THE IMPACT OF SOCIAL SUPPORT ON THE ASSOCIATION BETWEEN DEPRESSIVE SYMPTOMS AND CHANGE IN FRAILTY STATUS: A LONGITUDINAL COHORT STUDY

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Abstract

Frailty is a medical syndrome characterized by increased vulnerability to minor stressors that could be prevented. People who are depressed frequently experience worsened transition frailty status. Social support is an important concept closely related to frailty and depressive symptoms, and it may play a crucial role in preventing frailty in depressed older adults. This research aimed to investigate the association between depressive symptoms and change in frailty status over four years of follow-up and examine whether social support plays a moderator in the association between depressive symptoms and change in frailty status. We used data from the 20072011 waves of the Taiwan Longitudinal Study on Aging (TSLA), a longitudinal cohort study of adults over 65 (n = 1,283). Frailty was assessed using the Fried frailty phenotype. An 8-item version of the Center for Epidemiologic Studies Depression Scale (CES-D) was used to measure depressive symptoms. The social support scale consisted of receiving (five items) and providing (five items) social support. Multiple multinomial logistic regression analysis was performed to identify the

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effect of social support on the association between depressive symptoms and change in frailty status within a period of four years. Most participants worsened (33.0%) and maintained (40.1%) their frailty status, while only 11.6% improved within four years for the whole sample. The mean depressive symptoms and overall social support scores were 3.24 (± 4.41) and 6.55 (± 1.28), respectively. In the analysis of non-frail participants, older adults with more depressive symptoms had a higher risk of frailty worsening (RRR = 1.066) and a higher ratio of frailty improvement (RRR = 1.145) than stable frailty after controlling for individual covariates, chronic diseases, and social support components. This difference turned out to be non-significant for frail individuals at baseline. There was no potential moderating role of receiving and providing social support on the pathway from depressive symptoms and change in frailty status between both samples. Preventing depressive symptoms in the elderly may help keep the frailty stable over time. Social supportreceiving and givinghad no apparent moderating impact on the relationship between depressive symptoms and changes in frailty status. Identifying the moderators of the link between depressive symptoms and worsening in frailty status may help guide future research on strategies to avoid the onset of the condition in older adults with depressive symptoms.

1   Introduction

1.1   Statement of this research

Taiwans population has undergone a significant demographic transition, evolving from an aging society in 1993 to an aged society by 2018. It is projected to become a super-aged society by 2025, with over 20% of the population being over 65 years old, posing emerging challenges related to aging [1]. Frailty has emerged as a core concept in geriatric research, developed by multiple researchers [2, 3] yet lacking a single universal definition. It is widely acknowledged to lead to increased vulnerability and decreased resilience against stressors, resulting in higher risks of disability [4], comorbidities, reduced quality of life [5], and mortality [6]. The progression of frailty is influenced by several known risk factors, including age [7], physical inactivity [8], malnutrition [9], polypharmacy [10], cognitive impairment [11], unemployment [12], and poor self-rated health [13].

Frailty in older adults is not a static condition but rather characterized by dynamic transitions, fluctuating between states of improvement and worsening over time [14, 15]. Understanding these transitions is crucial as it allows healthcare professionals to identify both stable and deteriorating trajectories among the elderly. Identifying these patterns is essential for implementing targeted interventions aimed at promoting healthy aging and enhancing intrinsic capacity, in line with global health objectives [16, 17].

Particularly, those older adults on a deteriorating trajectory of frailty are at an increased risk for a range of adverse outcomes, including more frequent emergency department visits, hospitalizations, and even increased mortality rates [16]. Recognizing individuals on this path early on can significantly influence the effectiveness of preventive interventions. Accurately identifying these trajectories not only helps in allocating resources more efficiently but also improves the overall health outcomes and quality of life for the elderly, ensuring a more cost-effective healthcare system. Depression is a widespread mental disorder among the elderly, with prevalence rates ranging from 3.8 percent to 15 percent in various countries [18]. Its recognition as a contributing factor in late-life suicide emphasizes the critical need for effective prevention and treatment strategies, particularly as the elderly population continues to grow globally [19]. Depression in elderly individuals is often associated with intense loneliness, reduced perception of social support, poor physical function, and a higher perception of poor health status, underscoring the importance of understanding and addressing these factors in geriatric mental health [20-22].

Globally, approximately one in seven older adults are affected by depression, a condition that often coexists with frailty [23]. The prevalence of depression can be as high as 46.5% among older individuals with frailty [24], making it a potent predictor of frailty, especially in women with disabilities [25]. Research indicates that depressive symptoms significantly increase the risk of becoming frail in women aged 65 and older, even after adjusting for antidepressant use and other covariates [26]. Additionally, higher levels of depression have been linked with limited health literacy, further affecting various health outcomes in older adults [27, 28].

Depression's chronic course and high relapse rate among older adults are associated with a range of negative outcomes, including diminished well-being, increased healthcare utilization, and higher rates of morbidity and mortality. This represents a significant burden on both individuals and healthcare systems [29-33]. Consistent with the previous findings, depression has been shown to exacerbate the worsening of frailty, primarily due to shared physiological etiologies and unhealthy lifestyles influenced by depressive states. This interrelation highlights the need for integrated care approaches that address both mental and physical aspects of health in the elderly population [34].

As societies age, especially in developed countries, the quest for improved quality of life has intensified. The concept of healthy aging has become a global trend, focusing on enhancing the functional ability of older adults through intrinsic capacity and a supportive external environment [35, 36]. Evidence indicates that adequate interaction with the external environment, such as through social support, significantly improves health outcomes for older adults [37-39]. Social support, encompassing instrumental, emotional, and other types, is cru-

cial for enhancing life quality and health in the aging population [40-42].

Social support is intricately linked to the prevalence and progression of frailty among older adults. Studies have shown that varying levels and types of social support, including familial and community support, are associated with differing levels of frailty. Notably, a robust social network can mitigate the risks and impacts of frailty, leading to improved health outcomes [43-45]. The multifactorial nature of the relationship between social support and frailty necessitates a comprehensive understanding of how these social structures function and contribute to the health and well-being of older adults [46, 47].

The relationship between social support and depression is well-documented, with a clear correlation between various forms of social support and mental health outcomes in the elderly. Studies have shown that both objective and subjective aspects of social support play critical roles in mitigating depressive symptoms and improving overall well-being [48, 49]. For instance, subjective support has been found to be particularly effective in ameliorating depressive symptoms, emphasizing the importance of perceived emotional and instrumental support [50]. This evidence suggests that enhancing social support mechanisms could be a viable strategy for reducing depression and improving quality of life among older adults.

1.2   Significance of this research

The interplay between frailty status and depression is significantly influenced by social support. Research indicates that social support, particularly from family and community, can mediate and modify the relationship between depression and frailty, affecting the trajectory of both conditions [51]. Community-level social support has been found to moderate the association between frailty and psychological distress, highlighting its potential as a mitigating factor in the health of older adults [52]. Previous research has employed a cross-sectional study design to examine the association between frailty and depression, but few studies have explored the change in frailty status over time [51].

1.3   Aim of this research

1.3.1   General objective

To remedy this gap, this research aimed to investigate the association between depressive symptoms and change of frailty status over four years of follow-up and explore the impact of social support on this association using a national longitudinal population-based cohort study. We studied the moderating effects of different types of social support (receiving and providing social support) in the association between depressive symptoms and change of frailty status among older persons.

1.3.2   Specific objectives

The specific objectives of this study are:

1. To investigate the association between depressive symptoms and change in frailty status over four years.

2. To explore the moderating role of receiving and providing social support and whether receiving and providing social support would modify these effects on the association between depressive symptoms and change in frailty status.

We hypothesized that:

1. Older adults with depressive symptoms were associated with a higher risk of worsening and a lower ratio of improvement in frailty status.

2. Receiving and providing social support would significantly moderate the effects of depressive symptoms on change in frailty status. The impact of depressive symptoms on the worsening or improvement of frailty status might weaken or strengthen, respectively, with an increasing level of receiving and providing social support.

Identifying the depressive symptoms and social support elements may contribute to developing interventions to prevent or postpone the course of frailty in depressed older populations.

2   Methodology

2.1   Data Collection and Participant Selection

The research utilized datasets from the 2007 and 2011 iterations of The Taiwan Longitudinal Study on Aging (TSLA), targeting individuals who are 65 years old and above. This longitudinal study has been conducting biennial personal interviews via standardized questionnaires since 1989, boasting seven rounds of surveys with participation rates between 88% and 92%. Detailed methodologies for the TSLA have been elucidated in prior literature [53].

From the pool of 4534 individuals interviewed in the 2007 wave, the study included only those meeting specific criteria. Exclusions were made for participants under the age of 65 (n = 1834), those demonstrating cognitive impairments as per the Short Portable Mental Status Questionnaire (SPMSQ) with a score lower than 8 (n = 1246), residents of institutions (n = 111), or those with incomplete data on frailty status (n = 60). Consequently, the analytical cohort comprised 1283 non-institutionalized seniors aged 65 or older as per the baseline data of the referenced research [54].

2.2 Variables and Measurement Tools

2.2.1 Frailty Assessment

The evaluation of frailty utilized adapted versions [55] of the Fried frailty phenotype [2], encompassing five key dimensions: shrinking, weakness, exhaustion, slowness, and reduced physical activity. The legitimacy of this adapted definition of frailty has received wide acceptance and confirmation in various studies [13, 55, 56]. Shrinking was determined by individuals self-reporting a frequent or persistent lack of appetite over the preceding week. Those who indicated inapplicability to the question of poor appetite were categorized as not exhibiting shrinking. Difficulty or inability to lift objects weighing 12 kg was indicative of weakness, and those unsure about their carrying ability were likewise classified under weakness. Participants feeling mostly lethargic or that most activities required excessive effort in the prior week were labeled as exhausted. In cases where the applicability or knowledge of these conditions was uncertain, individuals were also assigned to the exhaustion category. Slowness was attributed to those facing challenges or inability to walk distances of 200 to 300 meters. A lack of engagement in any outdoor activities such as walking, hiking, jogging, or gardening at least bi-weekly was considered as low physical activity.

The aggregation of these five factors produced a cumulative frailty score ranging from 0 to 5, with increasing scores corresponding to deteriorating frailty conditions. For analytical clarity, physical frailty status was bifurcated into two categories: individuals meeting three or more criteria were classified as frail, while those meeting fewer were classified as non-frail.

2.2.2 Change in frailty status

The variation in frailty status over time was quantified by deducting the initial assessment score from the score obtained at the four-year follow-up interval. Numerical outcomes less than zero denoted an improvement in condition, those greater than zero indicated worsening, and outcomes equal to zero were indicative of a stable condition.

2.2.3 Depressive symptoms Measurement

To assess depressive symptoms, the study utilized a condensed, eight-item form of the Center for Epidemiologic Studies Depression Scale (CES-D), adapted by Hsu & Chang (2015a) from Radloff's (1977) original [57, 58]. This version of the CES-D scale has proven to be consistently reliable and internally consistent within the Taiwan Longitudinal Study on Aging (TLSA) survey, achieving Cronbach's alpha levels ranging from 0.79 to 0.87 [53]. The scale's items query respondents about their recent experiences with a variety of mood states and behavioral indicators over the last week, which includes a lack of appetite,

the perceived burdensomeness of daily activities, disrupted sleep, depressive mood, a sense of isolation, perceptions of unfriendliness from others, a sense of sadness, and a lack of motivation to engage in activities. The response scale is designed to quantify the frequency of these experiences, with 0 indicating infrequent or no occurrence and 3 indicating frequent or constant occurrence. The total possible scores on this scale range from 0, indicating an absence of depressive symptoms, to 24, indicating a high severity of depressive symptoms.

2.2.4   Social Support Determination

The study engaged the bi-directional Social Support Scale formulated by Shakespeare-Finch and Obst (2011) [59], which delineates two primary facets: the dispensation and receipt of social support. This scale was operationalized using a ten-item self-administered questionnaire that gauged both the provision and reception of instrumental and emotional support [57].

For the assessment of receiving instrumental support, participants gauged the extent of assistance available to them from their social network in situations of illness or for routine tasks such as shopping or medical visits. A binary scoring system was employed where affirmative responses were allocated one point and negatives none, yielding a score between zero and two.

Receiving emotional support was quantified by participants' perceptions of their social network's propensity to offer a listening ear, their level of expressed concern, and the satisfaction derived from the support provided. This was rated on a binary scale where zero indicated no satisfaction or availability, and one indicated high satisfaction or availability, cumulating in a score from zero to three.

The aggregation of scores for received social support could thus span from zero to five.

Providing instrumental support was measured by participants' involvement in caregiving activities, such as attending to grandchildren or assisting with daily or instrumental activities of daily living. Responses were scored similarly on a binary scale, with totals ranging from zero to three.

Providing emotional support was assessed based on the frequency and extent to which participants offered emotional support to their network and were consulted for advice. This too was scored on a binary scale, with potential scores ranging from zero to two.

Consequently, the cumulative scoring for provided social support could range from zero to five, with the comprehensive score for both received and provided social support extending from zero to ten. Higher totals indicated more robust levels of social support engagement.

2.2.5   Participant Demographics and Health Status

The demographic attributes assessed in the study encompassed age, categorized into two groups: 65 to 74 years, and 75 years or older; sex, distinguished as male or female; marital status, classified as married versus divorced, widowed, separated, or single; educational attainment, differentiated as illiterate and elementary school education versus junior high and higher education; residential locale, segregated into city/urban versus rural areas; the spectrum of social support, which was evaluated via receiving instrumental (two aspects) and emotional support (three aspects), as well as providing instrumental (three aspects) and emotional support (two aspects); and the incidence of chronic medical conditions, namely diabetes mellitus, heart disease, stroke, cancer, pulmonary disease, renal disorder, and musculoskeletal diseases, recorded as either present or absent.

2.3   Data processing and analysis

First, descriptive statistical analysis was used to describe the sample characteristics: mean (SD) for continuous variables and number (%) for categorical variables. We stratified the analysis between participants who were non-frail and frail at baseline. The change in frailty status was examined using two waves of data (2007 and 2011) and classified as an improvement, stability (reference), and worsening. We used Chi-square tests for categorical variables (personal characteristics variables) and the Analysis of variance (ANOVA) test for continuous variables (depressive symptoms and social support (overall and its components)) to test variances of sample characteristics by the change in frailty status. The multinomial logistic regression analyses were performed to examine the relationship between depressive symptoms and change in frailty status and its social support component differences. We first tested the effects of personal and disease covariates as well as depressive symptoms, receiving and providing social support on change in frailty status (Model 1) using univariate analysis. Then, the main effect terms (i.e., depressive symptoms and receiving and providing social support) in step 2 and the product interaction term of depressive symptoms by each dimension of social support in step 3. Slope analysis was used to determine the direction of the significant moderating effect [60]. Relative risk ratio (RRR) was calculated. All models were adjusted for potential significant covariates in Model 0. Statistical significance was defined as $p < 0.05$, and all analyses were performed with SPSS version 26.

3   Results

In this longitudinal study, over a four-year period, the majority of the older adults in the community dwelling sample either experienced a decline (34.7%) or no change (41.5%) in their frailty status, with a smaller proportion showing improvement (10.2%).

For those initially non-frail, the composition was predominantly males (64.0%), married individuals (73.2%), and residents of urban areas (68.8%), with a substantial number having received a lower level of education (59.7%) (Table 1). The progression of frailty was particularly notable among participants over the age of 75, females, and those with a medical history of significant conditions such as heart disease, cancer, pulmonary and renal diseases. These factors were markedly correlated with shifts in frailty status, highlighting the need for focused interventions in these subgroups.

Table 1 Characteristics of Participants on Change in Frailty status in Older Adults (N = 1283)

Variables in 2007	Among Non-frail Participants at Baseline (N = 1171)					
	Total	Improvement	Stability	Worsening	Death	p^{a}
	$n = 1171$	$n = 119$	$n = 486$	$n = 407$	$n = 159$	
	n (%)/ Mean (SD)	n (%)/ Mean (SD)	n (%)/ Mean (SD)	n (%)/ Mean (SD)	n (%)/ Mean (SD)	
Personal characteristics						
Age (year) in 2007						
65 – 74	649 (55.4)	75 (63.0)	308 (63.4)	202 (49.6)	64 (40.3)	<0.001
≥ 75	522 (44.6)	44 (37.0)	178 (36.6)	205 (50.4)	95 (59.7)	
Gender						
Male	749 (64.0)	71 (59.7)	321 (66.0)	230 (56.5)	127 (79.9)	<0.001
Female	422 (36.0)	48 (40.3)	165 (34.0)	177 (43.5)	32 (20.1)	
Marital Status						
Divorced/Widowed/ Separated/Single	313 (26.8)	34 (28.6)	120 (24.7)	118 (29.1)	41 (25.8)	0.487
Married	857 (73.2)	85 (71.4)	366 (75.3)	288 (70.9)	118 (74.2)	
Educational level[b]						
Lower	699 (59.7)	71 (59.7)	283 (58.2)	256 (62.9)	89 (56.0)	0.379
Higher	472 (40.3)	48 (40.3)	203 (41.8)	151 (37.1)	70 (44.0)	
Area of residence						
City + Urban	806 (68.8)	89 (74.8)	333 (68.5)	272 (66.8)	112 (70.4)	0.401
Rural	365 (31.2)	30 (25.2)	153 (31.5)	135 (33.2)	47 (29.6)	
Diseases						
Diabetes mellitus	177 (15.1)	18 (15.1)	68 (14.0)	58 (14.3)	33 (20.8)	0.199
Heart disease	279 (23.8)	43 (36.1)	85 (17.5)	110 (27.0)	41 (25.8)	<0.001
Stroke	45 (3.8)	6 (5.0)	12 (2.5)	17 (4.2)	10 (6.3)	0.130
Cancer	52 (4.4)	3 (2.5)	17 (3.5)	14 (3.4)	18 (11.3)	<0.001
Lung disease	144 (12.3)	15 (12.6)	44 (9.1)	53 (13.0)	32 (20.1)	0.003
Renal disease	112 (9.6)	11 (9.2)	39 (8.0)	37 (9.1)	25 (15.7)	0.038
Muscular skeletal disease[c]	366 (31.3)	47 (39.8)	143 (29.4)	129 (31.7)	47 (29.6)	0.169
Social Support (0–10)	6.61 (1.23)	6.59 (1.47)	6.69 (1.23)	6.57 (1.18)	6.49 (1.18)	0.264
Receiving social support (0–5)	4.72 (0.73)	4.61 (0.89)	4.72 (0.73)	4.76 (0.64)	4.70 (0.79)	0.290
Receiving instrumental support (0–2)	1.83 (0.45)	1.76 (0.53)	1.83 (0.46)	1.86 (0.41)	1.83 (0.44)	0.225
Receiving emotional support (0–3)	2.89 (0.43)	2.84 (0.54)	2.90 (0.42)	2.90 (0.40)	2.87 (0.44)	0.603
Providing social support (0–5)	1.89 (0.82)	1.98 (0.97)	1.96 (0.81)	1.80 (0.83)	1.79 (0.69)	0.006
Providing instrumental support (0–3)	0.22 (0.53)	0.34 (0.68)	0.24 (0.56)	0.21 (0.49)	0.13 (0.39)	0.004
Providing emotional support (0–2)	1.66 (0.59)	1.65 (0.62)	1.72 (0.55)	1.59 (0.63)	1.67 (0.58)	0.022

[a] Chi-square tests (two-tailed). 9

[b] Educational level: Lower: illiterate + elementary school, higher: from junior high school to senior high education and above.

[c] Muscular skeletal disease includes joint arthritis, hip fractures, and osteoporosis.

The participants average scores for depressive symptoms and social support classified by frailty status are shown in Table 2. The mean depressive symptoms score was higher among participants classified as frailty state improvement. The mean scores for providing social support were higher among participants classified as frailty state stability. The average score for providing instrumental support was greater among individuals with a frailty state improvement classification, whereas the mean score for providing emotional support was higher among those with stable frailty.

Table 2 Depressive Symptoms and Social Support on Change in Frailty Status between 2007 and 2011 (N = 1283)

Variables in 2007	Among Non-frail Participants at Baseline (N = 1171)						Among Frail Participants at Baseline (N =112)					
	Improvement	Stability	Worsening	Death	F	p [a]	Improvement	Stability	Worsening	Death	F	p [a]
	$n = 119$	$n = 486$	$n = 407$	$n = 159$	(post hoc)		$n = 30$	$n = 28$	$n = 17$	$n = 37$	(post hoc)	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)			Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
Depressive Symptoms (0–24)	4.30 (4.88)	1.98 (3.16)	2.81 (3.65)	2.98 (3.94)	11.440 (1>3,4>2)	<0.001	10.13 (6.70)	8.43 (5.79)	8.76 (6.14)	10.27 (5.46)	0.696	0.556
Social Support (0–10)	6.59 (1.47)	6.69 (1.23)	6.57 (1.18)	6.49 (1.18)	1.328	0.264	5.90 (2.01)	5.71 (1.70)	6.00 (1.00)	6.19 (1.24)	0.555	0.647
Receiving social support (0–5)	4.61 (0.89)	4.72 (0.73)	4.76 (0.64)	4.70 (0.79)	1.254	0.290	4.27 (1.51)	4.46 (1.00)	4.76 (0.44)	4.65 (0.79)	1.328	0.274
Receiving instrumental support (0–2)	1.76 (0.53)	1.83 (0.46)	1.86 (0.41)	1.83 (0.44)	1.461	0.225	1.77 (0.57)	1.82 (0.48)	1.88 (0.33)	1.84 (0.44)	0.242	0.867
Receiving emotional support (0–3)	2.84 (0.54)	2.90 (0.42)	2.90 (0.40)	2.87 (0.44)	0.619	0.603	2.50 (1.04)	2.64 (0.78)	2.88 (0.33)	2.81 (0.57)	1.522	0.219
Providing social support (0–5)	1.98 (0.97)	1.96 (0.81)	1.80 (0.83)	1.79 (0.69)	4.229 (2>3)	0.006	1.63 (1.00)	1.25 (0.97)	1.24 (0.75)	1.54 (0.80)	1.338	0.266
Providing instrumental support (0–3)	0.34 (0.68)	0.24 (0.56)	0.21 (0.49)	0.13 (0.39)	4.498 (1>4)	0.004	0.27 (0.69)	0.11 (0.42)	0.06 (0.24)	0.14 (0.48)	0.781	0.509
Providing emotional support (0–2)	1.65 (0.62)	1.72 (0.55)	1.59 (0.63)	1.67 (0.58)	3.254 (2>3)	0.022	1.37 (0.76)	1.14 (0.76)	1.18 (0.73)	1.41 (0.69)	0.930	0.429

[a] ANOVA test

Table 3 shows the findings of the regression analysis of depressive symptoms and social support on change in frailty status. In univariate analysis (Table 3, Model 1), older persons with greater depressive symptoms were associated with a higher risk of worsening (RRR: 1.075; 95% CI: 1.033, 1.118) and a higher ratio of frailty improvement (RRR: 1.164; 95% CI: 1.108, 1.223) rather than frailty stability. Participants who provided more social support had a lower risk of frailty worsening (RRR: 0.791; 95% CI: 0.674, 0.929) rather than remaining stable. Being older than 75 years, female, and having a history of heart disease were significantly associated with a higher risk of frailty worsening (RRR = 1.497ĩ.756) over frailty stability. In addition, participants with heart disease and muscular-skeletal disease had a higher ratio of frailty improvement (RRR = 2.669 and 1.588, respectively) than over stability (Table 3, Model 1).

In multivariate multinomial logistic regression (Table 3, Model 2), older adults with higher depressive symptoms had a higher risk of worsening (RRR = 1.066, 95% CI: 1.023, 1.111) and a higher ratio of frailty improvement (RRR = 1.145, 95% CI: 1.087, 1.207) rather than remaining stable. Therefore, older persons with greater depressive symptoms were associated with a higher ratio of frailty stability after adjusting for personal covariates and chronic diseases found in Model 0. In the meantime, after controlling for potential confounding variables, the associations between receiving and providing social support

and the change in frailty status were not statistically significant ($p > 0.05$). Being aged = 75 years old and female remained prognostic factors for frailty worsening. Furthermore, a history of heart disease also predicted the frailty stability.

With the additional inclusion of the effect modification of depressed symptoms by each social support component (Model 3, Table 3), there was no significant interaction between depressive symptoms and receiving and providing social support on changes in frailty status. In other words, receiving and providing social support had no significant moderating effect on the association between depressive symptoms and change in frailty status.

Analysis for participants who were frail at baseline

Among 112 community-dwelling older people who were frail at baseline, the majority were 75 years old or older (69.6%), female (56.3%), married (66.1%), resided in a city or urban area (66.1%) and had a lower level of education (72.3%). Overall, 30 (26.8%) participants improved their frailty status, 28 (25.0%) maintained their status, only 17 (15.2%) worsened, and 37 (33.0%) deaths. A history of diabetes mellitus and cancer were significantly associated with the change in frailty status over four years. There were no significant differences in average scores for depressive symptoms and social support by frailty status change classifications (Table 2). In Table 3, no factors were associated with changes in frailty status among the baseline frail elders.

Table 3 Regression analysis of Social Support and Depressive Symptoms on Change in Frailty Status

Variables	Among Non-frail Participants at Baseline (N = 1171)											
	Model 1: Univariate on Change in frailty status (Reference: Stability)				Model 2 Multivariate, Depressive symptoms, Social support on Change in frailty status with covariates (Reference: Stability)				Model 3: Multivariate, With further inclusion of the Depressive symptoms x Social support interaction term (Reference: Stability)			
	Improvement		Worsening		Improvement		Worsening		Improvement		Worsening	
	RRR* (95% CI)	p	RRR (95% CI)	p	RRR (95% CI)	p	RRR (95% CI)	p	RRR (95% CI)	p	RRR (95% CI)	p
Depressive Symptoms	1.164 (1.108, 1.223)	<0.001	1.075 (1.033, 1.118)	<0.001	1.145 (1.087, 1.207)	<0.001	1.066 (1.023, 1.111)	0.003	1.110 (0.874, 1.408)	0.392	0.922 (0.730, 1.166)	0.499
Receiving Social Support	0.835 (0.661, 1.054)	0.130	1.090 (0.896, 1.327)	0.387	0.896 (0.688, 1.168)	0.418	1.197 (0.969, 1.478)	0.095	0.858 (0.566, 1.301)	0.472	1.069 (0.796, 1.436)	0.657
Providing Social Support	1.029 (0.811, 1.307)	0.813	0.791 (0.674, 0.929)	0.004	1.134 (0.885, 1.455)	0.320	0.840 (0.704, 1.003)	0.054	1.204 (0.843, 1.720)	0.308	0.814 (0.646, 1.026)	0.081
Depressive Symptoms * Receiving Social Support	NA				NA				1.011 (0.960, 1.065)	0.685	1.027 (0.977, 1.081)	0.297
Depressive Symptoms * Providing Social Support									0.991 (0.936, 1.048)	0.747	1.012 (0.967, 1.059)	0.617
Personal characteristics												
≥ 75 years of age	1.015 (0.670, 1.538)	0.944	1.756 (1.343, 2.296)	<0.001	1.034 (0.661, 1.617)	0.883	1.693 (1.277, 2.243)	<0.001	1.038 (0.663, 1.624)	0.870	1.702 (1.284, 2.257)	<0.001
Female	1.315 (0.871, 1.985)	0.192	1.497 (1.141, 1.964)	0.004	1.007 (0.644, 1.577)	0.974	1.424 (1.067, 1.900)	0.016	1.007 (0.643, 1.577)	0.974	1.436 (1.076, 1.918)	0.014
Married	0.820 (0.524, 1.283)	0.384	0.800 (0.594, 1.077)	0.142	–	–	–	–	–	–	–	–
Higher education level	0.942 (0.627, 1.418)	0.776	0.822 (0.628, 1.077)	0.156	–	–	–	–	–	–	–	–
Living in rural	0.734 (0.465, 1.157)	0.183	1.080 (0.815, 1.431)	0.591	–	–	–	–	–	–	–	–
Chronic diseases												
Diabetes mellitus	1.096 (0.624, 1.924)	0.751	1.022 (0.700, 1.491)	0.912	–	–	–	–	–	–	–	–
Heart disease	2.669 (1.717, 4.149)	<0.001	1.747 (1.268, 2.407)	0.001	2.319 (1.459, 3.687)	<0.001	1.517 (1.088, 2.116)	0.014	2.321 (1.460, 3.691)	<0.001	1.506 (1.080, 2.102)	0.016
Stroke	2.097 (0.771, 5.708)	0.147	1.722 (0.812, 3.649)	0.156	–	–	–	–	–	–	–	–
Cancer	0.713 (0.206, 2.476)	0.595	0.983 (0.478, 2.019)	0.962	–	–	–	–	–	–	–	–
Lung disease	1.449 (0.777, 2.703)	0.244	1.504 (0.985, 2.297)	0.059	–	–	–	–	–	–	–	–
Renal disease	1.167 (0.579, 2.354)	0.665	1.146 (0.716, 1.835)	0.570	–	–	–	–	–	–	–	–
Muscular skeletal disease	1.588 (1.046, 2.409)	0.030	1.113 (0.836, 1.481)	0.463	1.173 (0.747, 1.842)	0.489	0.894 (0.659, 1.214)	0.474	1.177 (0.749, 1.852)	0.480	0.885 (0.652, 1.202)	0.435

Variables	Among Frail Participants at Baseline (N = 112)											
	Model 1: Univariate on Change in frailty status (Reference: Stability)				Model 2: Multivariate, Depressive symptoms, Social support on Change in frailty status with covariates (Reference: Stability)				Model 3: Multivariate, With further inclusion of the Depressive symptoms x Social support interaction term (Reference: Stability)			
	Improvement		Worsening		Improvement		Worsening		Improvement		Worsening	
	RRR* (95% CI)	p	RRR (95% CI)	p	RRR (95% CI)	p	RRR (95% CI)	p	RRR (95% CI)	p	RRR (95% CI)	p
Depressive Symptoms	1.046 (0.961, 1.139)	0.297	1.009 (0.914, 1.115)	0.857	1.047 (0.954, 1.148)	0.332	1.028 (0.927, 1.140)	0.603	1.237 (0.768, 1.991)	0.382	0.865 (0.375, 1.994)	0.734
Receiving Social Support	0.877 (0.572, 1.345)	0.547	1.478 (0.663, 3.293)	0.339	0.769 (0.435, 1.362)	0.368	1.830 (0.696, 4.811)	0.220	0.907 (0.196, 4.200)	0.901	0.977 (0.122, 7.831)	0.983
Providing Social Support	1.568 (0.880, 2.794)	0.127	0.982 (0.502, 1.921)	0.958	1.895 (0.937, 3.831)	0.075	0.781 (0.345, 1.766)	0.553	6.614 (1.257, 34.800)	0.026	2.391 (0.431, 13.269)	0.319
Depressive Symptoms * Receiving Social Support	NA				NA				0.995 (0.886, 1.118)	0.934	1.066 (0.885, 1.283)	0.503
Depressive Symptoms * Providing Social Support									0.889 (0.774, 1.020)	0.094	0.892 (0.765, 1.041)	0.147
Personal characteristics												
≥ 75 years of age	0.600 (0.200, 1.799)	0.362	1.300 (0.324, 5.212)	0.711	–	–	–	–	–	–	–	–
Female	0.619 (0.212, 1.811)	0.381	0.868 (0.243, 3.099)	0.828	–	–	–	–	–	–	–	–
Married	2.222 (0.681, 7.249)	0.186	0.494 (0.145, 1.684)	0.260	–	–	–	–	–	–	–	–
Higher education level	0.909 (0.287, 2.877)	0.871	1.042 (0.276, 3.926)	0.952	–	–	–	–	–	–	–	–
Living in rural	2.804 (0.883, 8.909)	0.080	3.259 (0.877, 12.106)	0.078	–	–	–	–	–	–	–	–
Chronic diseases												
Diabetes mellitus	0.329 (0.058, 1.854)	0.207	1.415 (0.322, 6.219)	0.646	–	–	–	–	–	–	–	–
Heart disease	0.667 (0.230, 1.936)	0.456	1.500 (0.447, 5.037)	0.512	–	–	–	–	–	–	–	–
Stroke	0.429 (0.072, 2.548)	0.352	1.846 (0.395, 8.625)	0.436	–	–	–	–	–	–	–	–
Cancer												
Lung disease	0.733 (0.196, 2.739)	0.645	0.489 (0.087, 2.757)	0.417	–	–	–	–	–	–	–	–
Renal disease	2.600 (0.461, 14.655)	0.279	4.000 (0.646, 24.768)	0.136	–	–	–	–	–	–	–	–
Muscular skeletal disease	1.133 (0.402, 3.193)	0.813	0.975 (0.291, 3.262)	0.967	–	–	–	–	–	–	–	–

4 Discussion

This study investigated the concurrent impact of depressive symptoms and social support on change in frailty status. Besides, we further examined the moderating effects of receiving and providing social support on the association between depressive symptoms and change in frailty status among the Taiwanese community-dwelling elderly.

Prior investigations have consistently shown that individuals are more likely to experience deterioration rather than improvement in frailty status, with only a small percentage showing positive change [14, 61-66]. Consistent with these findings, our study observed that improvements in frailty status (11.6%) were less common than stability (40.1%) or decline (33.0%). The patterns of frailty transition in our study were aligned with a recent meta-analysis, which indicated that a significant portion of the elderly population remains in the same condition over an average of 3.9 years [64]. Our study also aligns with previous literature in that the majority of participants did not change their frailty status at follow-up, though the proportion of participants whose condition worsened was slightly higher than reported in earlier research [67, 68]. Conversely, the rate of improvement in our study exceeded some prior estimates but was not as high as those reported in other countries, such as the U.S., Germany, Indonesia, Hong Kong, Japan, and Malaysia [14, 62, 66, 67, 69, 70]. These discrepancies might result from differences in participant demographics, follow-up durations, and frailty measurement tools [65].

In our multivariate analysis, a higher prevalence of depressive symptoms was associated with a reduced likelihood of maintaining a stable non-frail status, echoing the findings of previous studies where depressive symptoms often predicted unfavorable frailty transitions [62, 71-74]. Conversely, worsened frailty states were linked to higher levels of depressive symptoms [75], a correlation that may be partly attributed to the inclusion of depressive symptomatology within the frailty phenotype [71]. This potential overlap could be addressed in future research by employing frailty measures that exclude depressive symptoms. Additionally, past meta-analyses have suggested that both depression and frailty share common risk factors, including inflammation and hormonal imbalances [24, 76] [77], thus reinforcing the notion that depressive symptoms play a critical role in the persistence of frailty over time.

Moreover, our univariate analysis indicated that offering social support may reduce the risk of experiencing worsening frailty. This observation is supported by literature suggesting that providing social support, particularly among non-frail and prefrail elderly, may predict a reduced mortality risk compared to simply receiving support [78-80]. The act of giving support, especially in tangible forms to acquaintances and emotionally to spouses, has been linked to several health benefits, potentially due to its positive effects on cardiovascular, immune, and neuroendocrine system functions [81, 82]. Hence, we encourage older adults to engage in providing social support as a potential strategy for mitigating the risk of frailty progression.

Our study did not identify any significant moderating effects of social support on the relationship between depressive symptoms and frailty status change, suggesting that social support might not serve as a protective factor for older adults with depression against the progression of frailty. Identifying factors that could moderate this relationship is an important direction for future research.

Additionally, our findings indicated that being 75 years of age or older significantly correlated with a worsening frailty status among participants who were non-frail at baseline, which is consistent with prior studies [67, 70, 83, 84]. This relationship, alongside observed associations between advancing age and increased frailty risk [62, 84], underlines the necessity of devising preventive strategies for this high-risk demographic.

Our research also pointed to gender differences, with female gender emerging as a significant predictor for increased frailty progression. This finding aligns with the understanding that women, particularly due to physiological factors such as weaker grip strength and the prevalence of sarcopenia, may be more predisposed to frailty than men of the same age group [2].

Lastly, the study corroborated the heightened risk of frailty progression in individuals with multiple chronic conditions, with heart disease being a notable

predictor after adjusting for covariates, as supported by existing literature [70, 85]. This emphasizes the importance of early intervention and management of chronic diseases, especially heart disease, to mitigate their impact on frailty states.

However, this study has limitations, including the observational nature that precludes causal inferences, the potential for measurement error, and the reliance on self-reported data which could introduce recall bias. Future studies should strive for more objective frailty assessments and consider a wider array of social factors to provide a more comprehensive analysis. Additionally, to avoid the conflation of depression and frailty measures, future research might benefit from employing diagnostic criteria that distinctly define depression.

Despite these limitations, the study's strengths lie in its use of a nationally representative sample, the dynamic approach to frailty assessment, and its novel exploration of social support's role in the interplay between depressive symptoms and frailty. As the first study to assess the potential moderating effects of social support on frailty progression, it sets the stage for further investigation into the factors that may influence these dynamics.

5   Conclusions

In conclusion, this research provides insights into the evolution of frailty status over a four-year period, underscoring the prevalence of frailty progression among older adults and highlighting the significant influence of depressive symptoms on this process. It also underscores the need for future interventions that address the nuanced relationship between depressive symptoms and frailty status, particularly by identifying and targeting the specific variables that may moderate this association.

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