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The Loneliness of Low-Income Older Adults in a Federal Volunteering Program: A Network Perspective

Qiuchang (Katy) Cao[1], Holly Dabelko-Schoeny[2], Keith Warren[2], and Mo Yee Lee[2]

Abstract

Volunteering has been associated with increased social interactions and reduced feelings of loneliness among older adults. However, a growing number of social network analyses (SNA) conducted in the general population outside of volunteering contexts suggest that lonely individuals tended to interact with other lonely individuals in the network, reinforcing loneliness through peer associations. To better understand the psychosocial impact of peer interactions among older adults within volunteer programs, this study examines how older adults' loneliness is correlated with their peers' loneliness within the Senior Companions Program (SCP). This study collected information on the social networks within an SCP in a Midwest Metropolitan and feelings of loneliness among low-income Russian, Khmer, Somali, Nepali, and English-speaking older volunteers ($N = 41$). A linear network autocorrelation model (LNAM) was constructed to quantify how volunteers' loneliness is correlated with their peers' loneliness within SCP. The LNAM results indicated that less lonely volunteers tended to make friends with lonelier volunteers ($\rho = -.06$, $p < .05$) in SCP even when accounting for statistical controls. The finding that more and less lonely individuals connect indicates an altruistic tendency for less lonely individuals to interact with those who are lonelier. This may be an important pathway by which volunteering addresses loneliness.

Keywords

loneliness, volunteering, social network, low-income older adults

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Introduction

Loneliness is among the most significant public health problems in the United States (U.S.), and persistent loneliness has long-term physical, mental, and cognitive health consequences for older adults (National Academies of Sciences Engineering and Medicine [NASEM], 2020). Beyond serving as an expression of altruism (i.e., the desire and action to benefit others), volunteering has been associated with an increased sense of social connectedness and psychological well-being for diverse older volunteers (Torres & Serrat, 2019). Forming trusting relationships within the volunteer program plays a critical role in strengthening social connectedness among diverse older volunteers (Mui et al., 2013; Wiles et al., 2019).

However, previous quantitative studies on volunteering and older adults' loneliness were based on surveys of individuals (Carr et al., 2018; Crittenden, 2018). Few studies examined the social networks of the programs in which older adults volunteer. Overlooking social network structures within the volunteer program is problematic because findings from studies of complete social networks and psychological well-being among non-volunteers demonstrated that increased social interactions did not always lead to reduced loneliness or depression (Cacioppo et al., 2009; Elmer, 2020; Prochnow et al., 2020). These network dynamics would likely not be apparent in loneliness studies without consideration of social network structures.

Furthermore, a recent systematic review of qualitative papers suggested that the volunteering experiences among immigrants and diverse populations are shaped by how social support is exchanged and organized in different volunteer contexts (Sveen et al., 2023). Nevertheless, there is hardly any quantitative social network analysis (SNA) on the patterns of social relationships among diverse older volunteers *within* an organized volunteer

[1]Florida State University College of Social Work, Tallahassee, FL, USA
[2]The Ohio State University College of Social Work, Columbus, OH, USA

Corresponding Author:
Qiuchang (Katy) Cao, Florida State University College of Social Work, 296 Champions Way, Tallahassee, FL 32304, USA.
Email: qc22@fsu.edu

program. To address these gaps, this exploratory SNA investigates how diverse older volunteers within a Senior Companion Program (SCP) form relationships and whether loneliness among diverse volunteers correlates with that of peers in the program.

The Senior Companion Program

The Senior Companions Program (SCP) is one of the few federal volunteer programs that are designed to recruit and retain low-income diverse older volunteers (Georges et al., 2018). SCP volunteers are required to be age 55 years or older, and at or below 200% of the federal poverty line (Tan et al., 2016). To address the financial and logistic barriers of volunteering among low-income older adults, SCP volunteers receive a $2.65 hourly stipend and mileage reimbursement (Butler, 2006; Crittenden, 2018). SCP volunteers are usually expected to volunteer for at least 15 hours or more each week (Tan et al., 2016). The SCP program is structured so that low-income older adults (volunteers) provide companionship to homebound older adults (clients) to improve social connectedness and quality of life in both groups (Tan et al., 2016). Volunteers and clients are carefully matched based on their preferences, such as sharing similar interests or speaking the same language.

In addition to volunteer-client interactions, SCP provides organized socialization opportunities to foster peer interactions among diverse volunteers from various cultural backgrounds (Butler, 2006; Crittenden, 2018). Older volunteers interact with other volunteers through orientation, monthly in-service training, and other SCP activities. Relationships developed through these activities have been shown to increase the exchange of social support among volunteers, such as carpooling (Cao et al., 2021). Although the client and volunteer relationship within SCP has received increased scholarly attention (Tan et al., 2016), to our knowledge, no studies evaluated whether and how the social interactions among SCP volunteers are associated with their loneliness.

Social Network and Loneliness Among Older Adults

In a separate but related body of literature, most existing social network studies on older adults focused on their immediate personal support network (ego network) rather than the social interactions among older adults within a given boundary (whole network) according to a systematic review (Ayalon & Levkovich, 2019). The size of older adults' personal networks is the most commonly studied network characteristic in loneliness and gerontology literature (e.g., Ma et al., 2020; Park et al., 2021; Webber & Fendt-Newlin, 2017).

Social Networks and Volunteering Among Older Adults

Similarly, existing studies on volunteering and older adults' social networks also mainly focused on the association between volunteering and the size of older adults' immediate personal networks. For instance, one study suggested that older adults' personal friendship network sizes moderated the relationship between the frequency of volunteering and the change in life satisfaction of older adults (Jiang et al., 2019). Older volunteers who lost more friends over the 4 years experienced greater improvement in their quality of life through volunteering (Jiang et al., 2019). Perceived reciprocity in relationships (Siegrist & Wahrendorf, 2009) and the quality of community participation also moderated the effect of volunteering on older adults' psychological well-being (Matz-Costa et al., 2016). Due to the lack of whole network studies, the complex interpersonal dynamics within volunteer programs are not well understood.

Behavior and Emotions in Social Networks

Outside of gerontology, whole social network studies informed by the Social Contagion Theory suggest that individuals tend to form relationships with others who share similar emotions, attitudes, or behaviors and are also subsequently influenced by the emotions, attitudes, or behaviors of their network contacts through social contagion (Christakis & Fowler, 2013). How much individuals' emotions within a network affect the emotions of others depends on their relationship dynamic, contact frequency, proximity, and network density (Christakis & Fowler, 2013; Hill et al., 2010). Specifically, a systematic review of social network studies on health promotion suggested that individuals' health behavior (e.g., engagement in physical activity) is correlated with the behavior of their peers within a network (Prochnow & Patterson, 2022). Individuals tend to select their network connections based on shared experiences and behaviors (e.g., emotional status, health behaviors, and attitudes; Valente & Pitts, 2017).

Meanwhile, individuals' emotional experiences and behavior (e.g., engagement in physical activities, and drinking behavior) are shaped by the experiences and behavior of their peers in the social network (Prochnow & Patterson, 2022). In an SNA of depressive symptoms within an online gaming community, a linear network autocorrelation model (LNAM) showed a positive network correlation, suggesting that individuals tend to socialize with those sharing similar levels of depression (Elmer, 2020; Prochnow et al., 2020). People who are more depressed can be expected to socialize separately from people who are less depressed (Elmer, 2020). For instance, scholars found that depressed individuals in a graduate housing community were inclined to connect with other depressed individuals, resulting in dyadic isolation (Elmer, 2020). This pattern may worsen symptoms among individuals experiencing high levels of depression through co-rumination, that is, repeatedly revisiting negative emotions together with peers (Elmer, 2020; Prochnow et al., 2020). Other researchers have found that loneliness may spread through the clusters of peripheral individuals

in a network via a contagious process (Cacioppo et al., 2009). These whole SNA findings from research on depression and loneliness among younger and general populations suggest that peer interactions do not always protect against negative emotions (Cacioppo et al., 2009; Elmer, 2020; Prochnow et al., 2020).

Gaps in Knowledge and the Current Study

Existing SNAs on peer correlations of emotional experiences or health behavior were conducted among younger or general populations in environments that are much different from a volunteer program, which explicitly focused on supporting one another. The few existing whole network studies in gerontology focused on middle-class white older adults in long-term care facilities (e.g., nursing homes, assisted living facilities, memory care units, or continuing care facilities) or retirement communities that have clear network boundaries (Ayalon & Levkovich, 2019). There is little information on social interactions among community-living diverse older adults in different social settings (Ayalon & Levkovich, 2019), such as within volunteer programs. The lack of understanding of the role of peer correlation in older adults' loneliness within volunteer programs makes it unclear whether social interactions among older volunteers might protect against loneliness or exacerbate it. To advance our knowledge on volunteering, social networks, and loneliness, this SNA informed by the social contagion theory (Christakis & Fowler, 2013; Hill et al., 2010) explores how the loneliness of SCP volunteers correlates with that of peers.

Method

Sample

This study was conducted in a Midwest metropolitan area with a growing number of immigrants and refugees in recent years (Singer, 2015). In response to the local demographic change, the SCP in the Midwest Metropolitan recruited culturally and linguistically diverse older volunteers and clients into the program via recruitment talks in the community, often assisted by other non-profit organizations (e.g., Community Refugee and Immigrant Services [CRIS], Asian American Community Services [AACS], Senior Options) that serve marginalized populations. Collaboration with these non-profit organizations contributed to the diversity of older volunteers and clients in this local SCP. Thus, the local SCP consists of both immigrant and non-immigrant older adults. In general, SCP volunteers tend to be more ethnically diverse than older volunteers in other non-means-tested federal volunteer programs (Georges et al., 2018; Hood et al., 2018). Furthermore, the local SCP is affiliated with Catholic Social Services.

To investigate the social interactions among different groups of diverse older adults in a multicultural context (Hood et al., 2018; Torres & Serrat, 2019), researchers conducted convenience sampling from the local SCP. All current volunteers of SCP in the Midwest Metropolitan were eligible for the study. No cognitive or functional screening criteria were applied in the participant selection process for this study. Due to COVID-related restrictions and concerns, only approximately half of the senior companions attended the data collection. Although participants also nominated friends not present at the data collection, only those at the data collection completed a survey on their loneliness needed for this study, resulting in an $N=41$ in this study.

Data Collection

Data were collected in the SCP in-service training in October 2021. SCP was in the process of resuming their in-person meetings and services during that time. Volunteers of SCP completed a socio-demographic survey, a friendship nomination form (Appendix A), and the De Jong Gierveld Loneliness survey (DJGLS; Appendix B). The surveys were collected in five languages through eight focus groups for Nepali-, Russian-, Somali-, Khmer-, and English-speaking volunteers. The Nepali-speaking volunteers were Bhutanese who are ethnically Nepali. The number of volunteers in each group is presented in Table 1. Participants completed the survey in their preferred language. A facilitator provided instructions on the surveys in each focus group. Interpreters facilitated the process as needed. Using a name roster of SCP volunteers provided by SCP, the facilitators instructed participants to refer to the name roster and provide the names of their friends in English whenever possible. The study procedures were reviewed and approved by the Institutional Review Board (IRB) of the Ohio State University, Study ID 2021B0254. Further details of data collection procedures are described in Cao et al., (2023).

Measures

Outcome Variable. Loneliness was assessed through the 6-item version of the DJGLS presented in Appendix B (De Jong Gierveld & Van Tilburg, 2008). Those who scored 2 or more on the DJGLS were considered to be lonely (De Jong Gierveld & Van Tilburg, 2008). DJGLS demonstrated good reliability and validity in measuring the loneliness of older adults (Penning et al., 2014). The Cronbach's alpha for the 6-item DJGLS ranged between .70 and .76 (De Jong Gierveld & Van Tilburg, 2008). DJGLS has also been shown to be reliable and valid in assessing loneliness in a variety of other countries with varying economic and cultural backgrounds (e.g., France, Russia, and Japan; De Jong Gierveld & van Tilburg, 2010).

Covariates. Factors associated with loneliness among older immigrants and refugees according to previous literature are also included in this study. Age (subtracting the year of birth provided by participants from 2021),

Table 1. Descriptive Node Statistics.

Variable	Frequency	%	*M*	*SD*	*N*
Age			76.99	9.09	41
Gender					38
Female	20	52.63			
Male	18	47.37			
Country of origin					41
Bhutan	3	7.32			
Cambodia	5	12.2			
Ethiopia	1	2.44			
German	1	2.44			
Russia	10	24.39			
Somalia	2	4.88			
Ukraine	3	7.32			
USA	16	39.02			
Race					41
Asian or Pacific Islander	8	19.51			
Black or African American	11	26.83			
White	21	51.22			
Other	1	2.44			
Education					37
No high school degree	8	21.62			
High school degree or equivalent	6	16.22			
Some college no degree	8	21.62			
Associates degree	2	5.41			
Bachelor's degree	5	13.51			
Graduate or professional degree	8	21.62			
Marital status					40
Divorced or separated	5	12.5			
Married	19	47.5			
Never married	5	12.5			
Widowed	11	27.5			
Household composition					39
Live alone	17	43.59			
Live with spouse	19	48.72			
Live with children	6	15.38			
Live with grandchildren	2	5.13			
Live with other relatives	1	2.56			
Years of residence			26.12	11.73	24
Migration age			52.04	13.14	23
Better living standards	1	4.35			
Number of family members			8.31	6.84	35
Number of friends outside of SCP			7.97	9.06	33
Volunteer frequency in the past month			18.13	13.46	31
De Jong Gierveld Loneliness Score			2.53	1.67	32

Note. Only participants who were not born in the U.S. were instructed to respond to questions regarding their years of residence in the U.S., their age of migration, and reasons for migration. The incompleteness in the socio-demographic and loneliness survey contributed to the missing data. SCP = Senior Companions Program).

gender (male, female, and other), country of origin (United States, China, Bhutan, Cambodia, Nepal, Russia, Somalia, and other), education (no high school degree, high school degree or equivalent, some college, no degree, Associate degree, Bachelor's degree, and graduate or professional degree), self-rated health as measured by "How is your health in general" (very good, good, moderate, bad, and very bad), perceived neighborhood environment

(very good, good, fair, bad, and very bad), marital status (married, divorced or separated, never married, widowed, and cohabitation), the number of family or friends seen or heard from at least once a month, and the frequency of volunteering in the past month (De Jong Gierveld et al., 2015; Johnson et al., 2019) were included in the LNAM. Non-significant variables were removed from the final model unless removing them would change the significance of another variable.

Analysis

Linear Network Autocorrelation Modeling (LNAM). Social network data present a unique challenge for statistical analysis because the connection between participants violates the assumption of independent identical errors (also known as the i.i.d assumption). Standard regression analysis will therefore produce spurious results if applied to a social network (Cranmer et al., 2020). Thus, network autocorrelation models use techniques borrowed from the spatial autocorrelation literature to analyze social network data without the need to impose the i.i.d assumption (Leenders, 2002). Because the network autocorrelation models control Type I error rates well, the sample size required to identify a significant network effect is generally small (Wang et al., 2014). Simulation studies suggested that it is feasible to detect moderately sized network effects in smaller networks with approximately 40 nodes/individuals (Wang et al., 2014). A detailed description of the analytic approach in LNAM is presented in Appendix C.

Results

Social Demographic Characteristics

Among the 41 volunteers who participated in the data collection, the mean age was 76.99 ($SD = 9.09$) and 52.63% of the sample was female. Additionally, 39.02% of participants were from the U. S., 24.39% were from Russia,12.20% were from Cambodia, 7.32% were from Bhutan or Ukraine, and 4.88% were from Somalia. In terms of race and ethnicity, 51.22% of participants identified as White, 26.83% were Black or African American, and 19.51% identified as Asians or Pacific Islanders. On average, older immigrants and refugees in this sample spent 26.12 years in the US ($SD = 11.73$) and migrated at an average of 52.04 years old ($SD = 13.14$). Among older immigrants and refugees in this sample, 56.52% of them were refugees or asylees. Participants' average DJGLS score was 2.53 ($SD = 1.67$). Those who scored 2 or more on the DJGLS were considered lonely (De Jong Gierveld & Van Tilburg, 2008). In other words, out of 35 valid responses to DJGLS, 17 participants (48%) experienced loneliness. Table 1 presents detailed sociodemographic characteristics of the sample.

Findings From Linear Network Autocorrelation Model (LNAM)

The SCP network consists of groups of densely connected individuals with sparse connections between clusters along with isolates who did not nominate others and were not nominated by others (Borgatti et al., 2013). With a few exceptions, Figure 1 illustrated that less lonely volunteers (smaller nodes) nominated lonelier volunteers (larger nodes) in SCP. For instance, E06 nominated lonelier individuals (E11 and E09) as friends. The prevalence of the negative differences in the de Jong Gierveld Loneliness Score (Diff-DJG) between egos (participants) and alters (nominated friends) displayed in Figure 2 also indicates that it is more common for less lonely egos to connect with lonelier alters in this network.

After listwise deletion on the independent and dependent variables of LNAM, a total of 25 older adults were included in LNAM. Older age, being female, having lower levels of education, and interacting with fewer family and friends in a month were associated with higher levels of loneliness. The network autocorrelation term was negative ($\rho = -.06$, $p < .05$) indicating that volunteers with lower levels of loneliness were more likely to interact with those experiencing higher levels of loneliness. After the removal of the non-significant variables, the final LNAM (Table 2) had a higher adjusted R^2 (Adjusted $R^2 = .45$ vs. Adjusted $R^2 = .36$), lower AIC (AIC = 88.31 vs. AIC = 94.77), and lower BIC (BIC = 96.84 vs. BIC = 108.2) than the full model, indicating better model parsimony and fit.

According to Appendix D, the residuals of the model were approximately normally distributed. Detailed model fit evaluation is presented in the footnote section of Appendix D. The Net Influence Plot of Figure D1 in Appendix D is a plot of the network, only edges that represent the strongest network correlation were depicted in the plot (Butts, 2008). Strongly positive edges were marked green, whereas strongly negative edges were marked red (Butts, 2008). The net influence plot suggests that the negative ρ was driven by edges in several of the clusters.

Discussion

Although previous SNAs suggested that individuals are more likely to interact with those sharing similar levels of depression or loneliness (Cacioppo & Cacioppo, 2018; Elmer, 2020; Prochnow et al., 2020), this analysis suggests that volunteering may promote a different pattern of peer interactions. The SNA suggested that SCP volunteers often made friends with people who had a *different* level of loneliness. Specifically, the negative network autocorrelation is mainly driven by less lonely volunteers connecting with lonelier individuals

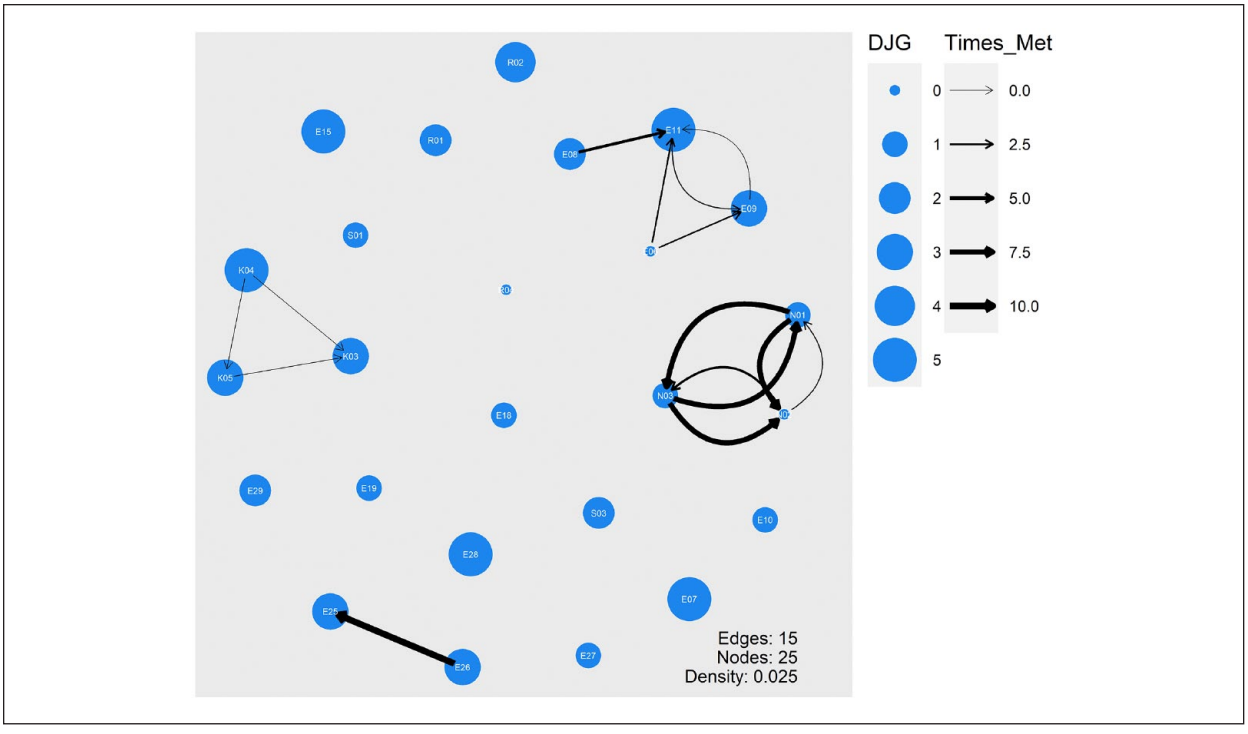

Figure 1. Visualization of the LNAM network.
Note. The size of the nodes represents individuals' DeJong Geirveild Loneliness Score (DJGLS). The larger the node, the lonelier the individual. The thickness of the ties reflects the frequency of meetings between the ego (participants) and their alters (nominated friends). After listwise deletion on the independent and dependent variables of LNAM, a total of 25 older adults were included in LNAM.

according to Figure 2, suggesting suggests that altruism on the part of the less lonely individuals may counteract any tendency for them to connect with others who are similar to themselves.

Results on the covariates in the LNAM are consistent with previous studies on diverse older adults (Dong & Chen, 2017; Johnson et al., 2019; Lee et al., 2020; NASEM, 2020). Age, gender, education, and the number of family and friends interacted with outside the program all correlate with the loneliness of SCP volunteers in expected directions. These factors appear to be correlated with loneliness regardless of nationality, which was removed from the model without altering their significance. This serves to replicate earlier findings from studies that did not account for social network structure. Moreover, although this SCP connected volunteers who were lonely with their less lonely peers, it did not appear to address other underlying factors associated with loneliness.

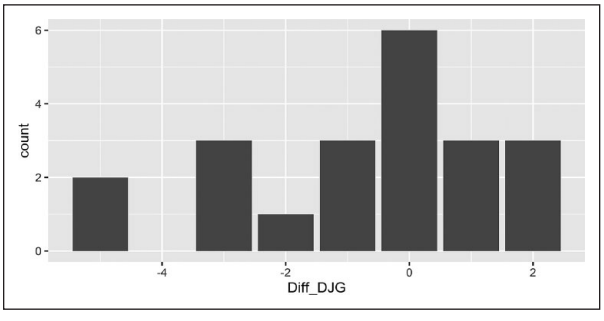

Figure 2. Histogram of difference in loneliness scores among edges.
Note. DJG refers to the scores of De Jong Gierveld Loneliness Scale. Higher scores in DGJ indicate higher loneliness. Diff_DJG = ego DJG-alter DJG. Diff-DJG is *negative* when alters (nominated friends) are lonelier than egos (participants) who nominated them. Count refers to the number of edges or ties.

Implications for Research

Building on this exploratory cross-sectional SNA, more scholars shall collect larger samples and conduct longitudinal SNAs to further examine the evolution of social network structures that might ameliorate loneliness. Analyses of social networks and mental health have typically sought to compare the role of *social selection* (connecting with lonely individuals because they are already feeling lonely) to that of *social influence* (feeling lonely after connecting to a lonely individual) in the process of social contagion (Prochnow & Patterson, 2022) to better comprehend the social mechanism between volunteering and older adults' psychosocial well-being. This study implies that researchers and practitioners should also consider the possibility that individuals might consciously select those who differ from them in certain characteristics.

Additionally, studies on older immigrants and refugees have tended to use community samples from

Table 2. Results From the Linear Network Autocorrelation Model.

	Estimate	*SE*	*Z* value	*p*-Value
Age	0.05	0.008	6.61	4e−10***
Gender	1.01	0.43	2.38	.018*
Education	−0.28	0.13	−2.17	.03*
Number of family and friends	−0.08	0.02	−4.51	6e−06***
Frequency of volunteering	0.02	0.02	1.39	.17
p-Value	−.06	.03	−2.21	.03*

Note. "Number of family and friends" refers to the number of family and friends participants see or hear from at least once a month. For gender, male = 0 and female = 1. Because Education has more than five ordered categories (no high school degree, high school degree or equivalent, some college, no degree, Associate degree, Bachelor's degree, and graduate or professional degree), it was treated as a continuous variable (Wu & Leung, 2017). The frequency of volunteering was kept in the final model because removing it would have changed the significance of education. AIC: 88.31 BIC: 96.84; Multiple R^2: .58, Adjusted R^2: .45. Also, ρ quantifies the network autocorrelation in a network. $p < \mathbf{0.}1$. *$p < .05$. **$p < .001$. ***$p < .0001$.

ethnic enclaves or ethnoburbs (Dong et al., 2014). This study demonstrates that agencies that serve diverse older adults offer alternative settings with the characteristics necessary to conduct studies of networks that include participants of multiple ethnicities (Leenders, 2002). Building on previous whole network studies of institutionalized older adults (e.g., Casey et al., 2016; Mauldin et al., 2021; Schafer, 2015), this study implies that non-profit organizations serving community-living older adults, such as volunteer programs, offer a natural programmatic boundary that is ideal for examining the whole networks of community-living older adults. Practitioners and researchers shall also more intentionally evaluate the social dynamics and psychosocial well-being of diverse older adults within multicultural programs.

Implications for Practice

Findings have implications for volunteer recruitment. By selecting individuals with altruistic intentions into the volunteer program, the volunteering environment may facilitate socialization among people with differing levels of loneliness, thereby preventing the reinforcement of negative emotions among lonely individuals. Given the nature of volunteering, such selection may happen naturally. In contrast to previous social network studies that illustrated how individuals' loneliness is correlated with others' loneliness in the network (Cacioppo et al., 2009), this study finds that interactions among volunteers are not only an integral component of organized volunteer programs but might also play a critical role in how volunteering alleviates loneliness. The altruistic tendencies among volunteers may prevent the reinforcement of loneliness among lonely volunteers. Volunteer programs could assess and facilitate social interactions among volunteers to maximize the social benefits of volunteering. Practitioners can consider facilitating the connection from lonelier to less lonely individuals to further prevent the negative reinforcement of loneliness.

Limitations

Although LNAM in this study suggested that older volunteers' loneliness is negatively correlated with the loneliness of their peers, causal peer influence cannot be established in this cross-sectional study. Furthermore, because a random sample cannot be used to construct a whole network in which nodes/individuals might know each other, each whole social network study is effectively a case study of the network in one setting. The findings in this study are therefore a case study of one SCP network and need replication. Additionally, because we did not conduct cognitive or functional screening when selecting study participants, it is unclear how generalizable the study is to individuals with varying cognitive or functional abilities. Due to the impact of COVID-19, only approximately half of SCP volunteers participated in the data collection, contributing to missing data in the friendship nomination form. As a result, the length of residence and age at migration did not yield sufficient valid responses to be included in the LNAM. Due to the lack of imputation software for LNAM in R, listwise deletion was employed, limiting the statistical power of this SNA (Wang et al., 2014). Although the network autocorrelation coefficient was significant in this study, it is likely underestimated due to missing data (Wang et al., 2014). Better-powered SNAs shall replicate this study to further validate the findings. Volunteers who participated in the study might also have differed from volunteers who did not in their received social support, health status, extraversion, etc.

Conclusion

To the best of our knowledge, this is the first study that uses a social network model to analyze the correlates of loneliness among older volunteers. Findings imply that interactions among volunteers are not only an integral component of organized volunteer programs but might also play a critical role in how volunteering alleviates loneliness. Future whole network studies shall collect larger samples to further examine how interactions among volunteers are associated with their loneliness.

Appendix A

Friendship Nomination FormCan you please name up to 5 people you met through Senior Companion Program (SCP) whom you regard as friends? Please only name people you consider as friends.

*Please answer the following questions regarding your **friends** a through e when applicable. Thank you.*

Your first and last name in print:.

1. Full names of people you met through SCP whom you regard as friends. *Please print their first and last name.*	2. What is the person's gender? *Please darken only one circle.*	3. What is the person's age?	4. What is the person's race? *Please check all that apply.*	5. What is the person's country/region of origin? *Please darken only one circle.*	6. What is the highest level of education the person received? *Please darken only one circle.*	7. How did you first meet the person? *Please darken only one circle.*	8. Have you introduced this person to your friends or family members outside of SCP? *Please darken only one circle.*	9. How many times have you interacted with (e.g., in-person, phone) this person in the past month?
Example: Jane Doe	• Female ○ Male ○ Other (please specify): _____	62	☐ White ☑ Black or African American ☐ American Indian or Alaska Native ☐ Asian or Pacific Islander ☐ Hispanic or Latino/ Latina/Latinx ☐ Other (please specify): _____	• United States ○ China ○ Bhutan ○ Cambodia ○ Nepal ○ Russia ○ Somalia ○ Other (please specify): _____	○ No high school degree ○ High school degree or equivalent ○ Some college, no degree Associate's degree • Bachelor's degree ○ Graduate or professional degree	• This person is also a volunteer of the Senior Companion Program (SCP) ○ This person is a client from the SCP ○ This person is a staff member of the SCP ○ Other (please specify): _____	• Yes ○ No	5

Note. The number of friends nominated is limited to five to minimize the participation burden and to capture true friendships within SCP recommended by SCP staff members familiar with the depth and breadth of the social relationships and referencing best practices from the literature (Marin & Hampton, 2007). Requesting more than five friendship nominations might lead to nominations of non-friends to fill the spaces (Marin & Hampton, 2007).

Appendix B

De Jong Gierveld Loneliness Scale

The following questions inquire about your experiences with loneliness. please darken • only one circle.

1. I experience a general sense of emptiness [EL]
   - ○ Yes
   - ○ More or less
   - ○ No
2. I miss having people around me [EL]
   - ○ Yes
   - ○ More or less
   - ○ No
3. I often feel rejected [EL]
   - ○ Yes
   - ○ More or less
   - ○ No
4. There are plenty of people I can rely on when I have problems [SL]
   - ○ Yes
   - ○ More or less
   - ○ No
5. There are many people I can trust completely [SL]
   - ○ Yes
   - ○ More or less
   - ○ No
6. There are enough people I feel close to [SL]
   - ○ Yes
   - ○ More or less
   - ○ No

Source. Gierveld and Tilburg (2006).

The first three questions in the DJGLS assess emotional loneliness via negatively worded items whereas the last three questions assess social loneliness via positively worded items. Each question had three response options (yes, more or less, and no). In the negatively worded questions (Questions 1–3), the neutral ("More or Less") and positive answers ("Yes") were scored as 1, suggesting the presence of emotional loneliness. For positively worded questions (Questions 4–6), the neutral answer ("More or Less") and the negative answer ("No") were scored as a 1, indicating the presence of social loneliness. A higher score indicates higher loneliness (De Jong Gierveld & Van Tilburg, 2008).

Appendix C

Analytical Details of LNAM

This study fits and evaluates Linear Network Autocorrelation Models (LNAM) using software from the *sna* package in R (need reference). LNAM quantifies the autocorrelation between individuals who are connected in a network (Leenders, 2002). Network autocorrelation refers to how the characteristics of one person correlate with those of others in the network (Salway et al., 2018). This study has adopted the *network effect model* (Leenders, 2002; Salway et al., 2018) to understand how the volunteers' loneliness correlates with that of peers. The *network effect model* uses a formula derived from that of linear regression and was given by

$$y = \rho W y + X\beta + \varepsilon, \quad \varepsilon \sim N(0, \sigma^2 I) \tag{1}$$

Here, y is a vector representing the dependent variable for all nodes, ρ is a coefficient expressing the correlation of network structure in combination with the dependent variable, W is the adjacency matrix representing the structure of the network, X represents the independent variables, β is the regression coefficient, and ε represents the error term, which is given by a normal distribution N with mean 0. Including y on *both sides* of equation (1) introduces the dependences of y into the model and allows researchers to identify how participants' loneliness is correlated with that of peers. In this study, a *positive* ρ indicates that individuals socialize with those sharing the *same* level of loneliness whereas a *negative* ρ indicates that individuals connect with those *differing* in their level of loneliness (Salway et al., 2018).

Appendix D

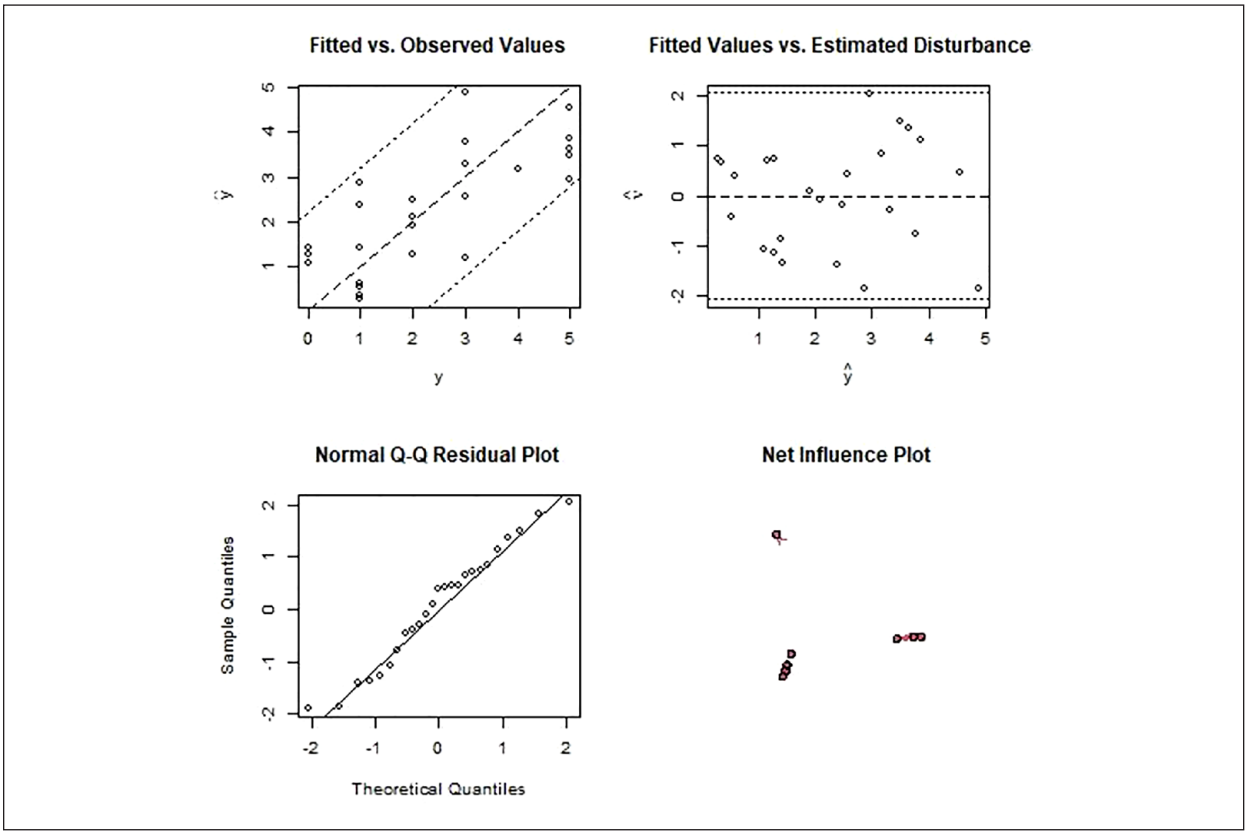

Figure D1. Residual plots and net influence plot from LNAM.
Note. The upper left plot displayed the fitted ($\hat{y}$) versus observed values (y) of loneliness. On the diagonal in this plot, $\hat{y}=y$. All points in this first plot were close to the diagonal, suggesting that our LNAM successfully produced loneliness estimates resembling the observed loneliness values in this network (Wasserman, 2005). The upper right plot comparing the fitted values ($\hat{y}$) and estimated disturbance $\hat{v}$ (errors) indicated that the error terms were randomly distributed in this model (Wasserman, 2005). An inspection of the normal quartile-to-quartile (Q–Q) residual plot in the lower left suggested that our sample quartiles were consistent with the theoretical quartiles that assume a normal distribution (Wasserman, 2005). In other words, the data were approximately normally distributed. The net influence plots of this network suggested that most edges had a mild correlation with one another and only a few edges had a strong negative correlation with others.

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Declaration of Conflicting Interests

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Ethical Approval

The study procedures were reviewed and approved by the Institutional Review Board (IRB) of The Ohio State University, Study ID 2021B0254.

ORCID iD

Qiuchang (Katy) Cao https://orcid.org/0000-0003-0461-4731

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