



Maintaining psychological well-being amidst the COVID-19 pandemic: The beneficial effects of health-promoting behaviors and sense of control

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Accepted: 7 March 2023 / Published online: 21 March 2023

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Abstract

The present research reports the findings of three studies, with objectives to demonstrate the impacts of health-promoting behaviors on psychological well-being as well as the mediating roles of sense of control (SOC) and perceived severity of COVID-19 in these relationships. Study 1 was a cross-sectional survey conducted in 473 middle-aged and older Chinese adults before the COVID-19 pandemic to assess their health-promoting behaviors, personal mastery and perceived constraints, life satisfaction, and depressive symptoms. Study 2 was conducted during the second wave of the COVID-19 outbreak in Hong Kong (between March to April 2020), in which 292 participants from Study 1 were successfully contacted to report their emotional responses to the pandemic. Using a different sample, Study 3 was a longitudinal study that measured 495 participants' health-promoting behaviors, personal mastery and perceived constraints at baseline, and their perceived severity and mental health outcomes during the outbreak of omicron cases in Hong Kong (i.e., the fifth wave of the COVID-19 outbreak) in March 2022. All three studies demonstrate that the beneficial effects of health behaviors can be extended to psychological well-being and reveal possible underlying mechanisms through enhancing one's SOC and lowering perceived severity of the COVID-19 outbreak. These results provide important insights to future health promotion programs for improving psychological resources and psychological well-being of middle-aged and older adults in face of disease-related threats.

Keywords Health behavior · Sense of control · Perceived severity · Psychological well-being · Coronavirus disease

Introduction

The coronavirus disease 2019 (COVID-19) was first identified in December 2019 in Wuhan, China, and has spread globally from February 2020 onwards. To minimize the spread of the virus, many countries have introduced containment or lockdown measures, including “stay at home”, closure of public entertainment places such as theaters and fitness centers, and travel restrictions. These anti-epidemic and social distancing measures restricted people's mobility and interrupted their social activities, resulting in reduction

in health-promoting behaviors and an increased risk of mental health. For instance, using a national activity tracking app, Di Sebastiano et al. (2020) found significant and substantial declines in incidental physical activity (e.g., walking to the workplace) and walking steps among young and middle-aged Canadian adults after the introduction of social distancing measures and closure of leisure facilities. With an increased trend of sedentary behaviors (e.g., sitting, reclining, using mobile devices, or playing video games) and hectic lifestyle resulting from prolonged homestay, many countries have encouraged their citizens to perform more health-promoting behaviors to maintain their physical health (e.g., Bailey et al., 2022; Centers for Disease Control & Prevention, 2022; Department of Health, 2021).

Past studies conducted before the pandemic have found the beneficial effects of health-promoting behaviors on physical health (Rosato et al., 2019; Wahid et al., 2016) and psychological well-being (Hua et al., 2015; Stenlund et al., 2021). However, given the aforementioned disturbance to health behaviors and the fluctuation of psychological states

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during the COVID-19 pandemic (e.g., Krendl & Perry, 2021; Massell et al., 2022), whether health-promoting behaviors are beneficial to one's psychological well-being in the long run remains largely uncertain. Moreover, with the established association between sense of control and psychological well-being (Infurna & Mayer, 2015; Windsor et al., 2009; Xiong et al., 2021), the present research also investigates whether the positive impact of health-promoting behaviors on psychological well-being can be accounted for by sense of control. Therefore, using cross-sectional and longitudinal data, the present research aims to fill these knowledge gaps.

Health-promoting behaviors and psychological well-being

According to Pender et al.'s (2019) Health Promotion Model, health-promoting behaviors refer to the self-initiated and enduring actions to control, maintain and promote physical health and prevent disease. These behaviors range from physical exercise and nutrition intake to stress management and spiritual growth (e.g., meditation and experiencing new things). Increasing evidence has shown that engagement in various types of health-promoting behaviors contributes to increased physical health, reduced risk of numerous non-communicable diseases, including cardiovascular and cerebrovascular disease, type 2 diabetes mellitus, cancer, and obesity (e.g., Rosato et al., 2019; Wahid et al., 2016).

During this large-scale COVID-19 pandemic, the quarantine and social distancing measures have worsened one's psychological well-being, resulting in anxiety, depression, and loneliness (e.g., Gualano et al., 2020; Wang et al., 2021; Zhao et al., 2020). For instance, a population-based study conducted in Hong Kong during the early stage of COVID-19 revealed that a longer period of stay-at-home requirement was associated with an increased risk of anxiety and depressive symptoms, especially among older adults (Zhao et al., 2020). Psychological well-being is often operationalized as life satisfaction, depressive symptoms, self-rated mental health, and affectivity (e.g., Gunderson & Barrett, 2015; Pan et al., 2018). Past studies have shown that engagement in health-promoting behaviors may potentially contribute to psychological well-being. For instance, balanced nutritional intake and dietary plans can reduce the risk of depression in older Chinese populations (Hua et al., 2015). In addition, a meta-analysis on 92 studies showed that in more than 4000 non-clinical participants, increased engagement in physical activity reduced depression and anxiety (Rebar et al., 2015). Similarly, Grant et al. (2009) demonstrated the positive association between health-promoting behaviors (e.g., physical activity and healthy dietary intake) and life satisfaction in more than 17,000 university students across 21 countries. Using cross-sectional data from 18 countries, Brand et al. (2020) found

that individuals who frequently exercised before the COVID-19 pandemic reported more positive affective responses during the lockdown than those who rarely exercised before the pandemic. However, to the best of our knowledge, only a few studies have revealed the longitudinal beneficial effects of health-promoting behaviors on psychological well-being (Feng et al., 2022; Stenlund et al., 2021), but none of them is related to the COVID-19 context. As a result, whether such a longitudinal protective effect remains even in the face of pandemic situation awaits further examination. Hence, the present research aims to fill this knowledge gap.

In addition, the past findings on the cross-sectional relationship between health-promoting behaviors and psychological well-being were often inconsistent. For instance, Godos et al. (2018) did not find a significant association between dietary intake and depressive symptoms in a sample of Italian adults. Some other studies also failed to demonstrate the relationship between health-promoting behaviors and quality of life (e.g., Bowling & Iliffe, 2011; Choi et al., 2015). As such, the effect of health-promoting behaviors on psychological well-being needs to be further clarified. Thereby, the first objective of the present research is to advance the current literature by examining the cross-sectional and longitudinal effects of health-promoting behaviors on psychological well-being. Specifically, the first hypothesis is:

H1: Health-promoting behaviors is positively associated with psychological well-being.

The possible mediating role of sense of control

Past studies mainly focused on demonstrating the positive effects of health-promoting behaviors on psychological well-being, while its underlying mechanism is under-researched. Unveiling such mechanism will help health professionals to improve the effectiveness of health promotion in the community. Inferring from previous work in which one's sense of control could be enhanced after participating in physical activity intervention (e.g., Pakarinen et al., 2017; Shami-zadeh et al., 2019), the present research thereby explores whether the sense of control could account for the positive effects of health-promoting behaviors on psychological well-being. To the best of our knowledge, such a mediating effect of sense of control on the relationship between health-promoting behaviors and psychological well-being has not yet been empirically tested.

Inspired by the Social Cognitive Theory (SCT) (Bandura, 1978, 2004), sense of control (SOC) is applied in the present research to investigate the mechanism underlying the association between health-promoting behaviors and psychological well-being. SOC refers to individuals' perception of their own power and control over their lives

and environments (Lachman et al., 2011). This construct is considered similar to other related constructs for measuring one's belief of his/her abilities or efforts in achieving the desired outcomes, such as self-efficacy, control beliefs, locus of control, and primary and secondary control (Pearlin & Pioli, 2003). SOC is operationalized with two dimensions, namely, personal mastery and perceived constraints (Lachman et al., 2011). Personal mastery refers to an individual's perceived effectiveness in pursuing goals, whereas perceived constraints denote the belief about certain obstacles that are beyond one's control and hinders him/her from reaching goals. Past research often combined these two dimensions into a single construct (e.g., Gerstorf et al., 2011; Hong et al., 2021; O'Brien, 2012). Among those studies separating the two dimensions, perceived constraints have been shown to exhibit stronger associations with psychological well-being than that of personal mastery (Infurna & Mayer, 2015; Windsor et al., 2009; Xiong et al., 2021). For example, in a sample of more than 2,000 American spousal dyads, Windsor et al. (2009) found that, as compared with personal mastery, perceived constraints were associated with life satisfaction and negative affect to a greater extent. Similarly, a cross-sectional survey conducted by Xiong et al. (2021) also revealed that the association with depression, anxiety, and stress in both medical and non-medical Chinese students during the early phase of the COVID-19 pandemic was stronger in perceived constraints than in personal mastery. Thereby, the present research aims to extend the previous findings by comparing the two dimensions of SOC to examine whether the long-term effects of personal mastery and perceived constraints on psychological well-being are different.

The central concept of SCT is reciprocal determinism (Bandura, 1978, 2004), which suggests that one's belief about himself/herself may lead to an activation of behaviors. At the same time, maintaining a particular behavior will trigger cognitive change in his/her perceived ability to perform an action (i.e., sense of control or self-efficacy). Although SOC is shown to be predictive of health-promoting behaviors in both clinical and non-clinical populations (e.g., Auerbach et al., 2014; Mohamad et al., 2019), recent research seems to support the latter proposition that SOC can be strengthened through performing health-promoting behaviors. For example, interventions on health behaviors have shown that regular participation in physical activity enhances individuals' SOC (e.g., Pakarinen et al., 2017; Shamizadeh et al., 2019). Proper dietary habits are also associated with a higher internal locus of control in older adults (Zielińska-Więczkowska, 2016). Hence, the present research aims to extend these recent works by examining the longitudinal effects of health-promoting behaviors on psychological well-being of middle-aged and older

adults via SOC. Accordingly, the following hypothesis is formulated:

H2: Health-promoting behaviors predicts psychological well-being through personal mastery and perceived constraints.

The possible mediating role of perceived severity of the COVID-19 pandemic

While it is postulated that one's heightened SOC, which is brought by the increased level of health-promoting behaviors, may contribute to a higher level of psychological well-being, its beneficial effect on psychological well-being may further be channeled through changing one's perceptions/interpretations towards the outer environment. Applying the SCT framework, health-promoting behaviors (as a behavioral factor) are expected to influence SOC (as a personal factor), and subsequently psychological well-being. However, this linkage fails to incorporate the environmental factors when explaining psychological well-being in the face of COVID-19 pandemic. According to the Health Belief Model (HBM) (Champion & Skinner, 2008; Rosenstock, 1990), one's perceived severity, as well as the potential consequences, of the COVID-19 pandemic, would influence the way health decision is made. However, whether the commitment of such a health decision would in turn lead to enhanced psychological well-being through reducing perceived severity of a health problem remains uncertain. Thus, the present research applies the theoretical frameworks of SCT and HBM to examine to what extent the effects of health-promoting behaviors on psychological well-being can be explained by first enhancing individuals' SOC and subsequently lowering their perceived severity of the COVID-19 pandemic. Given the recent studies showing that self-efficacy for preventing COVID-19 can negatively affect the risk perception toward COVID-19 (Figueiras et al., 2022) and that the threat perception toward COVID-19 can negatively predict one's mental health outcomes (Chong et al., 2021), it is reasonable to predict that SOC would also improve psychological well-being by minimizing the perceived threat of the COVID-19 pandemic. Accordingly, the following sequential mediation hypothesis is proposed:

H3: Health-promoting behaviors predicts psychological well-being through first enhancing individuals' personal mastery and reducing their perceived constraints and subsequently lowering their perceived severity of the COVID-19 pandemic.

The present research

The insufficient information on the means of infection and treatment of COVID-19 at the early stage of the pandemic led to heightened anxiety and depression among the public, especially in middle-aged and older adults (Choi et al., 2020; Kwok et al., 2020). A study found that engaging in physical exercise during the pandemic was associated with better mood among young adults (Brand et al., 2020), whereas another study discovered that participation in an 8-week mindfulness-oriented meditation course during the pandemic lowered the levels of anxiety and depressive symptoms among middle-aged adults (Matiz et al., 2020). Thus, the COVID-19 pandemic provides an arena to naturally examine the long-term effects of health-promoting behaviors and SOC on psychological well-being in the face of a negative natural event. The present research utilized both cross-sectional (Study 1) and longitudinal designs (Studies 2 and 3) to investigate the effects of health-promoting behaviors on the psychological well-being of middle-aged and older Hong Kong Chinese adults in usual and COVID-19 situations. Study 1 was conducted before the COVID-19 outbreak, while Studies 2 and 3 were carried out during the second (March and April 2020) and fifth (March 2022) waves of the COVID-19 outbreak in Hong Kong, respectively. In addition, the possible sequential mediating effects of SOC and perceived severity of COVID-19 were also examined in Study 3. The findings of this research will contribute to the literature by demonstrating the beneficial effects of health-promoting behaviors even in the face of naturally-occurring crises such as the COVID-19 pandemic, and unveiling its underlying mechanisms.

Study 1

Health-promoting behaviors were shown to be associated with psychological well-being in the past literature, and yet, inconsistent findings were also observed (Bowling & Iliffe, 2011; Choi et al., 2015; Godos et al., 2018). Study 1 first aimed to reaffirm such an association (H1) in a sample of middle-aged and older Hong Kong Chinese adults. It also explores the mediating effect of SOC on the relationship between health-promoting behaviors and psychological well-being (H2). With reference to past research on health behaviors and well-being (e.g., Briki, 2017; Hua et al., 2015), psychological well-being was indicated by the levels of life satisfaction and depressive symptoms in this study. These two indicators were chosen because their significant associations with health behaviors were reported in previous research (Grant et al., 2009; Hua et al., 2015). Whether SOC can account for these empirically demonstrated relationships is further examined in this study.

Method of Study 1

Participants and procedures

Participant recruitment was undertaken in 2019 through sending invitations to non-governmental organizations (NGOs) and tertiary institutions serving middle-aged and older adults and advertisement on social media platforms. Interested parties were interviewed by trained interviewers in either the Psychology Laboratories of the affiliated university or the community centers of the collaborating NGOs. A total of 473 middle-aged and older Hong Kong Chinese adults aged 45 and above were successfully recruited and completed the survey. Their mean age was 65.34 years ($SD = 10.35$, range = 45 – 96) and 73.78% of them were female. Most participants had completed middle school or lower education (43.34%).

Written consent was obtained from each participant prior to the interview. Upon successful completion, each participant received supermarket vouchers with a total amount of HKD150 (approximately USD19) as a token of appreciation for his/her participation.

Measures

Health-promoting behaviors The validated Chinese version of the short-form Health-Promoting Lifestyle Profile-II (HPLP-II) (Teng et al., 2010; Walker & Hill-Polerecky, 1996) was adopted to assess the participants' engagement in five domains of health-promoting behaviors, including spiritual growth (e.g., “be exposed to new experiences and challenges”), physical activity (e.g., “do stretching exercises”), health management (e.g., “have daily relaxation time”), nutrition (e.g., “eat 3–5 servings of vegetables each day”), and health responsibility (e.g., “discuss health concerns with health professionals”). Each of the 30 items was measured using a four-point Likert scale (1 = *never* to 4 = *always*), with higher scores indicating more frequent engagement in health-promoting behaviors. The Cronbach's alpha (α) was 0.90.

SOC Lachman and Weaver's (1998) Sense of Control Scale was used to assess the participants' personal mastery and perceived constraints. Each subscale contains five items. Sample items for personal mastery and perceived constraints are “I can do just about anything that I really set my mind to” and “what happens in my life is often beyond my control,” respectively. Ten items were rated on a six-point Likert scale (1 = *strongly disagree* to 6 = *strongly agree*). Higher scores in personal mastery denote a greater sense of efficacy in implementing goals, whereas higher scores in perceived constraints represent greater extents to which the respondents believed in the existence of obstacles that were beyond

their control in reaching goals. The α s of the personal mastery and perceived constraints subscales were 0.84 and 0.82, respectively.

Life satisfaction The validated Chinese version of the Satisfaction with Life Scale (Diener et al., 1985; Sachs, 2003) was adopted to assess the participants' general satisfaction with their life. Participants rated the five items using a five-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*), with higher scores indicating higher satisfaction with life ($\alpha = 0.86$).

Depressive symptoms The validated Chinese version of the short-form Center for Epidemiologic Studies Depression Scale (CESD-10) (Andresen et al., 1994; Boey, 1999) was used to measure the level of depressive symptoms experienced in the past week. Responses were measured using a four-point Likert scale (1 = *rarely* to 4 = *most of the time*), with a higher score indicating more depressive symptoms ($\alpha = 0.86$).

Covariates Participants' age, sex (0 = *male* and 1 = *female*), and education level (1 = *middle school or below*, 2 = *high school*, and 3 = *Bachelor's degree or above*) were recorded. Difficulty in instrumental activities of daily living (IADLs) (Lawton & Brody, 1969) was also assessed (0 = *no difficulty*; 1 = *have difficulty*). The average score of difficulties in the six IADL domains, namely, housework, cooking, shopping, using phone, managing medications, and managing finances, was calculated. These variables were controlled as

covariates in the analyses to rule out the potential confounding effects because they were shown to be associated with well-being outcomes (e.g., Blanchflower, 2021; Torres et al., 2016; Zuckerman et al., 2017).

Results of Study 1

Descriptive statistics

Tables 1 and 2 present the means and correlations of the demographic and major variables, respectively. Health-promoting behaviors were positively correlated with personal mastery ($r = 0.46$, $p < 0.001$) and negatively correlated with perceived constraints ($r = -0.38$, $p < 0.001$). In addition, health-promoting behaviors were positively correlated with life satisfaction ($r = 0.51$, $p < 0.001$) and negatively correlated with depressive symptoms ($r = -0.50$, $p < 0.001$). Personal mastery was found to be positively correlated with life satisfaction ($r = 0.59$, $p < 0.001$) and negatively correlated with perceived constraints ($r = -0.49$, $p < 0.001$) and depressive symptoms ($r = -0.54$, $p < 0.001$). In contrast, perceived constraints were negatively correlated with life satisfaction ($r = -0.50$, $p < 0.001$) and positively correlated with depressive symptoms ($r = 0.57$, $p < 0.001$).

Effects of health-promoting behaviors and SOC on psychological well-being

To examine the effects of health-promoting behaviors on psychological well-being (H1) and the mediating effect of

Table 1 Descriptive statistics of Study 1, Study 2, and Study 3 variables

	Study 1 ($N=473$) Mean (SD) / %	Study 2 ($N=292$) Mean (SD) / %	Study 3 ($N=491$) Mean (SD) / %
Age	65.34 (10.35)	64.67 (10.11)	61.96 (7.32)
Sex (female)	73.78%	72.60%	68.2%
Education	1.88 (.86)	1.89 (.85)	2.22 (.79)
Difficulty in IADLs	.07 (.38)	.07 (.34)	.13 (.50)
Health-promoting behaviors	2.47 (.47)	2.47 (.47)	2.42 (.45)
Personal mastery	3.99 (.94)	3.96 (1.00)	3.98 (.80)
Perceived constraints	3.05 (1.01)	3.06 (1.01)	3.14 (.89)
Life satisfaction	3.49 (.82)	—	—
Depressive symptoms ^a	1.79 (.61)	—	—
Positive emotions	—	2.83 (.85)	—
Negative emotions	—	2.84 (1.04)	—
Perceived COVID-19 severity	—	—	3.05 (.75)
Anxiety	—	—	.89 (.51)
Depression ^b	—	—	1.41 (.59)

Sex was coded as 0 = male and 1 = female. Education was coded as 1 = middle school education or below, 2 = high school education, and 3 = Bachelor's degree or above. IADLs = instrumental activities of daily life. ^a Depressive symptoms in Study 1 was measured with the Chinese validated short form of the Center for Epidemiologic Studies Depression Scale (CESD-10). ^b Depression in Study 3 was measured with the Anxiety and Depression Scale (HADS)

Table 2 Correlations among Study 1 variables ($N=473$)

		1	2	3	4	5	6	7	8
1	Age	—							
2	Sex	.07	—						
3	Education	-.35	-.34	—					
4	Difficulty in IADLs	.03	-.01	-.12	—				
5	Health-promoting behaviors	.22	-.14	.13	-.08	—			
6	Personal mastery	.16	-.07	.02	-.09	.46	—		
7	Perceived constraints	-.08	.15	-.19	.17	-.38	-.49	—	
8	Life satisfaction	.23	-.09	.07	-.17	.51	.59	-.50	—
9	Depressive symptoms ^a	-.15	.17	-.20	.25	-.50	-.54	.57	-.63

Sex was coded as 0=male and 1=female. Education was coded as 1=middle school education or below, 2=high school education, and 3=Bachelor's degree or above. IADLs=instrumental activities of daily life.

^a Depressive symptoms in Study 1 was measured with the short-form Center for Epidemiologic Studies Depression Scale (CESD-10). Correlation coefficients displayed in bold are significant at $p < .05$

SOC on such associations (H2), a parallel mediation analysis was performed using the R package lavaan (Rosseel, 2012) with health-promoting behaviors as the independent variable, personal mastery and perceived constraints as the mediators, and life satisfaction and depressive symptoms as the dependent variables. Age, sex, education level, and difficulty in IADLs were controlled as covariates. Prior to analyses, all continuous predictors including control variables were centered (Asparouhov & Muthén, 2019).

The results of the mediation analysis first showed that more frequent engagement in health-promoting behaviors was associated with higher life satisfaction ($\beta=0.24$, $p < 0.001$) and fewer depressive symptoms ($\beta = -0.21$, $p < 0.001$). Therefore, H1 is supported. In addition, significant indirect effects of health-promoting behaviors through personal mastery were found on life satisfaction ($\beta=0.16$, $p < 0.001$) and depressive symptoms ($\beta = -0.11$, $p < 0.001$).

Similarly, significant indirect effects of health-promoting behaviors through perceived constraints were also found on life satisfaction ($\beta=0.08$, $p < 0.001$) and depressive symptoms ($\beta = -0.13$, $p < 0.001$). Together, these results provide support to H2 that a partial mediating effect of SOC (i.e., personal mastery and perceived constraints) was observed, as the direct effects of health-promoting behaviors on life satisfaction and depressive symptoms remained significant even after including the two mediators in the model. The detailed results are illustrated in Fig. 1.

Discussion of Study 1

Previous studies have demonstrated that physical activity and nutrition can contribute to individual well-being (e.g., Hua et al., 2015; Rebar et al., 2015). Supporting H1, the present findings further indicated the beneficial effects

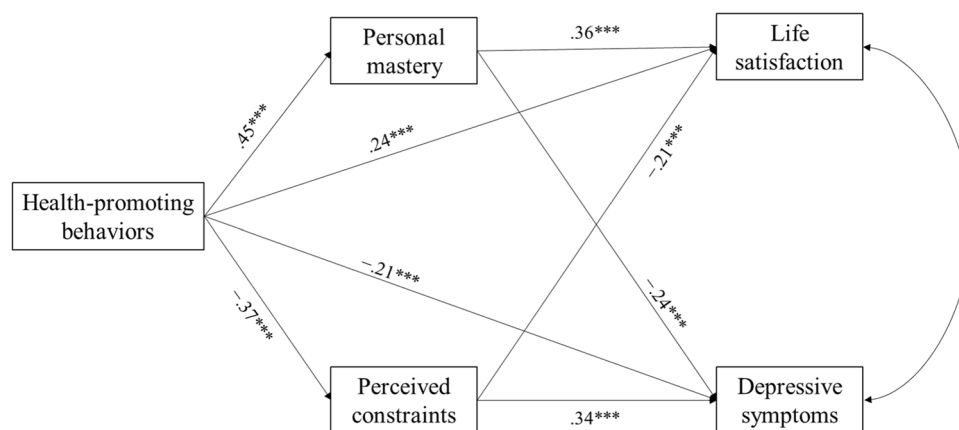


Fig. 1 The parallel mediation model on the relationships between health-promoting behaviors and psychological well-being through personal mastery and perceived constraints in Study 1. *Note.* Numbers in the figures indicate standardized regression coefficients. Age, sex, education, and difficulty in instrumental activities of daily

living were statistically controlled as covariates in the mediation analysis. Goodness of fit of this model: $\chi^2=24.48$, $df=8$, $p=.002$; CFI=.98, TLI=.93, RMSEA=.07, SRMR=.04. * $p < .05$; ** $p < .01$; *** $p < .001$

of health-promoting behaviors on life satisfaction and depressive symptoms. Furthermore, the results of the mediation analysis support H2 by revealing that engagement in health-promoting behaviors could boost one's SOC, which was subsequently associated with better psychological well-being. Both personal mastery and perceived constraints were found to mediate the effects of health-promoting behaviors on life satisfaction and depressive symptoms. Specifically, relative to perceived constraints, personal mastery demonstrated a greater mediating effect on the relationship between health-promoting behaviors and life satisfaction. However, the mediating effect of perceived constraints on the relationship between health-promoting behaviors and depressive symptoms was greater than that of personal mastery. Given the cross-sectional nature of this study, the longitudinal effects of health-promoting behaviors on psychological well-being via SOC will be examined in Study 2.

Study 2

The COVID-19 outbreak in Hong Kong and elsewhere had led to increased anxiety and fear (Choi et al., 2020; Kwok et al., 2020). Whether health-promoting behaviors exerted a long-term beneficial effect on psychological well-being during this naturally occurring crisis and whether SOC still exhibited a mediating effect on this relationship remained unknown. Thus, using data collected during the second wave of the COVID-19 pandemic (March to April 2020), Study 2 tested H1 and H2 to investigate the longitudinal effects of health-promoting behaviors on the emotional responses to the COVID-19 pandemic and the mediating effect of SOC. Given the observed robust change in affectivity during the COVID-19 pandemic (Li et al., 2021), assessing emotional responses to the COVID-19 pandemic could help to validate the cross-sectional findings shown in Study 1 in a more context-bound environment.

Method of Study 2

Participants and procedures

Participants who joined Study 1 were contacted and invited to take part in this study during the second wave of the COVID-19 pandemic (i.e., between March 29 and April 24, 2020). The commencement date of this study was four days after the HKSAR government's implementation of border closure to non-residents and compulsory quarantine order for returning residents. A total of 292 participants were successfully contacted and their emotional responses to the COVID-19 pandemic were measured (response rate=61.73%). Their mean age was 64.67 years ($SD=10.11$,

range=45–91), and 72.60% were female. Most participants had completed middle school or below education (42.12%). The participants who joined this study had no difference from those who did not join in terms of their age, sex, education level, health-promoting behaviors, and SOC (all $ps > 0.05$).

The participants who were contacted via instant message or email completed an online survey via the Qualtrics platform, while those who were contacted by phone completed a telephone survey administered by trained interviewers. Informed consent was sought from each participant prior to participation. The completion of the questionnaire took approximately 10 min. Participation in this study was voluntary, and no financial incentive was provided.

Measures

Emotional responses during the pandemic were measured in the survey conducted during the second wave of COVID-19 outbreak, whereas health-promoting behaviors and SOC were measured in Study 1.

Emotional responses to the pandemic With reference to previous studies assessing emotional responses to negative events (Yeung & Fung, 2007; Yeung et al., 2020), the participants were asked to indicate the extent of their emotional reactions to the COVID-19 pandemic in Hong Kong, including four positive emotions (happy, active, calm, and attentive) and four negative emotions (nervous, afraid, anxious, and upset). The eight emotion items were rated using a five-point Likert scale (1 = *not at all* to 5 = *very much*), with higher scores indicating a more intense experience of the emotion. The α s of the positive and negative emotions were 0.75 and 0.90, respectively.

Results of Study 2

Descriptive statistics

Tables 1 and 3 present the means and correlations among health-promoting behaviors, SOC, and emotional responses to the pandemic, respectively. Health-promoting behaviors were positively correlated with personal mastery ($r=0.48$, $p < 0.001$), and negatively correlated with perceived constraints ($r=-0.42$, $p < 0.001$). They also were positively correlated with positive emotions ($r=0.40$, $p < 0.001$) and negatively correlated with negative emotions ($r=-0.23$, $p < 0.001$). Moreover, personal mastery was found to be positively correlated with positive emotions ($r=0.37$, $p < 0.001$) and negatively correlated with perceived constraints ($r=-0.53$, $p < 0.001$) and negative emotions ($r=-0.20$, $p < 0.001$).

Table 3 Correlations among Study 2 variables ($N=292$)

	1	2	3	4	5	6	7	8
1 Age	—							
2 Sex	.06	—						
3 Education	-.36	-.30	—					
4 Difficulty in IADLs	.04	.02	-.10	—				
5 Health-promoting behaviors	.23	-.04	.10	-.13	—			
6 Personal mastery	.17	-.05	.02	-.10	.48	—		
7 Perceived constraints	-.10	.08	-.19	.17	-.42	-.53	—	
8 Positive emotions	.19	.09	.03	-.04	.40	.37	-.32	—
9 Negative emotions	.06	.19	-.29	.11	-.23	-.20	.31	-.31

Sex was coded as 0=male and 1=female. Education was coded as 1=middle school education or below, 2=high school education, and 3=Bachelor's degree or above. IADLs = Instrumental activities of daily life. Correlation coefficients displayed in bold are significant at $p < .05$

Mediating effect of sense of control

To examine the mediation model in which health-promoting behaviors were predictive of emotional responses to the COVID-19 pandemic through personal mastery and perceived constraints (H2), a parallel mediation analysis was performed with health-promoting behaviors as the independent variable, personal mastery and perceived constraints as the mediators, and positive and negative emotions as the dependent variables. Similar to Study 1, age, sex, education level, and difficulty in IADLs were statistically controlled as covariates, and all continuous predictors including control variables were centered (Asparouhov & Muthén, 2019).

The results of the mediation analysis showed that more frequent engagement in health-promoting behaviors was associated with higher personal mastery ($\beta=0.47$, $p<0.001$), and personal mastery was subsequently associated with more positive emotions ($\beta=0.19$, $p=0.006$) but had no association with negative emotions ($\beta=-0.02$, $p=0.78$). Thus, personal mastery partially mediated the effect of health-promoting behaviors on positive emotions ($\beta=0.09$, $p=0.009$), but not on negative emotions ($\beta=-0.01$, $p=0.78$). In addition, health-promoting behaviors were associated with lower perceived constraints ($\beta=-0.42$, $p<0.001$), and which were subsequently associated with fewer negative emotions ($\beta=0.23$, $p=0.002$) but had no association with positive emotions ($\beta=-0.10$, $p=0.14$). Thus, perceived constraints fully mediated the effect of health-promoting behaviors on negative emotions ($\beta=-0.10$, $p=0.004$) but not on positive emotions

($\beta=0.04$, $p=0.15$). Together, these results provide partial support to the mediating role of SOC as postulated in H2. The detailed results are illustrated in Fig. 2.

Discussion of Study 2

The findings of Study 2 revealed that the pre-pandemic health-promoting behaviors contributed positively to psychological well-being during the COVID-19 pandemic through SOC. Specifically, engagement in health-promoting behaviors before the pandemic were associated with higher personal mastery, which subsequently contributed to more positive emotional responses at the earlier stage of the COVID-19 pandemic when the infection means, treatment and vaccine were largely unavailable. Meanwhile, pre-pandemic health-promoting behaviors were also associated with lower perceived constraints, which subsequently contributed to fewer negative emotions during the COVID-19 pandemic. Thus, these findings advance the literature on health behaviors by demonstrating the long-term effect of health-promoting behaviors on psychological well-being even in the face of a pandemic and unveiling the mediating role of SOC in such a relationship. However, the infection number in the second wave of the COVID-19 pandemic was significantly lower than that of the subsequent outbreaks in Hong Kong and in other countries, which might lower the respondents' perceived severity of the event. Therefore, we further conducted Study 3 during the fifth wave of the COVID-19 pandemic (when the daily infection number of omicron cases was over 50,000 in Hong Kong) to further verify the impacts of the health-promoting behaviors and SOC on middle-aged and older adults' perceived severity threat of this coronavirus and their well-being.

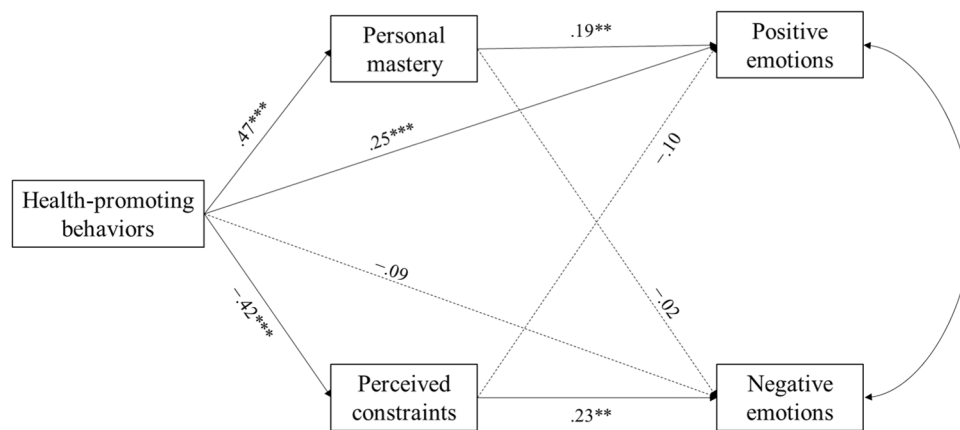


Fig. 2 The parallel mediation model on the relationships between health-promoting behaviors and emotional responses through personal mastery and perceived constraints in Study 2. *Note.* Numbers in the figures indicate standardized regression coefficients. The solid lines denote significant associations between variables at $p < .05$, whereas dashed lines represent non-significant associations. Age,

sex, education, and difficulty in instrumental activities of daily living were statistically controlled as covariates in the mediation analysis. Goodness of fit of this model: $\chi^2 = 13.85$, $df = 8$, $p = .09$; CFI = .98, TLI = .93, RMSEA = .06, SRMR = .03. * $p < .05$; ** $p < .01$; *** $p < .001$

Study 3

The COVID-19 development varies across the globe. Hong Kong experienced the most severe wave of the COVID-19 infection cases (i.e., the fifth wave) starting from late December in 2021. There were 1,195,616 reported cases of COVID-19 from December 31, 2021 to May 14, 2022, making up more than a seventh of the Hong Kong total population, and the death rate has climbed to 0.77% (Hong Kong SAR Government, 2022). The situation in Hong Kong was far more critical (e.g., 58,757 infected cases on 9 March, 2022) than the previous COVID-19 outbreaks (1st to 4th waves) where the highest number of daily confirmed cases was only 150 throughout 2020 – 2021 (Hong Kong SAR Government, 2022). It remains uncertain whether the positive indirect effects of health-promoting behaviors on psychological well-being through SOC shown in Study 2 can still be applied to a significantly more severe outbreak. Similar to Study 2, Study 3 also utilized a longitudinal design but the outcome variables examined in this study were closely relevant to the 5th wave of the outbreak. In particular, given the difference in terms of the seriousness of confirmed and death cases, psychological well-being was indicated by the levels of depression and anxiety in Study 3 (instead of common emotional feelings towards the COVID-19 pandemic as measured in Study 2). Furthermore, the mediating role of perceived severity of the COVID-19, as a core construct in HBM, was also examined in Study 3 to explore whether it could further account for the effect of health-promoting behaviors on psychological well-being.

Method of Study 3

Participants and procedures

The baseline assessment of Study 3 was carried out between December 2020 and December 2021. Similar to Study 1, this sample was recruited through sending invitations to NGOs and district councilors, and advertisement on social media platforms. Interested parties were interviewed by trained interviewers in either the Psychology Laboratories of the affiliated university or the community centers of the collaborating NGOs. All participants were contacted via instant message to participate in an online questionnaire during the fifth wave of the COVID-19 outbreak (i.e., between March 10 and March 19, 2022). A total of 491 participants who completed the baseline interview, were successfully contacted and took part in the online questionnaire. Participants' mean age was 61.96 years ($SD = 7.32$, range = 45–82), and 68.2% were female. Most participants had completed a bachelor's degree or above (44.40%).

Informed consent was obtained from each participant before participation in this study. While participants received HKD150 (approximately USD19) supermarket vouchers for their participation in the baseline interview, the participation in the online questionnaire during the 5th wave of outbreak was voluntary and no financial incentive was given. The online questionnaire took about 10 min to finish.

Measures

Health-promoting behaviors and SOC were measured in the baseline interview, whereas perceived severity of COVID-19, depression and anxiety were measured in the online questionnaire about COVID-19.

Health-promoting behaviors Same as Study 1, HPLP-IICR (Teng et al., 2010; Walker & Hill-Polerecky, 1996) was adopted to measure participants' health behaviors ($\alpha=0.92$).

SOC Same as Study 1, Lachman and Weaver's (1998) Sense of Control Scale was adopted to measure participants' personal mastery ($\alpha=0.85$) and perceived constraints ($\alpha=0.83$).

Perceived severity of COVID-19 Adapting from the study by Simione and Gnagnarella (2020), participants' perceived severity of COVID-19 was measured with three items (e.g., "the COVID-19 infection could lead to serious complications"). Participants were asked to rate each item on a five-point Likert scale ranging from 1 (*totally disagree*) to 5 (*totally agree*). An average score was computed, and higher scores indicate that the participants perceived the COVID-19 pandemic as threatening to a greater extent ($\alpha=0.74$).

Anxiety and depression Participants' levels of anxiety and depression during the fifth wave of COVID-19 in Hong Kong were measured using the Chinese version of Anxiety and Depression Scale (HADS) (Leung et al., 1993). There were seven items each for the subscale of anxiety (e.g., "I get a sort of frightened feeling like something awful is about to happen") and depression (e.g., "I still enjoy the things I used to enjoy"). Each item was rated on a four-point Likert scale (0 = *not at all* to 3 = *most of the time*), with higher scores

represent an intense level of anxious feelings and depressive symptoms ($\alpha=0.88$ and 0.85 , respectively).

Covariates The participants' age, sex, education level and difficulty in IADLs were controlled as covariates in the following analyses.

Results of Study 3

Descriptive statistics

Tables 1 and 4 present the means of and correlations among demographic and major variables, respectively. Consistent with Study 1 and Study 2, health-promoting behaviors were positively correlated with personal mastery ($r=0.41$, $p<0.001$), and negatively correlated with perceived constraints ($r=-0.23$, $p<0.001$). They were also negatively correlated with anxiety ($r=-0.22$, $p<0.001$) and depression ($r=-0.33$, $p<0.001$). Personal mastery was found to be negatively correlated with perceived constraints ($r=-0.42$, $p<0.001$), perceived COVID-19 severity ($r=-0.10$, $p=0.02$), anxiety ($r=-0.27$, $p<0.001$), and depression ($r=-0.36$, $p<0.001$). In contrast, perceived constraints were positively correlated with perceived COVID-19 severity ($r=0.13$, $p<0.001$), anxiety ($r=0.38$, $p<0.001$), and depression ($r=0.39$, $p<0.001$). Furthermore, perceived COVID-19 severity was positively correlated with both anxiety ($r=0.31$, $p<0.001$) and depression ($r=0.22$, $p<0.001$).

Mediating effects of sense of control and perceived COVID-19 severity

To examine H3 about the sequential mediation model in which health-promoting behaviors were predictive of the mental health outcomes in COVID-19 pandemic via

Table 4 Correlations among Study 3 variables ($N=491$)

	1	2	3	4	5	6	7	8	9
1 Age	—								
2 Sex	-.13	—							
3 Education	-.18	-.16	—						
4 Difficulty in IADLs	.11	.11	-.15	—					
5 Health-promoting behaviors	.17	-.17	.12	-.15	—				
6 Personal mastery	.12	-.07	.01	-.14	.41	—			
7 Perceived constraints	-.03	-.02	-.07	.15	-.23	-.42	—		
8 Perceived COVID-19 severity	.07	.07	-.10	.03	-.03	-.10	.13	—	
9 Anxiety	-.09	.12	-.11	.10	-.22	-.27	.38	.31	—
10 Depression ^a	-.12	.10	-.14	.14	-.33	-.36	.39	.22	.73

Sex was coded as 0=male and 1=female. Education was coded as 1=middle school education or below, 2=high school education, and 3=Bachelor's degree or above. IADLs = Instrumental activities of daily life. ^a Depression in Study 3 was measured with the Anxiety and Depression Scale (HADS). Correlation coefficients displayed in bold are significant at $p<.05$

personal mastery and perceived constraints and subsequently perceived COVID-19 severity, a sequential mediation analysis with two blocks of mediators was performed, with health-promoting behaviors as the independent variable, personal mastery and perceived constraints as the first mediators, perceived COVID-19 severity as the second mediator, and anxiety and depression as the dependent variables. Age, sex, education level, and difficulty in IADLs were statistically controlled as covariates. In line with the first two studies, all continuous predictors including control variables were centered (Asparouhov & Muthén, 2019).

The results of the sequential mediation analysis showed that the indirect effects of health-promoting behaviors through perceived constraints and subsequently perceived COVID-19 severity were significant on anxiety ($\beta = -0.01, p = 0.04$) and was marginally significant on depression ($\beta = -0.01, p = 0.06$). However, when the personal mastery was the first mediator, the indirect effects of health-promoting behaviors on both anxiety ($\beta = -0.01, p = 0.21$) and depression ($\beta = -0.01, p = 0.23$) were not significant.

In addition, indirect effects of health-promoting behaviors through a single mediator (perceived constraints or personal mastery) were also explored. Specifically, significant indirect effects of health-promoting behaviors through perceived constraints were found on both anxiety ($\beta = -0.08, p < 0.001$) and depression ($\beta = -0.08, p < 0.001$). On the contrary, a significant indirect effect of health-promoting behaviors through personal mastery was only found on depression ($\beta = -0.09, p = 0.001$), but not

on anxiety ($\beta = -0.04, p = 0.07$). Together, these results largely support H2 and partially support H3. The detailed results are illustrated in Fig. 3.

Discussion of Study 3

The findings of Study 3 demonstrated that the indirect effects of health-promoting behaviors on psychological well-being via SOC remained even in the most severe pandemic with inflated infection and death cases. Moreover, this study further revealed that part of the effect of SOC on psychological well-being can be explained by the severity perception toward the COVID-19. Specifically, engagement in health-promoting behaviors were associated with lower perceived constraints, which subsequently contributed to lower perceived severity of the 5th wave, resulting in a lower level of anxiety and depression in response to the COVID-19 outbreak of omicron cases. These results advance the literature by incorporating the environmental factor as an underlying mechanism through which health-promoting behaviors benefits one’s psychological well-being in times of adversity. The behavioral factors (health-promoting behaviors) not only exert their direct influences on personal factors and well-being (sense of control and mental health), but they can also exert effects through modifying one’s perception of the situation (perceived COVID-19 severity).

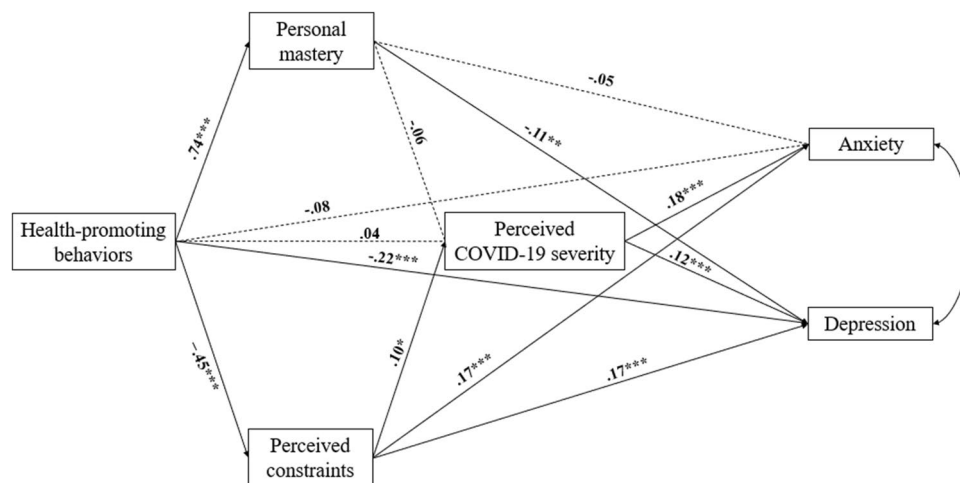


Fig. 3 The sequential mediation model on the relationships between health-promoting behaviors and, anxiety and depression through personal mastery, perceived constraints and perceived COVID-19 severity in Study 3. *Note.* Numbers in the figures indicate standardized regression coefficients. The solid lines denote significant associations between variables at $p < .05$, whereas dashed lines represent non-significant associations.

Age, sex, education, and difficulty in instrumental activities of daily living were statistically controlled as covariates in the mediation analysis. Goodness of fit of this model: $\chi^2 = 25.99, df = 12, p = .01$; CFI = .98, TLI = .95, RMSEA = .05, SRMR = .03. * $p < .05$; ** $p < .01$; *** $p < .001$

General discussion

Using both cross-sectional (Study 1) and longitudinal design (Study 2 and Study 3) and different outcome variables, the present research advances the literature on health behaviors by demonstrating the cross-sectional and long-term effects of health-promoting behaviors on psychological well-being and disclosing the mediating effects of SOC on such relationships. Moreover, threat perception is also seen to play a role in further bridging the connection between SOC and psychological well-being amidst the pandemic.

In line with previous studies showing enhanced SOC after regular physical activity (e.g., Pakarinen et al., 2017; Shamizadeh et al., 2019) and its positive direct effects on psychological well-being (e.g., Briki, 2017; Xiong et al., 2021; Zhou & Yao, 2020), the results of three studies provide support to our second hypothesis about the mediating effect of SOC on the relationship between health-promoting behaviors and psychological well-being among middle-aged and older adults. In Study 1 with cross-sectional data, both personal mastery and perceived constraints mediated the effects of health-promoting behaviors on life satisfaction and depressive symptoms. In Study 2 with longitudinal data, personal mastery accounted for the long-term effects of health-promoting behaviors on positive emotions whereas perceived constraints accounted for the long-term effects on negative emotions at the beginning stage of the COVID-19 pandemic. It was also noted that health-promoting behaviors did not have a direct effect on negative emotions (see Fig. 2). This was in line with the past study showing the lack of association between health behaviors in public spaces and perceiving alarming information about the severity of COVID-19 from media, which could produce negative emotions, such as fear and worry (Scopelliti et al., 2021). Similar patterns were also found in Study 3. Specifically, when the infection number and death rate was high in the Spring of 2022, perceived constraints were found to mediate the effects of health-promoting behaviors on both anxiety and depression, and personal mastery was found to mediate the effect of health-promoting behaviors on depression. According to SCT (Bandura, 1978, 2004), successful mastery experience is one of the major means to develop one's belief about his/her ability to influence the course of desired outcomes. The continuous engagement in health-promoting behaviors thus helps the individuals to accumulate more mastery experiences, which could enhance their control belief and thus contribute to better psychological well-being.

Further to the demonstrated effects of behavioral factors on personal factors in Studies 1 and 2, Study

3 supplements the evidence that environmental factors exert detrimental influences on psychological well-being when facing the most serious outbreak of COVID-19 in Hong Kong. In line with the past studies showing that factors related to personal resources (e.g., self-efficacy) were predictive of lower level of perceived COVID-19 risk (Figueiras et al., 2022) and that illness perceptions about COVID-19 negatively predicted mental health outcomes (Chong et al., 2021), the present research found that health-promoting behaviors could improve one's SOC, which subsequently led to a lower level of perceived COVID-19 severity and reduced their levels of anxiety and depression. This sequential mediation bridges the connection between individuals' health behaviors and the successive changes in personal and environment factors. These findings are unique in understanding the pathway through which engaging in health behaviors is beneficial to one's psychological well-being. These findings also echo with SCT that one's behavioral, personal, and environmental factors are reciprocally influencing one another, even in the face of the most severe stage of a naturalistic crisis. Specifically, the indirect effects of health-promoting behaviors on anxiety and depression were only present through perceived constraints, but not personal mastery, and then subsequently influenced perceived COVID-19 severity. This finding reveals that even though perceived constraints and personal mastery are characterized as personal beliefs under the SCT framework, the facet of perceived constraints seems to be more associated with external environment, thus affecting one's perceptions of the COVID-19 severity. Moreover, HBM proposes that one's health-related decision can be affected by one's personal (e.g., self-efficacy) and illness-related (e.g., perceived severity of illness) factors. The present research provides further empirical evidence to HBM that the commitment of such health-related behaviors could in turn reinforce one's level of psychological well-being through personal and illness-related factors.

The COVID-19 pandemic imposes substantial negative impacts on individual well-being such as elevated depressive and anxiety symptoms (e.g., Choi et al., 2020; Kwok et al., 2020). Yet, little is known about the protective factors in maintaining well-being in such a naturally-occurring crisis. The present research reveals that active engagement in health-promoting behaviors helps individuals to alleviate the negative emotional impacts of a pandemic through diminishing the perceived presence of obstacles. These findings therefore provide insights to health professionals to promote health behaviors among older adults to protect their psychological well-being even they are facing adversity and unforeseen crises.

Limitations and future directions

Several limitations should be considered when interpreting the findings of the present research. First, the participants were mainly recruited from community centers for older adults in Hong Kong, thus limiting the generalizability of the findings to other seniors such as hidden older adults. Second, the studies relied on self-reported measures to record the participants' health habits and responses to the pandemic. Future studies can include objective measures or behavioral indicators to minimize potential common method biases.

Nonetheless, the present research contributes to the current literatures on health behaviors and lifespan development by identifying factors influencing the psychological well-being of middle-aged and older adults in Hong Kong, as well as the underlying mechanisms where health-promoting behaviors affects psychological well-being. Future intervention programs are recommended to strengthen the cultivation of SOC and alleviation of threat perception to improve psychological well-being in middle-adulthood and old age.

To conclude, the three studies reported in this paper clearly demonstrate the beneficial effects of health-promoting behaviors on psychological well-being. The findings of the present research indicate that continuous engagement in health-promoting behaviors, particularly through cultivating SOC and alleviating perceived severity, is critical to reduce the psychological distress of middle-aged and older adults, even in the face of the COVID-19 pandemic.

Acknowledgements The authors thank the trained interviewers for their assistance in data collection as well as the participants for their participation in this study. They also appreciated the funding support from the Public Policy Research Funding Scheme and City University of Hong Kong.

Author contributions All authors listed have made a substantial, direct, and intellectual contribution to the work. Material preparation, data collection and analysis were performed by Edwin Chung, Alvin Ho, and Alfred Lam. The draft of the manuscript was written by Edwin Chung, Alvin Ho, Alfred Lam, and Dannii Yeung and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding This project was supported by the Public Policy Research Funding Scheme from the Policy Innovation and Co-ordination Office of the Government of the HKSAR (Project No.: 2020.A1.101.20B) and an internal grant from City University of Hong Kong (Project No.: 9610403), which were both awarded to Dannii Yeung. The funders had no role in study design, data collection, data analyses, data interpretation, or preparation of the manuscript.

Data availability The datasets generated in this research are available from the corresponding author upon reasonable request.

Declarations

Ethics approval The three studies were approved by the Human Subjects Ethics Sub-committee of the affiliated university (Reference no.:

Study 1: 3–4-201809_01; Study 2: B-PhD-202003–02; and Study 3: 3–3-202002–02 and B-SSPhD-202203–01). Written informed consent was obtained from all participants at the baseline measures of the three studies, whereas oral consent was sought from the participants joining Study 2 who completed the COVID-19 measures via telephone.

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

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