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# Social support and health behaviors of older adults during the COVID-19 pandemic in China: a moderated mediation model of loneliness and economic income

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## Abstract

**Background** The literature shows that social support is an important factor influencing health behaviors. This study aimed to explore the relationships and intrinsic pathways of social support, loneliness, economic income, and health behaviors among older adults during the Corona Virus Disease 2019 (COVID-19) pandemic, and to provide a theoretical basis for the implementation of health behaviors interventions for older adults.

**Methods** A cluster-random-sampling survey was adopted within two towns in Dongguan, China. Demographic characteristics, social support, loneliness, economic income and health behaviors were measured. The Social Support Appraisals scale (SS-A), the ULS-8 Loneliness Scale, and the Self-rated abilities for health practice scale (SRAHPS) were used to measure social support, loneliness, and health behaviors in older adults, respectively. A moderated mediation model was built to examine the relationships among social support, loneliness, economic income, and health behaviors using the SPSS PROCESS 4.0 macro. We conducted bootstrapping of regression estimates with 5000 samples and a 95% confidence interval.

**Results** 621 older adults completed the questionnaire. Most of the participants were female, accounting for 75.0%, and the average age was 81.11 years (SD = 8.11). The median (interquartile range) of the participants' average monthly economic income was 800 (500–1000)RMB. The results of the mediation analysis showed that loneliness partly mediated the relationship between social support and health behaviors ( $B = 0.024$ , 95%CI: 0.007, 0.042), with the mediating effect accounting for 4.56% of the total effect. The moderation mediation analysis revealed a positive moderating role of economic income in the relationship between social support and loneliness ( $B = 0.114$ , 95%CI: 0.054, 0.174). Specifically, the relationship between social support and loneliness was found to be weaker for older adults with a high economic income compared to those with a lower economic income.

**Conclusion** The provision of enhanced social support and the alleviation of loneliness among older adults during an epidemic can facilitate the development of healthy behaviours, particularly among those who are economically disadvantaged.

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**Keywords** Older adults, Social support, Health behaviors, Loneliness, Economic income

## Introduction

According to the *World Population Ageing 2020 Highlights*, the older population aged 65 and above reached 7.27 billion in 2020 and is expected to reach 15 billion in 2050, accounting for 16% of the world's population. China is experiencing a faster population aging process than other countries [1]; there are 260 million people aged 60 and above in China, accounting for 18.7% of the population. While the population is aging rapidly, the overall quality of life of older adults is an issue that needs attention, and the number of older adults with two or more chronic diseases is gradually increasing [2, 3]. In early 2020, the outbreak of Corona Virus Disease 2019 (COVID-19) in several regions of China [4] caused a major public health emergency due to its rapid spread, posing a great threat to people's physical and mental health [5]. Older adults as a vulnerable group are more prone to physical and psychological disorders such as headaches, tension, and depression, which undoubtedly caused mental health problems such as vicarious trauma, hypochondria, and compulsions during the epidemic, which in turn had a serious impact on the quality of life of older adults [6, 7].

According to the World Health Organization (WHO), 60% of quality of life is determined by individual and health behaviors. Health behaviors are actions taken by individuals with the intention of preventing disease or detecting disease at an early stage [8]. As the incidence of lifestyle-related chronic diseases rises on a global scale, researchers are increasingly focused on comprehending interventions that encourage healthy behaviors. This is particularly crucial for older individuals, who face greater physical and psychological vulnerabilities compared to their younger counterparts [9]. Studies have shown that good health behaviors can delay the further deterioration of health problems in older adults, such as reducing the incidence of chronic diseases and mortality [10, 11], and improving the quality of life of older adults [12]. However, the studies found that the health behaviors of older adults in developing countries are still at a low level [13]. Thus, it is essential to identify the relevant factors influencing health behaviors in the older adults and to investigate the potential pathways through which these factors affect health behaviors, especially considering the context of epidemics.

Social support plays an important role in an individual's health behaviors, which has been recognized by many studies in the field of health behaviors with the rise of social support theory in the field of health research [14]. Social support refers to the available social resources that individuals receive or perceive from their

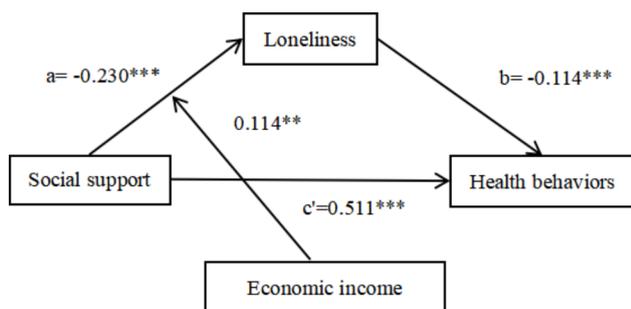
daily social networks [15]. Several studies have found that high levels of social support can lead to the development of good health behaviors [16], such as in regard to diet [17], physical activity [18], and smoking and drinking [19, 20]. It can occur in all age groups, but is more typical in older people [21, 22]. Nevertheless, the occurrence of numerous major negative life events in later life, such as bereavement, widowhood, and declining physical function, can seriously disrupt the continuity of older adults' social support networks [23, 24]. It is worth noting that older adults have more restricted interpersonal activities and further limited access to social support in the context of an epidemic, but the impact on their health behaviors is not yet known.

Nevertheless, not all individuals experiencing high levels of social support report adopting positive health behaviors [25]. Several factors may either enhance or diminish social support's positive influence on health behaviors. Notably, many international studies in this domain remain theoretical [26], lacking sample and life course diversity. Few studies have delved into potential pathways, such as mediators and moderators, between social support and health behaviors in older adults. Given the diverse factors influencing the health behaviors of older adults [27–29], it is imperative to consider potential moderators and other variables when examining the impact of social support on their health behaviors.

Loneliness has been established as a risk factor for health behaviors through research findings [30, 31]. Defined as perceived social isolation, loneliness is a negative emotional experience with significant impacts on an individual's physical and mental health [32], and is widely used as an important psychological outcome in many countries [33]. Previous studies have found that loneliness is an influential factor in health-promoting behaviors [34]. Older adults experiencing greater loneliness are prone to mood swings and are more likely to lose confidence in health-promoting behaviors due to their compromised mental health status [35]. Research further suggests that lower levels of social support may be associated with greater loneliness [36]. There is mounting evidence indicating that social support acts as a buffer against the detrimental effects of negative events and stressors [37]. Establishing, restoring, and maintaining a social identity through meaningful group-based connections has been shown to alleviate loneliness and support mental health [38, 39]. Additionally, loneliness has been identified as a mediating factor in the relationship between social support and mobile phone addiction [40]. Previous research has demonstrated that loneliness diminishes the association between the number of

illnesses and quality of life by 21.5% [41]. In the context of the current study, older adults, who typically experience lower levels of social support during the COVID-19 pandemic, may encounter heightened loneliness, subsequently contributing to compromised health behaviors. Thus, loneliness may act as a mediating factor in the relationship between social support and health behaviors.

As mentioned earlier, social support may contribute to reduced levels of health behaviors through the pathway of loneliness. However, variations in how this effect manifests and the presence of other contributing factors may contribute to the heterogeneity of outcomes. Research indicates that several factors influence the relationship between social support and loneliness, including perceived stress [42], physical condition [43], and sense of purpose [44]. Among these influencing factors, income is particularly noteworthy and has been highlighted by many experts [45, 46]. Individuals with higher economic incomes often seek independence and emotional distance from others, unlike those with lower economic incomes who may experience a lower sense of self-worth and fear of rejection and abandonment [47]. Lower economic income individuals may have a higher need for social support, making them more likely to adopt compensatory social support strategies to gain a sense of security [48]. Social support enables individuals to interact with others, strengthening interpersonal skills, which is especially important for those with lower economic incomes [49]. Furthermore, financial income serves as a predictor of loneliness. Some experts have found that individuals from low-income families may feel lonely due to limited participation in social activities and social relationships [50, 51]. On the other hand, better-off older adults are more likely to participate in recreational activities and generally experience lower levels of loneliness [52]. A cohort study confirms that individuals of lower economic status are much more likely to report loneliness, social isolation, and a lack of social support [53]. Therefore, it can be inferred that financial income may also play a moderating role in the relationship between social support and loneliness.



**Fig. 1** The final moderated mediation model. (\*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$ )

While most studies related to health behaviors primarily concentrate on the individual level, examining aspects like mental health [54], personal behaviors [55], positive orientation, etc [28]., few explore the societal perspective influencing health behaviors. Additionally, pathway analysis of health behaviors is seldom undertaken, and the underlying mechanisms remain unclear. There is an increasing demand for more diverse and theoretically grounded studies to extend findings and offer a comprehensive understanding of the factors that shape health behaviors. Hence, this study aims to integrate individual and social perspectives to comprehensively explore the factors influencing health behaviors. Based on existing research, a potential correlation among the four variables of social support, loneliness, economic income, and health behaviors has been noted. Identifying pathways for health behaviors becomes even more crucial during the COVID-19 outbreak, especially for older adult groups. As a result, this study has developed a moderated mediation model to systematically investigate the effects of social support, loneliness, and economic income on health behaviors and how these factors interact.

Based on a review of the literature, this study hypothesizes the following pathways: (1) social support significantly and positively predicts the health behaviors of older adults; (2) loneliness mediates the relationship between social support and the health behaviors of older adults. (3) Economic income can positively moderate the first half of the mediation pathway of “social support→loneliness→health behaviors”. Figure 1 shows a diagram of the model.

**Methods**

**Study design and participants**

Cluster random sampling was adopted for the study. In this study, the median number of 130 was used for the calculation of the variance inflation factor ( $m=130$ ). The overall standard deviation of health behaviors of older adults was predicted from previous studies:  $\sigma=19.09\%$  [56], and a difference of 10% was considered effective ( $\epsilon=0.1$ ). We assumed a probability of 0.05 ( $\alpha=0.05$ ) and a test efficacy of 0.8 ( $\beta=0.2$ ) for allowing a type I error, while the estimated intra-group correlation coefficient ( $\rho_1$ ) was 0.05. The minimum sample size was 426 according to the cluster randomization sample size formula.

$$n = \frac{2(Z_{1-\alpha/2} + Z_{1-\beta})^2 \sigma^2 [1 + (m-1)\rho_1]}{(\mu_2 - \mu_1)^2} = \frac{2 \times (1.96 + 0.84)^2 \times 0.1909^2 \times [1 + (130 - 1) \times 0.05]}{0.1^2} \approx 426$$

It was assumed that the sample efficiency rate was 80%, and therefore the minimum sample size was 533. According to the data from the *Dongguan Statistical Yearbook 2021*, nearly 25% of the communities have a resident

population of between 11,000 and 18,000. According to the data from the seventh census of Dongguan City, the percentage of people aged 60 and above in Dongguan is 5.47%, so it was estimated that the number of study subjects in the community who met the inclusion criteria would be about 600–980, and assuming a response rate of 50%, then approximately 300–490 subjects would be available in the community. Therefore, two communities were selected as the study sites in this study. The inclusion criteria were as follows: (1) Older adults who were 60 years old or above; (2) without cognitive dysfunction; and, (3) without the acute onset of disease when the survey was carried out. The exclusion criteria were: (1) not signing the informed consent form; and, (2) not cooperating with the investigation.

Face-to-face interview-based questionnaires were administered by trained interviewers in September–December 2021 during the COVID-19 prevention and control period. All procedures involving human subjects were approved by the Review Ethics Committee of the Affiliated Hospital of Guangdong Medical University (PJ2019-064).

## Measurements

### *Social support and health behaviors*

The Social Support Appraisals scale (SS-A) developed by Vaux et al. [57] was used to evaluate the social support of older adults. The Chinese version of the SS-A shows sufficient reliability and validity (Cronbach's alpha=0.927, Kaiser-Meyer-Olkin=0.924). The scale contains three dimensions (family support, friend support, and other support) and 20 items with a four-point Likert scale, which scores items from 1 (“strongly disagree”) to 4 (“strongly agree”) respectively. In order to facilitate a comparison, a standard formula was used to convert the original scores into percentages (0 to 100). The higher the score, the better the social support. The SS-A showed high internal consistency in this study (Cronbach's alpha=0.934).

The Self-rated abilities for health practice scale [58] (SRAHPS) was used to measure health behaviors. It contains four dimensions (health responsibility, psychological well-being, exercise, and nutrition) and 28 items with scores from 1 to 5 representing “totally incapable of doing” and “absolutely certain of doing” respectively. As above, the original scores were converted into percentages (0 to 100); the higher the total score, the better the health behaviors. The Cronbach's alpha of the scale was 0.969 in this study.

### *Loneliness and economic income*

The ULS-8 Loneliness Scale, which was simplified by Hays et al. [59] based on the University of California Los Angeles Loneliness Scale, was used for Loneliness. It is an

8-item measure with a four-point Likert scale from 1 to 4 representing “never” and “always”, with scores ranging from 8 to 32, and higher scores indicating higher loneliness. In this study, the Cronbach's alpha was 0.867.

The average monthly economic income of older adults (including pension, savings, rent, financial support from relatives and friends, government assistance, etc.) was used as a moderating variable to assess economic income.

### *Covariates*

To minimize bias, the covariates were adjusted including gender (male=1, female=2), age (60~64=1, 65~69=2, 70~74=3, 74~79=4, 80~84=5, ≥85=6), marital status (married=1, divorced/widowed=2, never married=3), and educational attainment (Primary school and below=1, Junior school=2, High school or technical secondary school=3, College and higher=4) with reference to the relevant literature findings.

### *Statistical analysis*

Data were analyzed by SPSS 26.0. Descriptive statistics were adopted to present the characteristics of the participants. The mean (standard deviation, SD) was used for the continuous variables, and frequencies (percentages) were used for the categorical variables. For the univariate analysis, the significance of the differences between participants with different sociological characteristics was examined by using an independent *t*-test or analysis of variance where appropriate. Pearson correlation analysis was employed to evaluate the correlation between social support, loneliness, and health behaviors. Model 4 and Model 7 of the PROCESS macro for SPSS was performed for the mediation and moderated mediation model, and the bias-corrected 95% confidence interval (CI) was calculated with 5000 bootstrapping resamples. If the confidence interval did not include 0, the effect was considered significant. In order to visualise the moderation results, a simple slope test was conducted on the mean ± 1 SD of the moderator. Conditional effects and confidence intervals were then plotted using the Johnson-Neyman (J-N) technique. All of the estimated effects reported by PROCESS were standardized regression coefficients.

## Results

### *Sociodemographic characteristics*

A total of 621 participants aged ≥ 60 years effectively completed the interviews, of whom 155 (25%) were men and 466 (75%) were women. The average age was 81.11 years (SD=8.11) and 38.6% of the participants were ≥ 85 years old. The vast majority (94.8%) of participants had a low level of education and 54.3% were divorced or widowed. The median (interquartile range) of the participants' average monthly economic income was 800 RMB (IQR: 500–1000). The average health behaviors score of

the older adults was 50.70 (SD=17.74), indicating a moderate level. There were significant differences in health behaviors between the subgroups of demographic characteristics except for gender. Overall, older adults in higher age groups, who had never married and with less education had relatively worse health behaviors ( $P < 0.05$ ). (Details in Table 1.)

**Bivariate correlations among all the variables**

Analysis of the correlation between social support, loneliness, and health behaviors in older people showed that social support and loneliness were negatively correlated ( $r = -0.317, P < 0.01$ ); Social support and health behaviors were positively correlated ( $r = 0.526, P < 0.01$ ), and health behaviors and loneliness were negatively correlated ( $r = -0.250, P < 0.05$ ). The results showed that higher social support meant less isolation and better health behaviors among older adults. (Details in Table 2.)

**Mediation analyses**

Model 4 of the Hayes Development PROCESS program was employed to test the mediating role of loneliness between social support and health behaviors (Table 3). Under the premise of controlling for confounding variables, the results showed that not only was the total effect (path c) of social support on health behaviors significant ( $B = 0.527, P < 0.001$ ), but the direct effect (path c') was also statistically significant ( $B = 0.053, P < 0.001$ ). Bootstrap analysis revealed that the mediating effect (path a \*path b) of loneliness was significant ( $B = 0.024, 95\%CI: 0.007, 0.042$ ), which meant that loneliness was partially mediated in the relationship between social support and health behaviors, and the direct effect (0.503) and the mediating effect (0.024) accounted for 95.44% and 4.56% of the total effect (0.527), respectively.

**Moderated mediation analyses**

Using the PROCESS macro in SPSS, we investigated the moderating impact of economic income on the association between social support and loneliness. The outcomes are presented in Table 4. The interaction term of social support and economic income had a significant positive predictive effect on loneliness ( $B = 0.114, 95\%CI: 0.054, 0.174$ ), which suggested that economic income plays a moderating effect in the prediction of social support on

**Table 1** Sociodemographic characteristics and the distribution of health behaviors (n=621)

| Variables                                 | n/(%)      | Health behaviors(M±SD) | F/t                | P      |
|---|------------|------------------------|--------------------|--------|
| <b>Gender</b>                             |            |                        | 1.079 <sup>a</sup> | 0.281  |
| Male                                      | 155(25%)   | 52.03±17.84            |                    |        |
| Female                                    | 466(75%)   | 50.25±17.70            |                    |        |
| <b>Age</b>                                |            |                        | 3.175 <sup>b</sup> | <0.001 |
| 60~64                                     | 9(1.4%)    | 48.91±19.12            |                    |        |
| 65~69                                     | 51(8.2%)   | 55.65±14.46            |                    |        |
| 70~74                                     | 76(12.2%)  | 54.88±12.95            |                    |        |
| 75~79                                     | 120(19.3%) | 50.21±17.03            |                    |        |
| 80~84                                     | 125(20.1%) | 46.45±15.41            |                    |        |
| ≥85                                       | 240(38.6%) | 50.85±20.49            |                    |        |
| <b>Marital status</b>                     |            |                        | 8.133 <sup>b</sup> | <0.001 |
| Married                                   | 254(40.9%) | 52.37±15.19            |                    |        |
| Divorced/widowed                          | 337(54.3%) | 50.50±18.86            |                    |        |
| Never married                             | 30(4.8%)   | 38.75±20.49            |                    |        |
| <b>Education attainment</b>               |            |                        | 3.391 <sup>b</sup> | 0.018  |
| Primary schools and below                 | 4 (0.6%)   | 29.02±13.39            |                    |        |
| Junior school                             | 581(94.2%) | 50.51±17.74            |                    |        |
| High school or technical secondary school | 29(1.1%)   | 56.89±15.14            |                    |        |
| College and higher                        | 7(1.1%)    | 55.35±20.26            |                    |        |

Notes: <sup>a</sup>Independent t-test: Gender;<sup>b</sup>One-way analysis of variance (ANOVA): Age, Marital status, Education attainment

**Table 2** Correlation matrix(n=621)

| Variables        | Social support | Loneliness | Health behaviors |
|------------------|----------------|------------|------------------|
| Social support   | 1.000          |            |                  |
| Loneliness       | -0.317**       | 1.000      |                  |
| Health behaviors | 0.526**        | -0.250**   | 1.000            |

Notes: \*\* $P < 0.01$

loneliness; therefore, hypothesis 3 is supported. The final model diagram is shown in Fig. 1.

**Simple slope test and J-N technique analysis of the moderating effect of economic income**

To further elucidate the mediating role of economic income on social support and loneliness, this study categorized economic income into high and low groups (one SD above the mean and one SD below the mean, respectively). As shown in Table 5, regardless of the level

**Table 3** Mediation analysis (n=621)

| Variable                      | Path c   |       | Path c' and b |       | Path a    |       | Path a * b |       | LLCI  | ULCI  |
|-------------------------------|----------|-------|---------------|-------|-----------|-------|------------|-------|-------|-------|
|                               | B        | SE    | B             | SE    | B         | SE    | B          | SE    |       |       |
| Social support                | 0.527*** | 0.036 | 0.503***      | 0.037 | -         | -     | 0.024      | 0.009 | 0.007 | 0.042 |
| Loneliness                    | -        | -     | -0.101**      | 0.038 | -0.237*** | 0.038 |            |       |       |       |
| R <sup>2</sup> <sub>adj</sub> | 0.278    |       | 0.286         |       | 0.202     |       |            |       |       |       |
| F                             | 39.388   |       | 35.087        |       | 25.984    |       |            |       |       |       |

Notes: controlling for gender, age, marital status, and educational attainment. \*\*\* $P < 0.001$ , \*\* $P < 0.01$

**Table 4** Moderated mediation analysis (n = 621)

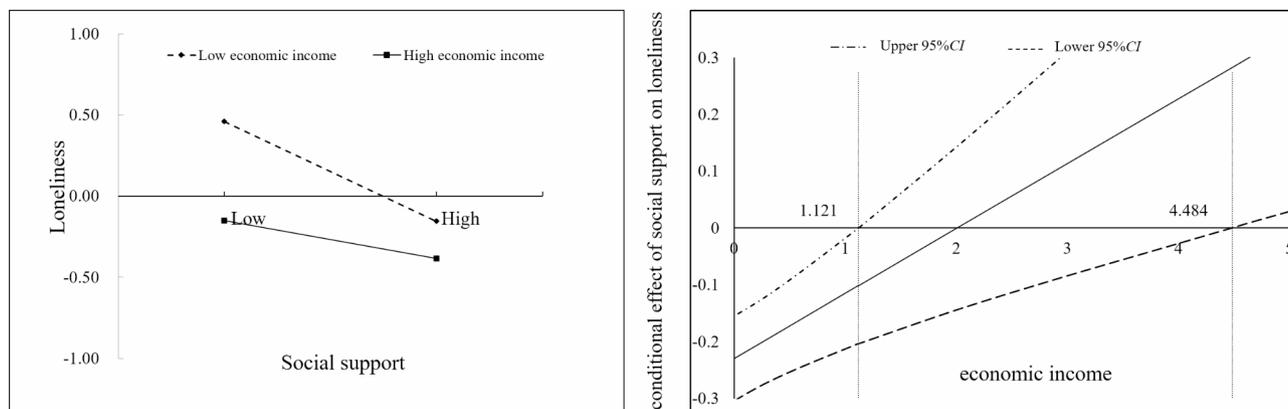
| Outcome: Loneliness              |        |       |           |        |        |
|----------------------------------|--------|-------|-----------|--------|--------|
| Variable                         | B      | SE    | t         | LLCI   | ULCI   |
| Social support                   | -0.230 | 0.038 | -6.130*** | -0.304 | -0.156 |
| Economic income                  | -0.251 | 0.062 | -4.018*** | -0.374 | -0.128 |
| Social support * Economic income | 0.114  | 0.031 | 3.728***  | 0.054  | 0.174  |
| Outcome: Health behaviors        |        |       |           |        |        |
| Variable                         | B      | SE    | t         | LLCI   | ULCI   |
| Social support                   | 0.511  | 0.037 | 13.889*** | 0.439  | 0.583  |
| Loneliness                       | -0.114 | 0.038 | -2.978**  | -0.190 | -0.039 |

Notes: \*\*\* $P < 0.001$ , \*\* $P < 0.01$

**Table 5** Effect of social support for older adults on loneliness at different levels of economic income

|                 | B      | SE    | t      | P       | LLCI   | ULCI   |
|-----------------|--------|-------|--------|---------|--------|--------|
| Mean-SD         |        |       |        |         |        |        |
| Economic income | -0.307 | 0.042 | -7.287 | < 0.001 | -0.389 | -0.224 |
| Mean            |        |       |        |         |        |        |
| Economic income | -0.230 | 0.038 | -6.130 | < 0.001 | -0.304 | -0.156 |
| Mean + SD       |        |       |        |         |        |        |
| Economic income | -0.116 | 0.049 | -2.344 | 0.019   | -0.213 | -0.019 |

Notes: SE = Standard Error, LLCI = low limit confidence interval, ULCI = upper limit confidence interval



a. The moderating role of economic income between social support and loneliness

b. The conditional effect of social support on loneliness at the values of economic income by the J-N method

**Fig. 2** Simple slope plots and J-N Fig

of economic income, the relationships between economic income on social support and loneliness were all significantly moderated, and the lower the level of social support, the more significant the moderating effect of economic income on loneliness ( $P < 0.05$ ). The results from the simple slope analysis revealed that, at any level of economic income, an increase in the level of social support was associated with a decrease in loneliness. Specifically, when comparing individuals with higher economic income ( $B = -0.116$ ), those with lower economic income ( $B = -0.037$ ) exhibited a stronger correlation between social support and loneliness (Details in Fig. 2a).

The findings indicate a statistically significant turning point within the observed range of economic income as identified by the Johnson-Neyman method. Figure 2b

shows that the 95% CI of the 0-point cutoff is 1.121 to 4.484, which suggests that there is a moderating effect of economic income in the relationship between social support and loneliness when the standard economic income score is less than 1.121 or greater than 4.484.

## Discussion

### Total effects of social support on health behaviors

In line with hypothesis 1, social support positively predicts health behaviors in older adults. Social support among older adults is a protective factor for health behaviors, which is consistent with the existing research findings both nationally and internationally [60, 61]. It is suggested that the increased level of social support during the COVID-19 pandemic promoted the development

of health behaviors in older adults. Social support was a positive resource during the pandemic, which might have contributed to responsible behaviors, such as health-protective self-care behaviors and other recommended actions to mitigate the spread of COVID-19 [62]. Furthermore, the perception of a positive and close interpersonal environment, driven by social support, influences the sense of belonging, which may also promote health behaviors [63]. As they age, most older adults inevitably experience social loss and are at risk of having their social support destroyed. Having adequate external support from family, friends and society can positively influence older adults' behaviors in the face of adverse physical and psychological symptoms [64]. In addition, for older adults, visits from family and loved ones are a major source of social interaction and happiness. The social distance measures resulting from COVID-19 required people to limit their contact with the outside world, which led to the inevitable "social isolation" of older adults, making the role of social support even more important [65].

#### **Mediating effects of loneliness between social support and health behaviors**

The current study found a partially mediating role of loneliness between social support and health behaviors and Hypothesis 2 is therefore supported. The study further extends the findings by showing that social support can affect older adults' health behaviors both directly and indirectly by influencing feelings of loneliness. In other words, high levels of social support were associated with lower levels of loneliness, which in turn were associated with lower levels of health behaviors. These findings are consistent with previous studies that showed a negative association between social support and loneliness [66] and a negative association between loneliness and health behaviors [67, 68]. Some studies point to social support as a buffer that reduces feelings of social isolation [69]. This is consistent with the assumptions of the buffer model [70] in which social support is a protective resource against loneliness, buffering the negative effects of stress, particularly on physical and mental health [71], and helping improve people's health behaviors. The cumulative effects of loneliness on poor health are greatest over time and therefore manifest themselves mostly in older adults, particularly those with the greatest cumulative exposure [72]. During epidemics of prevention and control, older adults experience greater loneliness due to stricter activity control and limited social interaction, which may further influence their health behaviors. Social support could have buffered against the adverse psychological conditions arising from the COVID-19 epidemic and mitigated the negative effects on older adults when faced with feelings of loneliness. Therefore, in the

context of a disease epidemic, the loneliness situation of older adults can be mitigated through positive buffers such as social support to meet the emotional and other needs of older adults [73], which may contribute to better health protective behaviors.

#### **Moderating effect of economic income between social support and loneliness**

After clarifying the mediating role of loneliness, this study found significant moderating effects of economic income on the effects of social support and loneliness, and hypothesis 3 was supported. With regard to the moderating effect of economic income, the social support for older adults with higher monthly income levels had a weaker effect on improving loneliness. In many countries, older adults with low economic income may suffer from poor mood and behavioral problems due to financial stress, and their families may be more prone to loneliness due to increased interpersonal conflict and decreased family warmth [74]. This will lead to higher levels of psychological distress, especially during outbreak prevention and control [75]. In addition, possible reasons for lower levels of loneliness in higher income groups may lie in the fact that the wealthy have more activity options (e.g., travel, recreational activities), which has the potential to reduce mental distress [76]. This means that older adults with higher incomes have more options to cope with their mental distress, which helps to reduce their level of loneliness. For the low-income group, their options are limited, so factors of social support are more important in determining their psychological well-being. The COVID-19 epidemic had an unprecedented impact on economic activity in China and the elderly are vulnerable to fluctuations in economic income [77]. Therefore, it seems particularly important for low-income Chinese older adults to increase the availability of spiritual comfort in their homes as well as community-based professional services such as life care, psychological support, moderate family involvement activities and social participation activities.

#### **Limitations of the study**

Despite the contributions of this paper, it also has some limitations. Firstly, the present study was a cross-sectional survey and it was not possible to verify the temporal order of the independent, mediating, moderating, and dependent variables. Therefore, further longitudinal studies should be conducted to validate the findings. Secondly, our sample is exclusively derived from Dongguan, China, a geographically limited area that restricts broader generalizations. Given our primary focus on the senior older adults population, which might have contributed to relatively more conservative outcomes in our study. Therefore, we recommend conducting multicenter

studies and incorporating participants from diverse age groups to enhance the relevance and applicability of the research findings. Finally, other variables (e.g., self-reported health and functional limitations) are also important such as contextual variables that may be associated with social support and health behaviors. Further research needs to include more variables to better understand this issue more fully.

## Conclusions

In summary, this is the first investigation into the relationship between social support and health behaviors of older adults during an epidemic through the use of a moderated mediator model. In the present study, loneliness mediated the association between social support and health behaviors. In addition, economic income moderated the strength of the mediator, with higher economic income leading to lower indirect effects of the mediator. For older adults with low social support, especially those who experience high levels of loneliness and suboptimal levels of economic income, it may be important to design interventions that combine increased economic income and decreased loneliness to promote the development of healthy behaviors.

## Abbreviations

|      |  |
|------|--|
| LLCI | Low limit confidence interval          |
| SD   | Standard Deviation                     |
| SE   | Standard Error                         |
| SPSS | Statistical Package for Social Science |
| ULCI | Upper limit confidence interval        |

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## Author contributions

Y.Lin designed the study, wrote the protocol, carried out the data collection and revised the manuscript. J. Peng carried out the data collection, management and undertook the statistical analysis, and wrote the manuscript. Q. Zhou, H. Qi, and Z. Fan carried out the data collection. All authors contributed to editing the manuscript and have approved the final manuscript.

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## Data availability

The datasets generated and/or analysed during the current study are not publicly available due to the owners considering further publications, but are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

This study received approval from the Institutional Review Board of Guangdong Medical University Affiliated Hospital (Approval No: PJ2019-064). All methods were performed in accordance with the relevant guidelines and

regulations, and informed consent was obtained from the study subjects before the investigation.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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