

# The Effect of Cognitive Impairment on the Association Between Social Network Properties and Mortality Among Older Korean Adults

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**Objectives:** This study investigated the effect of cognitive impairment on the association between social network properties and mortality among older Korean adults.

**Methods:** This study used data from the Korean Social Life, Health, and Aging Project. It obtained 814 older adults' complete network maps across an entire village in 2011-2012. Participants' deaths until December 31, 2020 were confirmed by cause-of-death statistics. A Cox proportional hazards model was used to assess the risks of poor social network properties (low degree centrality, perceived loneliness, social non-participation, group-level segregation, and lack of support) on mortality according to cognitive impairment.

**Results:** In total, 675 participants (5510.4 person-years) were analyzed, excluding those with missing data and those whose deaths could not be verified. Along with cognitive impairment, all social network properties except loneliness were independently associated with mortality. When stratified by cognitive function, some variables indicating poor social relations had higher risks among older adults with cognitive impairment, with adjusted hazard ratios (HRs) of 2.12 (95% confidence interval [CI], 1.34 to 3.35) for social non-participation, 1.58 (95% CI, 0.94 to 2.65) for group-level segregation, and 3.44 (95% CI, 1.55 to 7.60) for lack of support. On the contrary, these effects were not observed among those with normal cognition, with adjusted HRs of 0.73 (95% CI, 0.31 to 1.71), 0.96 (95% CI, 0.42 to 2.21), and 0.95 (95% CI, 0.23 to 3.96), respectively.

**Conclusions:** The effect of social network properties was more critical among the elderly with cognitive impairment. Older adults with poor cognitive function are particularly encouraged to participate in social activities to reduce the risk of mortality.

**Key words:** Interpersonal relations, Social networking, Social isolation, Cognitive dysfunction, Mortality

Received: August 10, 2022 Accepted: October 21, 2022

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## INTRODUCTION

An extensive body of literature indicates that the quantity and quality of social networks have decreased in recent years [1]. Prevalent loneliness and social isolation in industrialized societies have caused public health problems [2]. For instance, the cumulative effect of loneliness has been found to be associated with the number of risk factors for cardiovascular diseases, such as elevated body mass index, systolic blood pressure, and total cholesterol levels, as well as low levels of high-density lipoprotein cholesterol [3]. Moreover, many studies

have illustrated the impact of social relationships on mortality. Despite various definitions of social network properties and study populations, a poor social network has been consistently observed to be a strong predictor of mortality [4]. A meta-analysis including 148 studies demonstrated a 50% higher likelihood of mortality among those without sufficient social relations compared to those with sufficient social relations [5]. These effects of social network properties on mortality are comparable to the well-known risk factors of premature death, such as smoking, obesity, and physical inactivity [5].

Poor cognitive function has also shown associations with an increased risk of mortality in several studies [6]. Cognitive impairment, as measured by the Mini-Mental State Examination (MMSE) score, increases the risk of all-cause and cardiovascular disease mortality [6,7]. Cognitive impairment does not necessarily refer to only dementia, and encompasses mild cognitive decline. Literature on older adults with cognitive impairment, but without dementia, has repeatedly reported higher risks of progressing to dementia and premature death [8].

Although the associations of mortality with specific social aspects or cognitive function have been considerably studied, their combined effect remains unclear. Thus, this study aimed to investigate the effect of cognitive impairment on the association between social network properties and mortality among older Korean adults in a rural community.

## METHODS

### Study Participants

This study was conducted using data from the Korean Social Life, Health and Aging Project (KSHAP) study, which examined the entire population aged 60 or older in Village K, a typical rural community in Ganghwa, Korea, and collected complete social network maps for the elderly inhabitants of the village [9,10]. Among the target population (860 residents), 814 older adults and their spouses participated in the baseline survey from December 2011 to March 2012 (a response rate of 94.65%). Among them, 697 participants enrolled with personal identification numbers that make it possible to link to cause-of-death statistics. Those with missing data for social network properties, age, sex, education level, smoking, drinking, or comorbidities were excluded. In total, 675 respondents (5510.4 person-years) were analyzed in this study (Supplemental Material 1).

## Measures

### Social network properties

Using the complete network maps of the whole village, degree centrality was calculated as the number of social relations that a respondent had. Our analyses employed all-degree centrality, which includes both in-degree and out-degree centrality (i.e., the number of people who identify a participant as a network member and vice versa, respectively) [9]. We categorized participants as having higher or lower centrality compared to the median value of 4.0. Perceived loneliness was defined as feeling lonely for more than 1 day or 2 days over the past week based on the Center for Epidemiologic Studies Depression Scale questionnaires. Social non-participation was defined as not participating in any of the following 7 social activities: senior citizens' associations, volunteering, religious activities, meetings for friendship, hobbies, local associations, or senior job placement projects. The complete social network also made it possible to identify groups (components) where each respondent was connected within and separated by other groups. There were two types of components: strong and weak components. In strong components, every person was reachable by others following the directions of the discussion network, but not necessarily following the directions in weak components [11]. The KSHAP study identified 537 strong and 85 weak components [9]. As Village K is a typical rural community where relations between residents are relatively close and strong, weak components were used for our analyses to understand the effect of social dynamics. Among the weak components, ranging from 1 person to 757 persons, group-level segregation referred to belonging to a social group with a relatively limited range (66 persons or less in a component). Lack of support was defined as participants responding that they could not rely on any of their spouses, family members, relatives, friends, or neighbors when having a problem.

### Cognitive impairment

The Korean version of the Mini-Mental State Examination for Dementia Screening (K-MMSE) was used for the evaluation of cognitive function in the KSHAP study [10]. The K-MMSE has been established as a reliable and valid tool for screening cognitive impairment or dementia in a community setting [12]. The score ranges from 0 to 30. Based on previous studies, we categorized those with a score of 23 or less as having cognitive impairment and those with a score of 24 or more as having normal cognition [13-15].

### Mortality

Among participants, deaths until December 31, 2020 were confirmed using cause-of-death statistics. The observed period was from the first survey date to the death date on the basis of death certificates for event cases or to the last day of observation (December 31, 2020) for censored cases in this study.

### Covariates

Socio-demographic characteristics included age, sex, and educational attainment. The educational attainment level was categorized as no formal education, middle school or less, and high school or above. The health-related covariates included smoking status, alcohol use, and comorbidities. Among the diseases studied in the KSHAP study, hypertension, diabetes, cancer, stroke, and coronary heart disease were considered in our analyses, as the previous literature demonstrated that they increase mortality in the older population [16,17].

### Statistical Analysis

Along with the total study population, socio-demographic characteristics and social network properties were compared between those with normal cognition and with cognitive impairment using the *t*-test and chi-square test. Using a Cox proportional hazards model, the associations of low degree centrality, perceived loneliness, social non-participation, group-level segregation, and lack of support with the risk of all-cause death were evaluated. Kaplan-Meier curves were plotted according to social network properties and cognitive function. The proportional hazards assumption was also assessed for each variable using weighted Schoenfeld residuals. Unadjusted and adjusted hazard ratios (HRs) were presented with 95% confidence intervals (CIs). The multivariate model was adjusted for age, sex, educational attainment, smoking, drinking, and comorbidity. Identical analyses were repeated after stratifying by cognitive function. All analyses were carried out using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

### Ethics Statement

The KSHAP study was conducted with approval from the Institutional Review Board of Yonsei University (YUIRB-2011-012-01) in 2011. The current study was approved by the Yonsei University Health System, Severance Hospital (4-2021-1401) in 2021.

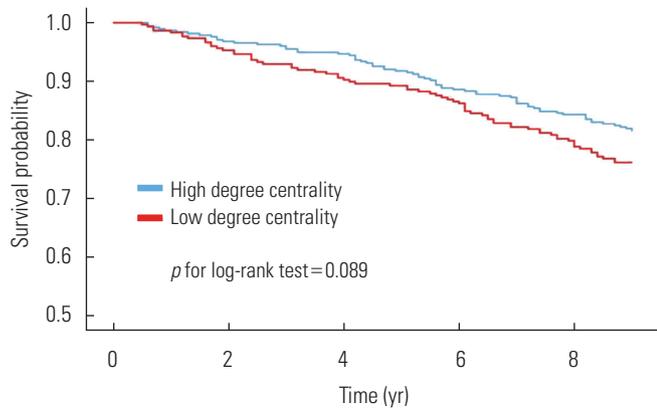
## RESULTS

The socio-demographic characteristics and social network properties of the study population stratified by cognitive func-

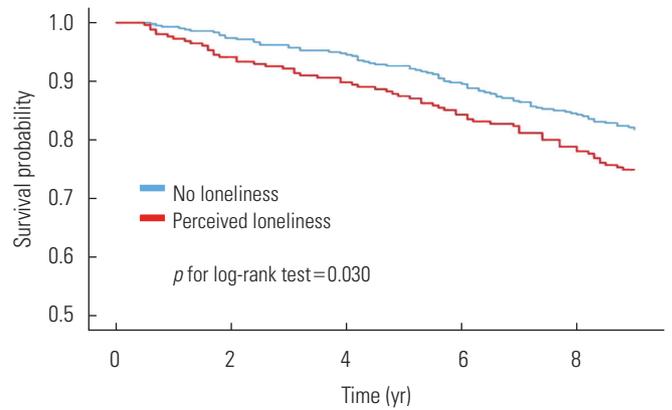
**Table 1.** Baseline characteristics of study participants by cognitive function

Characteristics	Total (n=675)	Normal cognition (n=417)	Cognitive impairment (n=258)	p-value
Socio-demographic characteristics				
Age, mean ± SD (y)	71.1 ± 7.7	68.4 ± 6.6	75.3 ± 7.5	<0.001
Sex				<0.001
Male	293 (43.4)	209 (50.1)	84 (32.6)	
Female	382 (56.6)	208 (49.9)	174 (67.4)	
Education				<0.001
None	186 (27.6)	54 (13.0)	132 (51.2)	
Middle school or less	393 (58.2)	276 (66.1)	117 (45.4)	
High school or above	96 (14.2)	87 (20.9)	9 (3.5)	
Smoking				0.073
No	587 (87.0)	355 (85.1)	232 (89.9)	
Yes	88 (13.0)	62 (14.9)	26 (10.1)	
Drinking				0.061
No	517 (76.6)	309 (74.1)	208 (80.6)	
Yes	158 (23.4)	108 (25.9)	50 (19.4)	
Comorbidities				
Hypertension	332 (49.2)	195 (46.8)	137 (53.1)	0.110
Diabetes	119 (17.6)	77 (18.5)	42 (16.3)	0.469
Cancer	27 (4.0)	20 (4.8)	7 (2.7)	0.180
Stroke	28 (4.2)	13 (3.1)	15 (5.8)	0.088
Coronary heart disease	50 (7.4)	30 (7.2)	20 (7.8)	0.788
Social network properties				
Degree centrality				0.016
High (≥4)	377 (55.9)	248 (59.5)	129 (50.0)	
Low (<4)	298 (44.2)	169 (40.5)	129 (50.0)	
Perceived loneliness				0.001
No	420 (62.2)	279 (66.9)	141 (54.7)	
Yes	255 (37.8)	138 (33.1)	117 (45.4)	
Social non-participation				<0.001
No	537 (79.6)	356 (85.4)	181 (70.2)	
Yes	138 (20.4)	61 (14.6)	77 (29.8)	
Group-level segregation				0.269
No	568 (84.2)	356 (85.4)	212 (82.2)	
Yes	107 (15.9)	61 (14.6)	46 (17.8)	
Lack of support				0.468
No	641 (95.0)	398 (95.4)	243 (94.2)	
Yes	34 (5.0)	19 (4.6)	15 (5.8)	

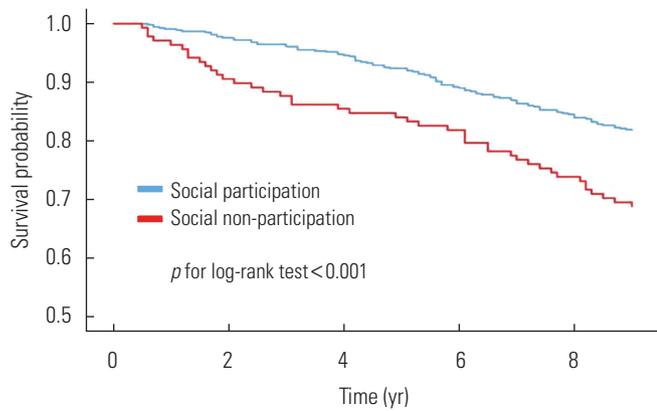
Values are presented as number (%). SD, standard deviation.



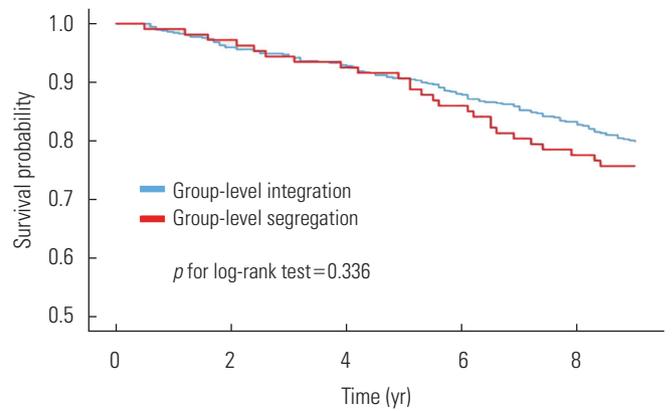
No. at risk					
—	377	365	357	334	318
—	298	284	270	258	238



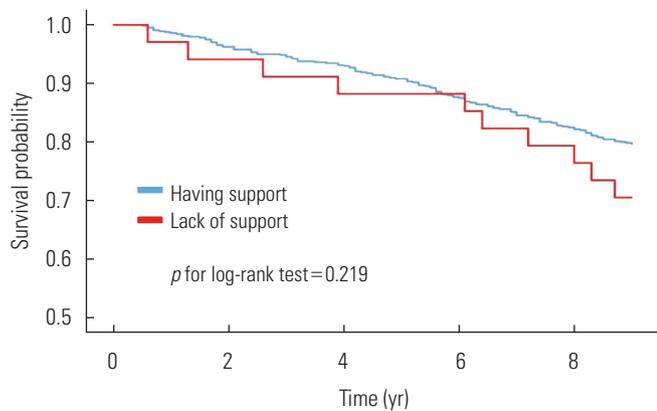
No. at risk					
—	420	409	398	377	355
—	255	240	229	215	201



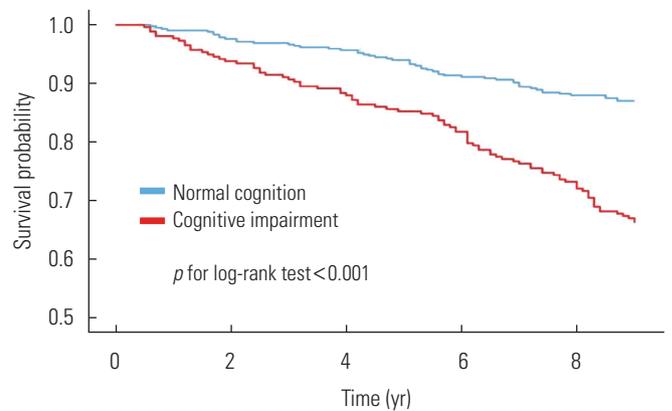
No. at risk					
—	537	524	509	479	454
—	138	125	118	113	102



No. at risk					
—	568	545	528	500	473
—	107	104	99	92	83



No. at risk					
—	641	617	597	562	529
—	34	32	30	30	27



No. at risk					
—	417	407	399	381	367
—	258	242	228	211	189

Figure 1. Kaplan-Meier plot of survival probability with risk tables according to social network properties and cognitive function.

tion are described in Table 1. The group with cognitive impairment had a higher proportion of older, female, and less-educated participants. They were also likely to show poor characteristics for all social network properties studied, although the prevalence of group-level segregation and lack of support was not statistically significantly different compared to those with normal cognition. The distributions of K-MMSE scores are also presented in Supplemental Material 2. The mean values of the scores were 23.94 among all participants, 26.79 among those with normal cognition, and 19.34 among those with cognitive impairment.

In Figure 1, the Kaplan-Meier curves and risk tables were plotted according to each characteristic of social networks and cognitive function. Older adults with low degree centrality, loneliness, social non-participation, group-level segregation, and cognitive impairment had a lower survival rate than each corresponding group. Additively, independence between the Schoenfeld residuals for each variable and time was diagnosed, and the proportional hazards assumption was confirmed (Supplemental Material 3).

Table 2 shows the results of the unadjusted and adjusted Cox proportional hazards regression between social network

properties or cognitive function and mortality. After adjusting for covariates, participants with cognitive impairment had a higher risk of mortality (adjusted hazard ratio [aHR], 1.71; 95% CI, 1.15 to 2.54) than those with normal cognition. In terms of social network properties, participants with all types of insufficient networks except perceived loneliness (aHR, 1.04; 95% CI, 0.74 to 1.47) showed significantly higher aHRs than their counterparts, although only the associations for social non-participation and lack of support were statistically significant (aHR, 1.64; 95% CI, 1.12 to 2.39 for social non-participation and aHR, 2.13; 95% CI, 1.10 to 4.13 for lack of support).

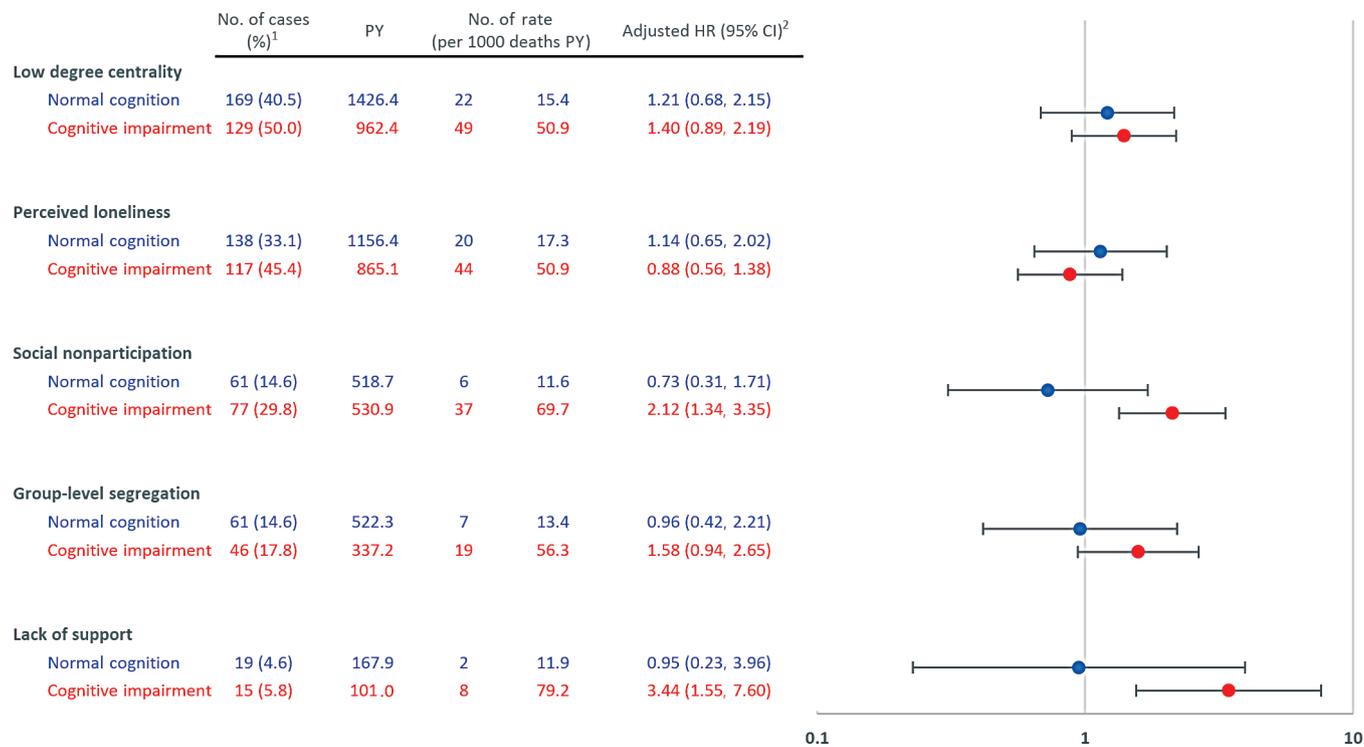
Figure 2 depicts different effects of social network properties on mortality according to cognitive function. Low degree centrality and perceived loneliness had similar HRs for mortality regardless of cognitive function. However, social non-participation significantly increased the risk of mortality among the elderly with cognitive impairment (aHR, 2.12; 95% CI, 1.34 to 3.35), whereas the effect of social non-participation was not observed among those with normal cognition. Likewise, group-level segregation among those with cognitive impairment showed an aHR of 1.58 (95% CI, 0.94 to 2.65) and lack of support had an aHR of 3.44 (95% CI, 1.55 to 7.60). In an addi-

**Table 2.** The risks of mortality according to social network properties and cognitive function among older Korean adults

Variables	No. of deaths	PY	Rate (per 1000 PY)	HR (95% CI)	
				Unadjusted	Adjusted <sup>1</sup>
Low degree centrality					
No	70	3121.6	22.4	1.00 (reference)	1.00 (reference)
Yes	71	2388.8	29.7	1.33 (0.96, 1.85)	1.35 (0.95, 1.91)
Perceived loneliness					
No	77	3488.9	22.1	1.00 (reference)	1.00 (reference)
Yes	64	2021.5	31.7	1.44 (1.04, 2.01)	1.04 (0.74, 1.47)
Social non-participation					
No	98	4460.8	22.0	1.00 (reference)	1.00 (reference)
Yes	43	1049.6	41.0	1.88 (1.31, 2.69)	1.64 (1.12, 2.39)
Group-level segregation					
No	115	4650.9	24.7	1.00 (reference)	1.00 (reference)
Yes	26	859.5	30.3	1.23 (0.81, 1.89)	1.37 (0.89, 2.10)
Lack of support					
No	131	5241.5	25.0	1.00 (reference)	1.00 (reference)
Yes	10	268.9	37.2	1.49 (0.78, 2.84)	2.13 (1.10, 4.13)
Cognitive impairment					
No	54	3525.2	15.3	1.00 (reference)	1.00 (reference)
Yes	87	1985.2	43.8	2.91 (2.07, 4.08)	1.71 (1.15, 2.54)

PY, person-years; HR, hazard ratio; CI, confidence interval.

<sup>1</sup>Adjusted for age, sex, educational attainment, smoking, drinking, and comorbidities.



**Figure 2.** Mortality risks of insufficient social network properties stratified by cognitive function among a total of 675 participants. PY, person years; HR, hazard ratio; CI, confidence interval. <sup>1</sup>The number of cases with poor social characteristics and the percentage of cases in each subgroup are presented. <sup>2</sup>Adjusted for age, sex, educational attainment, smoking, drinking, and comorbidity.

tional analysis of the interaction between social network properties and cognitive function on mortality, only social nonparticipation showed statistical significance (Supplemental Material 4).

## DISCUSSION

This study investigated the effect of cognitive impairment on the association between social network properties and mortality using data from the KSHAP study from 2011 to 2020. Overall, our result is consistent with previous studies showing that individuals with weak social networks had a lower likelihood of survival than those with sufficient networks [5]. Additionally, older adults with cognitive impairment showed a higher prevalence of having fewer social ties, feeling lonely, and not participating in any activities. Furthermore, these social network properties had a greater influence on mortality among older persons with cognitive impairment, compared to those with normal cognition.

Our study classified the magnitude of social relations using the median value of 4.0 in degree centrality, and showed in-

creased mortality in people with low centrality than in people with high centrality. Several studies have reported that social network size is strongly associated with mortality, although it is unclear which number of social connections is most influential [18]. One study in the United States showed that social interactions with 0-1 friend had an HR of 1.32 for mortality compared to those with 6-7 friends [18]. However, another study implied different effects between strong and weak ties on mortality; the risk of premature death was not necessarily increased with a small number of strong ties, but did show such a relationship with a small number of weak ties [19]. To investigate the optimal size of a social network, further research is required with consideration of the characteristics of social networks besides the number of connections.

Social non-participation significantly increased the risk of premature death in our study (aHR, 1.64; 95% CI, 1.12 to 2.39). Considering that the KSHAP study examined relatively healthy participants at baseline in a community-based setting and adjusted for other covariates, social non-participation per se, at least, partly accounts for a loss of physical health. A study in Japan, which is challenged by an aging society, showed that

social participation increased the probability of survival in older people [20]. Social activities—in particular, those relating to personal development, such as educational and physical activities, and short-term employment—resulted in lower hazards of death [20]. Participating in social activities may lead to the attainment of health information and access to health care services as well as its psychosocial benefits [21,22].

Lack of support was the strongest predictor of premature death in this study. The unadjusted HR was 1.49 (95% CI, 0.78 to 2.84), and the fully aHR was 2.13 (95% CI, 1.10 to 4.13). When independently controlling for each covariate, the increased strength of the association was mainly due to adjustment for age (Supplemental Material 5). Age seemed to weaken the association between lack of support and mortality in our study, where the participants with support tend to be older than those without (Supplemental Material 6). Older age increases mortality, but it is not known whether older age is associated with a higher likelihood of lack of support. Further studies need to reaffirm the association between age and lack of support with a larger sample. The protective effect of having support has been illustrated in previous research. Being embedded in a social network has a protective effect by giving individuals meaningful roles, generating self-esteem, and providing a sense of purpose in life [23]. Moreover, when stratified, the absence of timely help from a partner, family, and friends was more critical among the elderly who experienced a physical and cognitive decline (aHR, 3.44; 95% CI, 1.55 to 7.60). This may reflect, for instance, increased difficulties in the utilization of healthcare services and reduced motivation for healthier behaviors [24].

The complete-network analyses in the KSHAP study showed that insufficient social network properties at a group level also increased the risk of mortality. Social isolation at the group level, as well as at the individual level, was associated with a higher risk of mortality [17]. Participants classified as having group-level segregation may have been not isolated individually and may have even had strong and frequent social connections with others in the same group. Nevertheless, belonging to a group with a small diameter was associated with an increased risk of premature death. Group-level segregation may confine older adults to limited health information and hinder them from accessing a broad range of health services [25,26].

Along with social network properties, cognitive impairment had a significant influence on mortality. Univariate analysis

showed an HR of 2.91 (95% CI, 2.07 to 4.08) for cognitive impairment, and the higher risk was persistent after adjusting for covariates. This finding is consistent with other studies; one prospective study suggested that cognitive impairment was the strongest predictor of mortality, in particular deaths from ischemic stroke [6,27]. When considering both social network properties and cognitive function, the effect of social network properties on mortality differed by cognitive function. Social non-participation, group-level segregation, and lack of support increased the risk of mortality only among older adults with cognitive impairment, while the increased risk associated with social network size did not show a difference between those with normal cognition and without. To our knowledge, there is little research on the effect of cognitive function on the association between social network properties and mortality. One study using the National Health and Nutrition Examination Survey in the United States illustrated that cognitive impairment and social network properties each raised the risk of premature death, but did not observe the interaction between them [28]. Although further studies are required to fully explain the different effects of social network properties on mortality by cognitive function, there are some possible explanations; for instance, the protective effect of sufficient social network properties appears to be more critical among older adults with cognitive impairment than those without. For instance, emotional and psychosocial benefits, such as the stress-buffering effect from social interactions, could be stronger in older adults with cognitive decline [29]. Cognitive function may also influence the degree to which people obtain health information, access health care services, and facilitate positive health behaviors that are obtained through sufficient social relationships [4,30]. Cognitive function is related to the associations between health literacy and physical health among older adults, and it has been known as a significant risk factor for premature death [30].

Our study has some strengths in its investigation of the effect of cognitive impairment on the association between social network properties and mortality among older Korean adults. The KSHAP data enabled us to analyze various types of social relations. The complete social network analyses of all participants in the village provided both individual-level and group-level characteristics of the social network. Since the study population showed a high response rate (94.65%) and was relatively homogeneous in educational achievement and occupation, the study findings are unlikely to be severely con-

founded by socioeconomic status. Although the implications of this study could be relevant for epidemiological studies and community health settings, several limitations should also be taken into consideration. First, the results may not be generalizable to other populations, since they were derived from a study of older adults in a rural village in Korea. Second, the small sample size might undermine the findings. Further studies with larger sample sizes and longer follow-up periods are required to reaffirm the varying effects of cognitive impairment on the association between social network properties and mortality. Third, we defined cognitive impairment using the K-MMSE score rather than clinical diagnoses. Although there are some arguments regarding the use of the MMSE to screen for cognitive impairment, it is a valid and reliable tool, particularly in a community-based setting [12,15]. A considerable body of research suggests a general cut-point of 23/24 for the MMSE could be appropriate for detecting mild cognitive impairment and dementia in the general population [31,32]. Fourth, response bias, such as social-desirability bias, might have influenced our results. In terms of social network properties, survey participants could respond in a manner that would be viewed favorably by others (e.g., overrating their social network properties) [33]. Fifth, we adjusted for 5 comorbidities known to increase mortality in older adults: hypertension, diabetes, cancer, stroke, and coronary heart disease. Although previous studies have also suggested that social network properties per se are associated with an increased risk of morbidity and mortality, regardless of underlying diseases, the possibility should be taken into account that other diseases not included could affect our results [4]. Last, there was a possibility of residual confounding, as time-varying confounding variables were not sufficiently controlled, although we evaluated the proportional hazards assumption by confirming independence between the Schoenfeld residuals and time.

According to our study, it is crucial for older adults to have sufficient and strong social networks. Furthermore, the effects of social network properties were more critical among older adults with cognitive impairment, who are particularly encouraged to participate in social activities and be integrated into social networks to reduce the risk of mortality.

## SUPPLEMENTAL MATERIALS

Supplemental materials are available at <https://doi.org/10.3961/jpmph.22.350>.

## CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

## FUNDING

This work used data from the KSHAP study, which was supported by the Ministry of Education of the Republic of Korea, the National Research Foundation of Korea (grant No. NRF-2017S1A3A2067165).

## ACKNOWLEDGEMENTS

None.

## AUTHOR CONTRIBUTIONS

Conceptualization: Kim E, Kim HC. Data curation: Youm Y, Kim HC, Kim CO, Sung K. Formal analysis: Kim E. Funding acquisition: Youm Y. Methodology: Kim E, Kim HC, Youm Y. Visualization: Kim E. Writing – original draft: Kim E, Sung K. Writing – review & editing: Kim CO, Youm Y, Kim HC.

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