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Original Study

Bidirectional and Dynamic Relationships Between Social Isolation and Loneliness Among Older Adults in China

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Keywords:
Social isolation
Loneliness
Older adults
Longitudinal analysis

A B S T R A C T

Objectives: This study aimed to investigate the bidirectional associations and temporal dynamics between social isolation (SI) and loneliness among older adults.
Design: This is a prospective cohort study.
Setting and Participants: With the global phenomenon of population aging, there has been a significant increase in the prevalence of SI and loneliness among older adults. These factors exert substantial impacts on the health and well-being of this population. Consequently, it is imperative to implement more effective interventions targeting SI and combating loneliness in order to enhance the overall health and well-being of older adults.
Methods: Data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) were analyzed, focusing on individuals aged 65 and older. Generalized Cross-Lagged Modeling (GCLM) was used to assess these associations.
Results: The findings reveal significant cross-lagged effects between SI and loneliness over the course of 16 years. Higher levels of SI at 1 time point predict increased loneliness scores in subsequent periods, and greater levels of loneliness at 1 time point predict higher SI scores in future periods. Notably, the impact of SI on loneliness is found to be larger and more enduring compared to the influence of loneliness on SI. These cross-lagged effects persist over an extended period, indicating a long-term reciprocal relationship between SI and loneliness among older adults.
Conclusions and Implications: This study provides valuable insights into the bidirectional associations between SI and loneliness among older adults. Given that the effect of SI dominates, the findings suggest that public health strategies aimed at promoting health and well-being should prioritize interventions that enrich older adults' social networks. Emphasizing early interventions aimed at enhancing social networks is essential for promoting healthy aging and overall well-being.

With the global population aging rapidly, social isolation (SI) and loneliness are emerging as significant concerns for older adults. SI and loneliness are 2 dimensions of impoverished social relationships, representing objective and subjective aspects, respectively.[1] SI refers to a low frequency of social contacts,[2] and loneliness reflects dissatisfaction with objective social relationships.[3] Although these terms are often used interchangeably, they should be considered separate constructs. Feeling lonely does not necessarily imply SI, and experiencing SI does not necessarily mean feeling lonely.

Studies have shown that SI affects between 20.2% and 44.9% of older adults in their later years,[4] and China particularly stands out with a prevalence of 42.4%.[5] Similarly, between 22.9% and 35.0% of older adults worldwide experience loneliness,[4] whereas China reports a loneliness rate of 31.3% among its older population.[5] These findings emphasize the pronounced prevalence of SI and loneliness among older individuals in China, underscoring the importance of addressing these issues within this population. Research has shown that loneliness and SI can affect various aspects of health, including health-related quality of life, disability, cognitive function, and frailty.[6-9] The 2015 report by the World Health Organization (WHO) emphasized that "loneliness and SI can significantly influence the mental and physical health of older adults,"[10] attributing 40% to 80% of health

The data used in this paper are openly available in https://opendata.pku.edu.cn/dataset.xhtml?persistentId=doi:10.18170/DVN/WBO7LK&version=2.0.

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disparities directly or indirectly to these factors.[11] Therefore, it is imperative to implement more effective interventions to mitigate SI and loneliness and enhance the health of older adults.

The evolutionary theory of loneliness offers an explanation for the relationships between SI and loneliness.[12] According to this model, SI and loneliness interact with each other and can reinforce and perpetuate one another over time. Loneliness can trigger a range of interconnected behavioral, hormonal, neural, cellular, and transcript adjustments that promote short-term survival. However, loneliness can also lead individuals to develop a motivation to avoid others, increasing their tendency to rely on themselves if they lack aid and support. Consequently, lonely older adults may experience more negative social interactions, further intensifying their feelings of loneliness.[12]

Within this framework, several empirical studies have explored the relationship between SI and loneliness. Some research has indicated that SI is a risk factor for loneliness.[13,14] Conversely, only a limited number of studies have investigated how loneliness affects SI.[15,16] To our knowledge, only one study has explored the impact of loneliness on SI while controlling for reverse causality.[16] However, it is worth noting that the mean age of the participants in this study was around 60 years, which may not adequately represent the oldest-old population. In summary, it remains unclear whether bidirectional relationships exist between SI and loneliness among older adults. Further research is needed to gain a deeper understanding of these relationships and their implications for interventions aimed at promoting the health and well-being among older adults.

Exploring the bidirectional relationships between SI and loneliness is crucial for several reasons. First, current estimates regarding how loneliness affects SI (loneliness→SI) and how SI affects loneliness (SI→loneliness) may be flawed because of spurious connections created by reverse causality.[13,14,16] Therefore, it is necessary to use methods that account for reverse causality in order to establish the causal ordering between these 2 processes and obtain accurate estimates of their associations. Second, it remains unclear which factor has a more influential effect, which can have implications for targeting preventive measures. If loneliness has a greater influence in the bidirectional relationships, interventions should focus on reducing loneliness. Conversely, if SI has a more crucial role, interventions should prioritize reducing SI.[15] Last, neglecting to consider the bidirectional relationship between SI and loneliness can hinder our understanding of the temporal dynamics between these phenomena. Currently, we lack knowledge about the time frame for the dose-response relationship between SI and loneliness, as well as the autoregressive properties of these factors. Gaining a better understanding of these dynamics can optimize the timing of interventions aimed at reducing SI and loneliness among older adults, ultimately improving their efficiency and effectiveness.[16]

The aims of this study were to investigate the bidirectional associations between SI and loneliness among older adults, as well as to establish the temporal dynamics and effect horizons associated with these associations. To achieve this objective, we used 16-year follow-up data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), which is a nationally representative community-based survey of older adults in China. A General Cross-Lagged Panel Model (GCLM) was used to analyze the data. This model enables us to explore the causal ordering between these 2 constructs while accounting for potential confounding factors and addressing issues of reverse causality.

Methods

Data and Participants

The data for this study were obtained from CLHLS, a longitudinal social survey that covers 23 of the 31 provinces in China and represents approximately 85% of the total population. The initial survey was conducted in 1998, followed by data collection in 7 subsequent waves: 2000, 2002, 2005, 2008, 2011, 2014, and 2018. Participants aged 65 years and older were included in the survey starting from the 2002 wave. Data from the 2002, 2005, 2008, 2011, 2014, and 2018 waves of CLHLS were used. Further information about CLHLS can be found in other sources.[17] To ensure data reliability, we excluded individuals younger than 65, as they comprised only 1% of the total sample. In addition, participants who were tracked less than twice throughout the data collection waves were excluded. Consequently, the number of respondents for each wave was as follows: 2002 (n = 8136), 2005 (n = 11427), 2008 (n = 11571), 2011 (n = 9194), 2014 (n = 6551), and 2018 (n = 3469).

In this study, it is worth noting that there were missing data of 1.6% and 11.8% for SI and loneliness, respectively. To address potential biases associated with missing data, we used multiple imputation (MI) techniques to fill in missing data. This approach helps compensate for any gaps in the dataset and minimizes the impact of missing information. The "Markov Chain Monte Carlo" method was specifically used, with 5 imputations performed for robust estimates through MI. Five imputations were considered adequate for generating reliable results using MI. For a more detailed understanding of the "Markov Chain Monte Carlo" method, please refer to another study.[18] Additional details regarding the characteristics of the sample and the correlations among the variables analyzed in this study can be found in Supplementary Tables 1 and 2, respectively.

Measures

Social isolation

In this study, the measurement of SI in older adults used the SI index, which has been validated and confirmed for its reliability by multiple previous studies.[5,7,8,19,20] Consistent with the recommendations from existing literature,[5,20,21] we considered 5 dimensions to assess SI. These dimensions included (1) living alone, (2) having a spouse, (3) frequent contact with children, (4) frequent contact with siblings, and (5) participating in social activities like playing cards or mahjong, joining organized social events, or working. Individuals who resided alone, lacked a spouse, had infrequent contact with children/siblings, or had limited social participation were coded as 1. Conversely, a value of 0 was assigned to individuals who did not live alone, had a spouse, received frequent visits from children/siblings, or engaged in social activities. The cumulative scores ranged from 0 to 5.

Loneliness

For the purpose of assessing loneliness in this study, a solitary item was used. Participants were queried with the question, "Do you experience feelings of loneliness?" The provided response choices encompassed the following: "never" (0 points), "rarely" (1 point), "occasionally" (2 points), "frequently" (3 points), and "constantly" (4 points). The cumulative loneliness score spanned from 0 to 4 points. This singular item-based scale for measuring loneliness has been extensively applied in preceding research conducted with older adults, demonstrating robust face and predictive validity.[5,7,19,22,23]

Analysis

The study used GCLM to analyze the data.[24] This statistical technique allowed for estimating bidirectional associations between 2 variables and provided insights into the temporal dynamics of their relationships. GCLM has been increasingly applied in research investigating the bidirectional links of independent but interrelated variables.[21,24,25] To fit our model, we used MPlus 8 software and implemented a structural equation modeling framework following

the approach proposed by Zyphur and collegues.[24] The model specification used in this study can be formally expressed as follows:

$$L_{it} = \beta_1 SI_{it-1} + \beta_2 L_{it-1} + \theta_t + \mu_i + \epsilon_{it}$$

$$SI_{it} = \gamma_1 L_{it-1} + \gamma_2 SI_{it-1} + \sigma_t + \alpha_i + e_{it}$$

In the proposed model, the subscripts i and t represent individuals and time periods, respectively. *SI* denotes social isolation, and *L* represents loneliness. β_1, β_2, γ_1, and γ_2 are to be estimated, capturing the relationships between the variables. θ and σ represent the occasion effect, and μ and α capture the time-invariant effect. ϵ and e represent idiosyncratic error terms. Crucially, the model accommodates time-varying and time-invariant confounding factors by incorporating correlation terms between ϵ and e, as well as μ and α.[21,24] Prior research has demonstrated that incorporating these correlation terms is a more effective strategy for controlling confounding factors compared with including individual confounding variables as covariates.[24] This approach has gained growing recognition and has been increasingly used in other studies as well.[21,25]

Of particular interest are the cross-lagged coefficients β_1 and γ_1, which reveal whether and how differences in SI and loneliness at one time point predict differences in loneliness and SI at the next time point, respectively. The autoregressive paths β_2 and γ_2 indicate the extent to which within-individual deviations from expected scores in loneliness and SI, respectively, can be predicted from deviations from their past scores. The model allows for calculating the time horizon of dose-response relationships between loneliness and SI, as well as the corresponding autoregressive properties through linear combinations of the regression coefficients.[24] Before inclusion in the model, the variables were standardized, thereby expressing the regression coefficients as standard deviations (SD) from the mean. This standardization process facilitates comparisons across the different variables used in the analysis. To assess the goodness of fit of the model, several model fit indices were used, including the Confirmatory Fit Index (CFI), Tucker Lewis Index (TLI), root mean square error of approximation (RMSEA), and standardized root mean squared residual. Nonparametric bootstrapping with 10,000 replications was used to calculate confidence intervals (CIs).[24]

Results

The participants had an average age of 81.83 years. Women constituted 54.8% of the sample. Approximately 42.5% of the participants had received at least 1 year of education, and most (56.1%) lived in rural areas. The participants reported an average SI score of 2.87 and an average loneliness score of 0.98. For further comprehensive information, please consult Supplementary Table 1.

Table 1 presents standardized GCLM regression coefficients and their 95% CIs for key parameters of interest in relation to loneliness and SI over time. The analysis reveals that greater levels of SI at a given time point were associated with higher levels of loneliness in the future (β_1). Specifically, each increment of 1 SD in SI increased loneliness by 0.268 SDs (95% CI, 0.225–0.304). Similarly, higher levels of loneliness at a given time point were associated with higher SI in the future (γ_1), with each increment of 1 SD in loneliness increasing SI by 0.062 SDs (95% CI, 0.051–0.072). Furthermore, the autoregressive coefficients for loneliness ($\beta_2 = 0.087$; 95% CI, 0.073–0.102) and SI ($\gamma_2 = 0.396$; 95% CI, 0.369–0.423) were statistically significant. This suggests that the past levels of loneliness and SI can predict and increase their future levels.

Figure 1 depicts the dynamic impact of past within-subject variations in both SI and loneliness on future scores, with the baseline year being 2002. The figure shows the trends of autoregressive and cross-lagged effects over a span of 16 years. Except for the $L_{2002} \rightarrow SI_t$ path, both the autoregressive and cross-lagged effects show a decreasing trend over the subsequent 16 years. However, despite the decline, these effects remain statistically significant even after 16 years. The $L_{2002} \rightarrow SI_t$ path initially shows an increasing trend, followed by a subsequent decrease. Nonetheless, even after 16 years, this path still demonstrates significant effects. Overall, the model coefficients and the figure provide evidence of 2 key findings: (1) autocorrelations on SI are larger than those on loneliness over time, and (2) the effects of SI on loneliness are larger and more enduring compared with the effects of loneliness on SI.

Table 1
Key Model Parameters and Selected Goodness-of-Fit Statistics From GCLM (CLHLS, Waves 2002–2018)

	Standardized Coefficient (95% CI)
Model parameters	
$SI_{t-1} \rightarrow SI_t$	0.396 (0.369–0.423)
$SI_{t-1} \rightarrow L_t$	0.268 (0.225–0.304)
$L_{t-1} \rightarrow L_t$	0.087 (0.073–0.102)
$L_{t-1} \rightarrow SI_t$	0.062 (0.051–0.072)
Goodness-of-fit statistics	
CFI	0.993
TLI	0.988
RMSEA	0.016
SRMR	0.024

L, loneliness; SRMR, standardized root mean squared; t-1 represents the past levels, and t the future levels.

Discussion

With the significant aging of the population in China, SI and loneliness have become pressing issues that need to be addressed in order to enhance the health and well-being of older adults.[10] Building on the evolutionary theory of loneliness, the present study investigated the bidirectional associations between SI and loneliness among older adults using nationally representative data and GCLM. Overall, the study indicated bidirectional and dynamic relationships between SI and loneliness among Chinese older adults. More specifically, the study yielded 2 key findings of substantial importance in the context of promoting healthy aging through preventive interventions.

First, our findings revealed a significant association between higher levels of SI at a particular time point and increased loneliness scores in the future. Simultaneously, higher levels of loneliness at a given time point were associated with higher SI scores in the future. These discoveries substantiate the evolutionary theory of loneliness. This bidirectional relationship can be influenced by various factors, including socioeconomic status, self-perception of aging, and functional health.[26] Furthermore, they are in harmony with earlier studies that have identified SI as a contributing factor to loneliness.[13,14] However, our results differ from another study that also controlled for reverse effects between SI and loneliness.[16] That study found that loneliness did not have an impact on SI. It is important to note that the mean age of participants in our study was older than 85 years, which is considerably older than the participants in the other study. This age difference could potentially explain the inconsistent results because both SI and loneliness are known to be associated with age.[12]

The results of our analysis revealed that the standardized coefficient representing the effect of SI on future loneliness (0.268) was significantly larger than the standardized coefficient representing the reverse relationship (0.062). This emphasizes the importance of both SI and loneliness in understanding the experiences of older adults. However, the substantial difference in the coefficients suggests that placing a greater emphasis on promoting high-quality social relations could enhance the efficiency and effectiveness of policy strategies

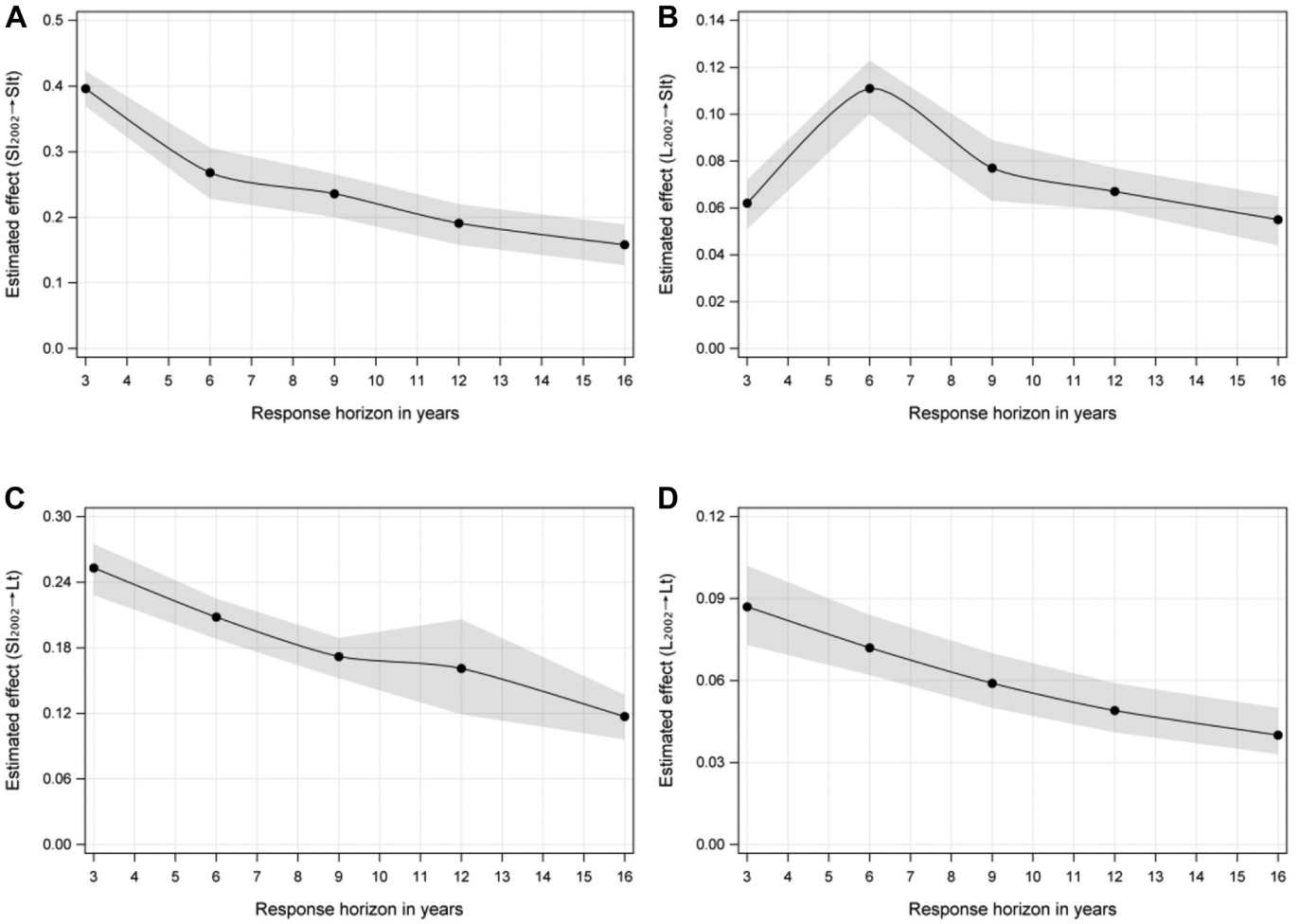

Fig. 1. Effect of past within-subject variations in SI and loneliness in the year 2002 on future scores (CLHLS, Waves 2002–2018).

aimed at reducing loneliness among older adults. A second important finding of our study was the recognition of robust temporal dynamics in the associations between SI and loneliness. Notably, our model revealed larger and more enduring effects running from SI to loneliness compared with the reverse relationship. Furthermore, even after a span of 16 years, both effects remained statistically significant.

The study carries several implications for addressing SI and loneliness. First, SI emerged as a more significant factor than loneliness in the bidirectional relationships. Thus, interventions should prioritize the reduction of SI. This intervention can positively influence health outcomes, both directly by decreasing SI and indirectly through alleviating loneliness. Second, early interventions aimed at addressing SI and loneliness can yield substantial and enduring impacts on reducing both factors in later life. Implementing interventions at an earlier stage, especially focusing on SI, proves essential for enhancing social connectedness and diminishing both SI and loneliness in later years. These interventions should be integrated into policies such as Healthy China 2030, recognizing the importance of addressing SI and loneliness in promoting overall well-being and health among older adults.

The current study exhibits several notable strengths. First, it draws on data from a substantial, nationally representative sample of individuals aged 65 and older, ensuring that the findings can be applied to Chinese older adults more broadly. Second, the study uses an innovative GCLM approach that effectively addresses concerns related to confounding by reverse causality. In addition, this model accounts for observable and unobservable time-invariant and time-varying confounds, thereby strengthening the ability to establish causal inferences. Moreover, the sophisticated model specification allows for the identification of temporal dynamics within the interrelationships between SI and loneliness.

However, it is important to acknowledge that the study also has some limitations. First, we used a single-item measure to assess loneliness. Although prior research has demonstrated a strong correlation between single-item and multidimensional loneliness scales,[5,27] using a composite measure could have potentially provided a more comprehensive understanding of the relationship between loneliness and SI. Second, the survey results solely represent community-dwelling older adults. Caution should be exercised when generalizing our findings to other populations, such as older adults living in nursing homes. Future research should analyze these populations to confirm our results. Finally, the data used in our study predates the COVID-19 pandemic, which may have significantly impacted rates of loneliness and SI among older adults.[4] Therefore, future studies using post-COVID-19 data are necessary to confirm and validate our findings.

Conclusions and Implications

In conclusion, our study provides valuable insights into the bidirectional associations between SI and loneliness among older adults. The findings reveal that higher levels of SI at a given time point predict increased loneliness scores in the future, and greater levels of

loneliness also lead to higher SI scores in subsequent periods. Importantly, the impact of SI on loneliness is larger and more enduring compared with the influence of loneliness on SI. Remarkably, these effects remain statistically significant even after a span of 16 years. These results underscore the importance of implementing interventions that focus on fostering meaningful social connections. Prioritizing interventions at an earlier stage, particularly addressing SI, is crucial for enhancing social connectedness and reducing both SI and loneliness in later years.

Disclosures

The author declares no conflict of interest.

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Supplementary Table 1
Baseline Characteristics of Sample in 2002

Variable	Mean (SD) or %
Loneliness	0.98 (0.99)
Social isolation	2.87 (1.01)
Age	81.83 (10.87)
Sex, female (%)	54.8
Education, received at least 1 year of education (%)	42.5
Residence, rural (%)	56.1

Supplementary Table 2
Bivariate Correlations Between SI and Loneliness

	Loneliness2	Loneliness3	Loneliness4	Loneliness5	Loneliness6	SI1	SI2	SI3	SI4	SI5	SI6
Loneliness1	0.186	0.137	0.130	0.131	0.106	0.212	0.174	0.155	0.150	0.122	0.173
Loneliness2	1	0.179	0.141	0.157	0.047	0.180	0.241	0.189	0.164	0.144	0.111
Loneliness3		1	0.152	0.117	0.109	0.181	0.198	0.266	0.216	0.197	0.157
Loneliness4			1	0.232	0.171	0.166	0.151	0.188	0.239	0.204	0.180
Loneliness5				1	0.197	0.130	0.135	0.170	0.196	0.243	0.203
Loneliness6					1	0.074	0.092	0.139	0.188	0.197	0.324
SI1						1	0.613	0.553	0.515	0.411	0.274
SI2							1	0.623	0.575	0.472	0.328
SI3								1	0.774	0.528	0.417
SI4									1	0.602	0.505
SI5										1	0.566