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Community Eldercare Services, Living Arrangements and Late-life Cognitive Vulnerability: A Cross-lagged Panel Network Study in China

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Abstract: Background: In China, cognitive impairment remains common despite social improvements. Community-based eldercare services are central to aging in place, yet evidence on how specific service components relate bidirectionally to distinct cognitive domains across living arrangements remains limited. Objectives: To estimate bidirectional, domain-specific longitudinal links between perceived availability of eight community-based eldercare services and five Mini-Mental State Examination (MMSE) cognitive domains, and to compare these dynamics between older adults living alone versus co-residing with family in China. Methods: Using two waves of the Chinese Longitudinal Healthy Longevity Survey (2014 and 2018; N = 1,649 adults aged ≥65 years), we modelled five MMSE domains and perceived availability of eight community services in cross-lagged panel networks, stratified by living alone versus co-residing with family. Results: Service–cognition networks were denser and more bidirectional in co-residing households, whereas among older adults living alone cross-domain links were sparser and primarily flowed from cognition to later service availability.

Keywords: Cognitive aging, Cross-lagged panel networks, Community-based eldercare services, Living arrangements

1. Introduction

Population ageing has brought late-life cognitive health to the foreground of public health and social policy (Jia et al., 2020; Prince et al., 2013). Although dementia remains a key endpoint, subtle declines in orientation, memory, attention, and language often precede clinical diagnosis by years and already compromise autonomy, increase fall risk, and accelerate long-term care use (Gnjidic et al., 2012). These cognitive domains follow partly distinct trajectories and determinants across adulthood, with some abilities showing earlier and steeper decline than others (Singh-Manoux et al., 2012). In China and other rapidly greying societies, cohort studies document that cognitive impairment remains common at older ages despite rising education and improving

living conditions, with prevalence rising sharply with age (Jia et al., 2020). Identifying modifiable social and service environments that preserve domain-specific cognitive function has thus become a central challenge for population ageing research and policy (Gao et al., 2024).

Home- and community-based eldercare services have emerged worldwide as a central policy instrument to support aging in place and potentially delay cognitive decline (Casado et al., 2011). These services typically include daily life assistance, home medical visits and medication delivery, emotional support and friendly visiting, help with shopping, social and recreational activities, legal aid, health education, and mediation of family or neighborhood disputes (Lin et al., 2023). Observational studies consistently find that greater availability or use of community-based services is associated with better global cognitive scores and lower subsequent risk of cognitive impairment, even after adjustment for socioeconomic and health covariates (Lin et al., 2023). At the same time, work in Europe, Australia, and North America shows that cognitive status itself predicts subsequent mixes and intensities of home- and community-based services, with more impaired clients tending to receive more respite care and social services but not necessarily more medical or preventive support (Sonnega et al., 2017). Together, this literature suggests a dynamic, bidirectional relationship in which concrete service components and specific cognitive domains may shape one another over time (Lin et al., 2023).

Household context is likely to condition these dynamics in fundamental ways (Burnette et al., 2021). In China and many other settings undergoing rapid demographic and social transition, the share of older adults living alone or only with a spouse has increased, while multi-generational households have declined (Burnette et al., 2021). Longitudinal studies indicate that living arrangements are associated with different trajectories of cognitive decline. Living alone has been linked to greater risks of cognitive decline, loneliness, and depression in some cohorts, yet coresidence with adult children can also be associated with stress, disability, and cognitive impairment, particularly under conditions of economic strain or intergenerational conflict (Lin et al., 2023). From a service perspective, people living alone with cognitive impairment appear simultaneously more reliant on formal support and at higher risk of receiving inadequate or poorly matched services compared with those living with others (Eichler et al., 2016). Nevertheless, little is known about how living alone versus living with others modifies the longitudinal interplay between specific community service components and distinct cognitive domains.

A further limitation of existing work lies in how both community-based services and cognition are operationalized and modelled. Most quantitative studies collapse heterogeneous items—such as different types of daily care, medical support, information provision and social activities—into a single “service availability” or “service use” index, and summarize cognition using a total Mini-Mental State Examination (MMSE) score (Lin et al., 2023). Yet late-life cognition is multidimensional: orientation, immediate memory, attention, delayed recall and language have partly distinct biological and social determinants, and support different everyday tasks and forms of independence (Tucker-Drob, 2011). Recent network and longitudinal analyses show that specific functional limitations and cognitive domains may act as bridge nodes linking broader systems of disability, mood symptoms and survival, underscoring the value of moving beyond global scores (Feng et al., 2025). Emerging longitudinal studies of social participation, community services and cognition, however, have largely relied on latent-variable or aggregate cross-lagged panel models, which are not

designed to identify which concrete services predict which cognitive domains, nor to capture feedback from cognition back to particular service components.

Against this background, we use data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), a large cohort of community-dwelling older adults, to construct cross-lagged panel networks linking 8 types of community-based eldercare services with five MMSE domains (orientation, immediate memory, attention, delayed recall and language). Building separate networks for older adults living alone and those living with others, we estimate which specific services prospectively predict improvements or declines in particular cognitive domains, which cognitive domains forecast subsequent uptake of distinct services, and how these patterns are conditioned by household context. By mapping domain-specific, bidirectional pathways between concrete community services and cognitive functioning across different living arrangements, our findings aim to inform the design of community-based care strategies that more precisely target the components, contexts and cognitive dimensions most amenable to intervention in rapidly ageing societies.

2. Method

2.1 Participants

Data were derived from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), an ongoing, nationally representative prospective cohort of older Chinese adults. The CLHLS, conducted by the Center for Healthy Aging and Development Studies at Peking University in collaboration with Duke University, employs multi-stage stratified sampling of roughly half of the counties and cities in 23 of China's 31 provinces, covering about 85% of the national population. It collects repeated, face-to-face interviews on sociodemographic characteristics, health status, cognitive function, family and community resources, and health behaviors among adults aged 65 years and older. By design, the CLHLS oversamples the oldest-old, providing a vibrant population-based resource for research on very late life and longevity.

We used the two most recent publicly available waves of the CLHLS, collected in 2014 (time 1, T1) and 2018 (time 2, T2). At the 2014 baseline, 5,246 participants were interviewed. By the 2018 follow-up, 1,259 individuals (24.0%) were lost to follow-up, and 1,547 (29.5%) had died. After listwise deletion of missing values and accounting for sample attrition from T1 to T2, the final analytic sample comprised 1,649 participants. A detailed participant flow diagram depicting sample selection between T1 and T2 is presented in Figure 1. In addition, we used a Love plot (Supplementary Figure S1) to evaluate the impact of attrition and missing data on the composition of the sample; the pattern of standardized differences indicated that loss to follow-up and missingness from T1 to T2 did not materially alter the distribution of baseline sociodemographic characteristics observed at T1.

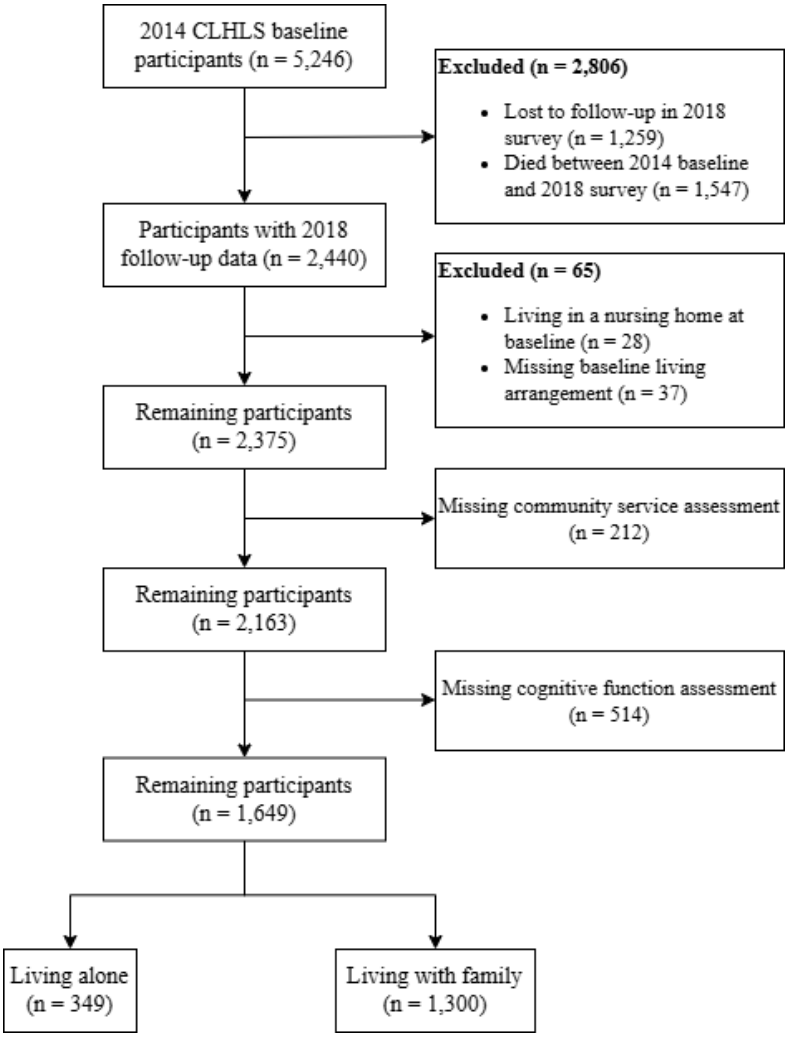


Figure 1: Participant Flow Diagram and Sample Selection Process

2.2 Measures

2.2.1 Cognitive function

Cognitive function was evaluated with the Chinese version of the Mini-Mental State Examination (MMSE) administered in the CLHLS. The version used in this survey comprises 24 items covering five domains of cognition: orientation, immediate memory, attention and calculation, delayed recall, and language. Domain-specific scores were obtained by summing the relevant items, with higher scores indicating better cognitive performance in that domain. To standardize the metric and facilitate comparison across domains and waves, each domain score was then linearly rescaled to a continuous 0–1 range, with higher values again reflecting better cognitive performance (Han et al., 2023). This MMSE adaptation has been widely applied in population-based studies of Chinese older adults, including CLHLS-based research, and shows good reliability, construct validity, and screening accuracy for cognitive impairment (Ma et al., 2025). The MMSE scale demonstrated good internal consistency across waves, with Cronbach's α values of 0.805 at T1 and 0.783 at T2.

2.2.2 Perceived availability of community-based eldercare services

Community-based eldercare services were assessed in the CLHLS using items on the perceived availability of eight types of formal home- and community-based supports for older residents in the respondent's neighborhood: personal daily care, home medical visits and medication delivery, psychological or emotional support, assistance with daily shopping, social and recreational activities, legal aid, health education, and mediation of family or neighborhood disputes. At each wave, each service type was coded as a binary indicator (1 = available, 0 = not available) and treated as a separate observed variable and node in the longitudinal cross-lagged network models (Yu et al., 2021; Yu et al., 2024). The scale demonstrated good internal consistency across waves, with Cronbach's α values of 0.761 at T1 and 0.814 at T2.

2.2.3 Living arrangement (living alone vs co-residing with family)

Living arrangement was defined using baseline (T1) information, following Li et al. (2022); Zheng et al. (2023). In the CLHLS, respondents were asked, "Who do you live with at present?", with response options: (1) with family members (including live-in domestic helpers), (2) living alone, and (3) living in an institutional care facility. For the present analyses, we restricted the sample to older adults who either lived alone or co-resided with family at T1, excluding those living in institutions because they fell outside the scope of community-based eldercare.

2.3 Analytical Strategy

All data preparation, cleaning, and descriptive analyses were conducted in Python (version 3.12). Cross-lagged panel networks (CLPNs) were estimated and visualized in R (version 4.5). Specifically, autoregressive and cross-lagged parameters were obtained using regularized regression models implemented in the glmnet package, relying on maximum likelihood estimation with a least absolute shrinkage and selection operator (LASSO) penalty. In line with recent methodological recommendations for CLPN modelling, cross-validation-based LASSO has been shown to yield relatively high sensitivity (albeit at the cost of lower specificity) across a range of conditions. We therefore applied LASSO regularization with the tuning parameter selected via 10-fold cross-validation to estimate the cross-lagged coefficients (Wysocki et al., 2025). All cross-lagged coefficients were reported as standardized estimates, facilitating comparison of effect sizes across variables and time points.

Network visualization and centrality analyses were performed using the qgraph and ggplot2 packages. Node centrality was quantified using four indices: in-expected influence (IEI), out-expected influence (OEI), 1-step bridge expected influence (BEI1), and 2-step bridge expected influence (BEI2). Expected influence indices were chosen because they incorporate both positive and negative edge weights in directed networks. Conceptually, IEI captures the extent to which a given node is influenced by all other nodes in the network, whereas OEI reflects the overall influence a node exerts on other nodes. To characterize bridging between communities of nodes, BEI1 indexes direct connections to nodes in other communities, while BEI2 additionally incorporates indirect connections mediated by intermediate nodes (Jones et al., 2021).

To evaluate the robustness and stability of the estimated networks, we followed established procedures implemented in the bootnet package. We used nonparametric bootstrapping with 5,000 resamples to assess the

precision and reliability of edge-weight estimates and derived 95% confidence intervals (CIs) around these parameters. In addition, we evaluated the accuracy and stability of node centrality indices using case-dropping subset bootstraps, yielding correlation stability (CS) coefficients. Current methodological guidelines suggest that CS values above 0.25 indicate acceptable stability, whereas values above 0.50 reflect highly robust and reliable network indices.

3. Results

3.1 Demographic characteristics

The analytic sample comprised 1,649 older adults (Supplementary Table S1), including 349 (21.16%) living alone and 1,300 (78.84%) co-residing with family. All participants were aged ≥67 years: 974 (59.07%) were 67–79 years, 504 (30.56%) were 80–89 years, 145 (8.79%) were 90–99 years and 26 (1.58%) were centenarians. Men and women were almost equally represented (822 [49.85%] and 827 [50.15%], respectively). Most respondents lived in rural areas (1,290; 78.23%), with 144 (8.73%) residing in urban settings; residence was missing for 215 participants (13.04%). Educational attainment was generally low: 519 (31.47%) had no formal schooling and 144 (8.73%) had attended school without completing primary education, whereas 299 (18.13%), 297 (18.01%) and 129 (7.82%) had completed primary, middle and high school, respectively; only 31 participants (1.88%) had a college education or higher, and education data were missing for 230 (13.95%). At T1, the mean normalized MMSE cognitive function score for the full sample was 0.926 (0.060), with no significant difference between older adults living alone and those co-residing with family (0.921 vs. 0.928; $t = -0.994$, $p = 0.320$). At T2, the mean cognitive function score had declined to 0.8836 (0.080), again with no significant difference between living-arrangement groups (0.883 vs. 0.885; $t = -0.143$, $p = 0.887$), indicating an overall decline in cognitive performance over time (see Supplementary Table S2 & S3).

3.2 Network stability and accuracy

Nonparametric bootstrap analyses yielded small-to-moderate 95% confidence intervals for edge weights in both CLPNs, indicating adequate accuracy of the estimated temporal associations for participants living with family and those living alone (Supplementary Figure S2 & S3). Case-dropping analyses further suggested robust edge-weight stability, with CS-coefficients of 0.543 for the co-residing network and 0.344 for the living-alone network. Centrality indices were also acceptably stable: CS-coefficients for bridge, in- and out-expected influence ranged from 0.378 to 0.626 in the co-residing network and from 0.272 to 0.415 in the living-alone network, all exceeding the recommended threshold of 0.250 (see Supplementary Table S4, Supplementary Figure S4 & S5).

3.3 Cross-lagged panel network models

Cross-lagged network structure differed sharply by living arrangement (Figure 2 & 3). Among older adults living alone, 42 non-zero cross-lagged edges (83.3% positive) yielded an edge density of 26.9%; among those co-residing with family, 72 edges (80.6% positive) produced a density of 46.2%. Across both networks, attention (C3; OEI = 0.23 in the living-alone network and 0.38 in the co-residing network) and orientation

(C1; OEI = 0.07 and 0.32, respectively) were the central cognitive nodes, while caregiving support (CS1; OEI = 0.45 and 0.11), companionship visits (CS3; OEI = 0.32 and 0.17), recreation activities (CS5; OEI = 0.15 and 0.20) and rights/advocacy services (CS6; OEI = 0.10 and 0.07) were the most influential service nodes (see Figure 4 & 5).

In the living-alone network (Figure 2 and Supplementary Table S5), influence flowed predominantly from cognition to later service availability. Cross-domain edges from cognition to services (7 edges) outnumbered those from services to cognition (4 edges). The strongest paths arose from attention and immediate memory: higher attention predicted fewer subsequent companionship visits (C3→CS3, $\beta = -0.08$), and better immediate memory predicted lower rights/advocacy services (C2→CS6, $\beta = -0.08$). Attention and immediate memory also showed the largest (negative) bridge expected influence among cognitive nodes, indicating that they were key senders towards the service domain. On the service side, recreation activities and rights/advocacy were the main bridges into cognition. Recreation predicted higher delayed recall and language (CS5→C4, $\beta = 0.06$; CS5→C5, $\beta = 0.02$) and had the highest bridge influence among services, while rights/advocacy predicted better subsequent attention (CS6→C3, $\beta = 0.03$). Within-domain influences were less pronounced; caregiving support and companionship had high out-expected influence (OEI = 0.45 and 0.32) but mainly targeted other services rather than cognition.

In contrast, the co-residing network (Figure 3 and Supplementary Table S6) showed denser and more reciprocal coupling between services and cognition. Cognition predicted later services through 15 cross-domain edges and services predicted cognition through 12 edges. Attention and language were the dominant cognitive bridges, sending cross-domain signals to caregiving, recreation, rights/advocacy and mediation services (e.g. C3→CS1/CS5/CS6/CS8, βs ≈ 0.02–0.03; C5→CS6, $\beta = 0.04$). On the service side, help with shopping and mediation/coordination had the largest bridge influence and were strongly linked to delayed recall and language (CS4→C4, $\beta = 0.06$; CS4→C5, $\beta = 0.04$; CS8→C4, $\beta = -0.07$). These edges converged on delayed recall as the most strongly influenced cognitive node (highest in-expected influence), while rights/advocacy was the most strongly influenced service node, receiving inputs from several services and from language and attention.

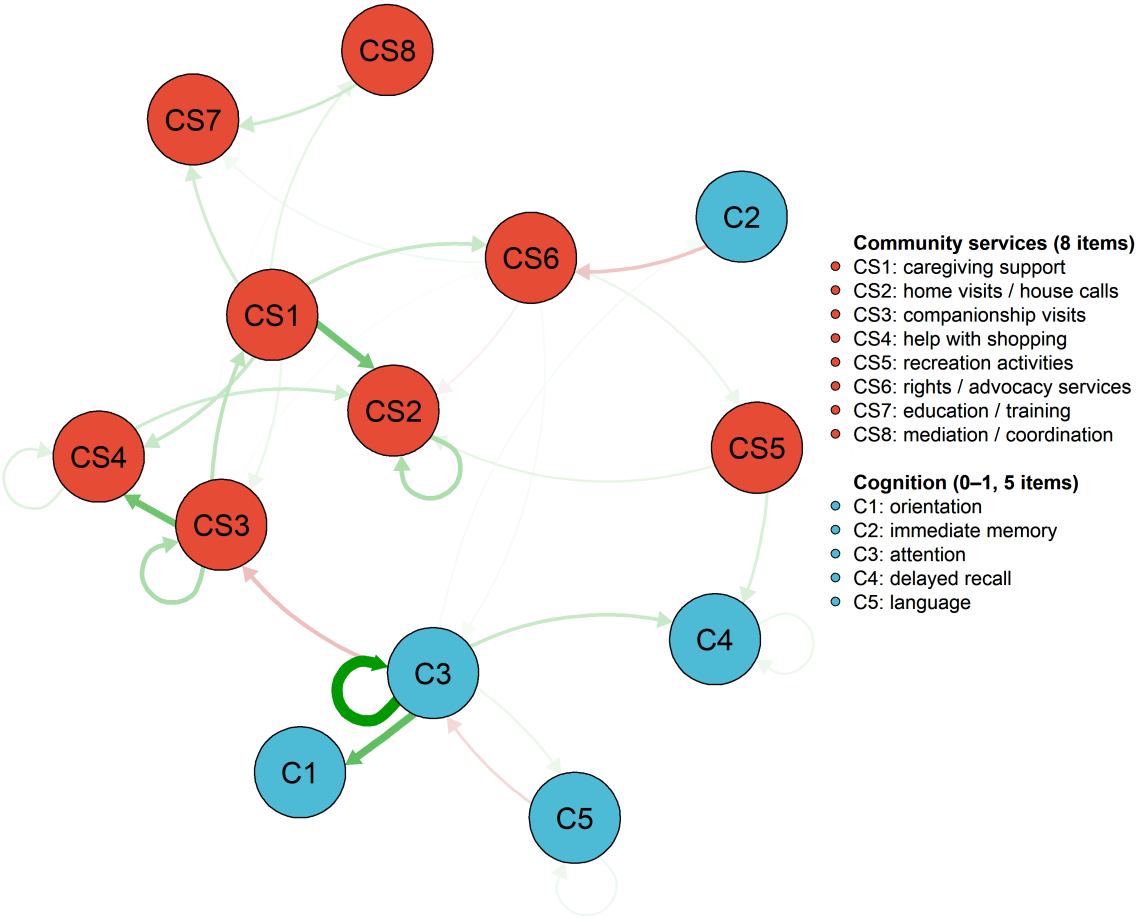


Figure 2: Cross-lagged panel networks of living alone group. Estimated using regularized regression on standardized variables within the CLPN framework. Edge color indicates the direction of association (red, positive; blue, negative), and edge thickness and opacity are proportional to the absolute magnitude of the corresponding regression coefficient.

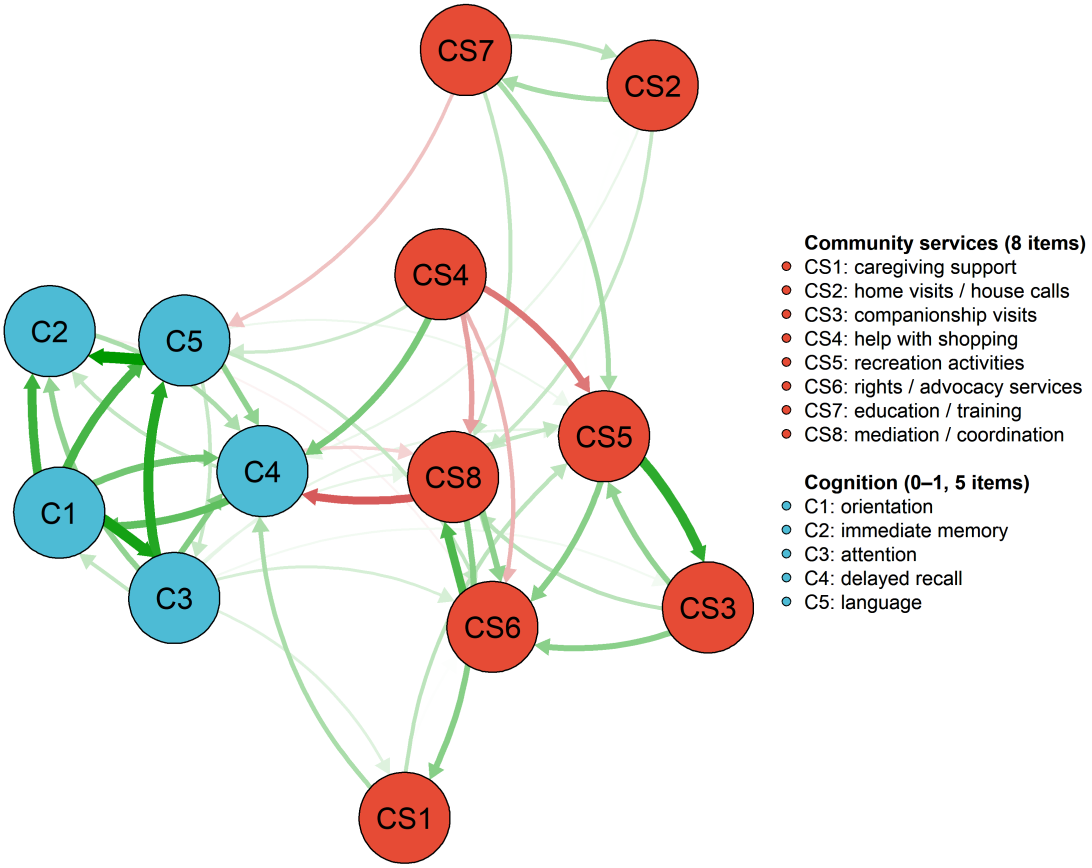


Figure 3: Cross-lagged panel networks of the co-residing group. Estimated using regularized regression on standardized variables within the CLPN framework. Edge color indicates the direction of association (red, positive; blue, negative), and edge thickness and opacity are proportional to the absolute magnitude of the corresponding regression coefficient.

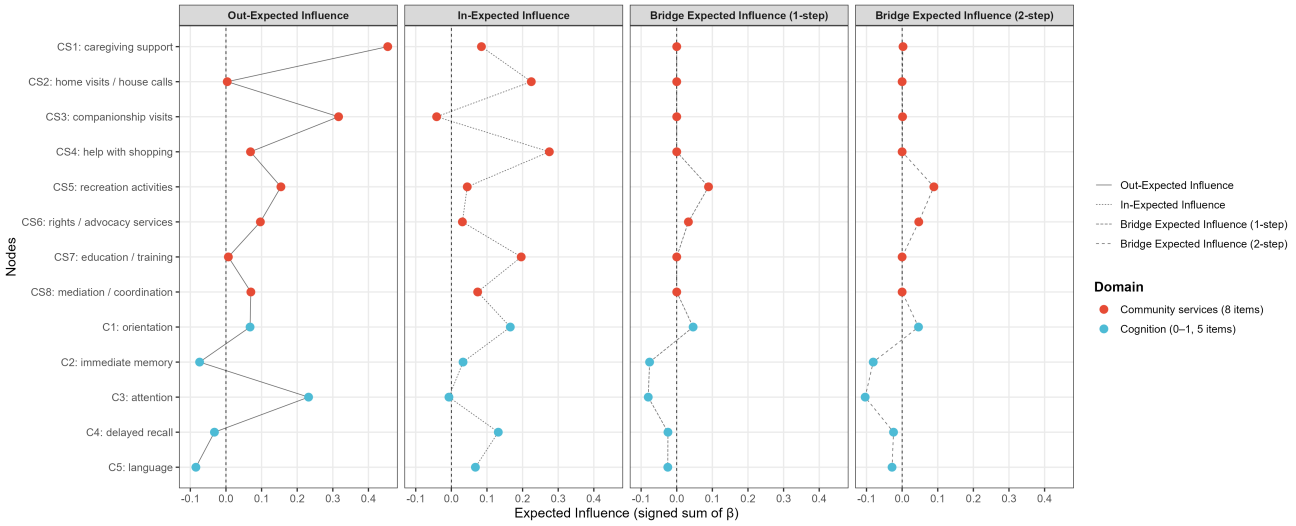


Figure 4: Node Centrality of the CLPN (living alone): Expected Influence and Bridge Expected Influence. Panels display out- and in-expected influence (signed sums of outgoing/incoming β) and 1-step/2-step bridge expected influence for each node; points are colored by domain, and the vertical dashed line marks zero, such that values farther from zero (i.e., larger absolute expected influence) indicate greater influence and cross-domain connectivity, while the sign reflects whether a node exerts a net positive or negative effect.

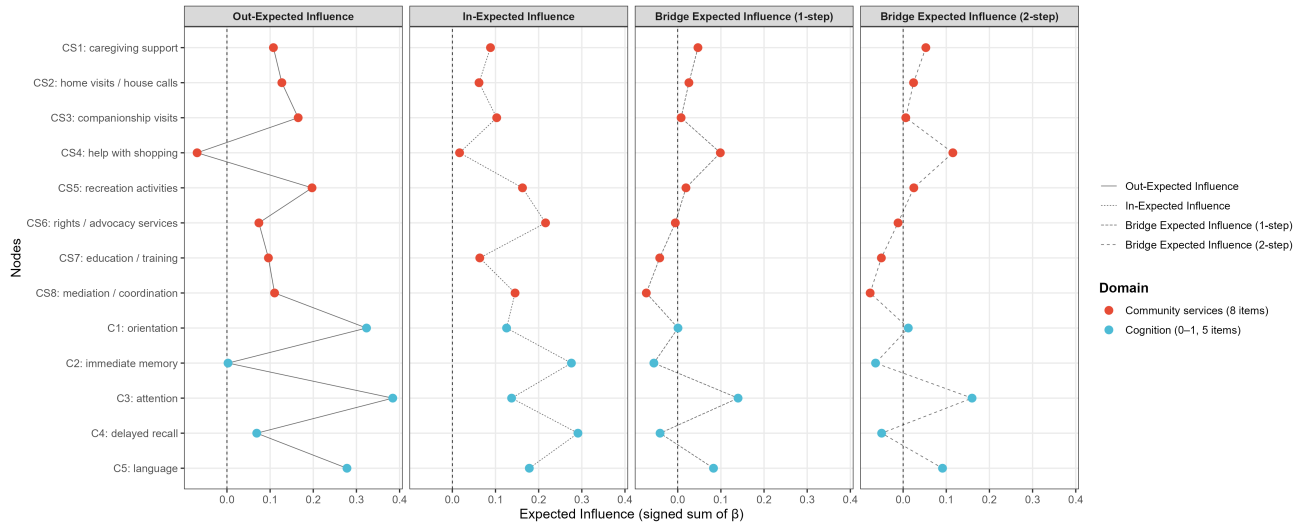


Figure 5: Node Centrality of the CLPN (co-residing group): Expected Influence and Bridge Expected Influence. Panels display out- and in-expected influence (signed sums of outgoing/incoming β) and 1-step/2-step bridge expected influence for each node; points are colored by domain, and the vertical dashed line marks zero, such that values farther from zero (i.e., larger absolute expected influence) indicate greater influence and cross-domain connectivity, while the sign reflects whether a node exerts a net positive or negative effect.

4. Discussion

This study used cross-lagged panel network analysis of nationally representative CLHLS data to examine how perceived community services and cognitive functioning are interconnected over time among older adults living alone and those living with others. By modeling temporal associations at the level of specific services and cognitive domains, and by estimating separate networks for different living arrangements, we were able to describe how the structure of these interdependencies changes with residential context. The findings suggest that living arrangement not only alters exposure to risks and resources, but also reshapes how community services and cognitive processes become linked over time.

A first central observation is that the network linking perceived community services and cognitive domains was denser among older adults who did not live alone than among those who lived alone. In the non-living-alone group, more services were connected to more cognitive domains, and the overall density of cross-domain associations was higher. This pattern suggests that, for older adults who share a household with family members or other co-residents, community services are more tightly embedded in the everyday cognitive environment. In contrast, the sparser network among those living alone indicates that perceived services are less systematically tied to changes in cognition in this group, and that the apparent “protective” structure of services is more fragmented. These findings are broadly consistent with previous research showing that co-residence and stronger social convoys are associated with greater awareness and use of formal services and with better maintenance of cognitive function, whereas living alone is often linked to weaker connections with formal support systems and higher risk for cognitive decline (Sharifian et al., 2020).

This contrast in network density can also be understood as reflecting different modes of service engagement. Among non-living-alone older adults, the more saturated and reciprocal network suggests a pattern closer to "pre-emptive" or "embedded" use: community services appear as part of an ongoing support system that interacts with cognition across multiple domains. By comparison, the weaker, more selective links among those living alone point toward a more "need-driven" pattern, in which services are mobilized for specific problems rather than being integrated into daily life. This interpretation is consistent with earlier work documenting that older adults living alone often delay help-seeking and underutilize preventive or enrichment services, especially when cognitive function is still relatively preserved (Du et al., 2022). Taken together, our results suggest that the existing configuration of community services may inadvertently reinforce inequalities, with non-living-alone older adults better positioned to translate service availability into cognitive benefits, while those living alone remain only loosely connected to the service infrastructure.

A notable finding in the non-living-alone group was the role of community-based dispute mediation services. In the CLPN network, perceived support for mediating disputes predicted lower subsequent cognitive scores. This pattern may reflect that older adults who need formal assistance to resolve family or neighborhood conflicts have often already developed subtle cognitive difficulties—for example, problems with memory, attention, or communication that make everyday interactions and negotiations more challenging (Martin et al., 2019). Conflicts related to finances, caregiving responsibilities, or co-residence may therefore come to the attention of community services at a stage when cognitive decline is already underway (Anantapong et al., 2025). In this sense, dispute mediation services are better understood as a marker of households in which cognitive vulnerability and psychosocial strain are already present (Bieber et al., 2019). The lack of a comparable predictive association in the living-alone group suggests that, when older adults live alone, conflicts either arise in different forms or are handled through informal channels that are not captured by the community service items, making dispute mediation a less informative indicator of cognitive status in that group.

Bridge analysis further clarifies which specific services and cognitive domains occupy central positions in linking the service and cognitive subsystems. Among older adults living alone, recreation activities and rights/advocacy services emerged as the primary service bridges to cognition, especially in relation to delayed recall and language. This indicates that these services are key points through which the community environment connects to cognitively relevant experiences for this group. Recreational activities typically provide structured social participation, opportunities for learning, and mentally stimulating tasks, all of which place demands on memory and communication. Rights and advocacy services often involve navigating administrative procedures, understanding entitlements, and articulating personal needs or complaints, which again require language and executive resources. The positive predictive associations observed between these services and subsequent performance in delayed recall and language suggest that older adults who are engaged with these service nodes tend to show more favorable trajectories in these domains, or that those with stronger memory and language are more likely to seek out and sustain such engagement (Lin et al., 2023).

In the non-living-alone group, the bridging structure was more complex and more balanced. On the cognitive side, attention and language were the main bridge domains that connected multiple services to other aspects of cognition. This pattern suggests that changes in attention and language are particularly important in organizing how different cognitive functions co-evolve in households where older adults live with others (Zhang et al.,

2025). These domains are also among the most observable in everyday conversation and joint activities, which may make them central in how family members recognize cognitive changes and respond by mobilizing community resources (Reppermund et al., 2013). On the service side, help with shopping and dispute mediation or coordination had the strongest bridge roles and were closely linked to delayed recall and language. Shopping assistance is a prototypical instrumental activity that requires planning, orientation, and communication; the decision to involve community services in this domain often arises when families notice difficulties in managing daily tasks independently (Rosenfeldt et al., 2024). Its central position in the network indicates that it is a major interface where cognitive change and formal support intersect.

The negative predictive association between dispute mediation and delayed recall in the non-living-alone network is consistent with this interpretation (Dieker et al., 2024). Older adults who become involved in community-level conflict mediation are likely to be embedded in households or neighborhoods that are already under strain, and subtle declines in memory and communication may contribute to misunderstandings, role conflicts, or disagreements about care and finances (Williams et al., 2023). Dispute mediation appears in the network as a node that is preferentially activated in such situations, which are also contexts in which less favorable cognitive trajectories are more common (Mitrani et al., 2006). More generally, the more numerous and evenly distributed cross-domain links, together with the higher overall network density in the non-living-alone group, suggest that cognition and community services tend to change in a more synchronized way when older adults share a household with family members (Epskamp et al., 2017). Family members may simultaneously facilitate recognition of cognitive change, help negotiate access to community resources, and incorporate service participation into daily life, thereby tightening the connections across the network (Perry-Young et al., 2018).

These findings have several implications for public health practice and future research. For older adults living alone, the sparse structure of the service–cognition network and the centrality of recreation and rights/advocacy services suggest that current patterns of engagement leave many potentially beneficial connections underused. Strengthening outreach that links single-person households to recreational, social, and empowerment-oriented programs, and ensuring that these programs are accessible to those at early stages of cognitive change, may help to build a more integrated support environment for this group. Designing services that are explicitly tailored to the circumstances of living alone—such as low-threshold group activities, mobile rights counseling, or home-based cognitive stimulation—may be particularly important (Fantin et al., 2013).

For older adults living with others, the central bridge roles of shopping assistance and dispute mediation indicate that these routine and problem-oriented services may offer practical entry points for integrating cognitive health into community practice. Incorporating brief cognitive assessments, structured observation of daily functioning, or caregiver guidance into shopping assistance and conflict resolution encounters could improve the alignment between community services and the needs of families managing emerging cognitive impairment. Training community workers who deliver these services to recognize cognitive warning signs and to connect families with specialized assessment or support may further enhance this potential. Future longitudinal and intervention studies could test whether strengthening specific service nodes identified here as bridges leads to more favorable cognitive trajectories, and whether redesigning community services to better reach older adults living alone can reduce disparities in cognitive aging across different living arrangements.

5. Limitations

While this study leverages a CLPN approach to probe the bidirectional associations between cognitive functioning and community-based eldercare service use, and to distinguish older adults living alone from those co-residing with family, several limitations should be noted. First, CLPN as implemented here does not warrant causal inference. A central constraint is its inability to disentangle between-person differences from within-person dynamics, such that some prospective edges may primarily reflect stable inter-individual differences rather than genuine intra-individual change, potentially giving rise to statistical artefacts. In addition, perceived availability of community-based services was assessed via self-report, whereas the actual provision of services has at least partly exogenous determinants (for example, local policy priorities and infrastructural constraints). In conjunction with the structural assumptions of cross-lagged panel network models, this implies that the prospective edges linking perceived service availability and cognitive domains are best interpreted as a statistical characterization of longitudinal association patterns, rather than as a causal graph. More precise identification of mechanisms will require designs that more directly address endogeneity and levels of analysis, such as quasi-experimental evaluations of service expansion, multilevel network models, and more intensive longitudinal data.

Second, our CLPN specification followed prevailing methodological guidelines in using standardized coefficients to enable comparisons across paths. Although standardization facilitates visual and numerical comparability within the network, the interpretability of the resulting edge weights is constrained by differences in variances across indicators, a concern repeatedly emphasized in the statistical literature (Li et al., 2025). These coefficients therefore, index relative associations conditional on scale dispersion, and their substantive interpretation should be made with caution (Han et al., 2023). Emerging indices such as percentage beta have been proposed to enhance comparability of effects across variables and are increasingly adopted in other modelling frameworks, but they have not yet been systematically applied or validated in CLPN research and were therefore not used here (Ao et al., 2023).

Finally, the external validity of our findings is limited by the data source. The CLHLS intentionally oversamples older adults and provides a rich window onto ageing and eldercare in China, yet community-based service provision operates within a cultural and institutional context that differs markedly from many Western welfare regimes, including norms around filial obligations, household composition and the role of the state and market in care. As a result, the observed network structure between cognitive domains and perceived service availability may not generalise to settings with different cultural expectations and service systems, and cross-cultural extrapolations should be made with considerable caution.

6. Conclusion

This study used cross-lagged panel network analysis of nationally representative CLHLS data to show that living arrangements shape how perceived community services and specific cognitive domains influence one another over time. Compared with those living alone, older adults living with others displayed denser service–cognition networks, in which shopping assistance and dispute mediation were key bridges, whereas recreation and rights/advocacy services played central bridging roles among those living alone. These patterns provide

guidance for improving targeted community services and mitigating inequalities in cognitive aging across community living arrangements.

Competing Interests

The authors declare that they have no competing interests.

Data Availability

The data that support the findings of this study are from the Chinese Longitudinal Healthy Longevity Survey (CLHLS)-Longitudinal Data (1998-2018) and are available to registered users from the Peking University Open Research Data Platform at https://doi.org/10.18170/DVN/WBO7LK.

Ethical Approval

Data collection for the CLHLS was approved by the Biomedical Ethics Committee of Peking University. The present study involved secondary analysis of publicly available, de-identified data and did not require additional institutional ethics approval.

Informed Consent

Informed consent was obtained from all respondents or their proxy respondents by the CLHLS research team.

Author Contributions

Dianshi Moses Li: Conceptualization, Methodology, Formal analysis, Data curation, Visualization, Writing - original draft, Writing - review & editing, Project administration.

Luxi Zhang: Formal analysis, Validation, Writing - review & editing.

Yanyi Deborah Wang: Validation, Writing - review & editing.

Qiuyi Gao: Validation, Writing - review & editing.

Qinru Ruby Ju: Conceptualization, Methodology, Supervision, Resources, Funding acquisition, Writing - original draft, Writing - review & editing, Project administration.

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