

Research paper

Preference for solitude paradox: The psychological influence of social isolation despite preference

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ABSTRACT

Background: Although a preference for solitude (PS) may mitigate the negative effects of social isolation (SI) owing to the enjoyment of time alone, its impact on mental health and its underlying factors remain unclear. **Methods:** An Internet survey was conducted with 9000 individuals aged 20–79 years in September 2023 and the analyses were performed across three generations. SI was defined as contact with non-cohabitating family members or relatives and friends/neighbors less than once a week. The PS scale, which was used to assess whether a person preferred spending time alone, stratified respondents into three PS-level groups. Mental health status was evaluated using the K6 (distress symptoms), the WHO-5 (well-being), and the UCLA Loneliness Score (severity of loneliness) as the main outcomes. The mediation analyses assessed whether troublesomeness in socializing, a potential negative aspect of PS, could explain the association between PS and mental health status. **Results:** A mixed-design two-way analysis of covariance showed that both SI and PS had significant main effects on all outcomes without interactions across generations, indicating that SI and higher PS were associated with poor mental health status. The association between higher PS and poor mental status was mediated by socializing troublesomeness across generations. **Limitations:** The cross-sectional design prevented making causal inferences from the results. Additionally, sampling bias from Internet surveys may limit the generalizability of the results. **Conclusions:** The results confirmed that there is no protective effect of PS on social isolation-related poor mental health. The hassle of socializing may partly explain why people with a higher PS experience poor mental status, including greater loneliness.

1. Introduction

Social connections with others are fundamentally important to quality of life and health across all generations. Social isolation (SI), defined as an objective lack of social connections with others, is a well-known risk factor for adverse health outcomes. Less frequent social contact among older adults is associated with an increased risk of dementia (Kuiper et al., 2015), incident coronary artery disease or stroke (Valtorta et al., 2016), and all-cause mortality (Holt-Lunstad et al., 2015; Sakurai et al., 2019b). Although some possible explanations for the association between SI and adverse health outcomes have been suggested (Cacioppo et al., 2002; Hawkey and Cacioppo, 2010), one potential mediator is poor mental health through negative health behaviors, either directly (e.g., suicide) or indirectly (e.g., smoking as a social

activity or to alleviate boredom or distress) (National Academies of Sciences et al., 2020).

Studies have demonstrated that SI is associated with higher rates of depression and lower well-being in both young and older adults (Courtin and Knapp, 2017; Heikkinen and Kauppinen, 2004; Sakurai et al., 2019a; Steptoe et al., 2013). For instance, social disconnectedness predicts higher subsequent perceived isolation, which, in turn, predicts higher depressive symptoms (Santini et al., 2020). Furthermore, socially isolated individuals exhibit greater psychological distress, lower life satisfaction, and less happiness (Mellor et al., 2008; Taylor et al., 2018). Poor mental health is a serious and debilitating disorder that has various negative consequences on physical health (Prince et al., 2007). Therefore, poor mental health linked to SI is a crucial issue that must be addressed at an early stage.

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Assuming that poor mental health due to SI is mainly caused by anxiety and agitation due to an extreme lack of interaction with others, it is possible that those who prefer solitude do not develop psychological disorders when socially isolated, as suggested in a previous systematic review (Chen and Liu, 2023). Solitude is the time spent in one's own company and is distinct from loneliness, which involves a subjective feeling of discomfort when alone (Peplau and Perlman, 1982). Although a stronger preference for solitude (PS) is linked to increased loneliness and reduced extraversion, it does not align with trait anxiety (Burger, 1995). People with a higher PS tend to enjoy solitary activities and thus feel more positive emotions than those with a lower PS, irrespective of the level of sociotropism (Leary et al., 2003). It has also been reported that PS among older adults improves their quality of life, is related to calmness and relaxation, and buffers unpleasant feelings (Chen and Liu, 2023). Considering these findings, if individuals prefer to spend a significant amount of their time alone without experiencing any negative side effects, those with higher PS may exhibit greater resilience to SI.

However, those who prefer solitude do not always have better well-being (Toyoshima and Sato, 2019), and it is unclear whether PS can mitigate the negative effects of isolation. To the best of our knowledge, only one study focusing on adolescents has assessed the effects of the interaction between PS and SI on mental health [21]. Interestingly, this study demonstrated no interactive effects and PS and SI were independently associated with poor mental status, including suicidal ideation and self-harm (Endo et al., 2017). Several studies support these findings, showing the coexistence of the negative and positive effects of PS (Chen and Liu, 2023; Weinstein et al., 2023). Furthermore, solitude has been associated with lower emotional positive affect; more importantly, solitude predicts lower negative affect among individuals with more conflictual social networks, but not among those with less conflictual networks (Birditt et al., 2019). This finding raises the possibility that PS may be an adaptive strategy for individuals immersed in challenging social contexts, including difficulties with socializing. Consequently, such individuals may not have sufficient resilience to SI. Given that the burden of socializing may mediate the association between PS and mental health, it is reasonable to infer that individuals who favor solitude may exhibit poor mental health. This is because people who avoid social interactions often experience mental status challenges. Understanding the association between PS, SI, troublesomeness of socializing, and mental health status among various generations is important to better understand the meaning of the preference for social interaction in our lives, including the underlying mechanisms and possible health impacts. However, most studies examining PS have focused on individual generations and the issue of intergenerational differences remains unclear.

This study aimed to (1) confirm whether socially isolated individuals receive mental health benefits from solitude and (2) assess whether the troublesomeness of socializing mediates the association between PS and mental health status. To this end, we conducted an Internet survey across three generations: young, middle-aged, and older adults. We hypothesized that socially isolated individuals with a higher PS would not exhibit better mental health than those who were socially isolated but have a lower PS, as seen in adolescents (Endo et al., 2017) (Hypothesis 1). Furthermore, based on previous findings indicating that solitude is associated with less positive emotional affect among older adults and less negative emotional affect among individuals with more conflicting social networks (Birditt et al., 2019), a higher PS may be associated with poor mental health due to the mediation of the hassle of socializing (Hypothesis 2). Although we cannot determine this due to a lack of prior findings, these hypotheses might apply to all generations because the negative aspects of PS have been observed in adolescents and older adults (Birditt et al., 2019; Endo et al., 2017; Toyoshima and Sato, 2019).

2. Methods

2.1. Study design and participants

We conducted a cross-sectional study involving a self-administered anonymous survey distributed on the Internet from September 15 to 20, 2023. The survey was commissioned by an independent research agency, My Voice Communications Inc., Tokyo, Japan. Survey invitations, along with the designated questionnaire URLs, were sent to 9000 randomly selected individuals from a survey panel registered with the research agency, which comprised approximately 1.06 million registrants as of August 2023. Study participants were eligible if they resided in Tokyo or three surrounding prefectures and were aged 20–79 years. We ensured equal representation of both sexes (female and male) and various age groups (20–70 years), with 750 participants in each of the 12 categories. After completing the questionnaire, respondents received redeemable cash points (equivalent to JPY 50). The questionnaire included a dummy question (i.e., a trick question) to verify whether the respondents had correctly read the text before providing their answers. Specifically, respondents were instructed to skip the following question and proceed to the subsequent question and presented with five options ranging from “agree” to “disagree” for the statement. The survey was terminated for those who responded to this question (i.e., selected an option). Only those who adhered to the instructions and moved on to the next question without responding were able to continue the main survey. The survey concluded once the target number of respondents was reached (750 in each category, total = 9000) and this sample was analyzed as study participants.

The study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki. Ethical approval for this study was obtained from the Tokyo Metropolitan Institute of Gerontology. Informed consent was obtained before the start of the survey in accordance with the protocols approved by the local institutional review board.

2.2. Measurements

2.2.1. Preference for solitude scale

The Preference for Solitude Scale developed by Burger (1995) assesses an individual's inclination to spend time alone, emphasizing the positive aspects of solitude (Burger, 1995). The scale comprises 12 previously validated two-choice questions. Scores range from 0 to 12, with higher scores indicating stronger PS. We used the Japanese version of the scale developed by Toyoshima et al. (Toyoshima and Kusumi, 2022; Toyoshima and Sato, 2019). In addition, participants were asked the following question: “Do you enjoy spending time alone more than with others?” to confirm the PS level using a single question. Participants were provided with four response choices: (1) agree, (2) somewhat agree, (3) somewhat disagree, or (4) disagree. They were then classified as either having a preference for solitude (agree or somewhat agree) or not (somewhat disagree or disagree).

2.2.2. Social isolation

SI was assessed using a widely used question (Ejiri et al., 2021; Sakurai et al., 2019b). Participants were asked about the frequency of both face-to-face and non-face-to-face (e.g., telephone, e-mail, and letters) interactions with family members and relatives who did not live with them, as well as friends and neighbors. The responses were categorized as follows: (1) more than twice a week, (2) once a week, (3) 2–3 times a month, (4) once a month, and (5) less than once a month. Based on previous studies (Mitsutake et al., 2021; Sakurai et al., 2019b), SI was defined as contact with anyone less than once a week.

2.2.3. Degree to which socializing is troublesome

The level of difficulty associated with socializing was evaluated using the following question: “Do you find socializing troublesome?”

Participants were presented with four response choices: (1) agree, (2) somewhat agree, (3) somewhat disagree, and (4) disagree. Responses (1) and (2) were classified as troublesome socializing. For mediation analysis, answers to the questions were converted to points ranging from 1 (disagree) to 4 (agree).

2.2.4. K6, WHO-5, and UCLA loneliness score

In this study, mental health status was operationalized using three measures: the K6, the WHO-5, and the UCLA Loneliness Score.

The K6, previously validated for Japanese samples, assesses distress symptoms, including overall worries and somatic complaints. Participants rated how well each of the six statements had applied to them within the last 30 days. Response categories spanned from “all of the time” to “none of the time,” yielding a total score ranging from 0 to 24, with higher scores indicating greater distress and depressive symptoms (Furukawa et al., 2008; Kessler et al., 2002).

The WHO-5 is a concise global rating scale for subjective well-being. It has demonstrated adequate validity as both a depression-screening tool and an outcome measure in clinical trials with Japanese samples (Awata et al., 2007). Participants rated how well each of the five statements had applied to them within the last 14 days. The scale ranges from 5 (“all of the time”) to 0 (“none of the time”), with scores spanning from 0 to 25 and lower scores indicating lower well-being.

The 20-item UCLA Loneliness Score was used to measure loneliness (Russell, 1996). Respondents rated their experiences on a scale ranging from 1 (“not at all”) to 4 (“often”). The total possible aggregate score ranges from 20 to 80, with higher scores indicating greater loneliness. The Japanese version has been confirmed to have high internal consistency and validity (Toyoshima and Sato, 2019).

2.2.5. Covariates and other variables

In this study, several sociodemographic and clinical variables were considered as covariates, including age, sex, living arrangements, subjective financial status, and health status. Subjective financial status was determined based on the method used in a previous study. Participants were asked to respond to a question regarding their financial leeway, with five choices ranging from “I have much financial leeway” to “My finances are very tight.” We then categorized the participants into either a moderate financial situation (from “I have much financial leeway” to “Average”) or a poor financial situation (from “My finances are tight” to “My finances are very tight”). Subjective health was assessed by asking, “How good is your health condition?” and was categorized as excellent, good, fair, or poor. We then assigned participants to either the good health group (comprising those who rated their health as excellent or good) or the poor health group (comprising those who rated their health as fair or poor). Additionally, we examined other relevant variables, including years of education, marital status, comorbidities, frequency of going outdoors, and work frequency to characterize the study participants.

We also explore the degree of loneliness experienced while eating alone. Participants responded on 4-point scale: (1) agree, (2) somewhat agree, (3) somewhat disagree, and (4) disagree. This was based on our speculation that, although eating alone is often perceived as a form of social disengagement (Kuroda et al., 2015; Sakurai et al., 2021a) leading to a sense of emptiness in life, those who prefer solitude might show resilience to such negative effects. Based on their responses, we assigned them to either the “feel lonely” group (comprising those who agreed or somewhat agreed) or the “not feel lonely” group (comprising those who somewhat disagreed).

2.3. Data analysis

Participants were initially divided into three groups (i.e., tertiles) based on their Preference for Solitude Scale results within each of the three age groups: young (20–39 years), middle-aged (40–59 years), and older adults (60–79 years). Descriptive statistics of the differences

among the three solitude groups were analyzed using the chi-square test for categorical variables and analysis of variance for continuous variables. To address Hypothesis 1 (H1), we conducted a separate two-way analysis of covariance (ANCOVA) for each age group. The independent factors were solitary and SI with adjustments for the aforementioned covariates. If an interaction was observed, we assessed the simple main effects using the Bonferroni correction. For Hypothesis 2 (H2), we performed mediation analyses using PROCESS macro in the Statistical Package for the Social Sciences (SPSS) by Preacher and Hayes (Version 3.5). Our goal was to explore whether changes in the hassle of socializing mediate the potential association between solitude and mental health. We also verified the prerequisites for conducting mediation analysis, including the associations between Y and X, Y and M, and M and X, using the regression model provided by PROCESS macro. The mediation analysis was adjusted for the same covariates as in the ANCOVA. These analyses were also carried out with stratification by sex to further evaluate the sex differences in H1 and H2. Finally, we conducted a sensitivity analysis to assess whether our PS classification was suitable for examining the associations with mental health. Specifically, we examined the mean scores of the outcome variables based on raw PS scores and confirmed consistent trends among the three groups (i.e., groups divided by PS score tertiles). Statistical analyses were performed using IBM SPSS (version 23.0; (SPSS Inc., Armonk, NY, USA).

3. Results

3.1. Characteristics of those who prefer solitude

None of the participants were excluded based on the dummy question. Fig. 1 shows the distribution of participants based on their PS scores across the three age groups. Additionally, it shows the percentage of participants who reported enjoying spending more time alone than with others on a single question and socializing as troublesome in relation to their PS scores. The number of participants with each PS score showed an upward trend across all age groups, suggesting a gradual increase in PS. Many participants expressed PS, regardless of their generational cohort. Furthermore, as the PS score increased, the percentage of participants who reported enjoying spending time alone (red solid polyline: 73.3 %, 74.3 %, and 62.3 % for young, middle-aged, and older adults, respectively) and who found socializing troublesome (blue dashed polyline: 64.2 %, 65.1 %, and 44.7 % for young, middle-aged, and older adults, respectively) increased.

Tables 1–3 show the demographic, clinical, and lifestyle characteristics of the participants according to age group. Among young and middle-aged adults, low, medium, and high PS scores corresponded to PS scores ranging from 0 to 7, 8 to 10, and above 11, respectively. For older adults, the PS scores decreased from 0 to 6, 7 to 9, and above 10. The characteristics of the three PS groups were consistent across the age groups, and this similarity was observed for most variables. No significant differences in sex ratios were found between the PS groups across the three generations. Individuals with a higher PS exhibited a greater prevalence of being unmarried, reporting poor subjective health, low social functioning scores, low frequency of going outdoors, and experiencing SI across all three age groups. Conversely, those with higher PS scores were less likely to perceive loneliness when eating alone. An association with poor mental health was observed, characterized by higher K6 scores, lower WHO-5 scores, and increased scores on the UCLA Loneliness Scale as the solitude preference intensified. An additional analysis evaluating sex differences revealed no significant differences in PS scores, with the exception of young adults, where females exhibited a slight yet significant higher tendency toward PS (Table S1 in Supplementary data). Consistent with the results of the comprehensive sample analysis, both females and males across all age groups who exhibited PS tended to have higher K6 scores, lower WHO-5 scores, and higher scores on the UCLA Loneliness Scale (Table S2 in Supplementary data).

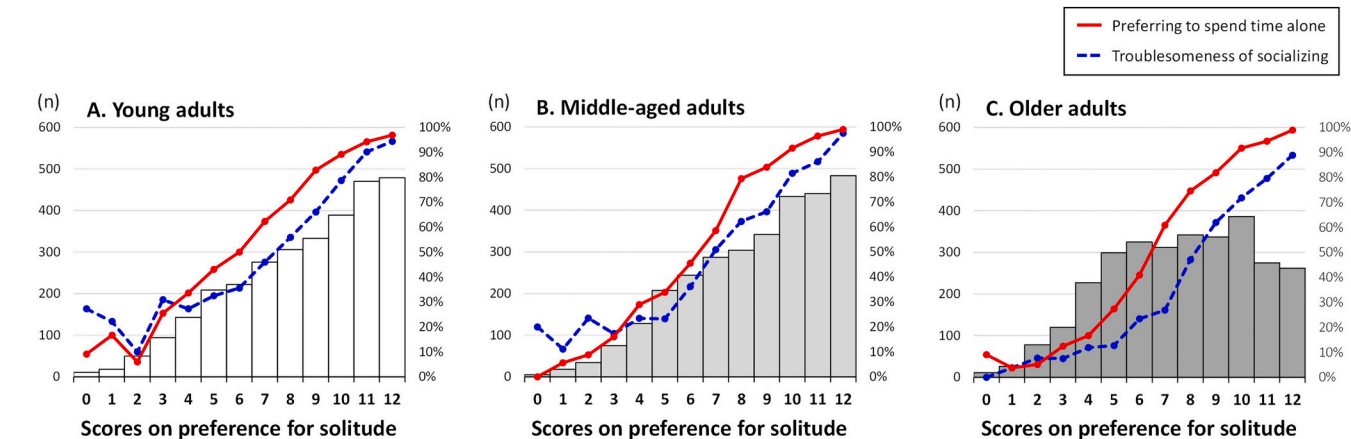


Fig. 1. Distribution of the Preference for Solitude Scale scores for three generations
The right vertical axis indicates the percentage of respondents who preferred to spend time alone (red solid polyline) and who experienced troubled socialization (blue dashed polyline) for each score on the Preference for Solitude Scale. Both percentages are the combined percentages of those who answered “agree” or “somewhat agree” to the question.

Table 1
Young respondent characteristics stratified by scores of Preference for Solitude Scale.

	Young adults (aged 20–39)						<i>p</i> -value
	Preference for Solitude score						
	Low		Medium		High		
	<i>n</i> = 1023		<i>n</i> = 1028		<i>n</i> = 949		
Age, mean (SD)	29.9	(5.6)	30.5	(5.6)	30.8	(5.7)	<i>p</i> < 0.001
Female, <i>n</i> (%)	488	(47.7)	537	(52.2)	475	(50.1)	0.121
Marital status, <i>n</i> (%)							
Married	377	(36.9)	321	(31.2)	226	(23.8)	<i>p</i> < 0.001
Unmarried	627	(61.3)	691	(67.2)	709	(74.7)	
Separation	17	(1.7)	15	(1.5)	14	(1.5)	
Widowed	2	(0.2)	1	(0.1)	0	(0.0)	
Living alone, <i>n</i> (%)	278	(27.2)	289	(28.1)	290	(30.6)	0.232
Comorbidities, <i>n</i> (%)							
Hypertension	15	(1.5)	9	(0.9)	15	(1.6)	0.325
Diabetes mellitus	11	(1.1)	4	(0.4)	6	(0.6)	0.168
Cerebrovascular disorder	0	(0.0)	0	(0.0)	1	(0.1)	0.339
Cancer	5	(0.5)	2	(0.2)	0	(0.0)	0.076
Liver disease	2	(0.2)	0	(0.0)	4	(0.4)	0.111
Heart disease	4	(0.4)	9	(0.9)	2	(0.2)	0.093
Poor subjective health, <i>n</i> (%)	180	(17.6)	244	(23.7)	284	(29.9)	<i>p</i> < 0.001
Low education level, <i>n</i> (%)	225	(22.0)	260	(25.3)	250	(26.3)	0.062
Poor SFS, <i>n</i> (%)	278	(27.2)	343	(33.4)	385	(40.6)	<i>p</i> < 0.001
Low frequency of going outdoors, <i>n</i> (%)	61	(6.0)	88	(8.6)	100	(10.5)	0.001
Work less than once a week, <i>n</i> (%)	192	(18.8)	222	(21.6)	242	(25.5)	0.001
Social isolation, <i>n</i> (%)	425	(41.5)	635	(61.8)	705	(74.3)	<i>p</i> < 0.001
Socializing troublesome, <i>n</i> (%)	354	(34.6)	697	(67.8)	876	(92.3)	<i>p</i> < 0.001
Feel lonely eating alone, <i>n</i> (%)	489	(47.8)	267	(26.0)	121	(12.8)	<i>p</i> < 0.001
K6 score, mean (SD)	6.0	(5.6)	7.2	(6.0)	8.7	(6.5)	<i>p</i> < 0.001
WHO-5 score, mean (SD)	15.3	(5.5)	12.8	(5.6)	11.5	(5.6)	<i>p</i> < 0.001
UCLA-LS score, mean (SD)	44.5	(12.3)	50.4	(11.3)	54.6	(11.4)	<i>p</i> < 0.001
Preference for Solitude score, mean (SD)	5.2	(1.7)	9.1	(0.8)	11.5	(0.5)	<i>p</i> < 0.001

Low education level, 12 years or less of schooling; SFS, subjective financial status; Low frequency of going outdoors was defined as going out every few days or less; UCLA-LS, UCLA Loneliness Scale.

3.2. Interactive effect of preference for solitude and social isolation

Table 4 shows the results of the two-way ANCOVA examining the impact of PS and SI on the main outcomes. For the WHO-5, consistent trends emerged across the three age groups; the main effects of PS and SI were both significant, independently influencing lower WHO-5 scores. Similarly, the UCLA Loneliness Scale followed the same pattern as the WHO-5; both main effects were observed but no interaction effects were detected. Specifically, the higher PS groups reported greater feelings of loneliness, regardless of their SI status, and vice versa. In the case of the K6, the ANCOVA revealed a significant main effect of PS among middle-

aged and older adults but no other significant main effects or interactions. Conversely, young adults exhibited significant main effects without any interactions. Supplementary analyses examining sex differences revealed a trend consistent with the results of the entire sample (Table S3 in Supplementary data). Only middle-aged males demonstrated the interactive effects of PS and SI on increased UCLA Loneliness Scale scores.

3.3. Mediation effect of the hassle of socializing

Table 5 presents the results of mediation analyses. For K6, we

Table 2
Middle-aged respondent characteristics stratified by scores of Preference for Solitude Scale.

	Middle-aged adults (aged 40–59)						<i>p</i> -value
	Preference for Solitude score						
	Low		Medium		High		
	<i>n</i> = 998		<i>n</i> = 1079		<i>n</i> = 923		
Age, mean (SD)	50.1	(5.6)	50.2	(5.4)	49.8	(5.4)	0.222
Female, <i>n</i> (%)	481	(48.2)	555	(51.4)	464	(50.3)	0.330
Marital status, <i>n</i> (%)							
Married	716	(71.7)	660	(61.2)	478	(51.8)	<i>p</i> < 0.001
Unmarried	227	(22.7)	350	(32.4)	390	(42.3)	
Separation	43	(4.3)	61	(5.7)	52	(5.6)	
Widowed	12	(1.2)	8	(0.7)	3	(0.3)	
Living alone, <i>n</i> (%)	139	(13.9)	218	(20.2)	230	(24.9)	<i>p</i> < 0.001
Comorbidities, <i>n</i> (%)							
Hypertension	100	(10.0)	103	(9.5)	92	(10.0)	0.924
Diabetes mellitus	30	(3.0)	34	(3.2)	36	(3.9)	0.506
Cerebrovascular disorder	5	(0.5)	9	(0.8)	6	(0.7)	0.646
Cancer	20	(2.0)	10	(0.9)	15	(1.6)	0.122
Liver disease	2	(0.2)	3	(0.3)	4	(0.4)	0.638
Heart disease	7	(0.7)	9	(0.8)	15	(1.6)	0.098
Poor subjective health, <i>n</i> (%)	181	(18.1)	271	(25.1)	306	(33.2)	<i>p</i> < 0.001
Low education level, <i>n</i> (%)	181	(18.1)	205	(19.0)	207	(22.4)	0.045
Poor SFS, <i>n</i> (%)	260	(26.1)	341	(31.6)	359	(38.9)	<i>p</i> < 0.001
Low frequency of going outdoors, <i>n</i> (%)	32	(3.2)	63	(5.8)	63	(6.8)	0.001
Work less than once a week, <i>n</i> (%)	166	(16.6)	236	(21.9)	236	(25.6)	<i>p</i> < 0.001
Social isolation, <i>n</i> (%)	494	(49.5)	686	(63.6)	658	(71.3)	<i>p</i> < 0.001
Socializing troublesome, <i>n</i> (%)	336	(33.7)	768	(71.2)	850	(92.1)	<i>p</i> < 0.001
Feel lonely eating alone, <i>n</i> (%)	463	(46.4)	215	(19.9)	101	(10.9)	<i>p</i> < 0.001
K6 score, mean (SD)	3.8	(4.6)	4.9	(5.2)	6.9	(6.0)	<i>p</i> < 0.001
WHO-5 score, mean (SD)	15.1	(5.2)	12.9	(5.3)	11.2	(5.5)	<i>p</i> < 0.001
UCLA-LS score, mean (SD)	42.8	(11.7)	48.5	(10.4)	54.2	(10.7)	<i>p</i> < 0.001
Preference for Solitude score, mean (SD)	5.3	(1.6)	9.1	(0.8)	11.5	(0.5)	<i>p</i> < 0.001

Low education level, 12 years or less of schooling; SFS, subjective financial status; Low frequency of going outdoors was defined as going out every few days or less; UCLA-LS, UCLA Loneliness Scale.

Table 3
Older respondent characteristics stratified by scores of Preference for Solitude Scale.

	Older adults (aged 60–79)						<i>p</i> -value
	Preference for Solitude score						
	Low		Medium		High		
	<i>n</i> = 1086		<i>n</i> = 991		<i>n</i> = 923		
Age, mean (SD)	69.6	(5.3)	68.8	(5.4)	67.7	(5.4)	<i>p</i> < 0.001
Female, <i>n</i> (%)	563	(51.8)	503	(50.8)	434	(47.0)	0.083
Marital status, <i>n</i> (%)							
Married	885	(81.5)	753	(76.0)	630	(68.3)	<i>p</i> < 0.001
Unmarried	60	(5.5)	91	(9.2)	137	(14.8)	
Separation	83	(7.6)	82	(8.3)	104	(11.3)	
Widowed	58	(5.3)	65	(6.6)	52	(5.6)	
Living alone, <i>n</i> (%)	146	(13.4)	164	(16.5)	217	(23.5)	<i>p</i> < 0.001
Comorbidities, <i>n</i> (%)							
Hypertension	334	(30.8)	299	(30.2)	244	(26.4)	0.077
Diabetes mellitus	95	(8.7)	84	(8.5)	98	(10.6)	0.213
Cerebrovascular disorder	13	(1.2)	9	(0.9)	13	(1.4)	0.591
Cancer	46	(4.2)	24	(2.4)	20	(2.2)	0.011
Liver disease	2	(0.2)	11	(1.1)	4	(0.4)	0.016
Heart disease	49	(4.5)	50	(5.0)	49	(5.3)	0.699
Poor subjective health, <i>n</i> (%)	140	(12.9)	209	(21.1)	257	(27.8)	<i>p</i> < 0.001
Low education level, <i>n</i> (%)	283	(26.1)	229	(23.1)	250	(27.1)	0.112
Poor SFS, <i>n</i> (%)	159	(14.6)	170	(17.2)	246	(26.7)	<i>p</i> < 0.001
Low frequency of going outdoors, <i>n</i> (%)	38	(3.5)	73	(7.4)	88	(9.5)	<i>p</i> < 0.001
Work less than once a week, <i>n</i> (%)	616	(56.7)	582	(58.7)	542	(58.7)	0.565
Social isolation, <i>n</i> (%)	339	(31.2)	487	(49.1)	558	(60.5)	<i>p</i> < 0.001
Socializing troublesome, <i>n</i> (%)	157	(14.5)	454	(45.8)	729	(79.0)	<i>p</i> < 0.001
Feel lonely eating alone, <i>n</i> (%)	584	(53.8)	311	(31.4)	151	(16.4)	<i>p</i> < 0.001
K6 score, mean (SD)	2.0	(3.0)	2.5	(3.3)	3.6	(4.2)	<i>p</i> < 0.001
WHO-5 score, mean (SD)	16.4	(4.6)	15.0	(4.7)	13.6	(5.2)	<i>p</i> < 0.001
UCLA-LS score, mean (SD)	36.6	(9.9)	42.8	(9.9)	48.3	(10.1)	<i>p</i> < 0.001
Preference for Solitude score, mean (SD)	4.5	(1.4)	8.0	(0.8)	10.9	(0.8)	<i>p</i> < 0.001

Low education level, 12 years or less of schooling; SFS, subjective financial status; Low frequency of going outdoors was defined as going out every few days or less; UCLA-LS, UCLA Loneliness Scale.

Table 4
Main outcome comparisons by level of preference for solitude and social isolation for three generations.

	PS: Low		PS: Medium		PS: High		PS	SI	PS × SI
	Non-SI	SI	Non-SI	SI	Non-SI	SI			
<i>Young adults</i>	<i>n</i> = 598	<i>n</i> = 425	<i>n</i> = 393	<i>n</i> = 635	<i>n</i> = 244	<i>n</i> = 705			
K6 score	5.8 (5.4)	6.3 (5.9)	7.1 (5.7)	7.2 (6.1)	8.0 (6.1)	9.0 (6.6)	<i>p</i> < 0.001	0.044	0.170
WHO-5 score	16.2 (5.1)	14.0 (5.8)	13.8 (5.5)	12.2 (5.6)	12.8 (5.3)	11.1 (5.7)	<i>p</i> < 0.001	<i>p</i> < 0.001	0.293
UCLA-LS score	42.7 (12.1)	47.0 (12.0)	48.5 (11.7)	51.6 (10.9)	51.0 (11.5)	55.9 (11.1)	<i>p</i> < 0.001	<i>p</i> < 0.001	0.147
<i>Middle-aged adults</i>	<i>n</i> = 504	<i>n</i> = 494	<i>n</i> = 393	<i>n</i> = 686	<i>n</i> = 265	<i>n</i> = 658			
K6 score	3.5 (4.5)	4.1 (4.8)	5.0 (5.1)	4.9 (5.3)	6.8 (5.6)	7.0 (6.1)	<i>p</i> < 0.001	0.574	0.254
WHO-5 score	15.8 (5.1)	14.4 (5.3)	13.7 (5.1)	12.5 (5.3)	11.8 (5.4)	10.9 (5.6)	<i>p</i> < 0.001	<i>p</i> < 0.001	0.773
UCLA-LS score	40.3 (11.4)	45.3 (11.5)	45.3 (9.9)	50.4 (10.1)	51.4 (10.7)	55.3 (10.5)	<i>p</i> < 0.001	<i>p</i> < 0.001	0.522
<i>Older adults</i>	<i>n</i> = 747	<i>n</i> = 339	<i>n</i> = 504	<i>n</i> = 487	<i>n</i> = 365	<i>n</i> = 558			
K6 score	1.8 (2.7)	2.4 (3.4)	2.4 (3.0)	2.6 (3.6)	3.5 (4.2)	3.7 (4.2)	<i>p</i> < 0.001	0.292	0.428
WHO-5 score	16.8 (4.3)	15.5 (5.1)	15.7 (4.4)	14.3 (5.0)	14.4 (5.1)	13.2 (5.2)	<i>p</i> < 0.001	<i>p</i> < 0.001	0.947
UCLA-LS score	35.0 (9.0)	40.1 (10.8)	40.5 (9.4)	45.2 (9.8)	45.9 (9.9)	50.0 (10.0)	<i>p</i> < 0.001	<i>p</i> < 0.001	0.485

PS: preference for solitude; SI: social isolation; UCLA-LS: UCLA Loneliness Scale. The numbers within parentheses represent standard deviations (SDs).

observed that medium and high PS scores were associated with higher K6 scores (i.e., total effects) across the three generations. After the significant indirect effects of socializing troublesomeness were observed in both the medium and high PS groups, the direct effects diminished (i.e., full mediation), except for the high PS group among middle-aged adults. Furthermore, beyond the total and direct effects, we identified indirect effects in the associations between PS groups and WHO-5 and UCLA Loneliness Scale scores across the three age groups (i.e., partial mediation). These associations remained statistically significant when assessed by stratification by sex, indicating indirect effects of troublesomeness of socializing on the associations between PS groups and measurements of mental health in both sexes (Tables S4 and S5 in Supplementary data).

3.4. Sensitivity analysis for our PS classification

A further sensitivity analysis (Fig. S1 in Supplementary data) showed that although the applicable cases were limited (constituting only 0.7 % to 1.2 % of the samples), individuals with a markedly lower propensity for PS, specifically those scoring 0 or 1 point, exhibited a consistent trend. Among young and middle-aged adults, these lower PS proxies showed lower WHO-5 scores and higher K6 and UCLA Loneliness Scale scores. However, this trend was not observed in older adults. When we removed samples with a markedly lower propensity for PS, the same underlying trends as in the original analyses were confirmed, and an increase in PS was linked to mental health status deterioration.

4. Discussion

The present study revealed that, regardless of generation and sex, individuals who strongly prefer solitude and experience SI do not necessarily exhibit better mental health than those who are less inclined toward solitude but are socially isolated. More importantly, individuals with a higher PS demonstrated poor mental health, similar to those who are socially isolated. Furthermore, the challenges associated with socializing played a mediating role in the observed association between solitude and mental health status across all three generations. These findings suggest that a higher PS does not confer greater resistance to SI and does not lead to improved mental health when arising from a rationalized PS due to social difficulties. Our results offer new insights into the underlying mechanisms linking preferences for social interaction and social engagement with mental health outcomes.

An upward trend in PS was observed across the three generations, indicating that many participants favored solitude, regardless of their generational cohort. Although this PS distribution may indicate the true nature of the general population, one possible explanation is the design of the Internet survey. It has been suggested that there are differences in

the data characteristics between face-to-face and Internet surveys (Heerwegh and Loosveldt, 2008). Considering the nature of an Internet survey, participants in this study may have had different demographics from the general population of the community and a higher percentage of those who preferred solitude. Notably, PS scores remained generally consistent across the three generations compared to previous Internet surveys conducted in Japan (Toyoshima and Sato, 2019). Since no community-based study has specifically assessed PS scores, the results of our survey were compared with those of a community-based study conducted in a town in central Tokyo, Japan, for the WHO-5 and K6. The comparison revealed similar values for both measures, although the K6 scores of young and older adults in this study were slightly higher and lower, respectively (Sakurai et al., 2021b). Overall, considering the WHO-5 and K6 scores, the participants in this study appeared to be homogeneous with the general community in terms of their mental health status.

As hypothesized, PS did not correlate with better mental health; instead, it showed worse mental status across the three generations, without any preventive effects against SI. Previous research has highlighted that PS is not a straightforward predictor of improved mental health; rather, it is intricately linked to poor mental well-being (Birditt et al., 2019; Endo et al., 2017; Toyoshima and Sato, 2019). Interestingly, older adults without high PS tend to experience more positive emotional affect during interactions with friends, whereas those with high PS find solace in spending time alone (Toyoshima and Sato, 2019). Similarly, solitude can benefit conflicting social networks (Birditt et al., 2019). Our findings underscore the fact that choosing isolation due to PS does not unconditionally promote mental health. Furthermore, higher PS may independently contribute to poor mental health, irrespective of SI. These results could be confounded by possible factors such as lower subjective health, which was observed to increase alongside PS scores, even though we controlled for it as a covariate.

Individuals with higher PS scores exhibited greater feelings of loneliness, as assessed using the UCLA Loneliness Scale. This finding aligns with that of previous research indicating that people with high PS tend to experience loneliness. This association implies that while they may prefer solitude, they also feel a lack of desire for social relationships. This speculation appears reasonable because PS does not enhance life satisfaction and may even have a negative impact (Toyoshima and Sato, 2019). In contrast, we found that individuals with higher PS tended to not perceive loneliness when eating alone. Eating alone is considered a behavioral risk factor for adverse outcomes due to poor social networks or social exclusion (Saito et al., 2024; Sakurai et al., 2021a). Our findings suggest that those with higher PS exhibit resilience to eating meals alone or experiencing social exclusion. It can also be interpreted as an adaptation to a lifestyle that does not prioritize

Table 5
Mediation analysis of the PS for mental health by troublesomeness for socializing.

	Young adults	Middle-aged adults	Older adults
	Effect (95 % CI)	Effect (95 % CI)	Effect (95 % CI)
PS→K6			
Relative total effects			
Medium	0.76 (0.28, 1.24)	0.77 (0.36, 1.19)	0.29 (0.003, 0.57)
High	1.91 (1.42, 2.41)	2.26 (1.82, 2.71)	1.04 (0.74, 1.33)
Relative direct effects			
Medium	0.02 (−0.47, 0.51)	−0.03 (−0.47, 0.40)	−0.10 (−0.39, 0.20)
High	0.45 (−0.11, 1.01)	0.83 (0.33, 1.34)	0.29 (−0.06, 0.64)
Relative indirect effects			
<i>PS→TS→K6</i>			
Medium	0.74 (0.57, 0.93)	0.81 (0.64, 0.99)	0.38 (0.28, 0.49)
High	1.46 (1.16, 1.77)	1.43 (1.16, 1.72)	0.74 (0.55, 0.95)
PS→WHO-5			
Relative total effects			
Medium	−2.01 (−2.45, −1.57)	−1.76 (−2.18, −1.34)	−1.31 (−1.72, −0.89)
High	−2.83 (−3.28, −2.38)	−3.01 (−3.45, −2.57)	−2.59 (−3.02, −2.17)
Relative direct effects			
Medium	−1.49 (−1.94, −1.04)	−0.93 (−1.37, −0.49)	−0.47 (−0.90, −0.04)
High	−1.81 (−2.32, −1.30)	−1.54 (−2.05, −1.03)	−0.94 (−1.44, −0.44)
Relative indirect effects			
<i>PS→TS→WHO-5</i>			
Medium	−0.52 (−0.68, −0.37)	−0.83 (−1.02, −0.65)	−0.84 (−1.02, −0.67)
High	−1.02 (−1.30, −0.74)	−1.47 (−1.77, −1.18)	−1.65 (−1.95, −1.34)
PS→UCLA-LS			
Relative total effects			
Medium	5.20 (4.25, 6.15)	5.01 (4.13, 5.90)	5.44 (4.63, 6.24)
High	8.63 (7.65, 9.60)	9.70 (8.77, 10.63)	9.76 (8.92, 10.60)
Relative direct effects			
Medium	2.79 (1.85, 3.73)	1.90 (1.03, 2.78)	3.02 (2.21, 3.83)
High	3.88 (2.81, 4.95)	4.18 (3.16, 5.20)	5.06 (4.11, 6.01)
Relative indirect effects			
<i>PS→TS→UCLA-LS</i>			
Medium	2.41 (1.99, 2.84)	3.11 (2.66, 3.57)	2.41 (2.04, 2.79)
High	4.75 (4.09, 5.38)	5.52 (4.89, 6.15)	4.70 (4.12, 5.29)

PS: preference for solitude; TS: troublesomeness of socializing; UCLA-LS: UCLA Loneliness Scale. The significant values are indicated in bold font.

socialization. Existing research indicates that when individuals face threats to their social bonds (e.g., social exclusion), their brains respond similarly to physical pain (e.g., activation of the anterior cingulate cortex) (Eisenberger et al., 2003). Individuals with high PS who report feelings of loneliness but also demonstrate a high tolerance for eating meals alone may not exhibit the same neural reactions when socially excluded owing to their PS characteristics.

The hassle of socializing mediates the association between higher PS and poor mental health. When we included the hassle of socializing as a

mediator, the direct effects on psychological distress, as assessed by the K6, diminished. As mentioned in the Introduction, PS can have both negative and positive effects (Chen and Liu, 2023; Weinstein et al., 2023). Our results clearly indicate that if PS coexists with a higher degree of socialization-related problems or arises from justifying difficulties in social interactions, it is associated with a greater tendency toward psychological distress. Although the association between PS and well-being or loneliness was partly explained by the challenges faced by individuals when socializing, given the cross-sectional design of our study, caution is necessary when interpreting the results. Specifically, we cannot definitively determine whether the participants' troublesomeness with socializing is an innate disposition or temperament that develops due to their deteriorating mental health. Longitudinal studies are needed to elucidate this causal relationship.

Although the strength of this study is that it was the first to confirm the lack of a protective effect of PS on SI-related poor mental health and to explore the mediating effects of socializing troubles, it is not without limitations. As previously mentioned, the cross-sectional design prevented us from establishing causal relationships based on the observed associations. Additionally, we cannot dismiss the possibility of sampling bias due to Internet survey participants, although we verified that our sample's mental health status was comparable to that of participants in a community-based study (Sakurai et al., 2021b). Future longitudinal studies involving the general population should investigate whether PS or the troublesomeness of socialization precedes mental health deterioration.

In conclusion, our study revealed that individuals who socially isolate themselves from (or because of) higher PS do not always experience good mental health. Across all the three age groups, those who preferred solitude tended to have poorer mental health and experience greater feelings of loneliness. Importantly, this association was mediated by the challenges associated with socializing. Our findings contribute to a deeper understanding of what a preference for social interaction signifies in our social lives and may aid in identifying individuals at risk of mental health issues.

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CRedit authorship contribution statement

RS structured the study design, collected the data, performed statistical analyses, interpreted the data, drafted the manuscript, and finalized it. MS designed the study, interpreted the data, and approved the final version of the manuscript. HS and FY interpreted the data and approved the final manuscript. All authors affirm their full access to the study data and accept responsibility for the decision to submit the manuscript for publication.

Declaration of competing interest

The authors declare no potential conflicts of interest with respect to the research.

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