Not Alone, Not Forgotten:
Protective Role of Quantity and Quality of Social Network on Cognitive Decline

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Abstract

This study examined whether outward-directed social connections, measured by weighted out-degree centrality, predict cognitive decline over time among older adults in South Korea. Using longitudinal data from the Korean Social Life, Health, and Aging Project (KSHAP), the analysis focused on identifying meaningful cognitive decline among cognitively normal older adults. To this end, the analytic sample was restricted to individuals with baseline MMSE scores of 27 or higher, thereby minimizing ceiling effects, reverse causality, and interpretive variability. Weighted out-degree—reflecting both the quantity and emotional closeness of individuals with whom respondents frequently discussed important matters—was significantly associated with less decline in cognitive ability at follow-up. This relationship remained robust even after adjusting for age, education, income, depressive symptoms, and other covariates. These findings suggest that frequent and emotionally meaningful social engagement may serve as a protective factor against cognitive deterioration in later life.

Introduction

This study examines the association between social network characteristics and cognitive decline among older adults. Specifically, it investigates how both the quantitative and qualitative aspects of social relationships in discussion networks influence cognitive decline, and explores the interaction between these two dimensions. Using data from the first wave of the Korean Social Life, Health, and Aging Project (KSHAP), the study provides empirical evidence on how the structure and quality of social networks shape cognitive resilience in later life.

Data

This study uses data from the first wave of the Korean Social Life, Health, and Aging Project (KSHAP). The survey was conducted in 2011 and 2013, and targeted all individuals aged 60 and over, along with their spouses (regardless of age), residing in a village (the smallest administrative unit) in Township K, Ganghwa Island, South Korea. A total of 814 respondents participated in the first wave and 590 in the third wave. Among them, 571 individuals who could be identified as the same respondents across both waves were included in the final analysis.

Measures

Covariates - In all regression models, age, sex, education level, income, and marital status, Instrumental Activities of Daily Living, and depressive symptoms at wave1 were controlled.

Depressive symptoms - Depressive symptoms were assessed using 20 items from the Korean CES-D scale, with three positively worded items reverse coded and all items rescaled from 1–4 to 0–3. The total score ranged from 0 to 60, with higher scores indicating more severe symptoms.

Weighted Out-Degree Centrality - Weighted out-degree centrality is the sum of the weights of all outgoing edges from a given node (ego) in a directed, weighted social network. In the context of this study, it captures both the number and the strength (emotional closeness) of social interactions within the discussion network. In this study, the strength was calculated by the intimacy. To capture the intimacy within this discussion network, “How close do you think you are to [name1]?” was asked. The response options were “not very close,” “somewhat close,” “very close,” and “extremely close”.

Network size - It was measured by asking the following question : “People often discuss their important issues with others. For example, it may be a good thing or bad thing that personally happened to you or it could be a concern or interest you are having. Over the past year, how many of these people have you had?”.

Cognitive Measure - Cognitive change was computed by using total MMSE scores (0–30). In Wave 1, "Not measured" was treated as "Incorrect," whereas in Wave 3, "Not measured" was treated as "Don't know." In Wave 1, responses marked as “Not measured” were treated as incorrect responses and included as such in the analysis. In contrast, in Wave 3, “Not measured” responses were excluded from the analysis by coding them as missing (NA).

To specifically examine cognitive decline rather than baseline differences in cognitive ability, in all of the regression models, we restricted the analytic sample to individuals with MMSE scores of 27 or higher at Wave 1. This approach minimizes potential ceiling effects, which occur when participants with initially high MMSE scores (e.g., 29–30) have little room to show further cognitive improvement, thus underestimating true cognitive stability or decline. By narrowing the baseline range, we also reduce the possibility of reverse causality—namely, that impaired cognition at baseline could have influenced social network size or depressive symptoms. Moreover, the same numerical decline in MMSE scores may carry different clinical implications depending on the baseline cognitive level. For individuals with lower baseline MMSE scores, even a small decrease (e.g., 2 points) may reflect a substantial deterioration in cognitive function, whereas the same decline from a higher baseline (e.g., from 29 to 27) may indicate minimal functional change. By restricting the sample to individuals with scores of 27 or higher at baseline, we aimed to reduce such interpretive variability and ensure that observed declines are more uniformly meaningful. Similar strategies have been used in prior research to isolate within-individual patterns of cognitive decline (e.g., Holtzman et al., 2004).

Residualized MMSE - To account for baseline cognitive performance, a residualized MMSE score was used as the main outcome variable in this research. This residualized score was derived by regressing MMSE at Wave 3 on MMSE at Wave 1 and saving the residuals. Specifically, a linear model of the form:

$$\text{MMSE}_{W3} = \beta_0 + \beta_1 \cdot \text{MMSE}_{W1} + \varepsilon$$

Residuals from this model were extracted as:

$$\text{Residualized MMSE} = \text{MMSE}_{W3} - (\hat{\beta}_0 + \hat{\beta}_1 \cdot \text{MMSE}_{W1})$$

This residual represents the portion of Wave 3 cognitive performance that cannot be explained by baseline MMSE and the deviation of each individual's follow-up cognitive performance from the expected value based on their baseline MMSE. Thus, a higher residual indicates better-than-expected follow-up cognitive function, given the baseline level. These residuals were then used as the dependent variable in regression models predicting the effects of social network characteristics.

Analysis

Descriptive Statistics of Continuous Variables

Variable	Mean	SD	Min	Max	Missing
Baseline MMSE	24.28	4.33	0.00	30.00	0.00
Depressive Symptoms (CES-D)	10.90	7.75	0.00	51.00	0.00
Age	70.80	7.14	42.00	94.00	0.00
Weighted Out-Degree	10.97	5.23	0.00	28.00	0.00
Follow-up MMSE	25.08	3.68	8.00	30.00	117.00

Frequency of Categorical Variables

Variable	Category	Count	Percent (%)
Education	No formal education	164	29.2
Education	Elementary	245	43.6
Education	Middle School	79	14.1
Education	High School	54	9.6
Education	College or higher	20	3.6
Income Level	Low	292	62.1
Income Level	Mid-low	115	24.5
Income Level	Mid	48	10.2
Income Level	High	15	3.2
Sex	Male	234	41.0
Sex	Female	337	59.0
Spouse Status	No Spouse	126	22.1
Spouse Status	Has Spouse	445	77.9

Table 1 presents the frequency distributions of key categorical variables. Table 2 summarizes the descriptive statistics of the continuous variables. The mean baseline MMSE score was 24.28 (SD = 4.33), and the mean follow-up MMSE was slightly higher at 25.08 (SD = 3.68), with 117 cases missing at follow-up.
Participants had a mean CES-D score of 10.90 (SD = 7.75).

Variable1	Variable2	Correlation	P_value
MMSE (Wave 3)	Weighted Out-degree (Wave 1)	0.241	0.002
Weighted Out-degree (Wave 1)	Depressive symptoms (Wave 1)	-0.224	0.004
MMSE (Wave 3)	Depressive symptoms (Wave 1)	-0.184	0.018
MMSE (Wave 1)	Depressive symptoms (Wave 1)	-0.165	0.034
MMSE (Wave 3)	MMSE (Wave 1)	0.137	0.079

Table 3 shows that baseline depressive symptoms (CES-D) were significantly negatively associated with cognitive function at both baseline (r = –.18, p < .05) and follow-up (r = –.22, p < .01), as well as with changes in Weighted Out-degree (r = –.21, p < .01), suggesting social withdrawal over time. Conversely, baseline Weighted Out-degree was positively correlated with cognitive function at follow-up (r = .24, p < .01), highlighting the protective role of emotionally close social ties for later cognitive health. The correlation between MMSE (Wave 1) and Weighted Out-degree (Wave 1) was 0.123 (p = 0.115), which was not statistically significant and not included in table 3. The lack of significance may be due to the sample in Wave 1 consisting only of individuals with MMSE scores of 27 or higher.

Effects of Covariates on Baseline MMSE, Residualized Change, and Cognitive Risk

Model 1: $MMSE_1$, Model 2–3: ΔMMSE (Residual), Model 4: MMSE ≤ 25

	Model 1: Baseline MMSE		Model 2–3: Residualized MMSE Change				Model 4: Serious MMSE Risk (Logistic)	
Variable	Model 1 Coef. (SE)	Model 1 p-value	Model 2 Coef. (SE)	Model 2 p-value	Model 3 Coef. (SE)	Model 3 p-value	Model 4 Coef. (SE)	Model 4 p-value
Intercept	29.928*** (2.414)	0.000	0.806 (2.921)	0.783	1.553 (2.639)	0.557	-0.154 (1.082)	0.887
Baseline MMSE							0.010 (0.032)	0.768
Depressive Symptoms (CES-D)	-0.045. (0.024)	0.063	-0.032 (0.033)	0.341	-0.021 (0.030)	0.496	0.001 (0.006)	0.837
Age	-0.089** (0.030)	0.003	-0.033 (0.037)	0.371	-0.043 (0.033)	0.201	0.008 (0.007)	0.245
Gender: Female	-0.275 (0.386)	0.477	0.402 (0.435)	0.357	0.485 (0.394)	0.221	-0.043 (0.080)	0.592
Has Spouse	-0.281 (0.517)	0.587	-1.671* (0.694)	0.017	-1.220. (0.624)	0.053	0.198 (0.128)	0.124
Education: Elementary	2.419*** (0.472)	0.000	1.787* (0.775)	0.023	1.433* (0.720)	0.049	-0.324* (0.142)	0.024
Education: Middle School	2.942*** (0.625)	0.000	2.140* (0.856)	0.014	1.533. (0.792)	0.055	-0.360* (0.157)	0.023
Education: High School	3.176*** (0.702)	0.000	2.587** (0.872)	0.004	2.002* (0.805)	0.014	-0.375* (0.160)	0.020
Education: College or Higher	2.545** (0.964)	0.009	3.650*** (1.007)	0.000	3.120*** (0.919)	0.001	-0.509** (0.185)	0.007
Income: Mid-low	0.355 (0.408)	0.384	-0.231 (0.483)	0.634	-0.232 (0.435)	0.594	0.008 (0.089)	0.926
Income: Mid	1.369* (0.553)	0.014	0.006 (0.547)	0.992	-0.165 (0.490)	0.736	-0.027 (0.101)	0.791
Income: High	2.157* (0.958)	0.025	-0.097 (0.793)	0.903	-0.153 (0.709)	0.830	-0.127 (0.146)	0.386
Weighted Out-Degree			0.077* (0.038)	0.044	0.062. (0.034)	0.069	-0.017* (0.007)	0.014

Models 1 to 3 employed residualized MMSE scores as the dependent variable, obtained by regressing follow-up MMSE scores on baseline MMSE. Model 1 included only demographic and control variables. In Model 2, weighted out-degree—a structural measure of outward social connections—was added as a predictor.

In Model 3, individuals whose MMSE scores at follow-up fell below 21 (defined as Q1 – 1.5 × IQR) were excluded as outliers. This exclusion aimed to reduce the possibility that sharp declines in cognitive function reflected distinct pathological processes (e.g., early-stage dementia) rather than typical age-related cognitive changes. By doing so, the analysis focused on whether the observed associations between social network structure and cognitive outcomes held within a cognitively robust population, independent of clinically significant decline.

Model 4 used logistic regression to examine the likelihood of scoring in the bottom quartile (MMSE ≤ 25) at follow-up. To capture the likelihood of experiencing serious cognitive decline, the dependent variable was coded as whether the MMSE score at Wave 3 was ≤ 25 and baseline MMSE was included as a control variable. Notably, depressive symptoms were significantly associated with cognitive decline in Models 1 through 3, but not in Model 4. However, no significant interaction was found between MMSE and weighted out-degree in any of the models.

Model1 shows that depressive symptoms and education were associated with the residualized MMSE score.

Model 2 and 3 show that the weighted out-degree, derived from the number of individuals with whom the respondent frequently discussed important matters over the past year, was significantly associated with better cognitive outcomes. (Model 2: $\beta = 0.077$, $p = 0.044$, Model 3: $\beta = 0.062$, $p = 0.069$) This result suggests that the one that has frequent engagement in meaningful social relationships will be a protective factor of cognitive resilience or less decline over time. The results of model 4 suggests that when weighted out-degree increases by one unit, the odds of scoring 25 or below on the MMSE at follow-up decrease by approximately 1.72% (OR = 0.983, $p = 0.014$). The outcome being predicted—scoring ≤ 25 on the MMSE at follow-up—represents a clinically meaningful decline.This threshold corresponds to the bottom 25% of cognitive performance among participants who had normal cognitive functioning (MMSE ≥ 27) at baseline (Wave 1). Therefore, even a 1.7% reduction in the odds of serious cognitive decline per unit increase in out-degree suggests that structural aspects of social networks may serve as a meaningful protective factor against late-life cognitive deterioration.

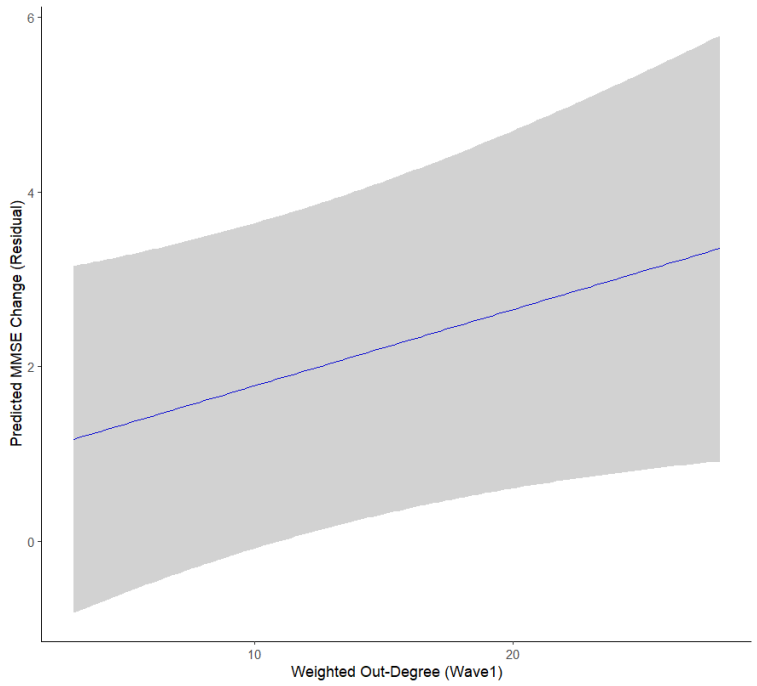

Figure 1 illustrates the association between Weighted Out-Degree at Wave 1 and residualized MMSE change scores. As shown, higher Weighted Out-Degree at baseline was significantly associated with greater cognitive improvement over time, even after controlling for baseline MMSE and other covariates. The positive slope indicates that individuals with more and stronger emotionally close ties at baseline tended to exhibit better-than-expected cognitive outcomes at follow-up. The shaded area represents the 95% confidence interval.

Conclusion

As pharmacological treatments for dementia remain limited, this study underscores the protective role of outward-directed, emotionally meaningful social connections in preserving cognitive function. Findings from four models consistently show that higher weighted out-degree centrality is associated with reduced cognitive decline among cognitively normal older adults. Even a modest increase in outward social engagement was linked to lower odds of clinically significant decline, suggesting that strengthening social networks may be a scalable and low-risk strategy to promote cognitive resilience in aging populations. Accordingly, policies that foster socially and emotionally engaging environments for older adults—such as peer support groups or community-based programs—should be prioritized as part of public health strategies to support healthy cognitive aging.

<Reference>

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