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Social isolation trajectories in midlife and later-life: patterns and associations with health

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Abstract

Objectives: Social isolation has objective and subjective dimensions. Few studies have simultaneously examined trajectories of both dimensions. We integrated multiple indicators of both dimensions to identify social isolation trajectory patterns and investigated how different patterns were related to adults' physical, mental, cognitive, and self-rated health.

Methods: We used latent class growth modeling to examine social isolation trajectory patterns, based on data from the 2008—2016 waves of the Health and Retirement Study ($N = 6457$). Mixed-effect linear models were used to examine how trajectory patterns were associated with functional limitations, depressive symptoms, memory deficits, and self-rated health over the 8-year study period.

Results: Four social isolation trajectory patterns were identified: severe isolation (15.4%), moderate isolation (37.6%), some objective and rare subjective isolation (35.4%), and rare objective and low subjective isolation (11.6%). Social isolation trajectory patterns showed a gradient in all health domains. The rare objective and low subjective isolation group had the best health (i.e., the fewest functional limitations, depressive symptoms, and memory deficits and the best self-rated health); the some objective and rare subjective isolation group had the next best health; the moderate isolation group had the second worst health; and the severe isolation group had the worst health.

Conclusions: The prevalence and stability of severe and moderate social isolation suggest it may be necessary to address social isolation at the national level. The most favorable health outcomes associated with the rare objective and low subjective isolation group supports interventions to strengthen social networks and engagement midlife and later-life.

KEYWORDS
HRS, latent class growth modeling, loneliness, social disconnectedness

Key points

- Objective social isolation and subjective social isolation are interrelated but different concepts
- This study conceptualizes social isolation as a multi-dimensional construct by considering objective isolation and subjective isolation simultaneously
- Four distinct patterns of social isolation trajectories are identified

- Estimates of the prevalence of severe isolation and moderate isolation among Americans aged over 50 years are 15.4% and 37.6%

1 | INTRODUCTION

Social distancing requirements related to COVID-19 have heightened concerns about social isolation and its health consequences. Social isolation has objective and subjective dimensions.[1] Objective social isolation refers to a lack of social contact and participation,[1,2] whereas subjective isolation refers to the subjective experience that accompanies a perceived discrepancy between one's desired and actual relationship quantity and quality.[3] Prior studies suggest that the two dimensions are only modestly correlated.[1,4] Conceptualizing social isolation as composing of objective and subjective dimensions, this study aims to (1) identify patterns of changes in social isolation over eight years in a sample of middle-aged and older adults and (2) examine how patterns of social isolation trajectories were associated with physical, mental, cognitive, and self-rated health.

1.1 | Prevalence of objective and subjective social isolation

Subjective and objective isolation are two interrelated but distinct aspects of social isolation. Objective social isolation is frequently indicated by social disconnectedness, which is often characterized by a small social network, infrequent social interaction, and low levels of participation in activities. Subjective social isolation or perceived social isolation, on the other hand, reflects the subjective experience of a shortfall in one's social resources, which is often indicated by feelings of loneliness and perceived lack of support in social relationships.[1]

Studies have reported a high prevalence of social disconnectedness and loneliness among U.S. older adults. For example, 24–40% of Medicare beneficiaries were classified as socially disconnected[5,6]; 43% of adults aged 60 years and older reported feeling lonely.[2,7] But few studies have examined the two dimensions together. Highlighting the discrepancy between objective and subjective isolation, McHugh and colleagues[8] report that a portion of participants in two Irish and English aging studies were robust to loneliness (less lonely than expected based on their objective social isolation, 10-24%) and susceptible to loneliness (more lonely than expected, 6-20%), although a majority (40-50%) were high in both objective and subjective isolation and about 6-22% were low in both dimensions.

1.2 | Trajectories of objective and subjective social isolation

Stability and change of loneliness have been well examined. Most studies found that loneliness was stable in adulthood until after 70 when it began to increase.[9,10] Fewer studies have investigated trajectories of objective social isolation. A recent study shows that a majority of older adults (62%) were rarely socially disconnected but 17% were persistently disconnected over an 8-year period, and 14% and 7%, respectively, steadily increased and decreased in social disconnectedness.[11] Almost all prior studies have focused on only one dimension of social isolation when examining stability and change of social isolation. Given the dual dimensions of social isolation, it seems imperative to examine both dimensions jointly in order to understand social isolation in mid- and later-life.

1.3 | Social isolation and health

In general, the literature supports that objective and subjective isolation, respectively, is significantly associated with physical, mental and cognitive health outcomes.[12-17] However, prior research has two limitations. First, the two social isolation dimensions are inadequately measured. Most prior studies relied on a single scale/ index/ item to measure objective (e.g., social ties, frequency of social interactions) and subjective (e.g., perceived lack of support, loneliness) isolation. A single measure may not fully capture the two constructs. For example, social ties do not necessarily represent the degree of social engagement, and perceived social support does not necessarily reflect loneliness. Second, the joint effects of objective and subjective social isolation on health have rarely been investigated. It is erroneous to assume that their effects are additive. In the study by McHugh and colleagues[8] mentioned above, they found that the "robust to loneliness" individuals had the best and the "susceptible to loneliness" had the worst cognitive performance among the four groups, while the other two groups (high/ low in both objective and subjective isolation) were in between. The contribution of social isolation towards health outcomes cannot be well-understood when each dimension of social isolation is studied separately.

We addressed the above-mentioned shortcomings by (a) using multiple indicators to assess objective isolation and two indicators to measure subjective isolation, (b) identifying patterns of social isolation trajectories based on changes in all the indicators over eight years, and (c) examining the associations of social isolation trajectory patterns with physical, mental, cognitive, and self-rated health.

2 | METHODS

2.1 | Data

This analysis was based on the Health and Retirement Study, a nationally representative longitudinal study of the U.S. population aged over 50 years conducted every 2 years since 1992. Starting with Wave

8 (2006), a random half sample was assigned to participate in an Enhanced Face-to-Face Interview (EFTF), which included a leave-behind questionnaire on psychosocial topics. Another half sample participated in the EFTF in Wave 9 (2008). The Wave 9 (2008) participants were followed in Waves 11 (2012) and 13 (2016). We studied the period between 2008 (baseline) and 2016 because 2008 was the first year with comparable information for all social isolation variables.

For the latent class growth analyses, the study sample was limited to respondents who participated in at least two waves of the EFTF interviews (N = 6,468) and provided information on all indicators of social isolation. The final sample consisted of 6,457 individuals with a total of 15,923 observations.

For the hierarchical linear analyses, we further limited the sample to those who provided complete information on all covariates and a given health outcome. The sample size differed across health outcomes to minimize sample selection bias. The HRS was approved by the Institutional Review Board at the University of Michigan. All participants provided informed consent.

2.2 | Social isolation measurement

Following the work of Cornwell and Waite,[1,18,19] we measured objective social isolation by four indicators: social engagement, composition of social network, number of social relationships, and contact with social network. Subjective isolation was operationalized by two indicators: perceived social support and loneliness.

2.2.1 | Social engagement

Social engagement measured levels of participation in social activities. Four types of activities were selected: volunteer/charity work; educational/training course; clubs (sport, social, other); non-religious organizations. Response options were presented on a 6-point scale (1 = Not in the last month, 2 = At least once a month, 3 = Several times a month, 4 = Once a week, 5 = Several times a week, 6 = Daily). Responses to the four items were summed.

2.2.2 | Composition of social network

Composition of social network was an index of four types of relationships.[20] Respondents were asked whether they lived with their spouse/partner; and whether they had any living children, other relatives, and friends. The index ranged from 0 to 4.

2.2.3 | Number of close social relationships

Respondents were asked about the number of children and other relatives and friends, respectively, that they felt close to. The reported number in each category, and the response to feeling of closeness with their partner (1 = having a close relationship, 0 = not having a close relationship), were summed.

2.2.4 | Contact with social network

Social contact was operationalized as frequency of contact with children, other relatives, and friends. For each relationship type, participants were asked to report the frequency of contact in three ways: in person, over the phone, and mail/emailed on a 6-point scale (1 = less than once a year or never to 6 = three or more times a week). Social contact scores were obtained by summing the nine items. Cronbach's alpha was above 0.71 for each wave.

2.2.5 | Perceived social support

Perceived social support measured the emotional and instrumental support respondents reported receiving from their spouse/partner, children, other relatives, and friends. For each of the four relationship types, seven questions were asked, with responses presented on a 4-point scale (1 = not at all to 4 = a lot). An index summing the 28 items was used. Cronbach's alpha was above 0.87 across the three waves.

2.2.6 | Loneliness

Loneliness was assessed with the abridged 11-item version of the Revised UCLA Loneliness Scale. The UCLA loneliness scale has become the gold standard for measures of loneliness and has been widely used as a measure of loneliness.[21] The efficacy and validity of this measure has been tested in the HRS sample. Following is an example item: "How often do you feel isolated from others?" Response options included "hardly ever," "some of the time," and "often." We calculated loneliness scale scores by summing the 11 items. Higher scores indicated greater loneliness. Cronbach's alpha was above 0.87 for each wave.

2.3 | Health outcomes

2.3.1 | Functional limitations

Functional limitations were measured by assessing whether respondents had difficulty with 12 different tasks, such as walking several blocks and sitting for 2 hours.[22] One point was given if the respondent had difficulty performing a given task.

2.3.2 | Depressive symptoms

Depressive symptoms were assessed using the Center for Epidemiological Studies-Depression (CES-D) scale.[23] The HRS used the 8-

item version. Each item was rated yes (1) or no (0). One item asked about loneliness and was excluded from our measure. We summed the remaining seven items. Cronbach's alpha was above 0.81 for each wave.

2.3.3 | Memory deficits

Respondents were read 10 words and asked to recall the words immediately and after a short delay. We summed correct answers in the two recalls and recoded the sum scores so that higher scores indicated more memory deficits.

2.3.4 | Self-rated health

Respondents rated their health on a 5-point scale (1 = *excellent* to 5 = *poor*). This single-item question has been verified in different studies and populations.[24,25]

2.4 | Covariates

In the analyses to examine the association between social isolation trajectory patterns and health outcomes, we controlled for respondents' sociodemographic characteristics and health-related behaviors in order to minimize potential confounding. Sociodemographic characteristics included age measured in years, sex (male, female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, other), education (less than high school, high school or equivalent, vocational/some college/associate degree, bachelor's degree or higher), partnership (non-partnered, partnered), and employment status (non-employed, employed). Health-related behavior included BMI (underweight, normal, overweight, obese), drinking (never drank, ever drank), and smoking (never smoked, ever smoked).

2.5 | Analytic approach

We performed three steps. First, latent class growth analysis (LCGA) was used to identify subgroups of individuals with similar social isolation trajectories. LCGA has the advantage of accounting for population heterogeneity in the outcome growth by classifying individuals into different trajectory groups. A series of models with an increasing number of classes were estimated. Several goodness-of-fit statistics and criteria were used to determine the optimal number of latent classes: (a) the Akaike information criterion (AIC)[26] and Bayesian and adjusted Bayesian information criteria (BIC and ABIC)[27,28]; (b) entropy and posterior class-membership probabilities[29,30]; (c) the adjusted Lo-Mendell-Rubin likelihood ratio test[31]; (d) class size that reflected at least 1% of the total sample[32]; and (e) interpretability of emerging classes based on theory and class distinctiveness.[33]

Second, older adults were assigned to a social isolation trajectory pattern based on posterior class-membership probabilities. Pattern-specific distribution for each social isolation trajectory was reported. Third, because person-years were nested in persons, mixed-effect linear regression models were used to examine how types of social isolation trajectories were associated with respondents' physical, mental, cognitive, and self-rated health in the 8-year study period. We estimated two models, one without and another with the covariates. All control variables except sex and race/ethnicity were time varying. LCGA analysis was done in Mplus version 8.[34] All other analyses were conducted using Stata 16.[35]

Attrition presented a selection problem. To account for the sampling structure and nonresponse, descriptive statistics of all variables were weighted by cross-sectional weights designed specifically for the subsample to which the psychosocial leave-behind questionnaire was administered. Measure-specific missingness within the analytic sample was handled using the full information maximum likelihood method (FIML), which uses all the information in the observed data for analysis and is more efficient and less biased than the other methods.[36]

We compared the characteristics of the included and excluded respondents. The results are shown in Supplementary Table A1. Compared with the analytic sample, excluded respondents were more likely to be older, male, racial minorities, less educated, non-partnered, and non-employed.

3 | RESULTS

3.1 | Sample characteristics

Table 1 displays the weighted baseline characteristics of the sample. Participants' average age was 64 years. A majority were female (54%), non-Hispanic White (84%), partnered (69%), non-employed (67%), and had some college and above education (55%). Also, a majority were overweight and obese (73%), had ever drunk (60%) and smoked (57%). A pooled correlation matrix of the study variables is reported in Supplementary Table A2. The six social isolation indicators were significantly correlated with each other.

3.2 | Latent class growth analysis (LCGA)

A series of LCGAs with up to six classes were performed. Table 2 displays the model fit statistics. The smaller AIC, BIC, and ABIC indicated improved model fit with increasing number of classes. The adjusted Lo-Mendell-Rubin likelihood ratio test was nonsignificant in the five- and six-class solution, suggesting no significant improvement beyond the four-class model. Further, the entropy value of the four-class model is 0.84, indicating high classification quality.[37] The posterior class-membership probabilities of the four-class model range from 0.89 to 0.94, indicating acceptable class classification.[30]

TABLE 1 Descriptive statistics of study variables at baseline (weighted)

Variables	%	Mean	SE
Social engagement (range: 1-24)		6.16	0.03
Composition of social networks (range: 0-4)		3.38	0.01
Number of close social relationships (range: 0-30)		9.15	0.05
Contact frequency with social networks (range: 2-54)		31.21	0.09
Perceived social support (range: 2-112)		81.52	0.16
Loneliness (range: 1-33)		16.49	0.05
Functional limitations (range: 0-11)		2.64	0.03
Depressive symptoms (CES-D score, range: 0-7)		1.14	0.02
Memory deficits (range: 0-20)		9.33	0.03
Self-rated health (range: 1-5)		2.66	0.01
Age		63.71	0.08
Female	54.15		
Race			
Non-Hispanic White	84.53		
Non-Hispanic Black	9.86		
Hispanic	2.72		
Other	2.89		
Education			
Less than high school	11.54		
High school or equivalent	33.74		
Vocational/ some college/ associate	26.43		
Bachelor's degree or more	28.29		
Partnered	68.81		
Employed	42.78		
BMI			
Underweight	0.77		
Normal	26.02		
Overweight	37.97		
Obese	35.24		
Drinking	59.89		
Smoking	56.89		

Figure 1 presents change of each social isolation indicator for the four classes. Class 1 (15.4%), labeled "*severe (objective and subjective) isolation*," scored the worst in nearly all indicators of objective and subjective social isolation. Class 2 (37.6%), labeled "*moderate (objective and subjective) isolation*," scored the lowest in social engagement; second lowest in social networks, close relationships, contact frequency, and perceived support; and second highest in loneliness. Class 3 (11.6%), labeled "*rare objective and low subjective isolation*," was distinguished by scoring the highest in social engagement and contact frequency (rare objective isolation). Although it scored the second highest in perceived support and second lowest in loneliness,

the scores were quite favorable (low subjective isolation). Class 4 (35.4%) was labeled "*some objective and rare subjective isolation*." It scored highest in perceived support and lowest in loneliness (rare subjective isolation). Compared with class 3, class 4 had much lower social engagement and less contact frequency (some objective isolation). But class 4 had larger social networks and more close relationships.

From 2008 to 2016, there was a trend of slight and gradual increase of social isolation—declined social engagement, smaller networks, fewer close relationships, decreased contact frequency, lower perceived support, and higher loneliness—for all four classes.

TABLE 2 Model fit statistics for estimated patterns of social isolation trajectory

Fit statistic	2 classes	3 classes	4 classes	5 classes	6 classes
AIC	538536	533311	530181	527112	526382
BIC	538827	533690	530648	527667	527026
Adjusted BIC	538691	533513	530429	527407	526724
Entropy	0.87	0.84	0.84	0.87	0.82
Adjusted Lo-Mendell-Rubin LRT	2 vs 1	3 vs 2	4 vs 3	5 vs 4	6 vs 5
	Value = 18307	Value = 5205	Value = 3129	Value = 3067	Value = 749
	($p < 0.001$)	($p < 0.001$)	($p < 0.001$)	($p = 0.42$)	($p = 0.21$)
N for each class	C1 = 2248	C1 = 2722	C1 = 992	C1 = 1315	C1 = 576
	C2 = 4209	C2 = 2681	C2 = 2447	C2 = 1411	C2 = 735
		C3 = 1054	C3 = 2283	C3 = 275	C3 = 1252
			C4 = 735	C4 = 2170	C4 = 726
				C5 = 786	C5 = 1927
					C6 = 1241

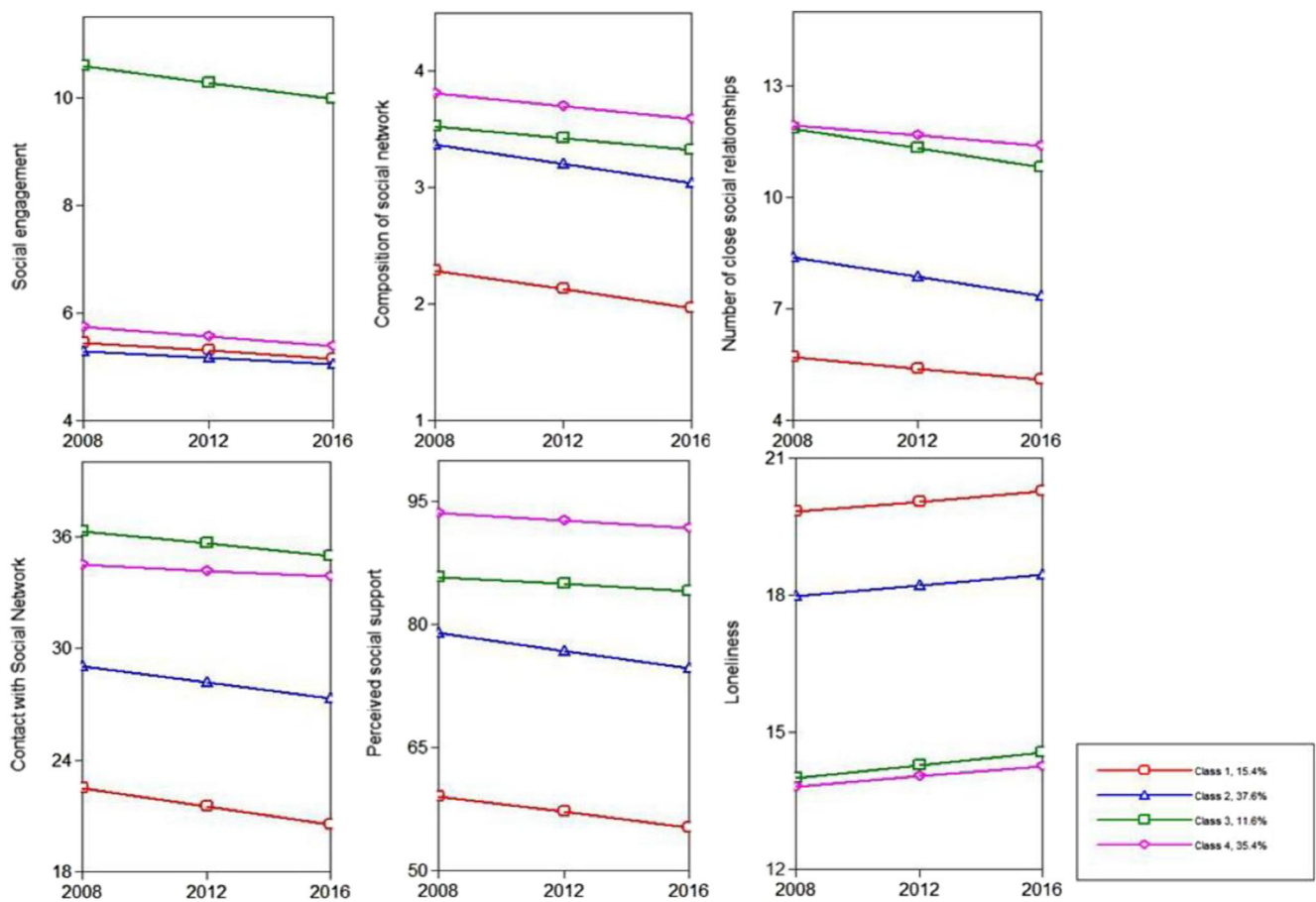Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion.

FIGURE 1 Estimated Patterns of Social Isolation Trajectories. Results are based on data from respondents aged over 50 years from the Health and Retirement Study (HRS 2008–2016). Each plotted line represents mean trajectory consistent with a latent class grouping. Four types of trajectories were derived: severe isolation, moderate isolation, rare objective and low subjective isolation, and some objective and rare subjective isolation. The four trajectory types are based on six indicators of social isolation: social engagement, composition of social network, number of social relationships, contact with social network, perceived social support, and loneliness. The former four measured objective isolation (social disconnectedness), the latter two measured subjective isolation (perceived isolation)

However, the four classes did not overlap or cross in their social isolation trajectories, which suggests that individual differences in objective and subjective social isolation are relatively stable during the 8-year period.

Sociodemographic characteristics associated with each of the four classes are presented in Supplementary Table A3. Relative to the other groups, the *severe isolation* group had more female, racial minority, low-educated, non-partnered, and non-employed individuals.

3.3 | Mixed-effect analyses

We next examined how patterns of social isolation trajectories were associated with individuals' physical, mental, cognitive, and self-rated health over the 8-year study period. Table 3 and Figure 2 present the results of mixed-effect linear regression models.

The unadjusted models (without covariates) clearly showed a "class" gradient in health outcomes. Model 1a showed that, on average, the functional limitations of the *severe isolation*, the *moderate isolation*, and the *some objective and rare subjective isolation* groups were 1.79, 1.39, and 0.59 units, respectively, higher than that of the *rare objective and low subjective isolation* group. The associations held even after controlling for covariates (sociodemographic characteristics and health-related behaviors; Model 2a). For depressive symptoms, belonging to the *severe and moderate isolation* groups, rather than the *rare objective and low subjective isolation* group, increased the expected CES-D scores by 1.28 and 0.74 scale points, respectively (Model 1b). The differences were reduced after adjusting for the covariates (Model 2b). The *some objective and rare subjective isolation* group did not significantly differ from the *rare objective and low subjective isolation* group in depressive symptoms. For the other two health outcomes—memory deficits and self-rated health, both the unadjusted and adjusted models (Models 3c-3d, 4c-4d) provided further evidence of the "class" gradient as described above.

4 | DISCUSSION

Using latent class growth analysis with multiple social isolation indicators and longitudinal data from a nationally representative sample of adults aged over 50 years, this study depicts a more comprehensive and nuanced picture of social isolation in middle and late adulthood than previous studies. Four distinct patterns of social isolation trajectories emerged from our data: *severe (objective and subjective) isolation* (15.4% of the sample), *moderate (objective and subjective) isolation* (37.6%), *rare objective and low subjective isolation* (11.6%), *and some objective and rare subjective isolation* (35.4%). The prevalence of the first two groups (severe and moderate isolation, together 53% of the sample) in our data is in line with findings reported by McHugh et al (2017) that 40-50% of individuals aged over 50 years in Ireland and England were high in both objective and subjective isolation.

The two other groups, labeled *rare objective and low subjective isolation* (11.6%) and *some objective and rare subjective isolation* (35.4%), have similarities and differences. Both groups scored similarly high on the number of close relationships and contact with network members and similarly low on loneliness. The former, however, had a very high level of social engagement that contrasted sharply with the low level of engagement in the latter. Nevertheless, the latter group does not appear to feel isolated. This may be explained by the socioemotional selectivity theory,[38] which suggests that older people regulate emotion by focusing on emotionally important relationships and reducing engagement in social activities that are not meaningful to them.

In addition, we showed that trajectories of social isolation do not overlap or cross, suggesting rank stability of social isolation. That is, individuals who initially exhibited high levels of social isolation remained highly isolated in the following eight years. This finding, in combination with one recent research on trajectories of objective social isolation among a nationally representative sample of older Americans and revealing that 17% of older adults were persistently objectively isolated over an 8-year period,[11] further implies that without interventions, those who are socially isolated are unlikely to do better in terms of social isolation. Our research advanced the literature by incorporating both subjective and objective dimensions of social isolation and identified the most socially isolated group.

Regarding the association between social isolation trajectory patterns and health outcomes, our findings are largely consistent with the existing literature. But we provided more information about the health gradient of social isolation. Across all four health outcomes, the *rare objective and low subjective isolation* group showed the best performance, followed by the *some objective and rare subjective isolation* group, the *moderate isolation* group, and the *severe isolation* group. The best health outcomes associated with the first group, even after adjusting for sociodemographic characteristics and health-related behavior, are interesting. This group had high social engagement scores—a lot higher than the other three groups. Perhaps active social engagement offers substantial health benefits, more than those derived from the subjective experience of high social support and low loneliness (the *some objective and rare subjective isolation* group). However, reverse causation may be another explanation: Good health enables individuals to have high levels of social engagement.

Our findings have practice implications. First, the prevalence of severe (15.4%) and moderate (37.6%) isolation among Americans aged over 50 years should be a major concern for policymakers. Recognizing the magnitude and severity of loneliness, the United Kingdom has established the Ministry for Loneliness and implemented the Loneliness Strategy. Our findings suggest that a national strategy to address social isolation may be needed in the United States, especially when considering that during this global pandemic social distancing is an important strategy for controlling the spread of the coronavirus virus. Second, given the stability of social isolation patterns, great efforts should be made to identify early individuals at risk of social isolation. One promising venue at which to intervene is

TABLE 3 Associations of social isolation trajectory patterns with health: mixed effect linear models (unweighted)

	M1a Functional limitations	M1b Depressive symptoms	M1c Memory deficits	M1d Self-rated health	M2a Functional limitations	M2b Depressive symptoms	M2c Memory deficits	M2d Self-rated health
Fixed part								
Patterns of social isolation trajectories (ref. = rare objective and low subjective isolation)								
Severe isolation	1.79***	1.28***	1.71***	0.83***	1.17***	0.94***	0.82***	0.58***
	(0.13)	(0.07)	(0.13)	(0.04)	(0.12)	(0.07)	(0.12)	(0.04)
Moderate isolation	1.39***	0.74***	1.34***	0.65***	0.98***	0.55***	0.59***	0.47***
	(0.11)	(0.06)	(0.12)	(0.04)	(0.10)	(0.06)	(0.10)	(0.04)
Some objective and rare subjective isolation	0.59***	0.07	0.57***	0.29***	0.45***	0.01	0.21*	0.20***
	(0.11)	(0.06)	(0.12)	(0.04)	(0.10)	(0.06)	(0.10)	(0.04)
Age					0.05***	−0.02***	0.12***	0.01***
					(0.00)	(0.00)	(0.00)	(0.00)
Female					0.77***	0.21***	−1.12***	−0.04
					(0.06)	(0.04)	(0.06)	(0.02)
Race (ref. = non-Hispanic White)								
Non-Hispanic Black					0.31***	0.07	1.41***	0.23***
					(0.09)	(0.05)	(0.08)	(0.03)
Hispanic					0.35*	0.09	1.35***	0.40***
					(0.17)	(0.10)	(0.17)	(0.06)
Other					0.27	0.21*	1.27***	0.25***
					(0.18)	(0.10)	(0.18)	(0.06)
Education (ref. = less than high school)								
High school or equivalent					−0.42***	−0.37***	−1.06***	−0.25***
					(0.10)	(0.05)	(0.09)	(0.03)
Vocational/some college/associate					−0.55***	−0.42***	−1.64***	−0.33***
					(0.10)	(0.06)	(0.10)	(0.04)
Bachelor's degree or more					−1.02***	−0.56***	−2.43***	−0.56***
					(0.11)	(0.06)	(0.11)	(0.04)
Partnered					−0.17**	−0.22***	−0.07	−0.03
					(0.06)	(0.04)	(0.06)	(0.02)
Employed					−0.69***	−0.26***	−0.00	−0.18***
					(0.05)	(0.04)	(0.06)	(0.02)
BMI (ref. = underweight)								
Normal					−0.32	−0.09	−0.50**	−0.33***
					(0.16)	(0.11)	(0.19)	(0.06)
Overweight					−0.04	−0.09	−0.58**	−0.27***
					(0.17)	(0.11)	(0.20)	(0.06)
Obese					0.68***	0.10	−0.66***	−0.07
					(0.17)	(0.11)	(0.20)	(0.06)
Drinking					−0.54***	−0.18***	−0.36***	−0.17***
					(0.05)	(0.03)	(0.05)	(0.02)

TABLE 3 (Continued)

	M1a Functional limitations	M1b Depressive symptoms	M1c Memory deficits	M1d Self-rated health	M2a Functional limitations	M2b Depressive symptoms	M2c Memory deficits	M2d Self-rated health
Smoking					0.57***	0.19***	0.18**	0.17***
					(0.06)	(0.03)	(0.06)	(0.02)
Constant	2.22***	0.67***	9.33***	2.37***	−1.02**	2.44***	4.04***	2.40***
	(0.09)	(0.05)	(0.10)	(0.03)	(0.33)	(0.20)	(0.36)	(0.12)
Random part								
Variance(cons)	5.53***	1.29***	5.65***	0.62***	4.26***	1.06*	3.41***	0.50***
	(0.12)	(0.03)	(0.14)	(0.01)	(0.10)	(0.03)	(0.10)	(0.01)
Variance(residual)	2.67***	1.35***	4.44***	0.41***	2.50***	1.32***	4.07***	0.40***
	(0.04)	(0.02)	(0.06)	(0.01)	(0.04)	(0.02)	(0.06)	(0.01)
$N_{observations}$	15923	15923	15843	15923	14677	14677	14605	14677

Note: Cell estimates represent unstandardized coefficients and standard errors (in parentheses). Omitted categories for female, partnered, employed, drinking, and smoking are male, non-partnered, unemployed, not drink, and not smoke.
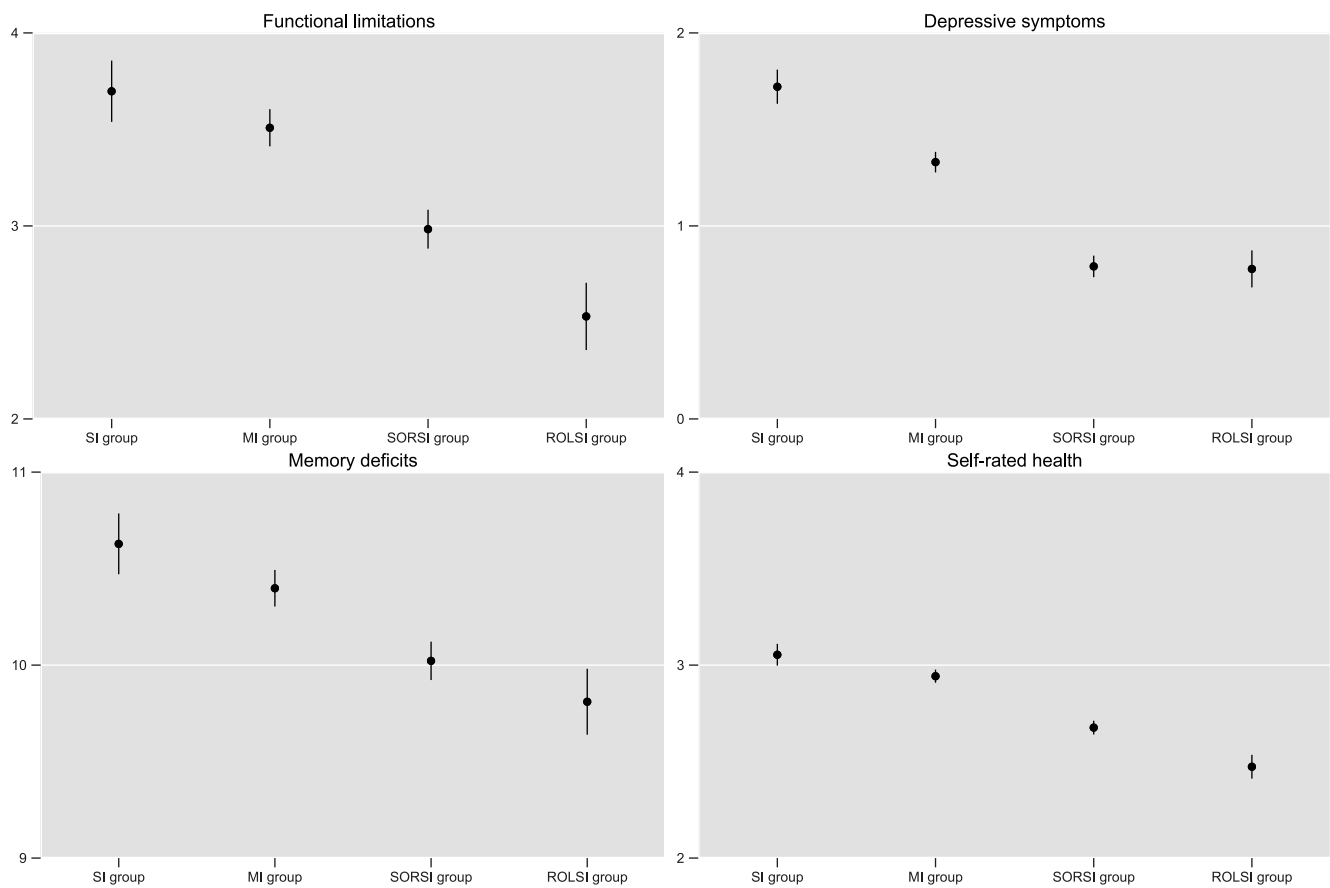
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

FIGURE 2 Estimates for each social isolation trajectory type on functional limitations, depressive symptoms, memory deficits, and self-rated health. Estimates were based on mixed-effect linear regression models (Table 3, Models 2a–2d); The vertical lines represent the 95% confidence intervals; MI, moderate isolation; SI, severe isolation; SORSI, some objective and rare subjective isolation; ROLSI, rare objective and low subjective isolation

health care clinics. Visits to the doctor are common activities among middle-aged and older adults. Each of these visits provides an opportunity for clinicians to assess their patients' social isolation and refer those at risk to appropriate services. Nonetheless, to cope with social isolation and promote social connections in later life, venues such as communities, including social clubs, churches, and veterans' organizations, are also important.

Third, given the aging of the U.S. population and the superior health outcomes of the *rare objective and low subjective isolation* group, more resources should be allocated to increasing social engagement and social contact among middle-aged and older adults.

Some limitations of this study should be noted. First, our analyses do not address time-varying factors (such as retirement and the loss of social relationships) that may confound the isolation-health relationships and thus cannot provide causal estimates of the relationships between patterns of social isolation trajectory and health outcomes. Second, as a result of attrition, the analysis excluded respondents who were relatively unhealthy; therefore, the isolation-health link derived from the analytic sample might be underestimated. Third, it is beyond our scope to examine pathways in the associations between patterns of social isolation trajectories and health outcomes. Future research is needed to investigate the pathways.

CONFLICT OF INTEREST
Authors declared no conflicts of interest.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available in HRS at https://hrs.isr.umich.edu. These data were derived from the following resources available in the public domain: https://hrs.isr.umich.edu.

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