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The relationship between socioeconomic status and social network with loneliness: A cross-sectional study of China older adults with ADL disabilities

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Abstract:

Objectives:

To examine the association between loneliness and social variables in older adults with ADL disabilities in China and investigate people who are more likely to feel lonely.

Methods:

This cross-sectional study aimed to assess loneliness status in older adults with ADL disabilities, its correlation with social networks, socioeconomic status, home-based rehabilitation, and gender differences (N = 880). The UCLA Loneliness Scale-3 and questionnaires, including social network, socioeconomic status, and home-based rehabilitation, were used to assess loneliness. Regression analysis was used to examine the correlates of loneliness in the whole sample and male and female separately. A classification and regression tree model (CART) was used as a predictive model to estimate the subsets of older people who are more likely to become lonely.

Results:

The mean loneliness score was 44.70 (SD=10.01). Regression showed that lower loneliness was associated with females (β=-1.523, p<0.05), frequent home-based rehabilitation (β=-5.941, p<0.001), and often communication with their children (β=-3.536, p<0.001). The CART model showed that fewer friends, lower communication frequency with children and rural areas were related to higher loneliness. Furthermore, additional analysis showed that males in rural areas were lonelier than those in urban areas (β=4.635, p<0.001). Among females, those who were single, divorced, or widowed (β=4.163, p<0.001) and with less home-based rehabilitation were more lonely than others.

Conclusions:

The psychological and physical effects of ADL disability in older adults were associated with socioeconomic

status and social networks. Attention should be paid to the psychological status of such vulnerable people, particularly those with ADL disabilities who live in rural areas and have fewer social networks.

Keywords: Older adults; ADL Disability; Loneliness; Socioeconomic status; Social network

Strengths and limitations of this study

- The first study to examine the association between loneliness and social variables in older adults with ADL disabilities in China.
- Subsample regression and regression tree models (CART) were used to estimate the subset of older adults who were more likely to become lonely.
- This was a cross-sectional study with limited ability to establish causal relationships among variables.
- The data were based on self-report and thus were susceptible to recall or reporting bias.

1. Introduction

Loneliness among older adults has become a worldwide public health concern, millions of older adults are in danger of bad health due to prolonged loneliness, which is almost as common as obesity [1]. The prevalence of loneliness varies in different countries. A longitudinal population-based cohort study showed that the prevalence of loneliness in older adults ranged from 9.2%-12.4% at wave 5 of the Survey of Health, Ageing, and Retirement in Europe project [2]. A cross-sectional survey also showed that 27.3% of older adults in Finland experience frequent loneliness [3]. The Chinese Longitudinal Healthy Longevity Survey (CLHLS) indicated that about 22.9% and 30.6% of older men and women suffer from loneliness [4]. Existing research shows that older adults with Activity of Daily Living (ADL) disabilities might be linked to an increased risk of experiencing loneliness. A cross-sectional study in the UK found that a staggering 45%-52% of adults who are experiencing difficulties in their functional capacity experienced feelings of loneliness [5, 6]. Moreover, the Health in Times of Transition (HITT) survey in the Soviet Union (FSU) showed that the severity of the disability was also important for loneliness [7]. However, little is known about the study of older adults with ADL disabilities in China; therefore, it has to be expanded.

Loneliness in older adults is associated with various health risks, such as cardiovascular health risks, cognitive dysfunction, and psychological issues (depression, anxiety, insomnia, and increased morbidity and mortality), thus reducing the quality of life [8-11]. In addition, socioeconomic status is related to loneliness in older adults. Socioeconomic status is defined as access to material, human, and social capital and is one of the fundamental bases of health [12]. There is some evidence that the level of education and place of residence are also associated with loneliness [13, 14]. As for older adults with ADL disabilities, the environment significantly affects loneliness among them. Physical disability and cognitive impairment signify that they have poor activities

of daily living, which leads to easy to have a stronger psychological gap than before [7, 15, 16]. In addition, the differences in age and gender can lead to varying degrees of loneliness, the females and elderly more feel lonely [4, 17]. Therefore, it is necessary to explore the predisposition related to loneliness and the gender differences among socioeconomic, especially among older adults with ADL disabilities.

The current study also examined the association between social networks and loneliness, which is reflected in several factors. Older adults undergo significant transitions in the size and composition of social networks, indicating that social networks can maintain the well-being and health of older adults [18]. The subjective experience of social networks is associated with loneliness with lack of companionship [19, 20]. Specifically, older adults who do not have social communication and connection with children and friends are more likely to experience loneliness, especially older adults with ADL disabilities [21]. Marital status is also associated with loneliness, married older adults reported lower feelings of loneliness than those who were widowed or divorced [22]. The social network is also crucial to loneliness among older adults with ADL disabilities. Moreover, older adults with ADL disabilities are related to personal care and mobility. Home-based rehabilitation provides the flexibility of place and time in rehabilitation therapy and can sustain independence and accommodate the preferences of older and disabled adults [24]. Home-based rehabilitation has increased in many countries due to the increased aging population [23].

Although several studies have assessed loneliness and the predisposition among older adults in Western societies, little information is known about loneliness among older adults with ADL disabilities. This study aimed to examine loneliness in older adults with ADL disabilities in Nantong, China, its relationship with social networks, home-based rehabilitation, socioeconomic status, and gender differences. The following hypotheses were made **(Fig.1)**:

(I) Socioeconomic status, social network, and home-based rehabilitation are related to loneliness in older adults with ADL disabilities;

(II) There are gender differences among social network, socioeconomic, and home-based rehabilitation among older adults with ADL disabilities, possibly due to the diversity of thinking styles and mental capacity between males and females.

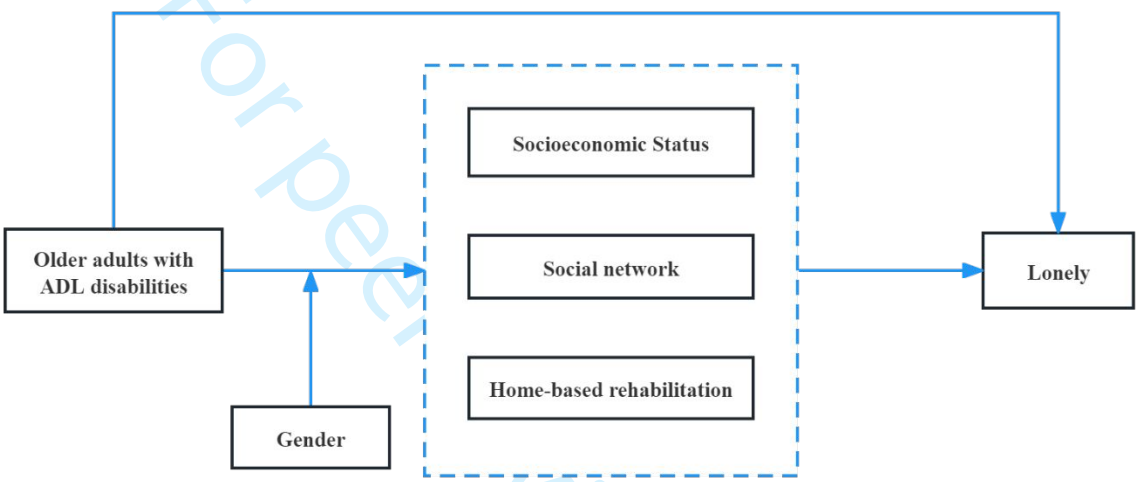

Figure 1. Conceptual Model

2. Methods

2.1 Research Design and Participants

The cross-sectional survey was conducted in Nantong, Jiangsu Province (east of China), which was the first batch of a pilot city for long-term care insurance (LTCI) systems. The LTCI systems in Nantong cover individuals with moderate and severe disabilities due to old age, and disease, as long as their score on the Assessment Scale for Activities of Daily Living (the Barthel Index Assessment Scale) is lower than 40 [25]. Insured individuals who are still unable to take care of themselves after at least six months of treatment can receive expenses subsidized related to a nursing home stay, assisted living facility or formal caretakers coming to your house. Although varied reimbursement catalogs, there is no threshold for treatment benefits.

Convenience sampling was used to collect data, and 1000 older adults with ADL disabilities were invited to participate in a face-to-face questionnaire survey administered by formal home caretakers who worked in service institutions. The survey was conducted from January 2020 to March 2020 to explore the status of loneliness among older adults with ADL disabilities. Inclusion criteria included: (I) individuals aged 60 years or above; (II) the scores on the Assessment Scale for Activities of Daily Living are lower than 40; (III) individuals who are long-term residents in the study area and able to communicate in Mandarin. The informed consent was obtained from each participant. Legally Authorized Representatives (literate family members) of illiterate participants provided informed consent for the study.

2.2 Measures

2.2.1 Independent variable

Loneliness. The UCLA Loneliness Scale-3, a validated metric of the construct of loneliness, was used to assess the level of loneliness, the main outcome variable [26]. UCLA is a 20-item Likert-type scale consisting of 10 positively-worded statements demonstrating satisfaction with social relationships and 10 negatively-worded statements showing dissatisfaction with social relationships [27]. The scale has the lowest and highest scores of 20 and 80, respectively. The score ranges for each dimension were obtained by summarizing answers to each item as follows; mild loneliness (20-34), moderate loneliness (35-49), moderate-severe loneliness (50-64), and severe loneliness (65-80). A low score indicated a low level of loneliness experienced by older adults while a higher score demonstrated a severe level of loneliness. The Cronbach's α=0.878 indicated that the scale was reliable.

2.2.2. Dependent variable

Socioeconomic status. A self-designed questionnaire was used to evaluate socioeconomic status based on four dimensions: residence (Urban vs. Rural), educational level, work, and monthly income. The permanent residence information of participants was obtained through a home-based rehabilitation company. Additionally, the participants were asked to answer three questions regarding their socioeconomic status: "Could you tell me something about your educational background?" "What did you do before you retired?" "How much is your monthly household income (including government subsidies)?". Participants answered according to the actual situation.

Social network. Social network is an independent variable including four dimensions: Marital status (single/divorced/widowed vs. Married), number of children, communication status with children, and number of

close friends. A self-designed questionnaire was used to measure the social network of the participants using the following questions: "What is your current marital status? " "How many kids do you have?" "How many close friends do you have?". In addition, the participants were asked about the frequency of visiting or chatting with their children daily.

Home-based rehabilitation. Long-term care and end-of-life care are crucial for older adults with ADL disabilities [28]. Home-based rehabilitation can guarantee the quality of life among older adults with ADL disabilities at home and enhance their sense of acquisition. Herein, two dimensions (time and frequency) were used to investigate the situation of home-based rehabilitation.

Sociodemographic factors. The sociodemographic variables as covariates included age and gender (Male vs. Female). Studies have shown that sociodemographic variables are related to loneliness [29].

2.3 Analytic plan

Statistical analyses were conducted using STATA 16.0. We first present descriptive statistics for the sample overall and by loneliness status. The frequency of each variable for the sample was calculated in terms of demographic parameters, socioeconomic position, social network, and home-based rehabilitation. Using chi-square and t-tests, the impact of factors on loneliness scores was assessed. Secondly, the variables of loneliness in the whole sample were explored using the ordinary least squares (OLS) regression models. In addition, we also examined how the variables would vary between males (N=357) and females (N=523) by sensitivity analyses. Finally, the interactive relationship between some indicators of socioeconomic status and social network and home-based rehabilitation associated with loneliness was evaluated using the classification and regression tree (CART) model. We tested the collinearity issues, and VIF showed that there was no such issue (VIF<5) [30].

3. Results

3.1 Participant characteristics

Of the 1000 respondents, 58 switched health status or passed away and 62 patients did not completely respond to the survey. In brief, 880 valid questionnaires were collected: with a response rate of 88%.

Of the 880 participants, the mean age was 80.64 years and about 40.57% were males. The mean loneliness score of the participants was 44.70 (SD=10.01), of which most participants suffered from moderate (39.89%) or moderate-severe (40.11%) loneliness.

Most participants were married (67.50%), with the highest education level of primary school or lower (56.59%), and living in urban areas (61.70%). The monthly income of most participants was less than or equal to 4000 yuan (77.5%). Only 7.84% of the participants were government personnel before retirement, while 29.77% were into individual businesses and peasants. Most participants showed that they often (42.61%) or sometimes (44.20%) communicate with their children. Meanwhile, 43.18% of the participants reported having one or two close friends. Furthermore, about 92.39% of the participants reported that they had less than or equal to 10 minutes per day of home-based rehabilitation, while 77.61% showed that they only reported once a month and below **(Table 1)**.

Table 1. Basic characteristics of the participants (N = 880)

Variables	Mean ± SD/n (%)	Loneliness scores	t/F	p-value
Loneliness	44.70±10.01			
Mild loneliness	167(18.98)	27.85±4.36		
Moderate loneliness	351(39.89)	44.00±4.32		
Moderate-severe loneliness	353(40.11)	52.76±2.84		
High loneliness	9(1.02)	68.00±3.20		
Sociodemographic factors				
Age (years)	80.64±10.29			
Sex				

Male	357(40.57)	45.25±9.67	1.84	0.175
Female	523(59.43)	44.32±10.22		
Socioeconomic Status				
Residence				
Urban	543(61.70)	43.25±10.47	30.56	0.001
Rural	337(38.30)	47.02±8.74		
Education level				
Illiteracy	382(43.41)	45.14±10.52	1.80	0.126
Primary school	280(31.82)	43.93±9.78		
Junior school	139(15.80)	44.65±9.56		
Senior school	56(6.36)	46.86±8.22		
Collage/Bachelor and above	23(2.61)	41.61±9.86		
Pre-retirement work				
Government personnel	69(7.84)	44.64±8.78	10.63	0.001
Private sector personnel	187(21.25)	43.42±10.04		
Individual businesses and peasants	262(29.77)	45.91±9.13		
Temporary and unpaid workers	220(25.00)	42.03±11.98		
Unemployed	142(16.14)	48.28±6.92		
Monthly income (¥)				
<2000	438(49.77)	45.59±10.05	2.46	0.031
2000~4000	244(27.73)	43.28±10.54		
4000~6000	98(11.14)	44.76±9.64		
6000~8000	51(5.80)	45.92±7.79		
8000~10000	31(3.52)	41.74±9.82		
>10000	18(2.05)	43.28±6.74		
Social Network				
Marital status				
Married	594(67.50)	43.60±10.29	22.46	0.001
Others (Single/Divorced/Widowed)	286(32.50)	46.97±9.00		
Number of children				
≤2	506(57.50)	44.62±10.09	0.06	0.807
≥3	374(42.50)	44.79±9.91		
Communication status with children				
Sometimes	389(44.20)	47.38±9.71	27.02	0.001
Often	375(42.61)	42.32±9.80		
Frequently	116(13.18)	43.40±9.52		
Number of close friends				
0	198(22.50)	47.09±9.00	41.37	0.001
1~2	380(43.18)	47.28±8.53		
3~5	171(19.43)	40.58±10.68		
≥6	131(14.89)	38.93±10.45		

Home-based rehabilitation				
Time (minutes)				
≤10	813(92.39)	44.97±9.91	2.36	0.052
11~20	50(5.68)	41.96±11.02		
21~30	11(1.25)	38.27±11.24		
31~59	4(0.45)	43.25±7.14		
≥60	2(0.23)	40.00±1.41		
Frequency				
Once a month and below	683(77.61)	45.44±9.68	9.57	0.001
Two or three times a month	41(4.66)	46.95±7.13		
Once or twice a week	33(3.75)	45.15±10.14		
Three to five times a week	6(0.68)	40.50±9.09		
Once a day	117(13.30)	39.64±11.26		

3.2 OLS regression analysis

The regression results from Model 1 reveal that sociodemographic factors including gender and age insignificantly affect loneliness of older adults with ADL disabilities. Significant predictors in Model 2 were socioeconomic status, including residence, education level, pre-retirement work, and monthly income. The model explained 7.6% of the variance in loneliness (Adj-R^2= 0.076). Based on Model 2, Model 3 additionally included the social network (marital status, number of children, communication status with children, number of close friends). Model 3 explained 22% of the variance in loneliness (Adj-R^2= 0.220). Furthermore, from Model 3 to Model 4, we added home-based rehabilitation, and the model explained 23.8% of the variance in loneliness (Adj-R^2= 0.238). These results also confirm the hypothesis I.

In Model 4, regression analysis showed that females (β=-1.523, $p<0.05$) experienced lower loneliness than males and participants in rural areas (β=2.056, $p<0.01$), and with an education level of senior school (β=3.174, $p<0.05$) were lonelier than others. Furthermore, participants who were government personnel (β=-4.143, $p<0.05$), private sector personnel (β=-4.091, $p<0.001$), those in business or peasants (β=-1.941, $p<0.05$), and temporary and unpaid workers (β=-5.334, $p<0.001$) experienced lower loneliness. Single, divorced, and widowed

participants (β=3.494, $p<0.001$), and those with one or two close friends (β=1.912, $p<0.05$) felt more lonely than others. However, participants who often communicated with children (β=-3.536, $p<0.001$), had three to five children (β=-4.004, $p<0.001$), or more than or equal to six children (β=-4.963, $p<0.001$) had lower loneliness than others. In addition, participants who underwent home-based rehabilitation once a day (β=-5.941, $p<0.001$) had lower loneliness than others (**Table 2**).

Table 2. Results of OLS regression analysis examining the association between sociodemographic factors, socioeconomic status, social network, home-based rehabilitation, and loneliness

Variables	Model1	Model2	Model3
	β(95%CI)	β(95%CI)	β(95%CI)
Sociodemographic factors			
Age (years)	0.019(-0.053,0.092)	-0.042(-0.119,0.035)	-0.063(-0.140,0.015)
Sex			
Male	1	1	1
Female	-1.387(-2.831,0.057)	-1.442(-2.802,-0.082)*	-1.523(-2.870,-0.176)*
Socioeconomic Status			
Residence			
Urban	1	1	1
Rural	3.421(2.096,4.746)‡	2.507(1.245,3.769)‡	2.056(0.774,3.338)†
Education level			
Illiteracy	1	1	1
Primary school	-1.279(-2.955,0.398)	-0.192(-1.750,1.366)	-0.291(-1.840,1.257)
Junior school	-0.878(-3.165,1.409)	0.304(-1.814,2.421)	-0.582(-2.172,2.055)
Senior school	1.869(-1.353,5.091)	3.007(0.031,5.982)*	3.174(0.185,6.164) *
Collage/Bachelor and above	-1.908(-6.745,2.930)	0.055(-4.410,4.520)	-0.824(-5.311,3.663)
Pre-retirement Work			
Unemployed	1	1	1
Government personnel	-5.758(-7.826,-3.690)‡	-5.527(-7.431,-3.623)‡	-4.143(-7.398,-0.887)*
Private sector personnel	-2.023(-4.025,-0.021)*	-2.223(-4.088,-0.359)*	-4.091 (-6.351,-1.830)‡
Individual businesses and peasants	-4.271(-6.702,-1.840)†	-4.733(-6.984,-2.483)‡	-1.941(-6.351,-1.830)*
Temporary and unpaid workers	-3.246(-6.730,0.239)	-4.806(-8.058,-1.553)†	-5.334(-7.236,-3.431)‡
Monthly income (¥)			
<2000	1	1	1
2000~4000	-1.279(-2.919,0.361)	-0.500(-2.016,1.016)	-0.788(-2.298,0.722)
4001~6000	0.231(-2.089,2.551)	1.342(-0.801,3.484)	1.352(-0.777,3.481)
6001~8000	1.052(-1.986,4.091)	1.163(-1.634,3.961)	0.979(-1.812,3.769)
8001~10000	-3.134(-6.997,0.729)	-0.858(-4.426,2.711)	-0.659 (-4.219,2.902)

>10000	-2.033(-6.741,2.675)	-0.315(-4.671,4.042)	1.336(-3.068,5.741)
Social Network			
Marital status			
Married		1	1
Others (Single/Divorced/Widowed)		3.498(2.081,4.915)‡	3.494(2.083,4.905)‡
Number of children			
≤2		1	1
≥3		0.503(-0.913,1.919)	0.431(-0.976,1.838)
Communication status with children			
Sometimes		1	1
Often		-3.649(-4.988,-2.309)‡	-3.536(-4.866,-2.207)‡
Frequently		-2.316(-4.287,-0.346)*	-1.773(-3.749,0.203)
Number of close friends			
0		1	1
1~2		1.617(0.018,3.217)*	1.912(0.311,3.513)*
3~5		-4.117(-6.040,-2.194)‡	-4.004(-5.941,-2.067)‡
≥6		-5.487(-7.629,-3.344)‡	-4.963(-7.119,-2.786)‡
Home-based rehabilitation			
Time (minutes)			
≤10			1
11~20			-0.188(-2.905,2.528)
21~30			-3.568(-9.143,2.007)
31~59			-2.828(-11.770,6.114)
≥60			4.558 (-8.050,17.165)
Frequency			
Once a month and below			1
Two or three times a month			1.838(-1.050,4.725)
Once or twice a week			-1.707(-4.897,1.482)
Three to five times a week			-10.486(-11.295,4.072)
Once a day			-5.941(-5.927,-2.035)‡
Adj-R^2	0.076	0.220	0.238

Note: all coefficients are unstandardized.

* $p < 0.05$, †$p < 0.01$, ‡$p < 0.001$.

3.3 Addition regression results based on gender group

Regression results suggested that the relationship between the variables and loneliness significantly differed between males and females (**Supplementary Table B1**). For example, communication with children, number of close friends, pre-retirement work, and monthly income were significantly correlated with loneliness in both males

and females. Addition analysis showed that males in rural areas were lonelier than those in urban areas (β=4.635, p <0.001). Among females, those who were single, divorced, or widowed (β=4.163, p<0.001) and with less home-based rehabilitation were more lonely than others, supporting hypothesis II.

3.4 Classification and regression tree model results

The CART model showed that loneliness was associated with the number of close friends, communication status with children, residence, pre-retirement work, marital status, and home-based rehabilitation frequency (**Fig. 2**).

The number of friends was the most significant factor related to loneliness level. Therefore, the participants were divided into subsets based on the number of friends. High loneliness was related to fewer friends, lower communication frequency with children and rural areas. Participants with less than or equal to two close friends (Node 1), those who were sometimes communicating with their children (Node 3), and those employed as government personnel, private sector personnel, temporary and unpaid workers (Node 7), or those who are in individual business or peasants (Node 8), experienced moderate-severe loneliness. Meanwhile, the participants who often or frequently communicated with children (Node 4) and were married (Node 9) experienced less loneliness than the single, divorced, and widowed participants (Node 10).

Participants with more than one to two close friends (Node 2), who lived in urban (Node 5) and had undergone home-based rehabilitation more than twice or thrice a month (Node 12) were likely to experience mild to moderate loneliness. However, participants with more than one to two close friends (Node 2) and who lived in rural (Node 6) were more likely to experience loneliness.

Figure 2. CART model analysis

4. Discussion

To the best of our knowledge, this is the first study to investigate loneliness and social variables among older adults with ADL disabilities in Nantong, Jiangsu province, Eastern China, and the gender differences. In this study, older adults with ADL disabilities had a relatively high level of loneliness. Moreover, loneliness was associated with socioeconomic status and social networks. Further analyses revealed that high loneliness was related to fewer friends, lower communication frequency with children, living in rural areas, and not working before retirement. It is noteworthy that males in rural areas were lonelier than those in urban areas and among females, those who were single, divorced, or widowed and with less home-based rehabilitation felt more lonely.

First, the prevalence of loneliness was high among older adults with ADL disabilities, consistent with previous studies [31]. A study conducted in Germany and Swiss also showed that the prevalence of loneliness in older adults who are experiencing difficulties in their self-maintenance and functional capacity is high [32, 33]. Besides, about 66.4% of older adults with chronic conditions had moderate to severe loneliness during the COVID-19 pandemic [34]. This could be because older adults with ADL disabilities are more prone to feeling hopeless because of mobility problems [35], suffering from losses of their spouses and friends [33, 36, 37], and poorer health conditions and being a notable financial burden on their families [38, 39]. These emotions make older adults with ADL disabilities worry and dread, thus leading to loneliness, which is like 'being in a Bubble' [40].

Second, our study showed that individuals who married, often communicated with their children, and had three to five children, or more than or equal to six children had lower loneliness, based on the social network indicators, similar to previous studies. The Longitudinal Aging Study Amsterdam (LASA) showed that older adults after negative life events, such as loss of social contacts or declining physical function, felt higher levels of

loneliness [31]. Studies in Germany using data taken from the German Socio-Economic Panel (SOEP) indicated that having a higher frequency of contact with family, and friends, contributes to reducing loneliness [32, 39]. A cross-sectional survey in Spain also found that the type and size of social networks have a role in the relationship between loneliness [41]. Interestingly, the results further revealed that older adults with one to two close friends were even more lonely than those without friends. This could be because of the anxiety of losing a few close friends and the low perceived quality of interpersonal connections [37, 42]. Furthermore, home-based rehabilitation for once a day could maintain engagement with others, consistent with the Canadian Community Health Survey and Midlife Development Survey in the United States [43-45]. In summary, these results confirm that social network is significantly related to loneliness and will make older adults with ADL disabilities have a higher sense of subjective well-being and lower loneliness.

Third, another meaningful finding of our study showed that a higher socioeconomic status (living in an urban area, any jobs before retirement, and having a senior school education) was associated with low loneliness in older adults with ADL disabilities. Previous studies showed that loneliness is associated with socioeconomic status [41, 46-48]. For example, a national longitudinal study of 5043 Chinese participants aged 65 years or more showed that a better socioeconomic status is associated with mild loneliness [49]. A case study also suggested that American adults with a higher socioeconomic status and those who lived closer to the city center were less likely to be lonely [50]. Adults with fewer resources and lower status cannot meet social adaptation and are thus perceived to be lonelier, leading to more health-risk behaviors [51, 52]. Additionally, the CART model was used as a predictive model to estimate the subsets of older people that are more likely to become lonely, which were observed with high loneliness in the CART model if older adults with poor social networks and taking up jobs before retirement. Our study revealed that the role of socioeconomic status on loneliness might partly depend on

the social network variables., suggesting that loneliness among ADL-disabled older adults with poor social networks and high economic status should not be ignored.

Finally, female older adults with ADL disabilities had lower loneliness. However, previous studies revealed that females were more likely to have a higher level of loneliness [39, 53, 54]. This difference could be accounted for the following reasons: First, different measurements were used to assess loneliness. Some studies measured loneliness by asking participants instead of using a scale [39, 53]; Second, females are more likely to recognize their feelings of loneliness than males, which contributes to underestimating males' loneliness in this research field [55, 56]; Third, the severity of mobility problems and mobility reductions [57]. However, more research should verify these results. Another important question we examined is the gender-specific differences in the correlates of loneliness. Interestingly, some of the significant factors for males lost their significance for females. Furthermore, variables, including residence, were significantly related to loneliness in males, while marital status and home-based rehabilitation frequency were significantly related to loneliness in females. These differences might be due to the different demands of the two groups [55]. The residence may not be significantly related to loneliness in females because females perceive loneliness in the social context [56, 58], such as whether there is company and communication. Therefore, the level of suffering associated with feelings of loneliness should be assessed to construct multi-factorial interventions targeting the deficiencies in lonely older adults.

This study provides key insights into loneliness interventions among older adults with ADL disabilities. First, the study suggests that older adults with ADL disabilities have a high prevalence of developing loneliness and deserve more concern in daily life, especially those having fewer friends, lower communication frequency with children, living in rural areas, and not working before retirement. Second, social activities can decrease loneliness among older adults [59]. Older adults with mild ADL disabilities should improve their self-worth and reduce

loneliness through activities such as community volunteering and low-paid helpers. Finally, gender-tailored interventions are needed to prevent or combat loneliness among older adults. For example, providing more supportive social environments for males can reduce their feelings of frustration, and providing more companionship and communication for females by home-based rehabilitation providers or volunteers can reduce loneliness among them.

This study has some limitations. First, this was a cross-sectional study with limited ability to establish causal relationships among variables. Therefore, future studies should use longitudinal data or randomized controlled trials to provide more evidence for the efficacy of interventions. Second, the ADL scores or status might lead to a better understanding of the association between the level of loneliness and other variables, explaining the inconsistency in the results. Future studies should provide a targeted analysis of loneliness factors affecting older persons with ADL difficulties based on ADL scores. Third, the data were based on self-report and thus were susceptible to recall or reporting bias. Fourth, research participants were only collected in a province of China, limiting the applicability of the findings to other areas or nations.

5. Conclusion

In summary, this is the first study to examine the association between loneliness and social variables in older adults with ADL disabilities in China, to investigate people who are more likely to feel lonely. Specifically, older adults with ADL disabilities reported a high prevalence of loneliness, while elderly men with ADL disabilities living in rural areas and elderly women having fewer social networks feel more lonely. Furthermore, high loneliness was related to fewer friends, lower communication frequency with children, living in rural areas, and not working before retirement. Therefore, attention should be paid to the psychological status of such vulnerable people.

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Consent for publication: This study does not include any identifiable information (images, faces, names, etc.) of the participants; therefore, the consent statement is not applicable.

Availability of data and materials: The data in this paper are from a field questionnaire survey. The data may be accessed after obtaining the author's consent (email: yxgao@ntu.edu.cn).

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Table B1. OLS Regression analysis examining the association between socioeconomic status, social network, home-based rehabilitation, and loneliness based on gender group.

Variables	Male sample (N=357)	Female sample (N=523)
	β(95%CI)	β(95%CI)
Socioeconomic Status		
Residence		
Urban	1	1
Rural	4.635(2.732,6.539)‡	0.134(-1.431,1.700)
Pre-retirement Work		
Unemployed	1	1
Government personnel	-6.354(-10.869,-1.838)†	-1.443 (-6.057,3.172)
Private sector personnel	-3.905(-7.063,-0.748)*	-4.311(-7.200,-1.423)†
Individual businesses and peasants	-2.166(-4.754,-0.422)	-1.091(-3.221,1.038)
Temporary and unpaid workers	-3.541(-6.833,-0.248)*	-6.305 (-8.597,-4.013)‡
Monthly income (¥)		
<2000	1	1
2000~4000	1.712(-0.763,4.186)	-2.472(-4.402,-0.543)*
4001~6000	3.411(0.383,6.439)*	0.560(-2.571,3.691)
6001~8000	3.399(-0.491,7.289)	0.180(-2.597,2.957)
8001~10000	1.667(-4.123,7.458)	-1.477(-5.615,2.660)

>10000	2.905(-1.610,7.420)	1.548(-5.282,8.378)
Social Network		
Marital status		
Married	1	1
Others (Single/Divorced/Widowed)	2.265(-0.368,4.899)	4.163(2.386,5.941)‡
Communication status with children		
Sometimes	1	1
Often	-3.196(-5.357,-1.034)†	-4.018(-5.756,-2.281)‡
Frequently	-2.442(-6.410,1.525)	-0.994(-3.600,1.612)
Number of close friends		
0	1	1
1~2	2.514(0.028,4.999)*	1.427(-0.437,3.291)
3~5	-2.992(-6.189,0.205)	-4.420 (-7.020,-1.820)†
≥6	-6.516(-10.470,-2.563)†	-3.549(-6.376,-0.721)*
Home-based rehabilitation		
Frequency		
Once a month and below	1	1
Two or three times a month	0.832(-3.512,5.176)	2.362(-1.604,6.329)
Once or twice a week	1.339(-2.036,4.713)	-5.313(-10.953,0.328)
Three to five times a week	-6.810(-13.546,-0.738)	-6.549(2.716,10.382)†

Once a day	-2.328(-5.837,1.181)	-5.300(-7.871,-2.730)‡

Note: * $p < 0.05$, †$p < 0.01$, ‡$p < 0.001$.

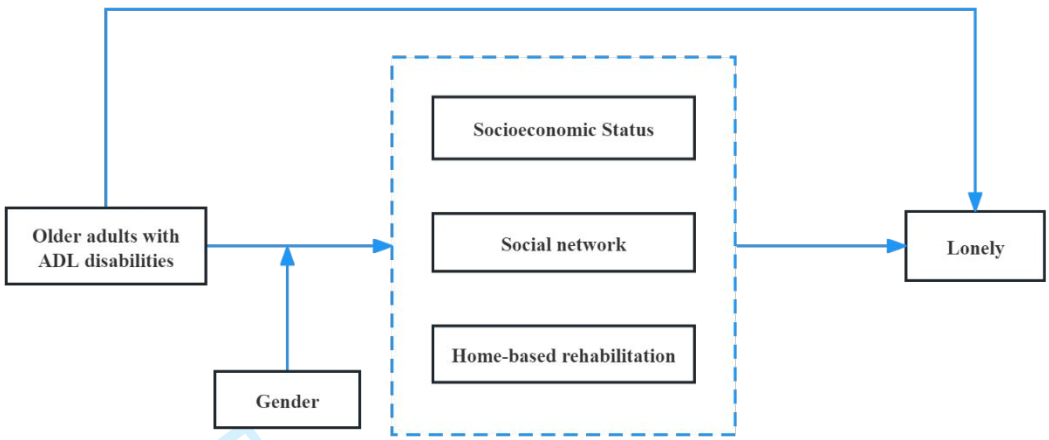

Figure 1. Conceptual Model

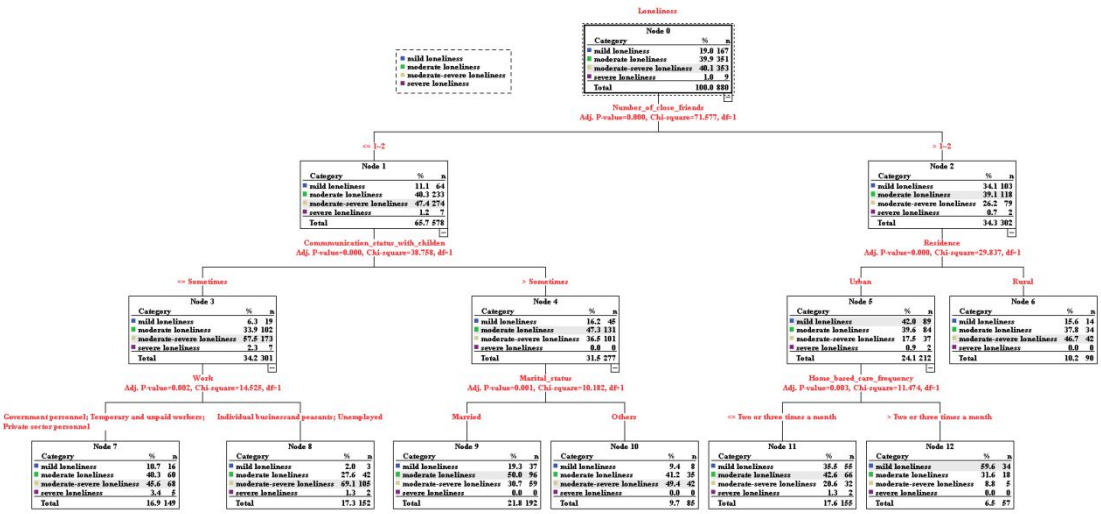

Figure 2. CART model analysis

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The relationship between socioeconomic status and social network with loneliness: A cross-sectional study of China older adults with ADL disabilities

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The relationship between socioeconomic status and social network with loneliness: A cross-sectional study of China older adults with ADL disabilities

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Abstract:

Objectives:

To explore the relationship between loneliness and socioeconomic status and social networks in older adults with Activity of Daily Living (ADL) disabilities in China and investigate people who are more likely to feel lonely.

Design: cross-sectional study

Setting: This study was conducted in six districts of Nantong, Jiangsu, China.

Participants: A total of 880 older adults with ADL disabilities who participated in long-term care insurance (LTCI) and had an ADL score of less than 40 were investigated by the convenient sampling method.

Primary outcome measures: the UCLA Loneliness Scale (Version 3) was used to assess loneliness.

Results:

Among 880 participants, the mean age was 80.64 years (SD 10.29), and 59.43% were females. The mean score of loneliness was 44.70 (SD=10.01), and the majority suffered from moderate (39.89%) or moderate-severe (40.11%) loneliness. Regression showed that lower loneliness was associated with being females (β=-1.534, 95%CI:-2.841,-0.228), married (β=-3.554, 95%CI:-4.959,-2.149), often communicating with children (β=-3.213, 95%CI:-4.519,-1.908), having more than two friends (β=-5.373, 95%CI:-6.939,-3.808), and receiving home-based rehabilitation once a day (β=-3.692, 95%CI:-5.642,-1.743). Participants who lived in rural areas (β=1.926, 95%CI:0.658,3.193) and were unemployed before retirement (β=4.691, 95%CI:1.485,7.898) experienced higher loneliness for older adults with ADL disability. The classification and regression tree (CART) model showed fewer friends and communication with children sometimes, and living in rural areas felt more lonely.

Conclusions:

The poorer socioeconomic status and social network among elderly adults with ADL disability perceived more

loneliness. Attention should be paid to the loneliness status of such vulnerable people, particularly those with ADL disabilities living in rural areas and having fewer social networks.

Keywords: Older adults; ADL Disability; Loneliness; Socioeconomic status; Social network

Strengths and limitations of this study

Examine the relationship between sociodemographic factors, socioeconomic status, social network, and home-based rehabilitation with loneliness among older adults with ADL disabilities in China.

The classification and regression tree models were used to estimate the subset of older adults who were more likely to become lonely.

This was a cross-sectional study with limited ability to establish causal relationships among variables.

The data were based on self-report and thus were susceptible to recall or reporting bias.

Data availability statement

Data are available from the corresponding author upon reasonable request.

1. Introduction

Loneliness is a painful emotional state caused by the discrepancy between the meaningful social relationships a person desires and the relationships they perceive they have[1]. It has been a prevalent health problem affecting 12% of the older population worldwide[2]. The prevalence of loneliness varies in different countries. A longitudinal population-based cohort study showed that the prevalence of loneliness in older adults ranged from 9.2%-12.4% at wave 5 of the Survey of Health, Ageing, and Retirement in Europe project[3]. The Chinese Longitudinal Healthy Longevity Survey (CLHLS) indicated that about 22.9% and 30.6% of older men and women suffer from loneliness[4]. Existing research shows that older adults with Activity of Daily Living (ADL) disabilities might be linked to an increased risk of experiencing loneliness[5]. A cross-sectional study in the UK found that people with disability experienced loneliness at significantly higher rates than people without disability[6]. The Health in Times of Transition (HITT) survey in the Soviet Union (FSU) showed that the severity of the disability was also crucial for loneliness[7]. However, little is known about loneliness among older adults with ADL disabilities in China. Therefore, the loneliness of older adults with ADL disability in China is worthy of further study.

Loneliness in older adults is associated with various health risks, such as cardiovascular health risks, cognitive dysfunction, and psychological issues (depression, anxiety, insomnia, and increased morbidity and mortality), resulting in reduced quality of life[8–11]. In addition, socioeconomic status (SES) is related to loneliness in older adults. Variables such as income, education, employment, and assets are treated as proxies for socioeconomic status[12]. Studies have shown that lower education and living in rural areas are associated with more loneliness[13,14]. As for older adults with ADL disabilities, the environment has a significant impact on their feelings of loneliness. Physical disabilities and cognitive impairments mean that their ability to perform daily

activities is diminished, leading to a more significant psychological gap than before[7]. In addition, the differences in age and gender can lead to varying degrees of loneliness, with women and older people feeling more lonely[4,15]. These findings highlight the importance of studying the relationship between socioeconomic status and loneliness in older adults with ADL disabilities.

Older adults inevitably undergo significant transitions in the size and composition of their social networks [16]. The increase in loneliness in later life can largely be explained by network changes and waning social contacts due to unavoidable and intractable life events such as retirement, widowhood, loss of close relatives, and chronic and functional limitations[17]. Some studies have found a negative correlation between family size, the frequency of contact with family members, and feelings of loneliness[18]. Marital status is also associated with loneliness; married older adults reported lower feelings of loneliness than those who were widowed or divorced[19]. The social network is also crucial to loneliness among older adults with ADL disabilities. Home-based rehabilitation has increased in many countries due to the increased aging population[20]. Home-based rehabilitation provides the flexibility of place and time in rehabilitation therapy and can sustain independence and accommodate the preferences of older and disabled adults[21]. No study has investigated a direct association between global social network properties and loneliness[16]. In addition, little research has focused on the relationship between home-based rehabilitation and loneliness, especially among older adults. Hence, the relationship between social networks, family rehabilitation, and loneliness deserves further study.

Although several studies have assessed loneliness and susceptibility among older adults in Western societies, little information is known about loneliness among older adults with ADL disabilities. This study aimed to examine loneliness among ADL-disabled older adults within Nantong, China. And to explore the relationship between loneliness, socioeconomic status, social networks, home-based rehabilitation, and gender differences in

these factors. The following hypotheses were made:

(I) Socioeconomic status, social network, and home-based rehabilitation are related to loneliness in older adults with ADL disabilities;

(II) There are gender differences among social network, socioeconomic, and home-based rehabilitation among older adults with ADL disabilities.

2. Methods

2.1 Research Design and Participants

The cross-sectional study was conducted in six districts of Nantong, Jiangsu Province in eastern China, a pilot city for long-term care insurance (LTCI) systems in China. The LTCI systems in Nantong cover individuals with moderate and severe disabilities due to old age and disease as long as their score on the Assessment Scale for Activities of Daily Living (the Barthel Index Assessment Scale) is lower than 40[22]. Insured individuals who are still unable to take care of themselves after at least six months of treatment can receive expenses subsidized related to a nursing home stay, assisted living facility, or formal caretakers coming to your house. Although there are varied reimbursement catalogs, there is no threshold for treatment benefits.

The sample size was calculated by $n = \frac{Z_{\alpha}^2 \times p(1-p)}{d^2}$. In the formula, n represents the sample size, Z is the statistic for significance testing, p is the estimated prevalence rate, and d is the allowable margin of error. The Chinese Longitudinal Healthy Longevity Survey (CLHLS) indicated that about 22.9% and 30.6% of older men and women suffer from loneliness[4]. Existing research shows that older adults with Activity of Daily Living (ADL) disabilities might be linked to an increased risk of experiencing loneliness[5]. This study set the loneliness rate among the elderly p at 30.6%. To ensure the accuracy of the sample size, α was set at 0.05, thus $Z_{0.05}$= 1.96.

To ensure the precision of the sample size, this study allows for a margin of error $d = 0.1p$. Substituting the above data into the formula yields the required sample size of 871. According to the 90% effective response rate, the sample size of this study should not be less than 968 participants. Convenience sampling was used to select 1000 older adults with ADL disabilities who participated in LTCI in Nantong to conduct a face-to-face questionnaire by formal home caretakers working in service institutions. The survey was conducted from January 2020 to March 2020 to explore the status of loneliness among older adults with ADL disabilities. Inclusion criteria included: (I) individuals aged 60 years or above; (II) whose scores on the Assessment Scale for Activities of Daily Living are lower than 40; (III) individuals who are long-term residents in the study area and able to communicate in Mandarin. Of the 1000 respondents, after removing 120 incomplete questionnaires, 880 valid questionnaires were collected, resulting in a response rate of 88%.

2.2 Measures

2.2.1 Dependent variable

Loneliness. The UCLA Loneliness Scale (Version 3), a validated metric of the construct of loneliness, was used to assess the level of loneliness, the primary outcome variable[23]. UCLA is a 20-item Likert 4-level scale (1, never to 4, always) consisting of ten positively-worded statements demonstrating satisfaction with social relationships and ten negatively-worded statements showing dissatisfaction with social relationships[24]. The summary of the scores of each item is the total score, with higher total scores indicating higher levels of loneliness. The scale has the lowest and highest total scores of 20 and 80, specifically mild loneliness (20-34), moderate loneliness (35-49), moderate-severe loneliness (50-64), and severe loneliness (65-80). The Cronbach's α=0.878 suggested that the scale was reliable.

2.2.2. Independent variable

Socioeconomic status. A self-designed questionnaire evaluated socioeconomic status based on four dimensions: residence (Urban vs. Rural), educational level, work, and monthly income (Additional file 1). The permanent residence information of participants was obtained through a home-based rehabilitation company. Additionally, the participants were asked to answer three questions regarding their socioeconomic status: "Could you tell me something about your educational background?" "What did you do before you retired?" "How much is your monthly household income (including government subsidies)?". Participants answered according to the actual situation.

Social network. The social network is an independent variable that includes four dimensions: Marital status (single/divorced/widowed vs. married), number of children, communication status with children, and number of close friends. A self-designed questionnaire measured the participants' social network using the following questions: "What is your current marital status? " "How many kids do you have?" "How many close friends do you have?". In addition, the participants were asked about the frequency of visiting or chatting with their children daily (Additional file 1).

Home-based rehabilitation service. Long-term care and end-of-life care are crucial for older adults with ADL disabilities[25]. Home-based rehabilitation services (HBRS) included in the Long-Term Care Insurance (LTCI) care package can significantly improve the quality of life for older adults with ADL disabilities. These services support their physical well-being and enhance their sense of autonomy and fulfillment in their daily lives. Herein, the time and frequency of receiving HBRS service utilization were used to assess the status of coverage of the LTCI care beneficial package (Additional file 1).

2.2.3. Covariates

Based on the findings of former research on the determinants of loneliness, some covariates, including age and gender, were controlled for sociodemographic variables related to loneliness[26].

2.3 Data analysis

Statistical analyses were conducted using STATA 16.0. First, descriptive statistics were used to describe the basic characteristics of the study sample. Then, mean scores and standard deviations of loneliness were calculated and compared according to t-tests or one-way analysis of variance. Secondly, the ordinary least squares (OLS) regression models were performed to predict loneliness among old adults with ADL disability by SES, social network, and HBRS utilization. In additional analysis, OLS regression models were run separately for men and women to explore the gender differences in loneliness affected by these predictor variables. Finally, the interactive relationship between some indicators of socioeconomic status and social network and home-based rehabilitation associated with loneliness was evaluated using the classification and regression tree (CART) model. To check for the multicollinearity, We calculated the variance inflation factor (VIF) [26]. The VIF was <3 for all independents, indicating no problems with multicollinearity.

2.4 Patient Involvement and Ethical Statement

All participants provided written informed consent, and illiterate participants were substituted for signing by literate family members. This study involves human participants and was approved by the Ethics Committees of Nantong University (ID: 2020-0571). Participants gave informed consent to participate in the study before taking part.

3. Results

3.1 Participants characteristics

Characteristics of the study participants are presented in Table 1. The mean age of participants was 80.64 years (SD 10.29), and 59.43% were females. Nearly 49.77% of old adults with ADL disability reported that their average monthly income was less than 2000 yuan, 41.14% were unemployed or temporary and unpaid workers before retirement, 38.30% were living in rural areas, and 43.41% had no education. The majority, 67.50%, were currently in marital status, communicated with their children often/frequently (55.79%), and had less than two close relationships with their friends (65.68%). Regarding home-based rehabilitation care service, 77.61% received this care once a month or below, and most received care time less than 10 minutes (92.39%).

Table 1. Basic characteristics of the participants (N = 880)

Variables	Mean ± SD/n (%)	Loneliness scores	t/F	p-value
Loneliness	44.70±10.01			
Mild loneliness	167(18.98)	27.85±4.36		
Moderate loneliness	351(39.89)	44.00±4.32		
Moderate-severe loneliness	353(40.11)	52.76±2.84		
High loneliness	9(1.02)	68.00±3.20		
Socioeconomic Status				
Residence				
Urban	543(61.70)	43.25±10.47	30.56	0.001
Rural	337(38.30)	47.02±8.74		
Education level				
Illiteracy	382(43.41)	45.14±10.52	1.80	0.126
Primary school	280(31.82)	43.93±9.78		
Junior school	139(15.80)	44.65±9.56		
Senior school	56(6.36)	46.86±8.22		
Collage/Bachelor and above	23(2.61)	41.61±9.86		
Pre-retirement work				
Government personnel	69(7.84)	44.64±8.78	10.63	0.001
Private sector personnel	187(21.25)	43.42±10.04		
Individual businesses and peasants	262(29.77)	45.91±9.13		
Temporary and unpaid workers	220(25.00)	42.03±11.98		
Unemployed	142(16.14)	48.28±6.92		
Monthly income (¥)				
<2000	438(49.77)	45.59±10.05	2.46	0.031

2000~4000	244(27.73)	43.28±10.54		
4000~6000	98(11.14)	44.76±9.64		
6000~8000	51(5.80)	45.92±7.79		
8000~10000	31(3.52)	41.74±9.82		
>10000	18(2.05)	43.28±6.74		
Social Network				
Marital status				
Married	594(67.50)	43.60±10.29	22.46	0.001
Others (Single/Divorced/Widowed)	286(32.50)	46.97±9.00		
Number of children				
≤2	506(57.50)	44.62±10.09	0.06	0.807
≥3	374(42.50)	44.79±9.91		
Communication status with children				
Sometimes	389(44.20)	47.38±9.71	27.02	0.001
Often	375(42.61)	42.32±9.80		
Frequently	116(13.18)	43.40±9.52		
Number of close friends				
0	198(22.50)	47.09±9.00	41.37	0.001
1~2	380(43.18)	47.28±8.53		
3~5	171(19.43)	40.58±10.68		
≥6	131(14.89)	38.93±10.45		
Home-based rehabilitation service				
Time (minutes)				
≤10	813(92.39)	44.97±9.91	2.36	0.052
11~20	50(5.68)	41.96±11.02		
21~30	11(1.25)	38.27±11.24		
31~59	4(0.45)	43.25±7.14		
≥60	2(0.23)	40.00±1.41		
Frequency				
Once a month and below	683(77.61)	45.44±9.68	9.57	0.001
Two or three times a month	41(4.66)	46.95±7.13		
Once or twice a week	33(3.75)	45.15±10.14		
Three to five times a week	6(0.68)	40.50±9.09		
Once a day	117(13.30)	39.64±11.26		
covariates				
Gender				
Male	357(40.57)	45.25±9.67	1.84	0.175
Female	523(59.43)	44.32±10.22		

The mean loneliness score was 44.70 (SD 10.01), and the majority of participants reported that they

experienced moderate (39.89%) or moderate-severe (40.11%) loneliness. Table 1 compares loneliness differences across various subgroups, including SES, social network, and HBRS utilization.

3.2 OLS regression analysis

The results of OLS regression are presented in Table 2. Participants in low socioeconomic status, living in rural areas (β=3.496,95%CI:2.171,4.821), and unemployed before retirement (β=3.965,95%CI:0.539,7.390) experienced more loneliness in Model 1(shown in Table 2), which explained 7.4% of the variance in loneliness (Adj-R^2= 0.074). From Model 1 to Model 2, social network variables were added to the model, which explained 14.4% of the variance in loneliness (Adj-R^2 changed from 0.074 to 0.218). Compared with those without a spouse, those with a spouse (β=-3.531,95%CI:-4.940,-2.123) were significantly associated with decreased loneliness in older adults with ADL disability. Likely, those with more than two friends (β=-5.266,95%CI:-6.826,-3.705) and often (β=-3.363,95%CI:-4.675,-2.051) or frequently (β=-2.095,95%CI:-4.047,-0.142) communicating with their children significantly experienced lower loneliness than those with two friends or below and sometimes communicating with their children. When we added HBRS utilization in model 3, we found that those who received the HBRS service once a day (β=-3.692,95%CI:-5.642,-1.743) had lower loneliness than those who received service once a month and below, which explained 1.4% of the variance in loneliness (Adj-R^2 changed from 0.218 to 0.232). In addition, when the SES variables and social network and HBRS utilization were entered in Model 3, female older adults with ADL disability were likely to feel less loneliness than male older adults(β=-1.534,95%CI:-2.841,-0.228).

Table 2. OLS regression examining the relationship of SES, social network, and HBRS utilization on loneliness

Variables	Model 1	Model 2	Model 3
	β(95%CI)	β(95%CI)	β(95%CI)
Socioeconomic Status			
Residence (reference: Urban)			

Rural	3.496(2.171,4.821)‡	2.365(1.117,3.613)‡	1.926(0.658,3.193)†
Education level (reference: Senior or above)			
Junior school	-1.911(-4.755,0.933)	-1.834(-4.453,0.785)	-2.056(-4.669,0.557)
Primary or below	1.921(-4.671,0.830)	-2.369(-4.901,0.164)	-2.315(-4.849,0.220)
Pre-retirement Work (reference: Government personnel)			
Private sector personnel	-0.548(-3.509,2.414)	0.512(-2.235,3.259)	0.624(-2.115,3.364)
Individual businesses and peasants	1.942(-1.195,5.079)	2.954(0.028,5.881)*	2.732 (-0.191,5.655)
Temporary and unpaid workers	-1.829(-5.056,1.399)	-0.394(-3.405,2.617)	-0.701(-3.699,2.298)
Unemployed	3.965(0.539,7.390)*	5.199(1.996,8.402)†	4.691(1.485,7.898)‡
Monthly income (¥) (reference: >10000)			
8001~10000	-1.587(-7.207,4.032)	-0.922(-6.103,4.260)	-2.280(-7.513,2.954)
6001~8000	3.299(-1.949,8.547)	1.674(-3.191,6.539)	0.078(-4.831,4.988)
4001~6000	2.446(-2.486,7.377)	1.837(-2.724,6.399)	0.403(-4.193,4.999)
2000~4000	0.844(-3.888,5.576)	-0.048(-4.421,4.325)	-1.754 (-6.196,2.689)
<2000	2.081(-2.628,6.791)	0.429(-3.930,4.789)	-1.023(-5.434,3.389)
Social Network			
Marital status (reference: Others (Single/Divorced/Widowed))			
married		-3.531(-4.940,-2.123)‡	-3.554(-4.959,-2.149)‡
Number of children (reference: ≤2)			
≥3		0.605(-0.810,2.020)	0.577(-0.830,1.985)
Communication status with children (reference: Sometimes)			
Often		-3.363(-4.675,-2.051)‡	-3.213(-4.519,-1.908)‡
Frequently		-2.095(-4.047,-0.142)*	-1.555(-3.518,0.408)
Number of close friends (reference: 0-2)			
3~5		-5.266(-6.826,-3.705)‡	-5.373(-6.939,-3.808)‡
≥6		-6.702(-8.500,-4.903)‡	-6.421(-8.234,-4.608)‡
Home-based rehabilitation services utilization			
Time (minutes) (reference: ≤10)			
11~20			0.041(-2.671,2.753)
21~30			-3.666(-9.247,1.916)
31~59			-1.700(-10.619,7.219)
≥60			3.078 (-9.468,15.623)
Frequency (reference: Once a month and below)			
Two or three times a month			2.033(-0.848,4.913)
Once or twice a week			-1.404(-4.591,1.783)
Three to five times a week			-3.345(10.617,3.928)
Once a day			-3.692(-5.642,-1.743)‡
Covariates			
Age	0.032(-0.036,0.100)	-0.049(-0.123,0.025)	-0.070(-0.145,0.005)

Gender (reference: Male)			
Female	-1.059(-2.455,0.337)	-1.466(-2.783,-0.149)*	-1.534(-2.841,-0.228)*
Adj-R^2	0.074	0.218	0.232

Note: all coefficients are unstandardized.

* $p < 0.05$, †$p < 0.01$, ‡$p < 0.001$.

3.3 Additional regression results based on gender group

Regression results indicated that the relationship between the variables and loneliness significantly differed between males and females (**Supplementary Table B1**). Additional analysis showed that males in rural areas were lonelier than those in urban areas (β=4.373, 95%CI:2.497, 6.248). Among females, those who were married (β=4.163, p<0.001) and receiving HBRS once a day(β=-5.044, 95%CI:-7.632, -2.456)were less lonely than others, supporting hypothesis II.

3.4 Classification and regression tree model results

The CART model showed that loneliness was associated with the number of close friends, frequency of communicating with children, residence, work status before retirement, marital status, and frequency of receiving HBRS (**Figure. 1**). Older adults with ADL disability who have fewer friends, a lower frequency of communicating with children and live in rural areas tend to experience higher loneliness.

The number of close friends is the most significant factor affecting the loneliness of older adults with ADL disability (Node 0). Older adults with two or more friends experienced lower levels of loneliness than those with fewer friends, with moderate to severe loneliness rates of 65.9% (Node 2) and 88.9% (Node 1), respectively. Less frequent communication with their children and living in rural areas are essential to older people's loneliness. Among older adults without close friends and having little communication with their children, the incidence of moderate to severe loneliness was 93.7% (Node 3). In contrast, those communicating frequently, even without

friends, experienced lower loneliness, with moderate to severe loneliness rates of 83.8% (Node 4). If older adults have more than two friends, the level of loneliness in rural areas was significantly higher than that of older adults in urban areas, with moderate to high loneliness rates of 84.4% (Node 6) and 58.0% (Node 5), respectively.

Home-based rehabilitation services are crucial for decreasing older adults' loneliness. In urban areas, disabled older adults who received HBRS 2-3 times or more per month had a lower incidence of loneliness compared to those who received fewer services, and the incidence of moderate to severe loneliness was 40.4% (Node 12) and 64.5% (Node 11), respectively.

4. Discussion

To our knowledge, this is the first study in China focusing on the loneliness status of older adults with ADL disability who enjoy long-term care insurance benefits and further explores the effect of socioeconomic status (SES) factors, social networks, and home-based rehabilitation services on loneliness. Older adults with ADL disabilities had a relatively high level of loneliness. Lower socioeconomic status, such as living in a rural area and being unemployed before retirement, is more likely to increase loneliness in older adults with ADL disabilities. More social networks, such as having a spouse and more than two close friends and communication with children often, are related to less loneliness. Finally, we further utilize a decision tree model to identify the classification combinations of factors that affect loneliness among older adults. Those having two or more friends, frequent communication with children, and home-based rehabilitation services utilization are essential for decreasing loneliness in older adults with ADL disability.

First, our study indicated that having more social networks, such as a greater number of friends and not being single, was associated with lower loneliness, similar to previous studies[27]. The Longitudinal Aging Study Amsterdam (LASA) showed that older adults felt higher levels of loneliness after adverse life events, such as loss

of social contacts or declining physical function [28]. Studies in Germany using data from the German Socio-Economic Panel (SOEP) indicated that having a higher frequency of contact with family and friends reduces loneliness[29,30]. A cross-sectional survey in Spain also found that the type and size of smaller social networks are positively correlated with feelings of loneliness.[31]. Overall, these results confirm that social network is significantly related to loneliness and will make older adults with ADL disabilities have a higher sense of subjective well-being and lower loneliness.

Second, our findings demonstrated that the higher the frequency of home-based rehabilitation services utilization, the lower the loneliness among older adults. Home-based rehabilitation once a day could maintain engagement with others, consistent with the Canadian Community Health Survey and Midlife Development Survey in the United States[32–34]. Home-based long-term care services have also proven to be effective in reducing hospitalization and improving well-being for older adults[35]. Certain community-based health care services, such as rehabilitation care, can be complementary to complement informal care[36]. Older adults need formal or informal care, which helps improve their physical health while reducing loneliness and mental issues. However, there is a great divide in long-term care availability: care services are mainly offered in provincial capitals or large cities, whereas they are not prevalent in poor rural counties and villages[37]. By 2022, formal home and community-based care services had covered most urban areas but only extended to half of the rural areas[38]. Older adults residing in prosperous urban regions may experience greater advantages from formal home and community-based care, which is more accessible and of higher quality than rural areas[39]. Therefore, providing LTCI services in rural areas should be given more attention.

Third, we also found that a lower socioeconomic status was associated with more loneliness in older adults with ADL disabilities. Previous studies showed that loneliness is related to socioeconomic status[31,40–42]. For

example, a national longitudinal survey of 5043 Chinese participants aged 65 years or more showed that a better socioeconomic status is associated with mild loneliness[43]. A case study also suggested that American adults with a higher socioeconomic status and those who lived closer to the city center were less likely to be lonely[44]. Adults with fewer resources and lower status cannot meet social adaptation and are thus perceived to be lonelier, leading to more health-risk behaviors[45,46]. Additionally, the CART model was used as a predictive model to estimate the subsets of older people who are more likely to become lonely, which were observed with high loneliness in the CART model if older adults have poor social networks and take up jobs before retirement. Our study revealed that the role of socioeconomic status on loneliness might partly depend on the social network variables, suggesting that loneliness among ADL-disabled older adults with poor social networks and high economic status should not be ignored.

In addition, female older adults with ADL disabilities had lower loneliness. However, previous studies revealed that females were more likely to have a higher level of loneliness[30,47,48]. This may be because most of the women in the survey were single, as our research on gender differences in influencing factors of loneliness found that non-married women were more lonely. Therefore, the level of suffering associated with feelings of loneliness should be assessed to construct multi-factorial interventions targeting the deficiencies in lonely older adults.

This study has some limitations. First, this was a cross-sectional study with limited ability to establish causal relationships among variables. Therefore, future studies should use longitudinal data or randomized controlled trials to provide more evidence for the efficacy of interventions. Second, the ADL scores or status might lead to a better understanding of the association between the level of loneliness and other variables, explaining the inconsistency in the results. Future studies should provide a targeted analysis of loneliness factors affecting older

persons with ADL difficulties based on ADL scores. Third, the data were based on self-report and thus were susceptible to recall or reporting bias. Fourth, research participants were only collected in one city from a province of China, limiting the applicability of the findings to other areas or nations.

5. Implication

This study provides critical insights into improving loneliness among older adults with ADL disabilities. Firstly, at the community level, volunteer social networks could be utilized to increase social interaction, especially for elderly individuals with ADL disability. Our study suggested that older adults with ADL disabilities deserve more concern in daily life, especially those having fewer friends, lower communication frequency with children, living in rural areas, and not working before retirement. Secondly, the increasing availability of insurance coverage for home-based rehabilitation services should be strengthened for older adults with ADL disability, especially in areas covered by long-term care insurance. As we know, older adults with ADL disabilities lose autonomy, have less social participation, and feel lonely. Our findings revealed that the more HBRS received, the less lonely older adults felt. Increasing the availability of HBRS enables older adults to perceive more social connections with professionals or social workers. Thirdly, at the family level, teaching older adults with ADL disabilities how to use technology, such as smartphones or tablets, for video calls can help them stay connected with family and friends, thereby reducing feelings of loneliness.

6. Conclusion

Older adults with ADL disabilities reported a high prevalence of loneliness. Older adults with lower socioeconomic status often experience higher levels of loneliness. However, increased social networks and greater utilization of home-based rehabilitation services have been shown to reduce feelings of loneliness in this population. Organizing regular home visits by volunteers, community workers, or professionals is essential to

provide companionship, support, and social interaction for these vulnerable groups, especially for rural adults and those without a spouse. In addition, encouraging family members to take an active role in the lives of older adults can also contribute significantly to their well-being.

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Consent for publication: This study does not include any identifiable information (images, faces, names, etc.) of the participants; therefore, the consent statement is not applicable.

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Figure legends: Figure 1. CART model analysis

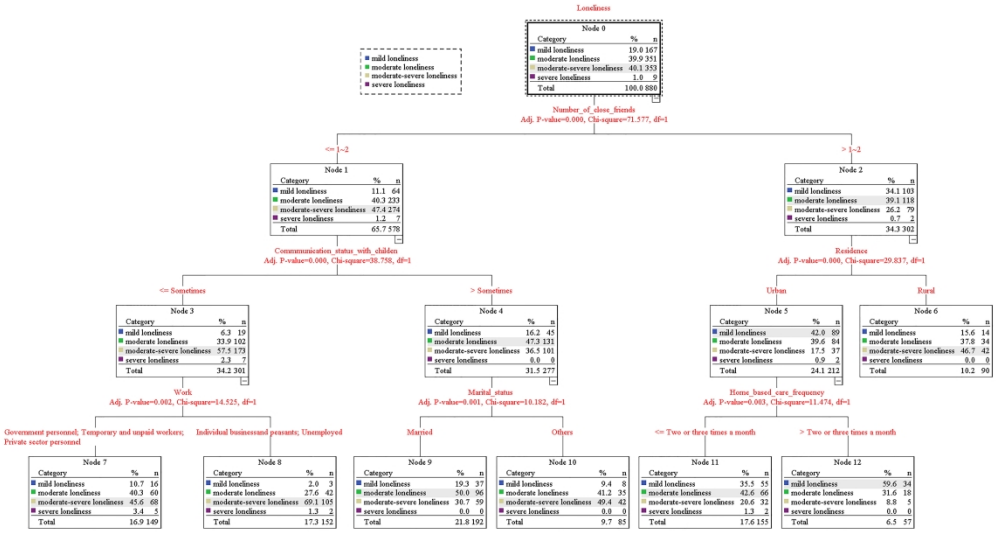

Figure1. CART model analysis

5481x3170mm (38 x 38 DPI)

Table B1. OLS Regression analysis examining the association between socioeconomic status, social network, home-based rehabilitation, and loneliness based on gender group.

Variables	Male sample (N=357)	Female sample (N=523)
	β(95%CI)	β(95%CI)
Socioeconomic Status		
Residence (reference: Urban)		
Rural	4.373(2.497, 6.248)‡	0.015(-1.586, 1.616)
Education level (reference: Senior or above)		
Junior school	-2.551(-5.716, 0.615)	-2.642(-7.546, 2.263)
Primary or below	-1.893(-4.917, 1.132)	-3.587(-8.22, 1.046)
Pre-retirement Work (reference: Government personnel)		
Private sector personnel	2.645(-1.204, 6.495)	-1.109(-5.514, 3.296)
Individual businesses and peasants	4.044(0.124, 7.964)*	2.203(-2.189, 6.596)
Temporary and unpaid workers	2.654(-1.880, 7.187	-3.091(-7.569, 1.387)
Unemployed	5.927(1.328, 10.527)*	3.369(-1.272, 8.010)
Monthly income (¥) (reference: >10000)		
8001~10000	-1.703(-7.244, 3.838)	-3.474(-10.922, 3.975)
6001~8000	0.091(-4.540, 4.722)	-0.504(-7.942, 6.934)
4001~6000	0.152(-4.532, 4.837)	-0.075(-7.484, 7.335)
2000~4000	-1.408(-5.846, 3.029)	-3.412(-10.571, 3.747)
<2000	-3.114(-7.631, 1.402)	-0.909(-7.999, 6.182)
Social Network		
Marital status (reference: Others (Single/Divorced/Widowed))		
married	-2.124(-4.808, 0.559)	-4.188(-5.956, -2.420)‡
Number of children (reference: ≤2)		
≥3	-0.818(-3.120, 1.484)	1.567(-0.267, 3.402)
Communication status with children (reference: Sometimes)		
Often	-2.651(-4.694, -0.607)*	-3.810(-5.536, -2.085)‡
Frequently	-2.081(-6.099, 1.937)	-0.932(-3.517, 1.654)
Number of close friends (reference: 0-2)		
3~5	-5.045(-7.517, -2.574)‡	-5.442 (-7.672, -3.212)‡
≥6	-8.579(-11.765, -5.393)‡	-4.606(-7.095, -2.117)‡
Home-based rehabilitation services utilization		
Time (minutes) (reference: ≤10)		
11~20	0.240(-4.434, 4.910)	-1.099(-5.140, 2.943)
21~30	-3.633(-9.058, 1.792)	-2.226(-11.502, 7.050)
31~59	-5.270(-12.016, 1.475)	0.545(-9.568, 10.657)
≥60	2.568(-2.588, 7.724)	0.445(-5.098, 5.988)
Frequency (reference: Once a month and below)		

Two or three times a month	1.180(-3.044, 5.404)	2.035(-1.784, 5.854)
Once or twice a week	1.885(-1.457, 5.227)	-5.753(-11.292, -0.214)*
Three to five times a week	-6.585(-12.875, -0.295)*	6.761(2.962, 10.560)†
Once a day	-2.037(-5.582, 1.509)	-5.044(-7.632, -2.456)‡

Note: * $p < 0.05$, †$p < 0.01$, ‡$p < 0.001$. All models controlled for age.

Additional file. The Questionnaire of this study (English version).

Table 1. Measurement of Socioeconomic Status

Resident		①Urban ②Rural
Education level	Could you tell me something about your education background?	①Illiteracy ②Primary school ③Junior school ④Senior school ⑤Collage/Bachelor and above
Pre-retirement work	What did you do before you retired？	①Government personnel ②Private sector personnel ③Individual business and peasants ④Temporary and unpaid workers ⑤Unemployed
Monthly income (¥)	How much is your monthly household income(including government subsidies)?	①<2000 ②2000~4000 ③4000~600 ④6000~8000 ⑤8000~10000 ⑥>10000

Table 1. Measurement of Social Network

Marital status	What is your current marital status?	①Married ②Others（single/divorced/widowed）
Number of children	How many kids do you have?	①≤2 ②≥3
Communication status with children	Could you tell us the frequency of visiting or chatting with your children in your daily life？	①Sometimes ②Often ③Frequently
Number of close friends	How many close friends do you have?	①0 ②1~2 ③3~5 ④≥6

Table 2. Home-based rehabilitation

Time (minutes)	How long do you accept home-based rehabilitation？	①≤10 ②11~20 ③21~30 ④31~59 ⑤≥60
Frequency	How often do you accept home-based rehabilitation？	①Once a month and below ②Two or three times a month ③Once or twice a week ④Three to five times a week ⑤Once a day

Table 3. Assessment of Loneliness

Question	Never	Rarely	Sometimes	Always
1. How often do you feel that you are "in tune" with the people around you?	1	2	3	4
2. How often do you feel that you lack companionship?	1	2	3	4
3. How often do you feel that there is no one you can turn to?	1	2	3	4
4. How often do you feel alone?	1	2	3	4
5. How often do you feel part of a group of friends?	1	2	3	4
6. How often do you feel that you have a lot in common with the people around you?	1	2	3	4
7. How often do you feel that you are no longer close to anyone?	1	2	3	4
8. How often do you feel that your interests and ideas are not shared by those around you?	1	2	3	4
9. How often do you feel outgoing and friendly?	1	2	3	4
10. How often do you feel close to people?	1	2	3	4
11. How often do you feel left out?	1	2	3	4
12. How often do you feel that your relationships with others are not meaningful?	1	2	3	4
13. How often do you feel that no one really knows you well?	1	2	3	4
14. How often do you feel isolated from others?	1	2	3	4
15. How often do you feel you can find companionship when you want it?	1	2	3	4
16. How often do you feel that there are people who really understand you?	1	2	3	4
17. How often do you feel shy?	1	2	3	4
18. How often do you feel that people are around you but not with you?	1	2	3	4
19. How often do you feel that there are people you can talk to?	1	2	3	4
20. How often do you feel that there are people you can turn to?	1	2	3	4

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The relationship between socioeconomic status and social network with loneliness: A cross-sectional study of China older adults with ADL disabilities

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Abstract:

Objectives:

To explore the relationship between loneliness and socioeconomic status and social networks in older adults with Activity of Daily Living (ADL) disabilities in China and investigate people who are more likely to feel lonely.

Design: cross-sectional study

Setting: This study was conducted in six districts of Nantong, Jiangsu, China.

Participants: A total of 880 older adults with ADL disabilities who participated in long-term care insurance (LTCI) and had an ADL score of less than 40 were investigated by the convenient sampling method.

Primary outcome measures: the UCLA Loneliness Scale (Version 3) was used to assess loneliness.

Results:

Among 880 participants, the mean age was 80.64 years (SD 10.29), and 59.43% were females. The mean score of loneliness was 44.70 (SD=10.01), and the majority suffered from moderate (39.89%) or moderate-severe (40.11%) loneliness. Regression showed that lower loneliness was associated with being females (β=-1.534, 95%CI:-2.841,-0.228), married (β=-3.554, 95%CI:-4.959,-2.149), often communicating with children (β=-3.213, 95%CI:-4.519,-1.908), having more than two friends (β=-5.373, 95%CI:-6.939,-3.808), and receiving home-based rehabilitation once a day (β=-3.692, 95%CI:-5.642,-1.743). Participants who lived in rural areas (β=1.926, 95%CI:0.658,3.193) and were unemployed before retirement (β=4.691, 95%CI:1.485,7.898) experienced higher loneliness for older adults with ADL disability. The classification and regression tree (CART) model showed fewer friends and communication with children sometimes, and living in rural areas felt more lonely.

Conclusions:

The poorer socioeconomic status and social network among older adults with ADL disability perceived more

loneliness. Attention should be paid to the loneliness status of such vulnerable people, particularly those with ADL disabilities living in rural areas and having fewer social networks.

Keywords: Older adults; ADL Disability; Loneliness; Socioeconomic status; Social network

1. Strengths and limitations of this study

-Examine the relationship between sociodemographic factors, socioeconomic status, social network, and home-based rehabilitation with loneliness among older adults with ADL disabilities in China.

-The classification and regression tree models were used to estimate the subset of older adults who were more likely to become lonely.

-This was a cross-sectional study with limited ability to establish causal relationships among variables.

-The data were based on self-report and thus were susceptible to recall or reporting bias.

2. Introduction

Loneliness is a painful emotional state caused by the discrepancy between the meaningful social relationships a person desires and the relationships they perceive they have[1]. It has been a prevalent health problem affecting 12% of the older population worldwide[2]. The prevalence of loneliness varies in different countries. A longitudinal population-based cohort study showed that the prevalence of loneliness in older adults ranged from 9.2%-12.4% at wave 5 of the Survey of Health, Ageing, and Retirement in Europe project[3]. The Chinese Longitudinal Healthy Longevity Survey (CLHLS) indicated that about 22.9% and 30.6% of older men and women suffer from loneliness[4]. Existing research shows that older adults with Activity of Daily Living (ADL) disabilities might be linked to an increased risk of experiencing loneliness[5]. A cross-sectional study in the UK found that people with disability experienced loneliness at significantly higher rates than people without disability[6]. The Health in Times of Transition (HITT) survey in the Soviet Union (FSU) showed that the severity of the disability was also crucial for loneliness[7]. However, little is known about loneliness among older adults with ADL disabilities in China. Therefore, the loneliness of older adults with ADL disability in China is worthy of further study.

Loneliness in older adults is associated with various health risks, such as cardiovascular health risks, cognitive dysfunction, and psychological issues (depression, anxiety, insomnia, and increased morbidity and mortality), resulting in reduced quality of life[8–11]. In addition, socioeconomic status (SES) is related to loneliness in older adults. Variables such as income, education, employment, and assets are treated as proxies for socioeconomic status[12]. Studies have shown that lower education and living in rural areas are associated with more loneliness[13,14]. As for older adults with ADL disabilities, the environment has a significant impact on their feelings of loneliness. Physical disabilities and cognitive impairments mean that their ability to perform daily

activities is diminished, leading to a more significant psychological gap than before[7]. In addition, the differences in age and gender can lead to varying degrees of loneliness, with women and older people feeling more lonely[4,15]. These findings highlight the importance of studying the relationship between socioeconomic status and loneliness in older adults with ADL disabilities.

Older adults inevitably undergo significant transitions in the size and composition of their social networks [16]. The increase in loneliness in later life can largely be explained by network changes and waning social contacts due to unavoidable and intractable life events such as retirement, widowhood, loss of close relatives, and chronic and functional limitations[17]. Some studies have found a negative correlation between family size, the frequency of contact with family members, and feelings of loneliness[18]. Marital status is also associated with loneliness; married older adults reported lower feelings of loneliness than those who were widowed or divorced[19]. The social network is also crucial to loneliness among older adults with ADL disabilities. Home-based rehabilitation has increased in many countries due to the increased aging population[20]. Home-based rehabilitation provides the flexibility of place and time in rehabilitation therapy and can sustain independence and accommodate the preferences of older and disabled adults[21]. No study has investigated a direct association between global social network properties and loneliness[16]. In addition, little research has focused on the relationship between home-based rehabilitation and loneliness, especially among older adults. Hence, the relationship between social networks, family rehabilitation, and loneliness deserves further study.

Although several studies have assessed loneliness and susceptibility among older adults in Western societies, little information is known about loneliness among older adults with ADL disabilities. This study aimed to examine loneliness among ADL-disabled older adults within Nantong, China. Furthermore, we verified the effects of socioeconomic status, social networks, and home-based rehabilitation on loneliness among older adults, and

explored gender differences in these relationships. The following hypotheses were made:

(I) Socioeconomic status, social network, and home-based rehabilitation are related to loneliness in older adults with ADL disabilities;

(II) There are gender differences among social network, socioeconomic, and home-based rehabilitation among older adults with ADL disabilities.

3. Methods

3.1 Research Design and Participants

The cross-sectional study was conducted in six districts of Nantong, Jiangsu Province in eastern China, a pilot city for long-term care insurance (LTCI) systems in China. The LTCI systems in Nantong cover individuals with moderate and severe disabilities due to old age and disease as long as their score on the Assessment Scale for Activities of Daily Living (the Barthel Index Assessment Scale) is lower than 40[22]. Insured individuals who are still unable to take care of themselves after at least six months of treatment can receive expenses subsidized related to a nursing home stay, assisted living facility, or formal caretakers coming to your house. Although there are varied reimbursement catalogs, there is no threshold for treatment benefits.

The sample size was calculated by $n = \frac{Z_{\alpha}^2 \times p(1-p)}{d^2}$. In the formula, n represents the sample size, Z is the statistic for significance testing, p is the estimated prevalence rate, and d is the allowable margin of error. The Chinese Longitudinal Healthy Longevity Survey (CLHLS) indicated that about 22.9% and 30.6% of older men and women suffer from loneliness[4]. Existing research shows that older adults with Activity of Daily Living (ADL) disabilities might be linked to an increased risk of experiencing loneliness[5]. This study set the loneliness rate among the elderly p at 30.6%. To ensure the accuracy of the sample size, α was set at 0.05, thus $Z_{0.05}$= 1.96.

To ensure the precision of the sample size, this study allows for a margin of error $d = 0.1p$. Substituting the above data into the formula yields the required sample size of 871. According to the 90% effective response rate, the sample size of this study should not be less than 968 participants. Convenience sampling was used to select 1000 older adults with ADL disabilities who participated in LTCI in Nantong to conduct a face-to-face questionnaire by formal home caretakers working in service institutions. The survey was conducted from January 2020 to March 2020 to explore the status of loneliness among older adults with ADL disabilities. Inclusion criteria included: (I) individuals aged 60 years or above; (II) whose scores on the Assessment Scale for Activities of Daily Living are lower than 40; (III) individuals who are long-term residents in the study area and able to communicate in Mandarin. Of the 1000 respondents, after removing 120 incomplete questionnaires, 880 valid questionnaires were collected, resulting in a response rate of 88%.

3.2 Measures

3.2.1 Dependent variable

Loneliness. The UCLA Loneliness Scale (Version 3), a validated metric of the construct of loneliness, was used to assess the level of loneliness, the primary outcome variable[23]. UCLA is a 20-item Likert 4-level scale (1, never to 4, always) consisting of ten positively-worded statements demonstrating satisfaction with social relationships and ten negatively-worded statements showing dissatisfaction with social relationships[24]. The summary of the scores of each item is the total score, with higher total scores indicating higher levels of loneliness. The scale has the lowest and highest total scores of 20 and 80, specifically mild loneliness (20-34), moderate loneliness (35-49), moderate-severe loneliness (50-64), and severe loneliness (65-80). The Cronbach's α=0.878 suggested that the scale was reliable.

3.2.2. Independent variables

Socioeconomic status. A self-designed questionnaire evaluated socioeconomic status based on four dimensions: residence (Urban vs. Rural), educational level, work, and monthly income (Additional file 1). The permanent residence information of participants was obtained through a home-based rehabilitation company. Additionally, the participants were asked to answer three questions regarding their socioeconomic status: "Could you tell me something about your educational background?" "What did you do before you retired?" "How much is your monthly household income (including government subsidies)?". Participants answered according to the actual situation.

Social network. The social network is an independent variable that includes four dimensions: Marital status (single/divorced/widowed vs. married), number of children, communication status with children, and number of close friends. A self-designed questionnaire measured the participants' social network using the following questions: "What is your current marital status? " "How many kids do you have?" "How many close friends do you have?". In addition, the participants were asked about the frequency of visiting or chatting with their children daily (Additional file 1).

Home-based rehabilitation service. Long-term care and end-of-life care are crucial for older adults with ADL disabilities[25]. Home-based rehabilitation services (HBRS) included in the Long-Term Care Insurance (LTCI) care package can significantly improve the quality of life for older adults with ADL disabilities. These services support their physical well-being and enhance their sense of autonomy and fulfilment in their daily lives. Herein, the time and frequency of receiving HBRS service utilization were used to assess the status of coverage of the LTCI care beneficial package (Additional file 1).

3.2.3. Covariates

Based on the findings of former research on the determinants of loneliness, some covariates, including age and gender, were controlled for sociodemographic variables related to loneliness[26].

3.3 Data analysis

Statistical analyses were conducted using STATA 16.0. First, descriptive statistics were used to describe the basic characteristics of the study sample. Then, mean scores and standard deviations of loneliness were calculated and compared according to t-tests or one-way analysis of variance. Secondly, the ordinary least squares (OLS) regression models were performed to predict loneliness among old adults with ADL disability by SES, social network, and HBRS utilization. In additional analysis, OLS regression models were run separately for men and women to explore the gender differences in loneliness affected by these predictor variables. Finally, the interactive relationship between some indicators of socioeconomic status and social network and home-based rehabilitation associated with loneliness was evaluated using the classification and regression tree (CART) model. To check for the multicollinearity, We calculated the variance inflation factor (VIF) [26]. The VIF was <3 for all independents, indicating no problems with multicollinearity.

3.4 Ethical considerations

All participants provided written informed consent. In cases where participants were illiterate, their spouses or children were authorized to sign on their behalf. This study was approved by the Ethics Committees of Nantong University (ID: 2020-0571). Participants gave informed consent to participate in the study before taking part.

3.5 Patient and Public Involvement Statement

None.

4. Results

4.1 Participants characteristics

Characteristics of the study participants are presented in Table 1. The mean age of participants was 80.64 years (SD 10.29), and 59.43% were females. Nearly 49.77% of older adults with ADL disability reported that their average monthly income was less than 2000 yuan, 41.14% were unemployed or temporary and unpaid workers before retirement, 38.30% were living in rural areas, and 43.41% had no education. The majority, 67.50%, were currently in marital status, communicated with their children often/frequently (55.79%), and had less than two close relationships with their friends (65.68%). Regarding home-based rehabilitation care service, 77.61% received this care once a month or below, and most received care time less than 10 minutes (92.39%).

Table 1. Basic characteristics of the participants (N = 880)

Variables	Mean ± SD/n (%)	Loneliness scores	t/F	p-value
Loneliness	44.70±10.01			
Mild loneliness	167(18.98)	27.85±4.36		
Moderate loneliness	351(39.89)	44.00±4.32		
Moderate-severe loneliness	353(40.11)	52.76±2.84		
High loneliness	9(1.02)	68.00±3.20		
Socioeconomic Status				
Residence				
Urban	543(61.70)	43.25±10.47	30.56	0.001
Rural	337(38.30)	47.02±8.74		
Education level				
Illiteracy	382(43.41)	45.14±10.52	1.80	0.126
Primary school	280(31.82)	43.93±9.78		
Junior school	139(15.80)	44.65±9.56		
Senior school	56(6.36)	46.86±8.22		
Collage/Bachelor and above	23(2.61)	41.61±9.86		
Pre-retirement work				
Government personnel	69(7.84)	44.64±8.78	10.63	0.001
Private sector personnel	187(21.25)	43.42±10.04		
Individual businesses and peasants	262(29.77)	45.91±9.13		
Temporary and unpaid workers	220(25.00)	42.03±11.98		
Unemployed	142(16.14)	48.28±6.92		
Monthly income (¥)				
<2000	438(49.77)	45.59±10.05	2.46	0.031

2000~4000	244(27.73)	43.28±10.54		
4000~6000	98(11.14)	44.76±9.64		
6000~8000	51(5.80)	45.92±7.79		
8000~10000	31(3.52)	41.74±9.82		
>10000	18(2.05)	43.28±6.74		
Social Network				
Marital status				
Married	594(67.50)	43.60±10.29	22.46	0.001
Others (Single/Divorced/Widowed)	286(32.50)	46.97±9.00		
Number of children				
≤2	506(57.50)	44.62±10.09	0.06	0.807
≥3	374(42.50)	44.79±9.91		
Communication status with children				
Sometimes	389(44.20)	47.38±9.71	27.02	0.001
Often	375(42.61)	42.32±9.80		
Frequently	116(13.18)	43.40±9.52		
Number of close friends				
0	198(22.50)	47.09±9.00	41.37	0.001
1~2	380(43.18)	47.28±8.53		
3~5	171(19.43)	40.58±10.68		
≥6	131(14.89)	38.93±10.45		
Home-based rehabilitation service				
Time (minutes)				
≤10	813(92.39)	44.97±9.91	2.36	0.052
11~20	50(5.68)	41.96±11.02		
21~30	11(1.25)	38.27±11.24		
31~59	4(0.45)	43.25±7.14		
≥60	2(0.23)	40.00±1.41		
Frequency				
Once a month and below	683(77.61)	45.44±9.68	9.57	0.001
Two or three times a month	41(4.66)	46.95±7.13		
Once or twice a week	33(3.75)	45.15±10.14		
Three to five times a week	6(0.68)	40.50±9.09		
Once a day	117(13.30)	39.64±11.26		
covariates				
Gender				
Male	357(40.57)	45.25±9.67	1.84	0.175
Female	523(59.43)	44.32±10.22		

The mean loneliness score was 44.70 (SD 10.01), and the majority of participants reported that they

experienced moderate (39.89%) or moderate-severe (40.11%) loneliness. Table 1 compares loneliness differences across various subgroups, including SES, social network, and HBRS utilization.

4.2 OLS regression analysis

The results of OLS regression are presented in Table 2. Participants in low socioeconomic status, living in rural areas (β=3.496,95%CI:2.171,4.821), and unemployed before retirement (β=3.965,95%CI:0.539,7.390) experienced more loneliness in Model 1(shown in Table 2), which explained 7.4% of the variance in loneliness (Adj-R^2= 0.074). From Model 1 to Model 2, social network variables were added to the model, which explained 14.4% of the variance in loneliness (Adj-R^2 changed from 0.074 to 0.218). Compared with those without a spouse, those with a spouse (β=-3.531,95%CI:-4.940,-2.123) were significantly associated with decreased loneliness in older adults with ADL disability. Likely, those with more than two friends (β=-5.266,95%CI:-6.826,-3.705) and often (β=-3.363,95%CI:-4.675,-2.051) or frequently (β=-2.095,95%CI:-4.047,-0.142) communicating with their children significantly experienced lower loneliness than those with two friends or below and sometimes communicating with their children. When we added HBRS utilization in model 3, we found that those who received the HBRS service once a day (β=-3.692,95%CI:-5.642,-1.743) had lower loneliness than those who received service once a month and below, which explained 1.4% of the variance in loneliness (Adj-R^2 changed from 0.218 to 0.232). In addition, when the SES variables and social network and HBRS utilization were entered in Model 3, female older adults with ADL disability were likely to feel less loneliness than male older adults(β=-1.534,95%CI:-2.841,-0.228).

Table 2. OLS regression examining the relationship of SES, social network, and HBRS utilization on loneliness

Variables	Model 1	Model 2	Model 3
	β(95%CI)	β(95%CI)	β(95%CI)
Socioeconomic Status			
Residence (reference: Urban)			

Rural	3.496(2.171,4.821)‡	2.365(1.117,3.613)‡	1.926(0.658,3.193)†
Education level (reference: Senior or above)			
Junior school	-1.911(-4.755,0.933)	-1.834(-4.453,0.785)	-2.056(-4.669,0.557)
Primary or below	1.921(-4.671,0.830)	-2.369(-4.901,0.164)	-2.315(-4.849,0.220)
Pre-retirement Work (reference: Government personnel)			
Private sector personnel	-0.548(-3.509,2.414)	0.512(-2.235,3.259)	0.624(-2.115,3.364)
Individual businesses and peasants	1.942(-1.195,5.079)	2.954(0.028,5.881)*	2.732 (-0.191,5.655)
Temporary and unpaid workers	-1.829(-5.056,1.399)	-0.394(-3.405,2.617)	-0.701(-3.699,2.298)
Unemployed	3.965(0.539,7.390)*	5.199(1.996,8.402)†	4.691(1.485,7.898)‡
Monthly income (¥) (reference: >10000)			
8001~10000	-1.587(-7.207,4.032)	-0.922(-6.103,4.260)	-2.280(-7.513,2.954)
6001~8000	3.299(-1.949,8.547)	1.674(-3.191,6.539)	0.078(-4.831,4.988)
4001~6000	2.446(-2.486,7.377)	1.837(-2.724,6.399)	0.403(-4.193,4.999)
2000~4000	0.844(-3.888,5.576)	-0.048(-4.421,4.325)	-1.754 (-6.196,2.689)
<2000	2.081(-2.628,6.791)	0.429(-3.930,4.789)	-1.023(-5.434,3.389)
Social Network			
Marital status (reference: Others (Single/Divorced/Widowed))			
married		-3.531(-4.940,-2.123)‡	-3.554(-4.959,-2.149)‡
Number of children (reference: ≤2)			
≥3		0.605(-0.810,2.020)	0.577(-0.830,1.985)
Communication status with children (reference: Sometimes)			
Often		-3.363(-4.675,-2.051)‡	-3.213(-4.519,-1.908)‡
Frequently		-2.095(-4.047,-0.142)*	-1.555(-3.518,0.408)
Number of close friends (reference: 0-2)			
3~5		-5.266(-6.826,-3.705)‡	-5.373(-6.939,-3.808)‡
≥6		-6.702(-8.500,-4.903)‡	-6.421(-8.234,-4.608)‡
Home-based rehabilitation services utilization			
Time (minutes) (reference: ≤10)			
11~20			0.041(-2.671,2.753)
21~30			-3.666(-9.247,1.916)
31~59			-1.700(-10.619,7.219)
≥60			3.078 (-9.468,15.623)
Frequency (reference: Once a month and below)			
Two or three times a month			2.033(-0.848,4.913)
Once or twice a week			-1.404(-4.591,1.783)
Three to five times a week			-3.345(10.617,3.928)
Once a day			-3.692(-5.642,-1.743)‡
Covariates			
Age	0.032(-0.036,0.100)	-0.049(-0.123,0.025)	-0.070(-0.145,0.005)

Gender (reference: Male)			
Female	-1.059(-2.455,0.337)	-1.466(-2.783,-0.149)*	-1.534(-2.841,-0.228)*
Adj-R^2	0.074	0.218	0.232

Note: all coefficients are unstandardized.

* $p < 0.05$, †$p < 0.01$, ‡$p < 0.001$.

4.3 Additional regression results based on gender group

Regression results indicated that the relationship between the variables and loneliness significantly differed between males and females (**Supplementary Table B1**). Additional analysis showed that males in rural areas were lonelier than those in urban areas (β=4.373, 95%CI:2.497, 6.248). Among females, those who were married (β=4.163, p<0.001) and receiving HBRS once a day(β=-5.044, 95%CI:-7.632, -2.456)were less lonely than others, supporting hypothesis II.

4.4 Classification and regression tree model results

The CART model showed that loneliness was associated with the number of close friends, frequency of communicating with children, residence, work status before retirement, marital status, and frequency of receiving HBRS (**Figure. 1**). Older adults with ADL disability who have fewer friends, a lower frequency of communicating with children and live in rural areas tend to experience higher loneliness.

The number of close friends is the most significant factor affecting the loneliness of older adults with ADL disability (Node 0). Older adults with two or more friends experienced lower levels of loneliness than those with fewer friends, with moderate to severe loneliness rates of 65.9% (Node 2) and 88.9% (Node 1), respectively. Less frequent communication with their children and living in rural areas are essential to older people's loneliness. Among older adults without close friends and having little communication with their children, the incidence of moderate to severe loneliness was 93.7% (Node 3). In contrast, those communicating frequently, even without

friends, experienced lower loneliness, with moderate to severe loneliness rates of 83.8% (Node 4). If older adults have more than two friends, the level of loneliness in rural areas was significantly higher than that of older adults in urban areas, with moderate to high loneliness rates of 84.4% (Node 6) and 58.0% (Node 5), respectively.

Home-based rehabilitation services are crucial for decreasing older adults' loneliness. In urban areas, disabled older adults who received HBRS 2-3 times or more per month had a lower incidence of loneliness compared to those who received fewer services, and the incidence of moderate to severe loneliness was 40.4% (Node 12) and 64.5% (Node 11), respectively.

5. Discussion

To our knowledge, this is the first study in China focusing on the loneliness status of older adults with ADL disability who enjoy long-term care insurance benefits and further explores the effect of socioeconomic status (SES) factors, social networks, and home-based rehabilitation services on loneliness. Older adults with ADL disabilities had a relatively high level of loneliness. Lower socioeconomic status, such as living in a rural area and being unemployed before retirement, is more likely to increase loneliness in older adults with ADL disabilities. More social networks, such as having a spouse and more than two close friends and communication with children often, are related to less loneliness. Finally, we further utilize a decision tree model to identify the classification combinations of factors that affect loneliness among older adults. Those having two or more friends, frequent communication with children, and home-based rehabilitation services utilization are essential for decreasing loneliness in older adults with ADL disability.

First, our study indicated that having more social networks, such as a greater number of friends and not being single, was associated with lower loneliness, similar to previous studies[27]. The Longitudinal Aging Study Amsterdam (LASA) showed that older adults felt higher levels of loneliness after adverse life events, such as loss

of social contacts or declining physical function [28]. Studies in Germany using data from the German Socio-Economic Panel (SOEP) indicated that having a higher frequency of contact with family and friends reduces loneliness[29,30]. A cross-sectional survey in Spain also found that the type and size of smaller social networks are positively correlated with feelings of loneliness.[31]. Overall, these results confirm that social network is significantly related to loneliness and will make older adults with ADL disabilities have a higher sense of subjective well-being and lower loneliness.

Second, our findings demonstrated that the higher the frequency of home-based rehabilitation services utilization, the lower the loneliness among older adults. Home-based rehabilitation once a day could maintain engagement with others, consistent with the Canadian Community Health Survey and Midlife Development Survey in the United States[32–34]. Home-based long-term care services have also proven to be effective in reducing hospitalization and improving well-being for older adults[35]. Certain community-based health care services, such as rehabilitation care, can be complementary to complement informal care[36]. Older adults need formal or informal care, which helps improve their physical health while reducing loneliness and mental issues. However, there is a great divide in long-term care availability: care services are mainly offered in provincial capitals or large cities, whereas they are not prevalent in poor rural counties and villages[37]. By 2022, formal home and community-based care services had covered most urban areas but only extended to half of the rural areas[38]. Older adults residing in prosperous urban regions may experience greater advantages from formal home and community-based care, which is more accessible and of higher quality than in rural areas[39]. Therefore, providing LTCI services in rural areas should be given more attention.

Third, we also found that a lower socioeconomic status was associated with more loneliness in older adults with ADL disabilities. Previous studies showed that loneliness is related to socioeconomic status[31,40–42]. For

example, a national longitudinal survey of 5043 Chinese participants aged 65 years or more showed that a better socioeconomic status is associated with mild loneliness[43]. A case study also suggested that American adults with a higher socioeconomic status and those who lived closer to the city center were less likely to be lonely[44]. Adults with fewer resources and lower status cannot meet social adaptation and are thus perceived to be lonelier, leading to more health-risk behaviors[45,46]. Additionally, the CART model was used as a predictive model to estimate the subsets of older people who are more likely to become lonely, which were observed with high loneliness in the CART model if older adults have poor social networks and take up jobs before retirement. Our study revealed that the role of socioeconomic status on loneliness might partly depend on the social network variables, suggesting that loneliness among ADL-disabled older adults with poor social networks and high economic status should not be ignored.

In addition, female older adults with ADL disabilities had lower loneliness. However, previous studies revealed that females were more likely to have a higher level of loneliness[30,47,48]. This may be because most of the women in the survey were single, as our research on gender differences in influencing factors of loneliness found that non-married women were more lonely. Therefore, the level of suffering associated with feelings of loneliness should be assessed to construct multi-factorial interventions targeting the deficiencies in lonely older adults.

This study has some limitations. First, this was a cross-sectional study with limited ability to establish causal relationships among variables. Therefore, future studies should use longitudinal data or randomized controlled trials to provide more evidence for the efficacy of interventions. Second, the ADL scores or status might lead to a better understanding of the association between the level of loneliness and other variables, explaining the inconsistency in the results. Future studies should provide a targeted analysis of loneliness factors affecting older

persons with ADL difficulties based on ADL scores. Third, the data were based on self-report and thus were susceptible to recall or reporting bias. Fourth, research participants were only collected in one city from a province of China, limiting the applicability of the findings to other areas or nations.

6. Implication

This study provides critical insights into improving loneliness among older adults with ADL disabilities. Firstly, at the community level, volunteer social networks could be utilized to increase social interaction, especially for elderly individuals with ADL disability. Our study suggested that older adults with ADL disabilities deserve more concern in daily life, especially those having fewer friends, lower communication frequency with children, living in rural areas, and not working before retirement. Secondly, the increasing availability of insurance coverage for home-based rehabilitation services should be strengthened for older adults with ADL disability, especially in areas covered by long-term care insurance. As we know, older adults with ADL disabilities lose autonomy, have less social participation, and feel lonely. Our findings revealed that the more HBRS received, the less lonely older adults felt. Increasing the availability of HBRS enables older adults to perceive more social connections with professionals or social workers. Thirdly, at the family level, teaching older adults with ADL disabilities how to use technology, such as smartphones or tablets, for video calls can help them stay connected with family and friends, thereby reducing feelings of loneliness.

7. Conclusion

Older adults with ADL disabilities reported a high prevalence of loneliness. Older adults with lower socioeconomic status often experience higher levels of loneliness. However, increased social networks and greater utilization of home-based rehabilitation services have been shown to reduce feelings of loneliness in this population. Organizing regular home visits by volunteers, community workers, or professionals is essential to

provide companionship, support, and social interaction for these vulnerable groups, especially for rural adults and those without a spouse. In addition, encouraging family members to take an active role in the lives of older adults can also contribute significantly to their well-being.

Figure legends: Figure 1. CART model analysis

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Consent for publication: This study does not include any identifiable information (images, faces, names, etc.) of the participants; therefore, the consent statement is not applicable.

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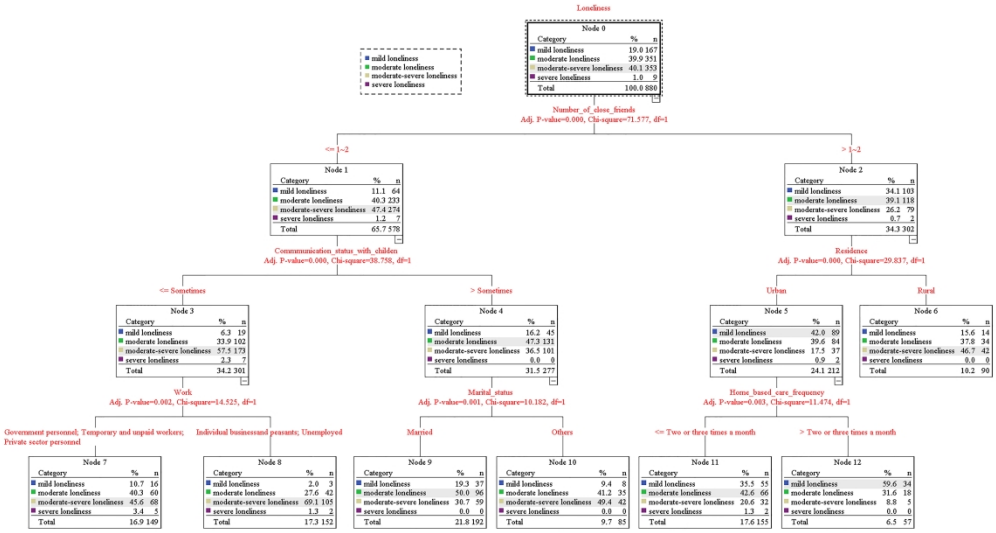

Figure1. CART model analysis

5481x3170mm (38 x 38 DPI)

Table B1. OLS Regression analysis examining the association between socioeconomic status, social network, home-based rehabilitation, and loneliness based on gender group.

Variables	Male sample (N=357)	Female sample (N=523)
	β(95%CI)	β(95%CI)
Socioeconomic Status		
Residence (reference: Urban)		
Rural	4.373(2.497, 6.248)‡	0.015(-1.586, 1.616)
Education level (reference: Senior or above)		
Junior school	-2.551(-5.716, 0.615)	-2.642(-7.546, 2.263)
Primary or below	-1.893(-4.917, 1.132)	-3.587(-8.22, 1.046)
Pre-retirement Work (reference: Government personnel)		
Private sector personnel	2.645(-1.204, 6.495)	-1.109(-5.514, 3.296)
Individual businesses and peasants	4.044(0.124, 7.964)*	2.203(-2.189, 6.596)
Temporary and unpaid workers	2.654(-1.880, 7.187	-3.091(-7.569, 1.387)
Unemployed	5.927(1.328, 10.527)*	3.369(-1.272, 8.010)
Monthly income (¥) (reference: >10000)		
8001~10000	-1.703(-7.244, 3.838)	-3.474(-10.922, 3.975)
6001~8000	0.091(-4.540, 4.722)	-0.504(-7.942, 6.934)
4001~6000	0.152(-4.532, 4.837)	-0.075(-7.484, 7.335)
2000~4000	-1.408(-5.846, 3.029)	-3.412(-10.571, 3.747)
<2000	-3.114(-7.631, 1.402)	-0.909(-7.999, 6.182)
Social Network		
Marital status (reference: Others (Single/Divorced/Widowed))		
married	-2.124(-4.808, 0.559)	-4.188(-5.956, -2.420)‡
Number of children (reference: ≤2)		
≥3	-0.818(-3.120, 1.484)	1.567(-0.267, 3.402)
Communication status with children (reference: Sometimes)		
Often	-2.651(-4.694, -0.607)*	-3.810(-5.536, -2.085)‡
Frequently	-2.081(-6.099, 1.937)	-0.932(-3.517, 1.654)
Number of close friends (reference: 0-2)		
3~5	-5.045(-7.517, -2.574)‡	-5.442 (-7.672, -3.212)‡
≥6	-8.579(-11.765, -5.393)‡	-4.606(-7.095, -2.117)‡
Home-based rehabilitation services utilization		
Time (minutes) (reference: ≤10)		
11~20	0.240(-4.434, 4.910)	-1.099(-5.140, 2.943)
21~30	-3.633(-9.058, 1.792)	-2.226(-11.502, 7.050)
31~59	-5.270(-12.016, 1.475)	0.545(-9.568, 10.657)
≥60	2.568(-2.588, 7.724)	0.445(-5.098, 5.988)
Frequency (reference: Once a month and below)		

Two or three times a month	1.180(-3.044, 5.404)	2.035(-1.784, 5.854)
Once or twice a week	1.885(-1.457, 5.227)	-5.753(-11.292, -0.214)*
Three to five times a week	-6.585(-12.875, -0.295)*	6.761(2.962, 10.560)†
Once a day	-2.037(-5.582, 1.509)	-5.044(-7.632, -2.456)‡

Note: * $p < 0.05$, †$p < 0.01$, ‡$p < 0.001$. All models controlled for age.

Additional file. The Questionnaire of this study (English version).

Table 1. Measurement of Socioeconomic Status

Resident		①Urban ②Rural
Education level	Could you tell me something about your education background?	①Illiteracy ②Primary school ③Junior school ④Senior school ⑤Collage/Bachelor and above
Pre-retirement work	What did you do before you retired？	①Government personnel ②Private sector personnel ③Individual business and peasants ④Temporary and unpaid workers ⑤Unemployed
Monthly income (¥)	How much is your monthly household income(including government subsidies)?	①<2000 ②2000~4000 ③4000~600 ④6000~8000 ⑤8000~10000 ⑥>10000

Table 1. Measurement of Social Network

Marital status	What is your current marital status?	①Married ②Others（single/divorced/widowed）
Number of children	How many kids do you have?	①≤2 ②≥3
Communication status with children	Could you tell us the frequency of visiting or chatting with your children in your daily life？	①Sometimes ②Often ③Frequently
Number of close friends	How many close friends do you have?	①0 ②1~2 ③3~5 ④≥6

Table 2. Home-based rehabilitation

Time (minutes)	How long do you accept home-based rehabilitation？	①≤10 ②11~20 ③21~30 ④31~59 ⑤≥60
Frequency	How often do you accept home-based rehabilitation？	①Once a month and below ②Two or three times a month ③Once or twice a week ④Three to five times a week ⑤Once a day

Table 3. Assessment of Loneliness

Question	Never	Rarely	Sometimes	Always
1. How often do you feel that you are "in tune" with the people around you?	1	2	3	4
2. How often do you feel that you lack companionship?	1	2	3	4
3. How often do you feel that there is no one you can turn to?	1	2	3	4
4. How often do you feel alone?	1	2	3	4
5. How often do you feel part of a group of friends?	1	2	3	4
6. How often do you feel that you have a lot in common with the people around you?	1	2	3	4
7. How often do you feel that you are no longer close to anyone?	1	2	3	4
8. How often do you feel that your interests and ideas are not shared by those around you?	1	2	3	4
9. How often do you feel outgoing and friendly?	1	2	3	4
10. How often do you feel close to people?	1	2	3	4
11. How often do you feel left out?	1	2	3	4
12. How often do you feel that your relationships with others are not meaningful?	1	2	3	4
13. How often do you feel that no one really knows you well?	1	2	3	4
14. How often do you feel isolated from others?	1	2	3	4
15. How often do you feel you can find companionship when you want it?	1	2	3	4
16. How often do you feel that there are people who really understand you?	1	2	3	4
17. How often do you feel shy?	1	2	3	4
18. How often do you feel that people are around you but not with you?	1	2	3	4
19. How often do you feel that there are people you can talk to?	1	2	3	4
20. How often do you feel that there are people you can turn to?	1	2	3	4