 8.8 Month 6: 426.7 ± 10.3 Month 12: 408.1 ± 10.5	Month 3: <i>p</i> < 0.05	NS
	C	Baseline: 89 End: 69	6MWD(m): 410.7	6MWD(m): Month 3: 428.7 ± 8.3 Month 6: 439.8 ± 9.9 Month 12: 430.5 ± 10.0	Month 3, 12: <i>p</i> < 0.05	

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TABLE 4 (Continued)

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
Cruz (2014) (34)	I	16	6MWD(m)(W1): 466.50 ± 81.56	6MWD(m): W12: 513.33 ± 86.18	W1 to W12: <i>p</i> = 0.001	NA
Song (2014) (64)	I	20	6MWD(m): 300.3 ± 86.6	6MWD(m): 333.5 ± 79.2	Not reported	NS
	C	20	6MWD(m): 290.0 ± 52.5	6MWD(m): 312.7 ± 72.1	Not reported	
Altenburg (2015) (39)	I	Baseline: 78 Month 3: 65 Month15: 50	6MWD(m): 454[361–509]*	6MWD(m): Changes after 3 months: 19.5[–5.6–45.2]* Changes after 15 months: 22.8[2.4–51.2]*	Not reported	NS
	C	Baseline: 77 Month 3: 55 Month15: 51	6MWD(m): 450[351–530]*	6MWD(m): Changes after 3 months: 6.0[–18.5–40.6]* Changes after 15 months: 11.2[–3.3–57.0]*	Not reported	
Kawagoshi (2015) (31)	I	12	6MWD(m): 369 ± 119	6MWD(m): 445 ± 138	<i>p</i> < 0.01	Not reported
	C	15	6MWD(m): 404 ± 148	6MWD(m): 467 ± 151	<i>p</i> < 0.01	
Mendoza (2015) (37)	I	Baseline: 52 End: 50	6MWD(m): 463.1 ± 83.2	6MWD(m): Changes after 3 months: 12.4 ± 34.6	Not reported	<i>p</i> = 0.03
	C	Baseline: 50 End: 47	6MWD(m): 469.7 ± 71.6	6MWD(m): Changes after 3 months: –0.7 ± 24.4	Not reported	
Cruz (2016) (44)	I	13	6MWD(m): 493.8 ± 63.0	6MWD(m): Month 3: 547.9 ± 47.9 Month 6: 540.4 ± 31.1	<i>p</i> < 0.001	NS
	C	13	6MWD(m): 476.2 ± 54.9	6MWD(m): Month 3: 529.7 ± 57.2 Month 6: 519.4 ± 50.8	<i>p</i> < 0.001	
Arbillaga-Etxarri (2018) (46)	I	132	6MWD(m): 499 ± 95	6MWD(m): 488 ± 106	<i>p</i> < 0.05	NS
	C	148	6MWD(m): 501 ± 83	6MWD(m): 493 ± 90	<i>p</i> < 0.05	
O'Neill (2018) (28)	I	Baseline:23 End: 16	ISWT (m): 253.0 ± 118.8	ISWT (m): 288.1 ± 107.0	Not reported	Not reported
	C	Baseline:26 End: 17	ISWT (m): 259.2 ± 140.6	ISWT (m): 280.0 ± 139.7	Not reported	

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TABLE 4 (Continued)

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
Wootton (2018) (30)	I	49	6MWD(m): 458 ± 87	6MWD(m): Changes after 14 months: −6 Changes from 2 months to 14 months: −23	Changes from 2 months to 14 months: <i>p</i> < 0.05	NS
	C	46	6MWD(m): 467 ± 80	6MWD(m): Changes after 14 months: −40 Changes from 2 months to 14 months: −39	Changes from 2 months to 14 months: <i>p</i> < 0.05	
Rutkowski (2019) (54)	I	34	6MWD(m): 469.9 ± 34.3	6MWD(m): 508.4 ± 44.3	<i>P</i> ≤ 0.05	NS
	C	34	6MWD(m): 494.9 ± 38.7	6MWD(m): 514.7 ± 33	<i>P</i> ≤ 0.05	
Sutanto (2019) (53)	I	10	6MWD(m): 376.6 ± 81.0	6MWD(m): 420 ± 77.6	<i>p</i> < 0.001	NS
	C	10	6MWD(m): 410.7 ± 105.3	6MWD(m): 477.5 ± 122.4	<i>p</i> < 0.001	
Kohlbrenner (2020) (35)	I	Baseline: 37 End: 29	1MSTS: 20.97 ± 7.04	1MSTS: Changes after 3 months: 0.74 ± 3.46 Changes after 12 months: 1.0 ± 7	Not reported	NS
	C	Baseline: 37 End: 31	1MSTS: 16.06 ± 8.72	1MSTS: Changes after 3 months: 1.81 ± 5.97 Changes after 12 months: −0.5 ± 6.9	Not reported	
Park (2020) (33)	I	22	6MWD(m): 378.32 ± 96.96	6MWD(m): 433.23 ± 107.23	<i>p</i> < 0.05	NS
	C	20	6MWD(m): 398.10 ± 78.67	6MWD(m): 437.60 ± 83.62	NS	
Rutkowski (2020) (55)	I/ET + VR	38	6MWD(m): 471.53	6MWD(m): 510.63	<i>p</i> = 0.000	ET vs. ET + VR: <i>p</i> = 0.011
	I/VR	34	6MWD(m): 487.91	6MWD(m): 523.38	<i>p</i> = 0.000	ET vs. VR: <i>p</i> = 0.031
	C/ET	34	6MWD(m): 492.07	6MWD(m): 508.3	<i>p</i> = 0.014	
Armstrong (2021) (27)	I	24	6MWD(m): 285 ± 92	6MWD(m): 339 ± 90	<i>p</i> = 0.001	NS
	C	24	6MWD(m): 276 ± 92	6MWD(m): 314 ± 99	<i>p</i> = 0.001	
Robinson (2021) (26)	I	75	6MWD(m): 360.8 ± 92.0	Changes after 3 months: 23.86 ± 82.97 Changes after 6 months: 25.14 ± 83.23	Changes after 3 months: Not reported Changes after 6 months: <i>p</i> = 0.010	NS

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TABLE 4 (Continued)

First author (year)	Group (intervention/control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	78	6MWD(m): 357.2 ± 103.5	Changes after 3 months: 27.58 ± 83.99 Changes after 6 months: 37.41 ± 85.05	Changes after 3 months: Not reported Changes after 6 months: <i>p</i> < 0.001	
Rutkowski (2021) (56)	I	25	6MWD(MET): 6.12 ± 2.12	6MWD(MET): 6.75 ± 2.24	<i>p</i> < 0.0018	Not reported
	C	25	6MWD(MET): 5.98 ± 1.84	6MWD(MET): 6.76 ± 1.28	<i>p</i> < 0.0002	
Yao (2021) (50)	I	50	6MWD(m): 362.31 ± 91.24	6MWD(m): 423.67 ± 102.32	Not reported	<i>p</i> = 0.030
	C	50	6MWD(m): 364.57 ± 93.66	6MWD(m): 382.28 ± 84.95		
Colombo (2023) (57)	I	12	6MWD(m): 478.00 ± 80.44	6MWD(m): 520.50 ± 69.24	<i>p</i> < 0.05	NA
Norweg (2023) (36)	I	12	6MWD(m): 358.27 ± 87.85	6MWD(m): 397.64 ± 92.2	<i>p</i> = 0.01	Not reported
	C	4	6MWD(m): 322.94 ± 72.66	6MWD(m): 347.93 ± 84.71	Not reported	
Self-efficacy						
Giardino (2004) (29)	I	20	COPD self-efficacy: 49 ± 22	COPD self-efficacy: 62 ± 20	<i>p</i> < 0.01	NA
de Blok (2006) (41)	I	8	Self-efficacy: 25.3	Self-efficacy: 28.5	Not reported	NS
	C	8	Self-efficacy: 27.0	Self-efficacy: 26.6	Not reported	
Hospes (2009) (32)	I	18	LIVAS: 29.8 ± 7.9	LIVAS: 31.0 ± 8.9	Not reported	NS
	C	17	LIVAS: 28.4 ± 7.9	LIVAS: 28.5 ± 8.3	Not reported	
Cruz (2016) (44)	I	13	Self-efficacy Scale: 77.0 ± 12.0	Self-efficacy Scale: Month 3: 75.3 ± 12.7 Month 6: 79.5 ± 11.4	NS	NS
	C	13	Self-efficacy Scale: 82.4 ± 10.4	Self-efficacy Scale: Month 3: 85.7 ± 11.1 Month 6: 79.6 ± 13.0	NS	
Jolly (2018) (38)	I	Baseline: 287 Month 6: 247 Month12: 228	Stanford self efficacy scale: 8.3 ± 1.6	Stanford self efficacy scale: Month 6: 8.1 ± 1.7 Month 12: 8.1 ± 1.6	Not reported	NS
	C	Baseline: 284 Month 6: 275 Month12: 272	Stanford self efficacy scale: 8.0 ± 1.7	Stanford self efficacy scale: Month 6: 7.8 ± 1.8 Month 12: 7.7 ± 1.8	Not reported	
Vayisoglu (2019) (63)	I	44	SE Scale: Coping SE: 12.05 ± 1.43 Action SE: 10.86 ± 1.95	SE Scale: Coping SE: 13.11 ± 1.08 Action SE: 11.70 ± 2.01	Coping SE: <i>p</i> < 0.001 Action SE: <i>p</i> < 0.001	Coping SE: <i>p</i> < 0.001 Action SE: <i>p</i> < 0.001

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TABLE 4 (Continued)

First author (year)	Group (intervention/control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	44	SE Scale: Coping SE: 11.39 ± 1.97 Action SE: 10.45 ± 2.52	SE Scale: Coping SE: 11.70 ± 2.01 Action SE: 10.93 ± 2.42	Action SE: <i>p</i> = 0.035	
Park (2020) (33)	I	22	SEMCD: 6.71 ± 1.93	SEMCD: 6.89 ± 1.75	NS	NS
	C	20	SEMCD: 6.47 ± 1.64	SEMCD: 6.69 ± 2.26	NS	
Yao (2020) (49)	I	64	ES-CA: 93.26 ± 11.23	ES-CA: 129.71 ± 23.22	Not reported	<i>p</i> < 0.05
	C	64	ES-CA: 94.13 ± 12.75	ES-CA: 109.25 ± 17.52	Not reported	
Yao (2021) (50)	I	50	health promotion self-care scale: 52.69 ± 9.36	health promotion self-care scale: 65.91 ± 11.39	Not reported	<i>p</i> < 0.001
	C	50	health promotion self-care scale: 52.74 ± 10.21	health promotion self-care scale: 56.36 ± 10.36		
Pulmonary function						
Esteve (1996) (42)	I	9	FEV1(% predicted): 33.2 ± 7.4	FEV1(% predicted): 40.1 ± 11.5	<i>p</i> = 0.038	NS
	C	10	FEV1(% predicted): 37.6 ± 14.8	FEV1(% predicted): 37.1 ± 12.9	NS	
Giardino (2004) (29)	I	20	FEV1(% predicted): 46 ± 16	FEV1(% predicted): 51 ± 17	NS	NA
Chau (2012) (59)	I	22	FEV1(% predicted): 33.59 ± 14.86	FEV1(% predicted): 33.64 ± 14.57	NS	Not reported
	C	18	FEV1(% predicted): 43.89 ± 29.11	FEV1(% predicted): 39.83 ± 15.36	NS	
Rutkowski (2021) (56)	I	25	FEV1%: 71.00 ± 23.66	FEV1%: 73.25 ± 23.24	NS	Not reported
	C	25	FEV1%: 86.48 ± 21.13	FEV1%: 90.24 ± 19.36	<i>p</i> < 0.049	
Clinical symptom						
Moy (2012) (25)	I	21	mMRC score: 2.48 ± 1.12	mMRC score: 3.22 ± 0.736	NS	NA
Tabak (2014) (47)	I	14	MRC score: 2.0 ± 0.9	MRC score: Changes after 3 weeks: −0.3 ± 0.7	NS	NS
	C	15	MRC score: 2.3 ± 1.4	MRC score: Changes after 3 weeks: −0.2 ± 0.9	NS	
Kawagoshi (2015) (31)	I	12	MRC score: 1.9 ± 0.8	MRC score: 1.2 ± 0.9	<i>p</i> = 0.039	Not reported
	C	15	MRC score: 1.9 ± 0.7	MRC score: 1.4 ± 0.9	NS	
Mendoza (2015) (37)	I	Baseline: 52 End: 50	CAT score: 15.5 ± 8.9	CAT score: Changes after 3 months: −3.5 ± 5.5	Not reported	<i>p</i> = 0.001

TABLE 4 (Continued)

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	Baseline: 50 End: 47	CAT score: 16.5 ± 7.3	CAT score: Changes after 3 months: −0.6 ± 6.6	Not reported	
Arbillaga-Etxarri (2018) (46)	I	132	CAT score: 12 ± 7	CAT score: 11 ± 7	$p < 0.05$	NS
	C	148	CAT score: 12 ± 8	CAT score: 11 ± 7	NS	
Jolly (2018) (38)	I	Baseline: 289 Month 6: 237 Month12: 247	MRC score: 1: 31% 2: 69%	MRC score: 1: 26% 2: 74%	Not reported	NS
	C	Baseline: 288 Month 6: 265 Month12: 269	MRC score: Month 6: 1 vs. 2 vs. 3 vs. 4 vs. 5: 32% vs. 58% vs. 6 3% vs. <1% Month 12: 1 vs. 2 vs. 3 vs. 4: 31% vs. 61% vs. 7 2%	MRC score: Month 6: 1 vs. 2 vs. 3 vs. 4: 32% vs. 60% vs. 7 2% Month 12: 1 vs. 2 vs. 3 vs. 4: 28% vs. 61% vs. 10 2%	Not reported	
O'Neill (2018) (28)	I	Baseline:23 End: 17	CAT score: 23.8 ± 6.9	CAT score: 22.5 ± 7.0	Not reported	Not reported
	C	Baseline:26 End: 19	CAT score: 18.7 ± 7.3	CAT score: 16.6 ± 5.3	Not reported	
Sutanto (2019) (53)	I	10	MRC score: 3(0.67)*	MRC score: 3(0.5)*	NS	$p = 0.036$
	C	10	MRC score: 2.5(0.5)*	MRC score: 2(0.4)*	NS	
Kohlbrenner (2020) (35)	I	Baseline: 37 End: 29	CAT score: 17.14 ± 6.77	CAT score: Changes after 3 months: −0.86 ± 5.18 Changes after 12 months: −1.32 ± 7.49	Not reported	NS
	C	Baseline: 37 End: 31	CAT score: 19.14 ± 6.15	CAT score: Changes after 3 months: −1.92 ± 4.45 Changes after 12 months: −1.63 ± 8.28	Not reported	
Park (2020) (33)	I	22	UCSD-SOBQ: 21.18 ± 16.05	UCSD-SOBQ: 21.45 ± 17.78	NS	NS
	C	20	UCSD-SOBQ: 19.25 ± 13.83	UCSD-SOBQ: 19.70 ± 14.34	NS	
Armstrong (2021) (27)	I	24	CAT score: 25.9 ± 6.4	CAT score: 21.7 ± 6.1	$p = 0.001$	$p = 0.025$

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TABLE 4 (Continued)

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	24	CAT score: 27.0 ± 6.4	CAT score: 24.9 ± 7.1	<i>p</i> = 0.002	
Geidl (2021) (45)	I	167	CAT score: 23.23 ± 6.57	CAT score: Week 6: 17.82 ± 8.04 Month 6: 19.04 ± 7.99	Not reported	NS
	C	160	CAT score: 23.32 ± 6.82	CAT score: Week 6: 17.61 ± 7.74 Month 6: 18.93 ± 7.96	Not reported	
Robinson (2021) (26)	I	75	mMRC score: 2.0 ± 1.2	Changes after 3 months: −0.17 ± 1.82 Changes after 6 months: −0.06 ± 1.82	Changes after 3/6 months: Not reported	NS
	C	78	mMRC score: 2.1 ± 1.2	Changes after 3 months: 0.07 ± 1.85 Changes after 6 months: 0.00 ± 1.85	Changes after 3/6 months: Not reported	
Quality of life						
Giardino (2004) (29)	I	20	SGRQ: 50.1 ± 15.4	SGRQ: 41.9 ± 14.1	<i>p</i> < 0.01	NA
de Blok (2006) (41)	I	8	SGRQ: 59.1	SGRQ: 56.3	Not reported	NS
	C	8	SGRQ: 50.8	SGRQ: 44.7	Not reported	
Woo (2006) (48)	I	33	SGRQ: 53.69 ± 19.61	SGRQ: 34.72 ± 14.12	<i>p</i> < 0.001	NA
Wewel (2008) (23)	I	21	SGRQ: 59[51–64]*	SGRQ: 52[45–66]*	NS	NA
Hospes (2009) (32)	I	18	SGRQ: 37.7 ± 12.4	SGRQ: 34.2 ± 13.5	Not reported	<i>p</i> = 0.05
	C	17	SGRQ: 35.2 ± 18.7	SGRQ: 38.3 ± 16.8	Not reported	
Berry (2010) (14)	I	Baseline: 87 End: 61	CRQ: 4.3	CRQ: Month 3: 4.6 ± 0.1 Month 6: 4.5 ± 0.1 Month 12: 4.6 ± 0.1	Month 3, 12: <i>p</i> < 0.05	NS
	C	Baseline: 89 End: 69	CRQ: 4.3	CRQ: Month 3: 4.8 ± 0.1 Month 6: 4.7 ± 0.1 Month 12: 4.6 ± 0.1	Month 3, 12: <i>p</i> < 0.05	
Chau (2012) (59)	I	22	CRQ: Dyspnea: 4.27 ± 1.23 Fatigue: 4.09 ± 1.26 Emotion: 4.84 ± 1.47 Mastery: 4.60 ± 1.43	CRQ: Dyspnea: 3.97 ± 1.17 Fatigue: 4.11 ± 1.25 Emotion: 4.92 ± 1.40 Mastery: 4.61 ± 1.62	NS	NS

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TABLE 4 (Continued)

First author (year)	Group (intervention/control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	18	CRQ: Dyspnea: 4.20 ± 0.83 Fatigue: 4.40 ± 0.99 Emotion: 5.24 ± 1.42 Mastery: 4.94 ± 1.16	CRQ: Dyspnea: 4.45 ± 0.96 Fatigue: 4.79 ± 1.07 Emotion: 5.61 ± 1.17 Mastery: 4.88 ± 1.27	NS	
Moy (2012) (25)	I	23	SF-36: 3.13 ± 0.757	SF-36: 3.22 ± 0.736	NS	NA
Song (2014) (64)	I	20	SGRQ: 52.9 ± 18.2	SGRQ: 42.3 ± 7.9	Not reported	<i>p</i> = 0.033
	C	20	SGRQ: 62.1 ± 17.4	SGRQ: 66.8 ± 6.4	Not reported	
Tabak (2014) (47)	I	14	CCQ: 2.0 ± 0.8	CCQ: Changes after 3 weeks: −0.3 ± 0.5	<i>p</i> = 0.046	NS
	C	15	CCQ: 1.8 ± 1.0	CCQ: Changes after 3 weeks: 0.0 ± 0.6	NS	
Altenburg (2015) (39)	I	Baseline: 78 Month 3: 65 Month15: 50	CRQ: 102[86–118]*	CRQ: Changes after 3 months: 4[−2–15]* Changes after 15 months: 2[−6–10]*	Not reported	NS
	C	Baseline: 77 Month 3: 55 Month15: 51	CRQ: 109[87–119]*	CRQ: Changes after 3 months: 2[−7–14]* Changes after 15 months: 2[−5–12]*	Not reported	
Kawagoshi (2015) (31)	I	12	CRQ: 98 ± 20	CRQ: 108 ± 19	<i>p</i> = 0.027	Not reported
	C	15	CRQ: 99 ± 19	CRQ: 110 ± 19	<i>p</i> < 0.01	
Mendoza (2015) (37)	I	Baseline: 52 End: 50	SGRQ: 41.9 ± 19.8	SGRQ: Changes after 3 months: −8.8 ± 12.2	Not reported	<i>p</i> = 0.02
	C	Baseline: 50 End: 47	SGRQ: 43.7 ± 16.7	SGRQ: Changes after 3 months: −3.8 ± 10.9	Not reported	
Cruz (2016) (44)	I	13	SGRQ: 31.5 ± 15.7	SGRQ: Month 3: 24.0 ± 13.6 Month 6: 23.1 ± 10.3	<i>p</i> < 0.001	NS

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TABLE 4 (Continued)

First author (year)	Group (intervention/control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	13	SGRQ: 34.9 ± 14.7	SGRQ: Month 3: 26.9 ± 15.2 Month 6: 26.2 ± 15.3	$p < 0.001$	
Arbillaga-Etxarri (2018) (46)	I	132	CCQ: 1 ± 1	CCQ: 1 ± 1	$p < 0.05$	NS
	C	148	CCQ: 1 ± 1	CCQ: 1 ± 1	NS	
Jolly (2018) (38)	I	Baseline: 277 Month 6: 222 Month 12: 217	SGRQ: 27.8 ± 14.6	SGRQ: Month 6: 28.6 ± 17.1 Month 12: 27.9 ± 15.7	Not reported	NS
	C	Baseline: 272 Month 6: 237 Month 12: 256	SGRQ: 29.5 ± 14.5	SGRQ: Month 6: 30.5 ± 16.7 Month 12: 30.9 ± 17.0	Not reported	
O'Neill (2018) (28)	I	Baseline: 23 End: 16	EQ-5D weighted health index: 0.5 ± 0.2 EQ-5D health state VAS: 56.2 ± 20.8	EQ-5D weighted health index: 0.5 ± 0.3 EQ-5D health state VAS: 58.6 ± 23.0	Not reported	Not reported
	C	Baseline: 26 End: 19	EQ-5D weighted health index: 0.6 ± 0.3 EQ-5D health state VAS: 60.8 ± 12.3	EQ-5D weighted health index: 0.7 ± 0.2 EQ-5D health state VAS: 74.0 ± 19.9	Not reported	
Wootton (2018) (30)	I	49	SGRQ: 46 ± 18	SGRQ: Changes after 14 months: −5 Changes from 2 months to 14 months: 1	Changes after 14 months: $p < 0.05$	NS
	C	46	SGRQ: 47 ± 16	SGRQ: Changes after 14 months: −2 Changes from 2 months to 14 months: 4	Changes from 2 months to 14 months: $p < 0.05$	
Collins (2019) (40)	I	58	CRQ: Dyspnea: 16.6 ± 4.2 Fatigue: 15.9 ± 4.0 Emotion: 33.3 ± 7.9 Mastery: 18.8 ± 5.1	CRQ: Dyspnea: 21.1 ± 5.4 Fatigue: 17.7 ± 4.8 Emotion: 36.6 ± 8.6 Mastery: 21.2 ± 5.0	Not reported	Not reported ^d

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TABLE 4 (Continued)

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
	C	61	CRQ: Dyspnea: 16.2 ± 5.4 Fatigue: 16.5 ± 4.7 Emotion: 33.6 ± 9.4 Mastery: 19.6 ± 5.4	CRQ: Dyspnea: 19.4 ± 6.7 Fatigue: 18.4 ± 5.0 Emotion: 36.9 ± 9.0 Mastery: 21.0 ± 5.3	Not reported	
Sutanto (2019) (53)	I	10	SGRQ: 57.7 ± 11.6	SGRQ: 30.6 ± 5.9	<i>p</i> = 0.001	NS
	C	10	SGRQ: 54.1 ± 16.3	SGRQ: 29.4 ± 9.9	<i>p</i> = 0.002	
Jung (2020) (52)	I	10	CRQ: Dyspnea: 2.22 ± 1.09 Fatigue: 3.11 ± 1.43 Emotion: 3.85 ± 1.52 Mastery: 3.83 ± 1.19	CRQ: Dyspnea: 2.96 ± 1.15 Fatigue: 3.27 ± 1.15 Emotion: 4.36 ± 1.01 Mastery: 4.22 ± 0.74	Not reported	NA
Park (2020) (33)	I	22	SF-36: PCS: 43.43 ± 9.00 MCS: 51.62 ± 8.71	SF-36: PCS: 43.94 ± 8.97 MCS: 50.10 ± 8.33	NS	NS
	C	20	SF-36: PCS: 46.36 ± 5.58 MCS: 52.13 ± 8.49	SF-36: PCS: 44.95 ± 5.95 MCS: 49.03 ± 11.02	NS	
Yao (2020) (49)	I	64	Not reported	QLQ-C: Role function: 78.25 ± 2.41 Emotional function: 80.27 ± 2.38 Physical function: 80.43 ± 2.44 Cognitive function: 79.91 ± 3.32 Social function: 80.15 ± 2.57	Not reported	<i>p</i> < 0.001
	C	64	Not reported	QLQ-C: Role function: 60.29 ± 2.11 Emotional function: 61.43 ± 2.39 Physical function: 61.02 ± 3.03 Cognitive function: 60.95 ± 2.86 Social function: 61.48 ± 2.43		
Armstrong (2021) (27)	I	24	CCQ: 2.5 ± 1.1	CCQ: 2.2 ± 1.1	NS	NS
	C	24	CCQ: 2.5 ± 1.3	CCQ: 2.4 ± 1.3	NS	

(Continued)

TABLE 4 (Continued)

First author (year)	Group (intervention/ control)	<i>n</i>	Baseline measurement	Follow-up measurement	Within group significant result	Between groups significant result
Criner (2021) (61)	I	Baseline: 67 End: 58	CCQ: 2.3 ± 0.91	Reported in diagram format	NS	Not reported
	C	Baseline: 70 End: 67	CCQ: 2.8 ± 0.97	Reported in diagram format	NS	
Geidl (2021) (45)	I	167	SGRQ: 55.5 ± 16.8	SGRQ: Week 6: 40.9 ± 21.6 Month 6: 44.3 ± 19.8	Not reported	NS
	C	160	SGRQ: 57.0 ± 17.1	SGRQ: Week 6: 40.4 ± 20.7 Month 6: 43.6 ± 20.5	Not reported	
Robinson (2021) (26)	I	75	SGRQ: 40.0 ± 15.3	Changes after 3 months: –14.63 ± 31.09 Changes after 6 months: –13.05 ± 31.09	Changes after 3/6 months: Not reported	NS
	C	78	SGRQ: 38.0 ± 17.8	Changes after 3 months: –13.86 ± 28.44 Changes after 6 months: –15.13 ± 28.44	Changes after 3/6 months: Not reported	
Norweg (2023) (36)	I	12	SGRQ: 52.47 ± 18.08	SGRQ: 40.72 ± 16.48	<i>p</i> = 0.01	Not reported
	C	3	SGRQ: 56.65 ± 11.79	SGRQ: 46.69 ± 0.85	Not reported	

I, intervention; C, control; NS, No significance; NA, Not applicable; 6WMD, 6-min walking distance; SGRQ, St. George Respiratory Questionnaire; QLQ-C30, Quality of Life Questionnaire-Core 30; ES-CA, Exercise of self-care agency; CRQ, Chronic Respiratory Questionnaire; MMAS-8, Morisky Medication Adherence Scale 8 items; CCQ, Clinical COPD Questionnaire; SF-36, Medical Outcome Study Short Form-36; PCS, Physical component subscale; MCS, Mental component subscale; ISWT, Incremental Shuttle Walk Test; MRC scale, Medical Research Council Dyspnea Scale; SEMCD, Self-Efficacy for Managing Chronic Disease 6-Item Scale; 1MSTS, 1-min sit-to-stand test; 2MST, 2-Minute Step Test; UCSD-SOBQ, The University of California, San Diego Shortness of Breath Questionnaire.

*Values are median values and quartiles (in parentheses).

*The total CRQ score was not reported.

TABLE 5 Effectiveness of nudge elements by delivery mode and targeted outcome.

	Medication adherence	Inhalation technique	Smoking cessation	Influenza vaccination	Physical activity	Exercise capacity	Self-efficacy	Pulmonary function	Clinical symptom	Quality of life
Social influence										
Mobile applications					1 ^a	1 ^b	2 ^b			1 ^b
Web-based										
Pedometer/devices										
Group sessions					1 ^a	2 ^a				2 ^c
Text materials										
Gamification										
Mobile applications					1 ^a					
Web-based						1 ^b				
Pedometer/devices						4 ^c		1 ^a	1 ^b	2 ^a
Group sessions										
Text materials										
Reminder										
Mobile applications	2 ^b									1 ^a
Web-based										
Pedometer/devices								1 ^a		1 ^a
Group sessions										
Text materials	1 ^b	1 ^b		1 ^b		1 ^a	1 ^b			1 ^b
Feedback										
Mobile applications					1 ^a				1 ^a	1 ^a
Web-based										
Pedometer/devices	3 ^b		1 ^a		17 ^c	17 ^c	6 ^c	2 ^a	11 ^c	19 ^c
Group sessions										
Text materials										

Numbers in the table represent the number of literatures corresponding to the intervention mode (vertical columns) and targeted outcome (horizontal columns).

^aNo statically significant outcome.

^bStatically significant outcome.

^cMixed results.

this time, which made it even more challenging to assess if the nudge was beneficial. Future research should take into account the duration time of the intervention and seasons that would affect the health outcomes of patients with COPD.

The extent of the change in patients' health behaviors depends on the study design. Several studies have reported the same effects of nudges on patients' health outcomes, but the conclusions were different. For example, pedometers were utilized in all of these studies as feedback tools to encourage physical activity of patients. The study from Wewel et al. (23) that lacked a control group showed that the physical activity and exercise capacity significantly improved in the intervention group. Similar intervention regimens were employed in other research (45, 46), but no substantial improvements in the outcomes were noted. In the absence of a control group, there is no reason to rule out the possibility that routine care is responsible for improvements in health outcomes. For instance, the study by Geidl et al. (45) indicated that while patients in the control group merely got pulmonary rehabilitation without any nudging intervention, they still exhibited significant changes over time in parameters such as physical activity. A similar result was also observed in the comparison between Berry et al. (14) and Woo et al. (48).

4.1 Limitations

There are several limitations to this study. First, the classification of interventions that fall within the notion of nudge has not yet been widely accepted (11). Numerous studies that supported the nudging theory failed to use this phrase explicitly. To broaden the scope of our search, we chose potentially pertinent research, which also made our search formula not concise. Second, despite having sufficient RCTs (31 of 43), due to the high heterogeneity of the type of intervention, included outcome variables, and study designs, quantitative meta-analysis to examine the intervention effects of nudges is not feasible, so we had to choose the vote counting method as the last thing for narrative synthesis, which did not allow us to critically quantify the effect of nudges. Third, the validity of the results of some studies may be impacted by the small sample size or inadequate statistical power. Last, 15 out of the 43 publications were found to have a high risk of bias. These findings were consistent with those made by Kwan et al. (17) and were related to selection biases, differences in baseline characteristics and outcomes, high attrition rates, and lack of blinded assessment. Although it is currently unknown how these biases affect the way interventions based on nudge are carried out, we did not rule out this research due to its significance in real-world circumstances.

4.2 Implications for future research

This study provides a novel viewpoint on COPD management from the standpoint of behavioral economics since it is the first to

explore the application of nudge theory and strategies to the health behaviors and outcomes of patients with COPD. Though the theory is still in its infancy and research on the efficacy of interventions is also still in its early phases, we believe the theory has a promising future. To further examine the impact of nudge in the management of chronic diseases such as COPD, future studies may need to take into account the following points.

Firstly, assuming that academics have come to a consensus on the classification of nudges, we may attempt, incrementally, to examine the individual intervention effect of a particular type of nudge or narrow our emphasis to a single health behavior or result. Whenever feasible, using randomized controlled trials (RCTs) for study design and quantitative meta-analysis may reach more reliable conclusions.

Secondly, to assess the effects of nudges, aim to conduct research in the same context to test their effects, including selecting subjects with the same characteristics, such as age, gender, ethnicity, and even COPD stage. Also consider the impact of the delivery mode of the nudge, the duration and frequency of the intervention, and the season on the effectiveness of the intervention. Performing subgroup analyses based on patient characteristics or intervention delivery mode, etc., might also support the study.

Lastly, a more thorough exploration of the degree to which nudge interventions are effective in their own right requires the exclusion of the confounding effects of other concurrent non-nudge interventions such as education, training, general encouragement, and traditional pulmonary rehabilitation.

5 Conclusion

We have delineated a list of nudging interventions for patients with COPD, including social influence, gamification, reminders, and feedback, which provides a new approach and strategy for COPD management. In particular, medication adherence was significantly improved by reminders via mobile applications (60, 61) or text materials (64), as well as feedback based on devices. Reminders through text materials also greatly enhance inhalation techniques and vaccination behaviors in patients, which can be extensively advocated and employed in healthcare settings. Furthermore, we propose factors such as the delivery modes, the baseline characteristics of patients, and the duration and seasons of interventions that could affect the effectiveness of interventions. By employing the same background settings, further research might verify the impacts of various nudging strategies. It is also important to design the type of study as appropriately as possible.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding authors.

Author contributions

QW: Writing – review & editing, Conceptualization, Methodology, Writing – original draft. RZ: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. LT: Writing – review & editing, Formal analysis. WC: Formal analysis, Writing – original draft. XC: Formal analysis, Writing – original draft. ZM: Supervision, Writing – review & editing. JZ: Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1404590/full#supplementary-material>

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