

RESEARCH ARTICLE

How do social networks, perception of social isolation, and loneliness affect depressive symptoms among Japanese adults?

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Abstract

Objective

This study aims to elucidate the complex relationship among social isolation, loneliness, and perception of social isolation and its influence on depressive symptoms by evaluating a hypothetical model. This understanding is essential for the formulation of effective intervention strategies.

Methods

We conducted an online survey on Japanese adults ($N = 3,315$) and used the six-item Lubben Social Network Scale to assess the size of their social networks. We employed a single question to gauge their perception of social isolation. Loneliness was assessed using the three-item UCLA Loneliness Scale, and depressive symptoms were examined using the Patient Health Questionnaire-9. Structural equation modeling was employed to test the hypothesized model.

Results

The final model demonstrated satisfactory fit with data ($\chi^2(1) = 3.73$; not significant; RMSEA = 0.03; CFI = 1.00; TLI = 1.00). The size of social network demonstrated a weak negative path to loneliness and depressive symptoms ($\beta = -.13$ to $-.04$). Notably, a strong positive association existed between perception of social isolation and loneliness ($\beta = .66$) and depressive symptoms ($\beta = .27$). Additionally, a significant positive relationship was found between loneliness and depressive symptoms ($\beta = .40$). Mediation analysis indicated that perception of social isolation and loneliness significantly intensified the relationships between social networks and depressive symptoms.

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Conclusions

Results indicate that interventions of psychological approaches, such as cognitive-behavioral therapy, are effective in reducing the perception of social isolation and loneliness, which may lead to the prevention of depressive symptoms. Future longitudinal studies are expected to refine and strengthen the proposed model.

Introduction

Social isolation and loneliness have emerged as prominent global societal challenges. Initiatives, such as the designation of a *Minister of Loneliness* in 2018 in the United Kingdom, which underscore the severity of the issue, serves as evidence of this fact. In Japan, the phenomenon of *hikikomori*, in which individuals exhibit extreme social withdrawal, epitomizes this challenge. A particularly acute issue, which is known as the *8050 problem*, involves octogenarian parents caring for their socially reclusive children aged in their 50s [1]. In this problem, socially withdrawn children become middle-aged, and the parents who have cared for them typically become elderly, such that caring for their children becomes increasingly difficult. This issue is not unique to Japan; instead, it is a grave one internationally [2] and measures are required to address this issue. Factors, such as social anxiety, avoidant personality disorder, and modern depression, are increasingly linked to increased social isolation and loneliness in Japan [3–5], where these issues are more pronounced compared with those in other cultures [6, 7]. Specifically, social anxiety and avoidant personality disorders are considered to lead to social withdrawal, especially among young people [8]. Additionally, the increase rise of individuals *Not in Employment, Education or Training* (NEET) and unemployment-related economic challenges are associated with increased social isolation and loneliness [9, 10]. The COVID-19 pandemic has exacerbated this situation, which emphasizes the need for assessment and intervention strategies that are globally effective [11].

Social isolation and loneliness

Although social isolation and loneliness are related, they are distinct concepts that need to be clearly distinguished [12]. Social isolation refers to the *objective* state of having limited social contact with others, including family, friends, and the broad community [13]. This condition is marked by factors such as the number of social ties of a person (e.g., marital status, circle of friends, and family connections) [14, 15], living alone [16], and frequency of interactions with family members [17]. Conversely, a widely used definition of loneliness is the lack of social connections (social loneliness) or the presence of negative feelings (emotional loneliness) that emerge when the quantity or quality of relationships with particular partners/peers is *subjectively* deficient compared with one’s ideal [13]. Both conditions adversely affect health but in distinct ways [18]. Social isolation can negatively impact health due to the absence of support and neglect of healthy behaviors [19]. At the same time, loneliness can lead to health decline through psychosomatic pathways, which manifests in decreased self-esteem, a diminished sense of social support, and an increased negative mood [20, 21]. Interestingly, research has demonstrated only weak to moderate correlations between social isolation and loneliness [22], suggesting that having numerous social connections does not automatically alleviate feelings of loneliness [23]. Hence, addressing social isolation and loneliness as separate entities is essential for an accurate assessment and understanding [14].

Perception of social isolation

The objective state of social isolation and how a person subjectively perceives their isolation are essentially different. Research indicates that one's perceptions of the size of one's social circle are closely linked to experiences of loneliness and social isolation [24]. Notably, perceived social isolation can lead to loneliness, which significantly impacts health more than objective social isolation can [25]. Therefore, when assessing health outcomes related to social isolation and loneliness, evaluating the objective (i.e., size of social networks) and subjective perceptions of social isolation is crucial.

Social isolation, loneliness, and depressive symptoms

Depressive symptoms rank among the most significant health consequences of social isolation and loneliness. Social isolation, which acts as a direct stressor, leads to increased stress responses in the brain [20], and is identified as a partial cause of long-term depression [26]. Research demonstrates that factors that lead to depression due to social isolation include living alone, having a weak social network, and limited social interaction [27, 28]. Loneliness has a well-established connection with depression [29] and is even considered a stronger predictor of depression than the objective measure of social connectedness [30, 31]. These studies indicate that deep-seated loneliness is associated with severe depressive symptoms across age groups [30, 31]. Additionally, perceived social isolation and the lack of societal support can exacerbate depressive symptoms, which complicates the recovery of depressed individuals [32]. Although numerous studies explored the link among social isolation, loneliness, and perception of social isolation, only a few examine these factors as distinct concepts that sequentially influence depression. Scholars propose different treatment and intervention approaches for social isolation and loneliness [12, 33, 34]. However, effectively tailoring treatments and interventions to the specific characteristics of social isolation, loneliness, and perception of social isolation requires a thorough investigation of the contribution of factors to depressive symptoms and their influence on one another.

The present study

This study intends to elucidate the relationships and underlying mechanisms that link social isolation, perception of social isolation, loneliness, and depressive symptoms. Drawing on prior research, the current study developed a hypothetical model (Fig 1) for exploring the influence of social isolation (assessed by the size of social networks), perception of social isolation, and loneliness on depressive symptoms. On the basis of the existing literature, we hypothesize that increasing one's social networks is negatively related to perception of social isolation, loneliness, and depressive symptoms [24, 27, 28]. We expect that the perception of social isolation, which emerges from the evaluation of individuals of their social networks, is positively related to loneliness and depressive symptoms [24, 25, 32]. Consistent with its established link to depression [29], we propose that loneliness is positively related to depressive symptoms. Furthermore, we argue that the perception of social isolation and loneliness potentially mediates the relationship between social networks and depressive symptoms, because this perception frequently exerts a significant impact on mental health more than do measures of objective social isolation [25, 30, 31]. Although earlier studies on social isolation and loneliness primarily focus on older adults [35], we recognize that these issues can affect individuals at any stage of life [30, 31] and broaden the scope by including other age groups [36, 37].

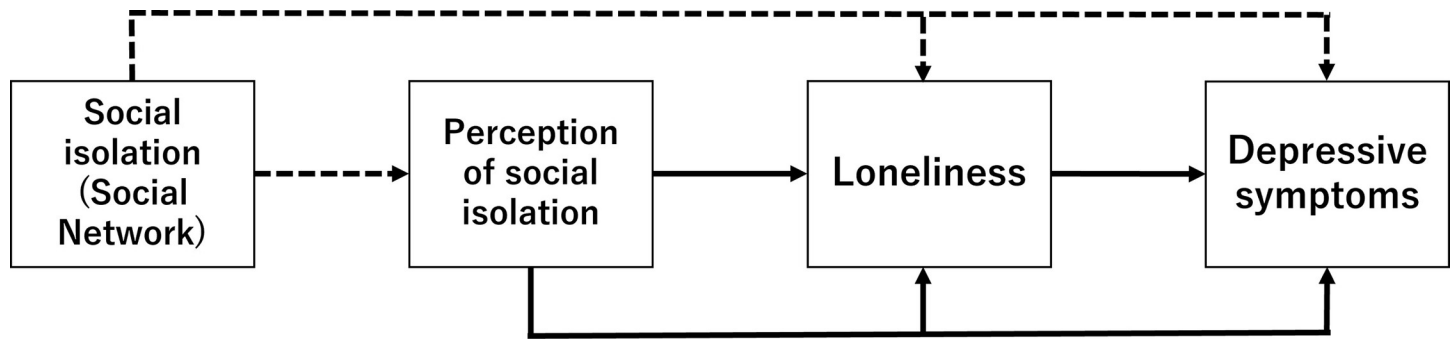


Fig 1. Hypothetical model. In this diagram, squares represent different psychological variables. Arrows between these squares depict the relationships among these variables. Dashed arrows illustrate negative paths, while solid arrows indicate positive ones.

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Method

1. Participants and procedures

This research was conducted from March 23 to 28, 2022, in partnership with Cross Marketing Inc. We opted to collaborate with Cross Marketing Inc, because it is the most prominent research company in Japan. Sample size was determined using G*Power 3.1.9.7 [38, 39]. The objective of this study was to explore a hypothetical model, which requires a sample size of 779 based on a two-tailed test with an assumed correlation coefficient of 0.10, a significance level of 5%, and a power of 80%. We also conducted structural equation modeling (SEM). However, no consensus was reached on precalculating the power and sample size for SEM [40]. Scholars recognized that a small sample size may compromise the accuracy and reproducibility of SEM results [41]. Therefore, we aimed to use the largest feasible sample size within our funding constraints, which exceeds 779 participants, to ensure a robust analysis and to capture trends representative of the Japanese population. The participants were recruited through a website through the 3.55 million monitor base of Cross Marketing Inc., which targeted Japanese individuals aged 20 years and above. This recruitment procedure ensured targeting a broad spectrum of respondents throughout Japan. The survey was considered complete after receiving 3,500 responses.

We excluded entries from the dataset with missing or incomplete information to ensure the quality and integrity of the data. Prior to the survey, the participants were informed that their responses will remain anonymous and that no negative consequences will be incurred for opting to withdraw at any point or not to respond. The researchers explained that all responses would be processed statistically, which ensures no individual identification. Furthermore, the study followed strict protocols in handling all responses, from the processing stage to data storage and eventual disposal. Participation was entirely voluntary and based on informed consent. They received reward points from the survey agency as a gesture of gratitude for their time and input. These points, which were determined by the number of questions answered, are a unique feature of Cross Marketing and could be exchanged by participants for goods or cash.

The criteria for exclusion included responses that were evidently dishonest (e.g., identical numerical answers for all items) and missing responses to the scales for measuring social networks, perception of social isolation, loneliness, and depressive symptoms. Therefore, we analyzed 3,315 valid responses (men: 1,805, women: 1,493, other genders: 7, and undisclosed gender: 10; average age: 50.05 years, $SD = 10.69$). The research ethics committee of Toyo Gakuen University approved the study (approval number 2021–010).

2. Measures

Social networks of participants. We utilized the Lubben Social Network Scale (LSNS-6) [42] to evaluate the extent of social networks. This scale assesses social isolation from friends, neighbors, and family by examining three aspects, network size, closeness of contacts, and perceived availability of help [43]. The LSNS-6 consists of six items, which are equally divided into three items each for family and friends/neighbors [44]. Items were rated using a six-point scale ranging from 0 (*none*) to 5 (*9 or more*), in which high scores indicate more social connections.

Perceptions of social isolation. To assess the perception of social isolation, we used one item: “Do you consider yourself isolated in society?” This item was rated using a four-point scale ranging from 1 (*not at all*) to 4 (*very much*).

Loneliness. We employed the three-item revised UCLA Loneliness Scale (R-UCLA) [45], which is a condensed form of the original 20-item revised UCLA Loneliness Scale [46]. Items were rated using a three-point scale ranging from 1 (*rarely*) to 3 (*often*) with high scores indicating high levels of loneliness.

Depressive symptoms. The study used the Patient Health Questionnaire (PHQ-9) [47] to evaluate depressive symptoms. Nine items were rated using a four-point scale ranging from 0 (*not at all*) to 3 (*almost daily*). High scores indicate more severe depressive symptoms.

Statistical analysis

We first conducted a chi-square test on the sociodemographic variables to ensure representativeness. We then conducted confirmatory factor analysis (CFA) to verify the structural validity of the LSNS-6. Based on previous research [42], we analyzed a model in which three items each represented the factors of the LSNS-6 Family and LSNS-6 Friend. Goodness of fit was assessed using several metrics: chi-square (χ^2) test statistic, root mean squared error of approximation (RMSEA), comparative fit index (CFI), and the Tucker–Lewis index (TLI). A nonsignificant χ^2 test statistics implies acceptable fit, but noting its sensitivity in large sample sizes is essential [48]. CFI and TLI values more than 0.95 indicate a good model fit [49], whereas RMSEA values less than 0.05 point to an optimal fit; values between 0.05 and 0.08 and between 0.08 and 0.10 denote moderate and marginal fit, respectively [50]. The study determined the reliability of each scale using Cronbach’s alpha, a widely recognized measure of reliability [51]. An alpha value of 0.70 or higher is considered acceptable [52]. We then calculated the descriptive statistics for the LSNS-6 Family, LSNS-6 Friend, perception of social isolation, R-UCLA, and the PHQ-9 scale. Finally, we examined the relationships among these variables by computing Pearson’s correlation coefficients.

We employed SEM to validate the model proposed in Fig 1. This process began with developing paths for each variable. We then refined the model by removing paths that were statistically nonsignificant. The significance of path coefficients was established at the 5% level. Path coefficients, denoted by β , indicate the strength of the relationship between variables (weak: < .20); moderate: .20 to .50); strong: > .50) [53]. The goodness of fit of the model was indicated by the χ^2 test statistic, RMSEA, CFI, and TLI.

Given the large sample size, we considered the increased likelihood of obtaining statistically significant results for SEM, which necessitates caution in interpretation: the model validation involved data from respondents who provided complete and valid responses. The initial analysis included data from participants with unspecified or other gender identities for a comprehensive assessment of the model. We then conducted separate analyses for male and female participants to identify gender-specific differences within the model.

We performed mediation analysis using the bootstrap method to assess indirect effects within the SEM framework. This method takes a sample of researchers of size N and creates a new sample from which to extract the replacement N values of the independent, mediating, and dependent variables. For example, this option can be repeated 5,000 times to compute 5,000 estimates of indirect effects [54]. The bootstrap method is known for providing accurate confidence intervals for indirect effects, because this method is based on the empirical distribution of the estimates [55, 56]. We computed bootstrap confidence intervals corrected for bias using 5,000 resamples, which maintains 95% confidence interval. All statistical analyses were conducted using SPSS 28.0 and Amos 28.0.

Results

Characteristics of participants

The participants were composed of 1,805 (54.5%) men and 1,493 (45.0%) women, which represents a broad age range. Table 1 outlines the detailed sociodemographic characteristics of the respondents. To assess the representativeness of the sample relative to the Japanese population, we conducted chi-square tests for sex and age using demographic data from the Ministry of Internal Affairs and Communications as of March 2022 as reference. Notably, the sample consisted of fewer participants in their 20s and 70s than expected and more in their 40s and 50s compared with the broad Japanese population. This discrepancy poses the possibility that the data may only partially reflect the demographic composition of Japan.

Validity of the LSNS-6 and reliability of each scale

We conducted CFA to test the structural validity of the LSNS-6. The model demonstrated a good fit ($\chi^2(8) = 81.03, p < .001, RMSEA = .05, CFI = .99, TLI = .99$). This result confirmed the validity of the two-factor structure for the data. We reached Cronbach's alpha coefficients of 0.88 and 0.89 for LSNS-6 Family and LSNS-6 Friend, respectively, which indicates appropriate reliability for both scales. In addition, Cronbach's alpha coefficients for R-UCLA and PHQ-9 were 0.85 and 0.92, respectively, which were sufficiently reliable.

Table 1. Characteristics of respondents.

Variable	N (%)	Variable	N (%)
Sex		Occupation	
Male	1,805 (54.5%)	Employed	2,395 (72.2%)
Female	1,493 (45.0%)	Homemaker	392 (11.8%)
Other gender	7 (0.2%)	Unemployed	473 (14.3%)
Unknown	10 (0.3%)	Student	25 (0.8%)
Age group		Other	30 (0.9%)
20–29	155 (4.7%)	Annual house hold income	
30–39	409 (12.4%)	<2.0 million	291 (8.7%)
40–49	890 (26.8%)	<2.0–3.9 million	533 (16.1%)
50–59	1237 (37.4%)	<4.0–5.9 million	566 (17.1%)
60–69	549 (16.5%)	<6.0–7.9 million	423 (12.8%)
70–	73 (2.1%)	≥8.0 million	694 (20.9%)
Unknown	2 (0.1%)	Unknown	808 (24.4%)

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Descriptive statistics and correlation analysis

Table 2 presents the results of descriptive statistics and correlation analysis. Pearson's correlation coefficients indicated that LSNS-6 Family and LSNS-6 Friend were significantly and negatively correlated with perceived social isolation, loneliness, and depressive symptoms. Moreover, perceived social isolation was positively correlated with loneliness and depressive symptoms. Lastly, loneliness and depressive symptoms were significantly and positively correlated.

Validation of the hypothetical model

We utilized SEM to evaluate the hypothetical model (Fig 1). Initially, we established paths between each variable as proposed in the model. We assumed a covariance between the LSNS-6 Family and LSNS-6 Friend error variables. The threshold for statistical significance of the path coefficients was set to 5%. Analysis revealed that the path that links social isolation from friends to depressive symptoms was statistically nonsignificant, which leads to its exclusion from the model. Fig 2 illustrates the model after omitting these nonsignificant paths. The study confirmed the goodness of fit of the model ($\chi^2(1) = 3.73$ (not significant); RMSEA = .03, CFI = 1.00, TLI = 1.00). The findings exhibited significant negative correlation of social isolation from family to perceived social isolation ($\beta = -.20$, 95% CI [-.24, -.17], $p < .001$) and of social isolation from friends to perceived social isolation ($\beta = -.24$, 95% CI [-.27, -.20], $p < .001$). Additionally, perceived social isolation displayed significant positive associations with loneliness ($\beta = .66$, 95% CI [.63, .68], $p < .001$) and depressive symptoms ($\beta = .27$, 95% CI [.23, .31], $p < .001$). Loneliness also exhibited a significant positive relationship with depressive symptoms ($\beta = .40$, 95% CI [.36, .44], $p < .001$). Furthermore, social isolation from family and friends exhibited significant negative paths to loneliness ($\beta = -.04$, 95% CI [-.06, -.01], $p < .01$; and $\beta = -.13$, 95% CI [-.15, -.10], $p < .001$, respectively). Moreover, social isolation from family demonstrated a notable negative correlation with depressive symptoms ($\beta = -.05$, 95% CI [-.08, -.02], $p < .001$). Given the sample size, the study inferred that social isolation from family and friends exerted a relatively minor impact on loneliness and depressive symptoms.

Table 2. Descriptive statistics and correlations between variables.

		Correlation coefficient (r)				
		1	2	3	4	5
1	LSNS-6 Family	–				
2	LSNS-6 Friend	.43 ***	–			
3	Perception of social isolation	–.31 ***	–.32 ***	–		
4	R-UCLA	–.29 ***	–.36 ***	.71 ***	–	
5	PHQ-9	–.25 ***	–.23 ***	.57 ***	.61 ***	–
<i>Descriptive statistics</i>						
	Mean	5.10	3.28	2.21	5.03	5.53
	SD	3.33	3.49	0.92	1.94	6.24
	Minimum	0	0	1	3	0
	Maximum	15	15	4	9	27
	Skewness	0.14	0.85	0.31	0.65	1.40
	Kurtosis	–0.79	–0.13	–0.74	–0.66	1.47

Note. LSNS-6 Family: Social isolation from family. LSNS-6 Friend: Social isolation from friends. Perception of social isolation: subjective perception of the degree of social isolation. R-UCLA: measures level of loneliness. PHQ-9: assesses the severity of depressive symptoms.

*** $p < .001$.

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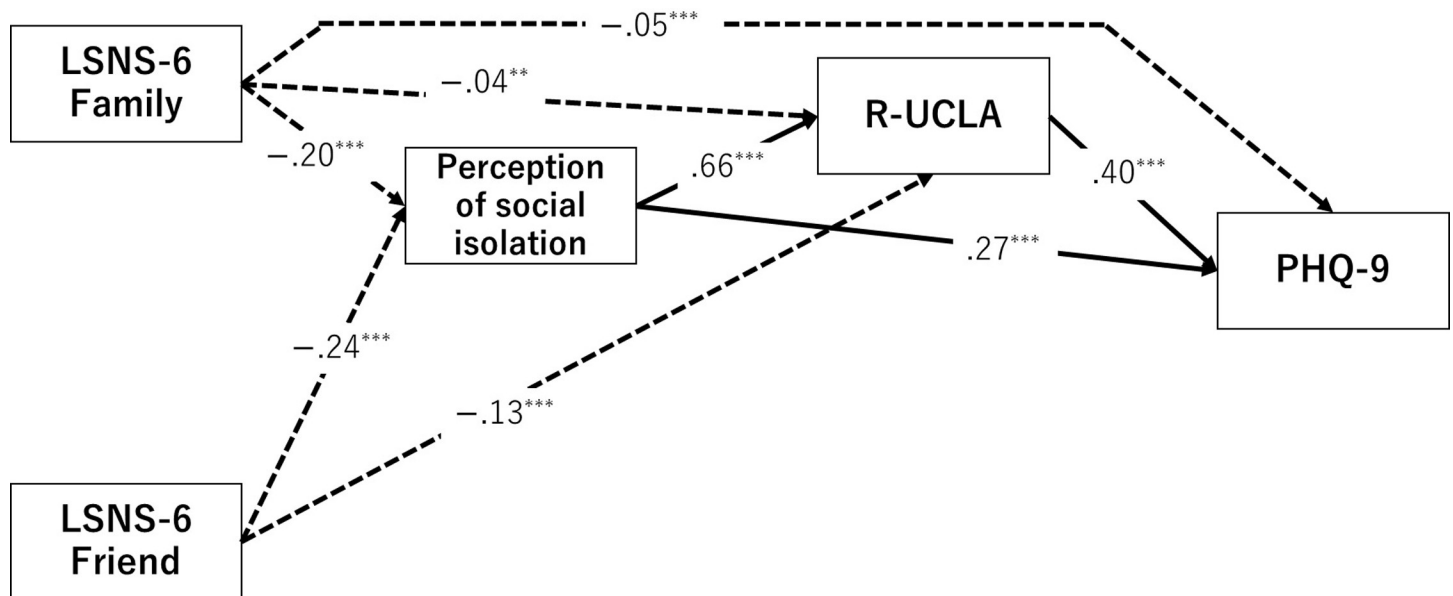


Fig 2. Structural Equation Modeling (SEM) of the hypothetical model. Rectangular shapes represent the psychological scales used in the study. Arrows indicate the nature of the relationships between these scales: dashed and solid arrows for negative and positive relations, respectively. For clarity, error variables and covariances were omitted from the illustration.

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Table 3 presents the SEM results of the hypothetical model, which were categorized according to gender. The coefficients represent the paths identified through SEM analysis. For example, the values demonstrate that male and female participants exhibited a significant negative path from social isolation (family) to perceived social isolation, with minor differences in the

Table 3. Gender-specific results from structural equation modeling.

	Men	Women
LSNS-6 Family → PSI	-.21 ***	-.22 ***
LSNS-6 Friend → PSI	-.21 ***	-.27 ***
LSNS-6 Family → R-UCLA	-	-.08 *
LSNS-6 Friend → R-UCLA	-.13 ***	-.14 ***
LSNS-6 Family → PHQ-9	-.06 ***	-.05 ***
LSNS-6 Friend → PHQ-9	-	-
PSI → R-UCLA	.67 ***	.63 ***
PSI → PHQ-9	.26 ***	.27 ***
R-UCLA → PHQ-9	.43 ***	.38 ***
<i>the goodness of fit of the model</i>		
RMSEA	.02	.00
CFI	1.00	1.00
TLI	1.00	1.00

Note. Values in the table represent the path coefficients derived from SEM analysis. PSI: perception of social isolation indicates one’s perception of social isolation. LSNS-6 Family: Social isolation from family members. LSNS-6 Friend: Social isolation from friends. R-UCLA: measures the level of loneliness experienced by an individual. PHQ-9: assesses the severity of depressive symptoms.

* $p < .05$
 *** $p < .001$.

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effects of variables between genders. Thus, we concluded that the results in Fig 2 apply to both genders.

The SEM results indicate that the perception of social isolation and loneliness could mediate the relationship between social networks and depressive symptoms. To investigate this possibility, we performed a mediation analysis using the bootstrap method with a focus on the indirect effects of the LSNS-6 Family on the perception of social isolation and loneliness leading to depressive symptoms. Analysis revealed significant indirect effects ($\beta = -.10$, 95% CI $[-.12, -.08]$, $p < .001$), as evidenced by the 95% confidence interval excluding zero. Similarly, the impact of LSNS-6 Friend on the indirect relationship between social isolation and loneliness with depressive symptoms displayed a significant indirect effect ($\beta = -.11$, 95% CI $[-.13, -.09]$, $p < .001$). These findings suggest that LSNS-6 Family and LSNS-6 Friend amplify loneliness and depressive symptoms through the mediation of perceived social isolation.

Discussion

We explored the hypothetical model illustrated in Fig 2, which displays the influence of social networks, social isolation, and loneliness on depressive symptoms. The findings revealed that the direct effect of the size of social networks on loneliness and depressive symptoms was marginal. However, comprehensively analyzing social networks, perception of social isolation, and loneliness and examining their effects on depressive symptoms identified a mechanism in which the relationship between social network size and depressive symptoms was mediated by perception of social isolation and loneliness, which increase feelings of loneliness and depressive symptoms. This result extends those of previous studies that examined these variables in isolation [24–26, 29–32].

The results of the current study and prior research that primarily focus on adolescents [25] underscore the age-independent trend of this finding. Moreover, the gender-based SEM of the proposed model identified no significant disparities between men and women. Thus, the current results indicate that perception of social isolation and loneliness are critical mediators that can worsen mental health challenges regardless of gender. Although the majority of studies and intervention methods on social isolation and loneliness have focused on older adults [18, 35, 57], the findings are significant for demonstrating that social isolation and loneliness can lead to a decline in mental health regardless of age or gender, which underscores their universal applicability.

Interestingly, the mechanism identified in this study suggests that perception of isolation increases loneliness instead of the actual state of social isolation, which was assessed using the sheer number of social networks as a proxy. This finding implies that merely expanding social networks may be unable to effectively diminish loneliness due to perceived social isolation [25]. The size of social networks exerts a minimal direct impact on depressive symptoms, whereas the perception of social isolation and feelings of loneliness play more direct roles in contributing to these symptoms. Notably, loneliness serves as a mediator, which indicates that increased feelings of loneliness and perceptions of social isolation could intensify depressive symptoms.

The findings underscore the importance of addressing the transition from perception of social isolation and loneliness to depressive symptoms. Interventions that target altering the perception of social isolation can help reduce depressive symptoms and alleviate loneliness if they target cognitive and emotional aspects across age groups. Psychoeducational approaches and cognitive-behavioral therapy for changing cognition and emotion effectively alleviate loneliness [34]. These interventions can be pivotal in transforming perceptions and reducing loneliness and depressive symptoms. Additionally, reminiscence-based psychological interventions

have demonstrated effectiveness [58]. We advocate for strategies that focus on the cognitive and emotional facets of social isolation and loneliness instead of the mere expansion of social networks [37], because social isolation does not necessarily lead to loneliness [23].

Previous research underscores the importance of primary prevention in addressing social isolation and loneliness [59–61]. However, studies on the effectiveness of such preventive measures are limited, which emphasizes the need to develop intervention programs that focus on primary prevention against social isolation and loneliness. The study suggests the development of early psychoeducational programs for school education and community-based cognitive-behavioral therapeutic interventions to prevent social isolation and loneliness. Such initiatives could play a vital role in preventing depressive symptoms emerging from social isolation and loneliness.

The following limitations constrain the findings. First, the study was unable to establish causal relationships due to its cross-sectional nature. Future research using longitudinal data would be beneficial for understanding the evolution of perception of social isolation and its consequent impact on loneliness and depressive symptoms. Second, reliance on self-reported data could introduce bias, as individuals who are socially isolated or acutely lonely may negatively respond due to inherent negative self-perceptions [30]. Future studies should incorporate latent markers and third-party evaluations alongside current methods. Lastly, the online nature of data collection may lead to sampling bias. Data may not fully represent the Japanese population; notably, the survey may have missed individuals without Internet access or with severe social isolation or loneliness. To enhance these findings, further research should consider conducting in-depth interviews with people that encounter social isolation or intense loneliness (e.g., individuals who have withdrawn from society) and demographic studies in specific communities.

Despite these challenges, the significance of this study lies in its extensive, data-driven exploration of the contribution of social isolation, perception of social isolation, and loneliness to depressive symptoms. The identified patterns are essential for developing support strategies for individuals facing social isolation and loneliness. Future research should build on these insights and focus on specific subgroups, including those who are socially isolated, and use various methods of evaluation across diverse cohorts.

Conclusion

This study provides an in-depth analysis of the interplay among social networks, perception of social isolation, and loneliness, and their collective impact on depressive symptoms. Although social isolation and loneliness were long associated with depressive symptoms, the findings reveal that the individual perception of isolation and the consequent feelings of loneliness play more crucial roles in the development of depressive symptoms instead of the actual state of social isolation. This finding highlights the importance of not only expanding social networks but also addressing and correcting perceptions of social isolation and loneliness as critical strategies for preventing depressive symptoms.

Supporting information

S1 Dataset. Anonymized data set.

(XLSX)

S1 Checklist. STROBE-checklist-v4-combined-PlosMedicine.

(DOCX)

Author Contributions

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References

1. Sekimizu T. "Hikikomori" and dependency on family: focusing on father–son relationships. *International Journal of Japanese Sociology*. 2021; 30(1):182–96. <https://doi.org/10.1111/ijjs.12121>
2. Kato TA, Tateno M, Shinfuku N, Fujisawa D, Teo AR, Sartorius N, et al. Does the 'hikikomori' syndrome of social withdrawal exist outside Japan? A preliminary international investigation. *Soc Psychiatry Psychiatr Epidemiol*. 2012; 47(7):1061–75. <https://doi.org/10.1007/s00127-011-0411-7> PMID: 21706238
3. Kato TA, Shinfuku N, Sartorius N, Kanba S. Are Japan's hikikomori and depression in young people spreading abroad? *Lancet*. 2011; 378(9796):1070. [https://doi.org/10.1016/S0140-6736\(11\)61475-X](https://doi.org/10.1016/S0140-6736(11)61475-X) PMID: 21924990
4. Kato TA, Kanda S, Teo AR. Hikikomori: Multidimensional understanding, assessment, and future international perspectives. *Psychiatry Clin Neurosci*. 2019; 73(8):427–40. <https://doi.org/10.1111/pcn.12895> PMID: 31148350
5. Teo AR, Stufflebam K, Saha S, Fetters MD., Tateno M, Kanba S, et al. Psychopathology associated with social withdrawal: idiopathic and comorbid presentations. *Psychiatry Res*. 2015; 228(1):182–3. <https://doi.org/10.1016/j.psychres.2015.04.033> PMID: 25977071
6. Heinrichs N, Rapee RM, Alden LA, Bögels S, Hofmann SG, Oh KJ, et al. Cultural differences in perceived social norms and social anxiety. *Behav Res Ther*. 2006; 44(8):1187–97. <https://doi.org/10.1016/j.brat.2005.09.006> PMID: 16325145
7. Schreier SS, Heinrichs N, Alden L, Rapee RM, Hofmann SG, Chen J, et al. Social anxiety and social norms in individualistic and collectivistic countries. *Depress Anxiety*. 2010; 27(12):1128–34. <https://doi.org/10.1002/da.20746> PMID: 21049538
8. Gallagher M, Prinstein MJ, Simon V, Spirito A. Social anxiety symptoms and suicidal ideation in a clinical sample of early adolescents: examining loneliness and social support as longitudinal mediators. *J Abnorm Child Psychol*. 2014; 42(6):871–83. <https://doi.org/10.1007/s10802-013-9844-7> PMID: 24390470
9. Ishida K, Wels J. The Reciprocal relationship between unemployment and social isolation in contemporary Japan: a longitudinal approach using the Japanese life course panel survey. *JLPS Project Discussion Paper Series*. 2020; 120:1–22.
10. Dieckhoff M, Gash V. Unemployed and alone? Unemployment and social participation in Europe. *International Journal of Sociology and Social Policy*. 2015; 35(1/2):67–90. <https://doi.org/10.1108/IJSSP-01-2014-0002>
11. Feifei B, Steptoe A, Fancourt D. Loneliness during a strict lockdown: trajectories and predictors during the COVID-19 pandemic in 38, 217 United Kingdom adults. *Soc Sci Med*. 2020; 265:113521. <https://doi.org/10.1016/j.socscimed.2020.113521> PMID: 33257177
12. Fakoya OA, McCorry NK, Donnelly M. Loneliness and social isolation interventions for older adults: a scoping review of reviews. *BMC Public Health*. 2020; 20:129. <https://doi.org/10.1186/s12889-020-8251-6> PMID: 32054474

13. Valtorta N, Hanratty B. Loneliness, isolation and the health of older adults: do we need a new research agenda? *J R Soc Med*. 2012; 105(12):518–22. <https://doi.org/10.1258/jrsm.2012.120128> PMID: [23288086](https://pubmed.ncbi.nlm.nih.gov/23288086/)
14. Coyle CE, Dugan E. Social isolation, loneliness and health among older adults. *J Aging Health*. 2012; 24(8):1346–63. <https://doi.org/10.1177/0898264312460275> PMID: [23006425](https://pubmed.ncbi.nlm.nih.gov/23006425/)
15. Stafford M, Gardner M, Kumari M, Kuh D, Ben-Shlomo Y. Social isolation and diurnal cortisol patterns in an ageing cohort. *Psychoneuroendocrinology*. 2013; 38(11):2737–45. <https://doi.org/10.1016/j.psyneuen.2013.07.002> PMID: [23920224](https://pubmed.ncbi.nlm.nih.gov/23920224/)
16. Kimberley JS, Christina V. Typologies of loneliness, living alone and social isolation, and their associations with physical and mental health. *Ageing & Society*. 2018; 39(8):1709–30. <https://doi.org/10.1017/S0144686X18000132>
17. Tilvis RS, Routasalo P, Karppinen H, Strandberg TE, Kautiainen H, Pitkala KH. Social isolation, social activity and loneliness as survival indicators in old age; a nationwide survey with a 7-year follow-up. *European Geriatric Medicine*. 2012; 3(1):18–22. <https://doi.org/10.1016/j.eurger.2011.08.004>
18. Dickens AP, Richards SH, Greaves CJ, Campbell JL. Interventions targeting social isolation in older people: a systematic review. *BMC Public Health*. 2011; 11:647. <https://doi.org/10.1186/1471-2458-11-647> PMID: [21843337](https://pubmed.ncbi.nlm.nih.gov/21843337/)
19. Umberson D. Family status and health behaviors: social control as a dimension of social integration. *J Health Soc Behav*. 1987; 28(3):306–19. pmid:PMID: [3680922](https://pubmed.ncbi.nlm.nih.gov/3680922/)
20. Cacioppo JT, Hawkley LC. Social isolation and health, with an emphasis on underlying mechanisms. *Perspect Biol Med*. 2003; 46(3):39–52. pmid:PMID: [14563073](https://pubmed.ncbi.nlm.nih.gov/14563073/)
21. Cacioppo JT, Hawkley LC, Ernst JM, Burleson M, Berntson GG, Nouriani B, et al. Loneliness within a nomological net: An evolutionary perspective. *Journal of Research in Personality*. 2006; 40(6):1054–85. <https://doi.org/10.1016/j.jrp.2005.11.007>
22. Shankar A, McMunn A, Banks J, Steptoe A. Loneliness, social isolation, and behavioral and biological health indicators in older adults. *Health Psychol*. 2011; 30(4):377–85. <https://doi.org/10.1037/a0022826> PMID: [21534675](https://pubmed.ncbi.nlm.nih.gov/21534675/)
23. Victor C, Scambler S, Bond J, Bowling A. Being alone in later life: Loneliness, social isolation and living alone. *Reviews in Clinical Gerontology*. 2000; 10(4):407–17. <https://doi.org/10.1017/S0959259800104101>
24. Child S., Lawton L. Loneliness and social isolation among young and late middle-age adults: Associations with personal networks and social participation. *Aging Ment Health*. 2019; 23(2):196–204. <https://doi.org/10.1080/13607863.2017.1399345> PMID: [29171764](https://pubmed.ncbi.nlm.nih.gov/29171764/)
25. Brett L, Amy CH. Understanding loneliness during adolescence: developmental changes that increase the risk of perceived social isolation. *J Adolesc*. 2013; 36(6):1261–68. <https://doi.org/10.1016/j.adolescence.2013.06.003> PMID: [23866959](https://pubmed.ncbi.nlm.nih.gov/23866959/)
26. Gask L, Aseem S, Waqas A, Waheed W. Isolation, feeling ‘stuck’ and loss of control: understanding persistence of depression in British Pakistani women. *J Affect Disord*. 2011; 128(1–2):49–55. <https://doi.org/10.1016/j.jad.2010.06.023> PMID: [20633932](https://pubmed.ncbi.nlm.nih.gov/20633932/)
27. Chen R, Wei L, Hu Z, Qin X, Copeland JRM, Hemingway H. Depression in older people in Rural China. *Arch Intern Med*. 2005; 165:2019–25. <https://doi.org/10.1001/archinte.165.17.2019> PMID: [16186473](https://pubmed.ncbi.nlm.nih.gov/16186473/)
28. Chan A, Malhotra C, Malhotra R, Østbye T. Living arrangements, social networks and depressive symptoms among older men and women in Singapore. *Int J Geriatr Psychiatry*. 2011; 26(6):630–9. <https://doi.org/10.1002/gps.2574> PMID: [20677171](https://pubmed.ncbi.nlm.nih.gov/20677171/)
29. Cacioppo JT, Hawkley LC, Thisted RA. Perceived social isolation makes me sad: 5-year cross-lagged analyses of loneliness and depressive symptomatology in the Chicago Health, Aging, and Social Relations Study. *Psychol Aging*. 2010; 25(2):453–63. <https://doi.org/10.1037/a0017216> PMID: [20545429](https://pubmed.ncbi.nlm.nih.gov/20545429/)
30. Cacioppo JT, Hughes ME, Waite LJ, Hawkley LC, Thisted RA. Loneliness as a specific risk factor for depressive symptoms: cross-sectional and longitudinal analyses. *Psychol Aging*. 2006; 21(1):140–51. <https://doi.org/10.1037/0882-7974.21.1.140> PMID: [16594799](https://pubmed.ncbi.nlm.nih.gov/16594799/)
31. Ge L, Yap CW, Ong R, Heng BH. Social isolation, loneliness and their relationships with depressive symptoms: A population-based study. *PLoS One*. 2017; 12(8):e0182145. <https://doi.org/10.1371/journal.pone.0182145> PMID: [28832594](https://pubmed.ncbi.nlm.nih.gov/28832594/)
32. Jingyi W, Farhana M, Brynmor LE, Ruimin M, Sonia J. Associations between loneliness and perceived social support and outcomes of mental health problems: a systematic review. *BMC Psychiatry*. 2018; 18(1):156. <https://doi.org/10.1186/s12888-018-1736-5> PMID: [29843662](https://pubmed.ncbi.nlm.nih.gov/29843662/)
33. Lim MH, Pennm DL, Thomas N, Gleeson JFM. Is loneliness a feasible treatment target in psychosis? *Soc Psychiatry Psychiatr Epidemiol*. 2020; 55(7):901–6. <https://doi.org/10.1007/s00127-019-01731-9> PMID: [31127348](https://pubmed.ncbi.nlm.nih.gov/31127348/)

34. Masi CM, Chen HY, Hawkey LC, Cacioppo JT. A meta-analysis of interventions to reduce loneliness. *Pers Soc Psychol Rev.* 2011; 15(3):219–66. <https://doi.org/10.1177/1088868310377394> PMID: 20716644
35. Bedard-Thomas J, Gausvik C, Wessels J, Regan S, Goodnow K, Goroncy A. I live alone but don't feel alone: social isolation and loneliness from the patient perspective. *J Patient Cent Res Rev.* 2019; 6(4):262–66. <https://doi.org/10.17294/2330-0698.1715> PMID: 31768405
36. Karen ES, Seth DP. Early life stress and perceived social isolation influence how children use value information to guide behavior. *Child Dev.* 2022; 93(3):804–14. <https://doi.org/10.1111/cdev.13727> PMID: 34971461
37. Timothy M, Andrea D, Jasmin W, Candice LO, Antony A, Terrie EM, et al. Social isolation, loneliness and depression in young adulthood: a behavioural genetic analysis. *Soc Psychiatry Psychiatr Epidemiol.* 2016; 51(3):339–48. <https://doi.org/10.1007/s00127-016-1178-7> PMID: 26843197
38. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods.* 2007; 39(2):175–91. <https://doi.org/10.3758/bf03193146> PMID: 17695343
39. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behav Res Methods.* 2009; 41(4):1149–60. <https://doi.org/10.3758/BRM.41.4.1149> PMID: 19897823
40. Wolf EJ, Harrington KM, Clark SL, Miller MW. Sample size requirements for structural equation models: an evaluation of power, bias, and solution propriety. *Educ Psychol Meas.* 2013; 76(6):913–34. <https://doi.org/10.1177/0013164413495237> PMID: 25705052
41. Theodoros AK. Applied psychometrics: sample size and sample power considerations in factor analysis (EFA, CFA) and SEM in general. *Psychology.* 2018; 9(8):2207–30. <https://doi.org/10.4236/psych.2018.98126>
42. Kurimoto A, Awata S, Ohkubo T, Tubota-Utsugi M, Asayama K, Takahashi K, et al. Reliability and validity of the Japanese version of the abbreviated Lubben Social Network Scale. *Nihon Ronen Igakkai Zasshi.* 2011; 48(2):149–57. Japanese. <https://doi.org/10.3143/geriatrics.48.149> PMID: 21778631
43. Lubben J. Assessing social networks among elderly populations. *Family & Community Health.* 1988; 11(3):42–52. <https://doi.org/10.1097/00003727-198811000-00008>
44. Lubben J, Blozik E, Gillmann G, Iliffe S, von Renteln Kruse W, Beck JC, et al. Performance of an abbreviated version of the Lubben Social Network Scale among three European community-dwelling older adult populations. *Gerontologist.* 2006; 46(4):503–13. <https://doi.org/10.1093/geront/46.4.503> PMID: 16921004
45. Igarashi T. Development of the Japanese version of the three-item loneliness scale. *BMC Psychology.* 2019; 7(1):20. <https://doi.org/10.1186/s40359-019-0285-0> PMID: 30953545
46. Russell DW, Peplau LA, Cutrona CE. The revised UCLA Loneliness Scale: concurrent and discriminant validity evidence. *J Pers Soc Psychol.* 1980; 39(3):472–80. <https://doi.org/10.1037/0022-3514.39.3.472> PMID: 7431205
47. Muramatsu K, Miyaoka H, Kamijima K, Muramatsu T, Yoshida M, Otsubo T, et al. The patient health questionnaire, Japanese version: validity according to the mini-international neuropsychiatric interview-plus. *Psychol Rep.* 2007; 101(3):952–60. <https://doi.org/10.2466/pr.101.3.952-960> PMID: 18232454
48. Alison PD. *Introduction to Structural Equation Modeling.* Washington D.C.; 2015.
49. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal.* 2009; 6(1):1–55. <https://doi.org/10.1080/10705519909540118.50>
50. Browne MW, Cudeck R. Alternative ways of assessing model fit. In: Bollen KB, Long JS, editors. *Testing Structural Equation Models.* Newbury Park, CA: SAGE; 1993. pp. 136–162.
51. Chronbach LJ. Coefficient alpha and the internal structure of tests. *Psychometrika.* 1951; 16:297–334.
52. Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL, editors. *Multivariate Data Analysis: a global perspective.* 7th ed. Upper Saddle River, NJ: Prentice Hall; 2010.
53. Cohen J. *Statistical power analysis for the behavioral sciences.* 2nd ed. Hillsdale NJ: Lawrence Erlbaum Associates; 1988.
54. Preacher KJ, Hayes AF. SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behav Res Methods Instrum Comput.* 2004; 36(4):717–31. <https://doi.org/10.3758/bf03206553> PMID: 15641418
55. MacKinnon DP, Lockwood CM, Williams J. Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behav Res.* 2004; 39(1):99–128. https://doi.org/10.1207/s15327906mbr3901_4 PMID: 20157642

56. Zhao X, Lynch JG, Chen Q. Reconsidering Baron and Kenny: myths and truths about mediation analysis. *Journal of Consumer Research*. 2010; 37(2):197–206. <https://doi.org/10.1086/651257>
57. Routasalo PE, Tilvis RS, Kautiainen H, Pitkala KH. Effects of psychosocial group rehabilitation on social functioning, loneliness and well-being of lonely, older people randomized controlled trial. *J Adv Nurs*. 2009; 65(2):297–305. <https://doi.org/10.1111/j.1365-2648.2008.04837.x> PMID: 19054177
58. Hickin N, Käll A, Shafran R, Sutcliffe S, Manzotti G, Langan D. The effectiveness of psychological interventions for loneliness: A systematic review and meta-analysis. *Clin Psychol Rev*. 2021; 88:102066. <https://doi.org/10.1016/j.cpr.2021.102066> PMID: 34339939
59. Valtorta NK, Kanaan M, Gilbody S, Ronzi S, Hanratty B. Loneliness and social isolation as risk factors for coronary heart disease and stroke: systematic review and meta-analysis of longitudinal observational studies. *Heart*. 2016; 102(13):1009–16. <https://doi.org/10.1136/heartjnl-2015-308790> PMID: 27091846
60. Holt-Lunstad J, Smith TB. Loneliness and social isolation as risk factors for CVD: implications for evidence-based patient care and scientific inquiry. *Heart*. 2016; 102(13):987–9. <https://doi.org/10.1136/heartjnl-2015-309242> PMID: 27091845
61. Crowe CL, Liu L, Bagnarol N, Fried LP. Loneliness prevention and the role of the Public Health system. *Perspect Public Health*. 2024; 144(1):31–38. <https://doi.org/10.1177/17579139221106579> PMID: 35815809