

Multidimensional trajectories of intergenerational support and subsequent functional limitations among middle-aged and older adults in China: A population-based cohort study

Ping Wang

201710120@jxutcm.edu.cn

Jiangxi University of Finance and Economics

Chunhai Tao

Jiangxi University of Finance and Economics

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Abstract

Maintaining functional independence is a key goal of healthy ageing, yet intergenerational support is often examined as isolated dimensions or at single time points. We investigated whether longitudinal configurations of financial, practical, and relational exchanges with adult children were associated with subsequent functional limitations among middle-aged and older adults in China. Data were drawn from 12,769 participants aged 45–85 years in the China Health and Retirement Longitudinal Study (2011–2018). Group-based multi-trajectory modelling jointly characterized six indicators of intergenerational financial exchange, caregiving, and contact during 2011–2015. Multivariable regression models estimated associations between trajectory membership and 2018 instrumental activities of daily living (IADL) and activities of daily living (ADL) scores. Five trajectories were identified with good classification quality. Compared with the high multidimensional exchange–stable interaction trajectory, all other trajectories were associated with higher adjusted IADL scores, with the largest differences observed for increasing financial reciprocity–minimal interaction (mean difference 0.67, 95% CI 0.46–0.87) and increasing financial exchange–declining interaction (0.57, 0.24–0.91). ADL differences were smaller and did not remain statistically significant after correction for multiple comparisons. Results were robust across alternative outcome specifications, longitudinal weighting, restriction to participants without baseline functional limitations, and analyses accounting for trajectory-classification uncertainty. Associations varied most clearly by age and educational attainment. Multidimensional intergenerational-support trajectories were more consistently differentiated in instrumental functioning than in basic self-care, suggesting that jointly considering how financial, practical, and relational exchanges evolve over time may provide a more informative account of family-support contexts and functional ageing.

1. Introduction

Population ageing has made the preservation of functional independence a central concern of healthy ageing and long-term care. The World Health Organization conceptualizes healthy ageing in terms of maintaining functional ability through the interaction between individual capacities and physical and social environments (Organization, 2020). This issue is particularly salient in China, where population ageing is expected to substantially increase the number of older adults requiring assistance; by 2030, nearly 60 million adults aged 60 years or older may experience some degree of activities of daily living (ADL) or instrumental activities of daily living (IADL) dependency (Gong et al., 2022). Although closely related, IADL and ADL capture different dimensions of functioning. IADL reflects more complex activities required for independent community living, whereas ADL concerns basic self-care abilities (Pan et al., 2021). Examining both domains may therefore provide a more differentiated account of how social and family contexts are associated with functional ageing.

In China, these contexts remain strongly shaped by intergenerational relationships. Adult children are important sources of financial, practical, and relational support, but exchange is not simply unidirectional. Middle-aged and older parents may continue to provide financial assistance and grandchild care while receiving financial support, personal care, and contact from adult children. Intergenerational support is therefore increasingly understood as a reciprocal and multidimensional process embedded within changing family circumstances (Li & Guo, 2022; Liu, 2024; Yan, 2023; Yang et al., 2023). At the same time, smaller families, population mobility, changing living arrangements, and expanding formal care services are reshaping how these exchanges are organized. Rather than uniformly weakening family responsibility, such changes may generate increasingly diverse combinations of obligation, interaction, material exchange, and care (Liu, 2024; Yan, 2023).

This diversity may be relevant to functional health because different forms and directions of support do not necessarily have equivalent meanings. Financial transfers, practical assistance, and interpersonal contact represent distinct aspects of family exchange, while support received from adult children may also be responsive to emerging parental needs. Deteriorating health or functional difficulty may, for example, coincide with greater financial assistance, care, or contact. Consistent with this complexity, Chinese studies have reported heterogeneous associations between intergenerational support and health according to support type and direction, living arrangement, social context, and outcome (Kong et al., 2024; Li & Guo, 2022; Yang et al., 2023; Y. Zhao et al., 2023). Cross-sectional typological research has also linked receipt of instrumental support with greater functional limitations, illustrating why greater support receipt cannot necessarily be interpreted as indicating a more favourable family context (Kong et al., 2024). The functional relevance of intergenerational support may therefore depend not only on the amount of any single form of support, but also on how different forms and directions of exchange coexist within the family.

Most previous research, however, has examined support dimensions separately or characterized intergenerational relationships at a single point in time. Such approaches may obscure how financial exchange, caregiving, and contact develop together, substitute for one another, or change as family circumstances and support needs evolve. Cross-sectional studies have identified distinct configurations of parent–child relationships in China (Kong et al., 2024), whereas longitudinal evidence indicates that individual dimensions of family and social support are dynamic and may show different associations with health over time (Y. Wang et al., 2023). More recently, multidimensional trajectories of reciprocal intergenerational support have been associated with subsequent mortality among middle-aged and older Chinese adults (P. Wang & Tao, 2026). Mortality, however, does not capture changes in everyday independence that are central to healthy ageing and later-life care needs. It remains less clear whether longitudinal configurations of intergenerational exchange are associated with subsequent functional limitations, or whether such associations differ between complex instrumental functioning and basic self-care. Examining these questions in China may also inform

understanding of family support under broader demographic and social changes affecting ageing and care arrangements (González-Mariscal et al., 2025; Y. Yu et al., 2024).

Using data from the China Health and Retirement Longitudinal Study (CHARLS), we examined associations between multidimensional trajectories of intergenerational support during 2011–2015 and functional status in 2018. Six indicators jointly captured financial exchange, caregiving, and intergenerational contact, including both support received from and provided to adult children where applicable. We first identified distinct joint trajectories of these exchanges and then examined their associations with subsequent IADL and ADL limitations. By treating intergenerational support as an evolving configuration of financial, practical, and relational exchanges rather than as isolated indicators, this study aimed to clarify how different family-support contexts are associated with later functional independence among middle-aged and older adults in China.

2. Methods

2.1 Data source and study population

Data were drawn from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative longitudinal survey of Chinese adults aged 45 years and older. CHARLS used a multistage probability sampling design covering 150 county-level units and 450 urban communities or rural villages across 28 provincial-level regions (Y. Zhao et al., 2014). The study was approved by the Institutional Review Board of Peking University (IRB00001052-11015), and all participants provided informed consent.

We combined the Harmonized CHARLS dataset (Version D) with wave-specific files from the original 2011, 2013, 2015, and 2018 surveys. Harmonized CHARLS provided consistently coded longitudinal measures, whereas original files were used when more detailed or wave-specific information was required. Intergenerational-support trajectories were characterized during 2011–2015, and functional outcomes were assessed in 2018.

The trajectory-analysis sample included respondents aged 45–85 years at baseline who participated in at least two of the three trajectory-assessment waves (2011, 2013, and 2015). Analyses of functional outcomes were restricted to participants with eligible 2018 outcome data. Sample derivation is shown in Supplementary Figure S1.

2.2 Measures

2.2.1 Functional outcomes

Functional limitations were assessed in 2018 using instrumental activities of daily living (IADL) and activities of daily living (ADL), representing complex activities required for independent community living and basic self-care, respectively.

IADL comprised household chores, meal preparation, grocery shopping, money management, and medication use. For each activity, responses indicating no difficulty, difficulty without assistance, need for assistance, or inability to perform the activity were coded 0–3 and summed to obtain a score of 0–15, with higher scores indicating greater limitation (J. Yu et al., 2024).

ADL comprised dressing, bathing, eating, getting into or out of bed, toileting, and controlling urination and defecation. Items were coded using the same 0–3 scale and summed to obtain a score of 0–18, with higher scores indicating greater limitation (Zheng & Huang, 2023).

2.2.2 Intergenerational support

Intergenerational support was assessed across financial exchange, care exchange, and intergenerational contact, with direction distinguished where applicable (Kong et al., 2024; P. Wang & Tao, 2026; Y. Zhao et al., 2023). Six indicators were included: financial support received from adult children, financial support provided to adult children, informal care received from younger family members, grandchild care provided, face-to-face contact with adult children, and remote contact with adult children.

Measures were aggregated across eligible family members and transformed using $\ln(x + 1)$ to reduce right skewness. Relevant family-structure measures, including the number of children and the number of grandchildren cared for, were included in adjusted analyses to account for differences in potential exchange opportunities. Detailed definitions, coding procedures, and cross-wave harmonization rules are provided in Supplementary Table S1.

2.2.3 Covariates

Baseline covariates were selected a priori based on previous evidence concerning functional health in middle-aged and older adults (Li & Guo, 2022; P. Wang & Cheng, 2024; P. Wang & Tao, 2026). They included sociodemographic characteristics (sex, age, educational attainment, rural residence, and marital status); family circumstances (co-residence with children, number of children, and number of grandchildren cared for); socioeconomic resources and social protection (employment, household economic resources, pension income, and health insurance); lifestyle

and social factors (smoking and drinking history and social participation); and baseline health (IADL and ADL scores, depressive symptoms measured using the 10-item Center for Epidemiologic Studies Depression Scale [CESD-10], cognitive function, and number of physician-diagnosed chronic conditions). Definitions and coding are provided in Supplementary Table S2.

2.3 Statistical analysis

2.3.1 Descriptive analyses and trajectory identification

Continuous variables were summarized using means and standard deviations or medians and interquartile ranges, as appropriate, and categorical variables using frequencies and percentages. Baseline characteristics across trajectory groups were compared using one-way analysis of variance or the Kruskal–Wallis test for continuous variables and the chi-square test for categorical variables. Maximum absolute pairwise standardized mean differences (SMDs) were also calculated to quantify between-group heterogeneity with less dependence on sample size.

Group-based multi-trajectory modelling was used to jointly characterize the six transformed intergenerational-support indicators measured in 2011, 2013, and 2015 among participants contributing data to at least two waves. Indicators were modelled using censored normal distributions. Candidate models differing in the number of groups and polynomial orders were evaluated using the Bayesian information criterion (BIC), convergence, parsimony, classification quality, group size, and substantive interpretability (Jones et al., 2001; Nagin et al., 2018; Nagin & Odgers, 2010). Classification quality was assessed using standardized entropy, average posterior probability (AvePP), odds of correct classification (OCC), maximum posterior probability, and agreement between model-estimated and assigned group proportions. AvePP ≥ 0.70 and OCC ≥ 5 indicated adequate classification, whereas groups representing $< 5\%$ of participants were considered potentially unstable. Participants were assigned to the group with the highest posterior probability for the primary analyses.

2.3.2 Associations with subsequent functional outcomes

Trajectory membership was modelled as a categorical exposure, with Group 5 as the reference. IADL and ADL outcomes in 2018 were analysed separately, with adjustment for the prespecified covariates and the corresponding baseline functional score.

Primary analyses modelled continuous IADL and ADL scores using linear regression and reported adjusted mean differences with 95% confidence intervals (CIs). Robustness to outcome specification was assessed using binary thresholds (> 0 , ≥ 3 , and ≥ 5), proportional-odds models for the full ordinal scores (McCullagh, 1980), two-part models separating the occurrence and severity of limitation, and negative-binomial models of the full scores.

All 10 pairwise contrasts among the five trajectory groups were estimated for the primary continuous outcomes. Holm's procedure was applied separately for IADL and ADL to control the family-wise error rate across these comparisons (Holm, 1979).

Potential heterogeneity was examined using prespecified subgroup analyses and trajectory-by-subgroup interaction terms. Age was modelled continuously in primary analyses and categorized as 45–59, 60–74, and 75–85 years for stratified analyses. Interpretation emphasized omnibus interaction tests and stratum-specific estimates with 95% CIs rather than differences in statistical significance between strata.

2.3.3 Sensitivity and robustness analyses

To examine potential health selection related to pre-existing functional limitations, analyses were repeated among participants with a baseline score of 0 in the corresponding functional domain. Incident IADL or ADL limitation was defined as a score > 0 in 2018 and analysed using modified Poisson regression with robust variance to estimate adjusted risk ratios (RRs) and 95% CIs (Zou, 2004). Weights were re-estimated for each restricted cohort, and adjustment followed the corresponding primary model except that the baseline functional score was omitted because it was invariant.

Trajectory-classification uncertainty was addressed using posterior probability weighting (PPW) and the Bolck–Croon–Hagenaars (BCH) correction approach (Asparouhov & Muthén, 2014; Lê et al., 2025). Outcome definitions and covariate adjustment were kept consistent with the corresponding primary analyses where supported by each approach.

2.3.4 Missing data and longitudinal weighting

Missing covariate data were handled using multiple imputation for 11 covariates, with missingness ranging from 0.01% to 29.83% (median 1.03%; Supplementary Table S3). Twenty imputed datasets were generated, and estimates and standard errors were combined using Rubin's rules (White et al., 2011). For nonlinear models, coefficients were pooled on the linear-predictor scale before transformation to the reported effect measures.

To reduce potential bias from longitudinal selection and attrition, stabilized inverse-probability weights were constructed sequentially for selection into the trajectory-analysis sample and availability of the corresponding 2018 outcome. These weights were combined with baseline

CHARLS survey weights (Cole & Hernan, 2008; De Silva et al., 2021) and truncated at the 1st and 99th percentiles. Analyses using truncated combined weights were primary, with unweighted and untruncated weighted analyses conducted as sensitivity analyses. Diagnostics included weight and predicted-probability distributions, effective sample size, Kish's design effect, and covariate balance before and after weighting; absolute SMDs < 0.10 indicated adequate balance. Variance estimation accounted for clustering at the community level.

2.3.5 Software and statistical inference

Group-based multi-trajectory modelling, multiple imputation, longitudinal weighting, weighted regression, and PPW and BCH analyses were conducted in SAS version 9.4; graphical displays were produced in R version 4.5.0. All tests were two-sided. Interpretation emphasized effect estimates and 95% CIs, consistency across analytical specifications, formal interaction tests, and multiplicity-adjusted P values where applicable.

3. Results

3.1 Analytical sample and trajectory identification

Among 16,973 baseline-eligible participants, 15,538 were included in the joint trajectory analysis and 12,769 contributed an eligible 2018 functional outcome to the final analytical sample (Supplementary Figure S1). Participants not retained were generally older, less likely to be married or currently working, and had greater baseline IADL and ADL limitations; additional differences were observed in rural–urban residence, pension income, and health-insurance coverage (Supplementary Table S4). Longitudinal weighting improved covariate balance, with 98.2% of assessed contrasts achieving an absolute standardized mean difference < 0.10 after Stage 2 weighting (Supplementary Table S5).

Joint trajectory models with two to five groups were estimated using the six intergenerational-support indicators measured during 2011–2015. Model fit improved as additional groups were introduced, whereas a six-group specification did not yield a stable converged solution. Considering model fit, classification quality, group size, parsimony, and substantive interpretability, the five-group solution was retained (Supplementary Table S6). Classification quality was good: standardized entropy was 0.844, mean maximum posterior probability was 0.908, group-specific average posterior probabilities ranged from 0.838 to 0.951, and no model-estimated group comprised < 5% of participants (Supplementary Table S7).

The five trajectories differed in the level, direction, composition, and temporal pattern of intergenerational exchange (Fig. 1). **Group 1, increasing financial reciprocity–minimal interaction (26.07%)**, showed increasing financial transfers in both directions, particularly support received from adult children, while grandchild care and both forms of contact remained low. **Group 2, increasing multidimensional reciprocity (28.61%)**, combined increasing financial exchange with increasing grandchild care, face-to-face contact, and digital communication. **Group 3, child-to-parent support–high face-to-face contact (11.25%)**, was characterized by relatively high and increasing financial and informal-care support received from adult children, limited financial support to children, consistently high face-to-face contact, and lower digital communication after baseline. **Group 4, increasing financial exchange–declining interaction (11.88%)**, combined increasing financial support in both directions with marked declines in grandchild care and contact. **Group 5, high multidimensional exchange–stable interaction (22.19%)**, maintained comparatively high financial exchange and grandchild care together with relatively stable face-to-face and digital contact.

3.2 Baseline characteristics and primary functional outcomes

Among the 12,769 participants in the final analytical sample, 3,360 (26.3%) were assigned to Group 1, 3,929 (30.8%) to Group 2, 1,146 (9.0%) to Group 3, 1,520 (11.9%) to Group 4, and 2,814 (22.0%) to Group 5. Baseline demographic, family, socioeconomic, and health characteristics differed across groups (Table 1). Group 3 had the most distinct profile, with older age (mean 67.04 years, SD 8.89), lower proportions married (59.16%) and currently working (42.80%), more children (mean 3.66, SD 1.59), greater baseline functional limitation, more depressive symptoms and chronic conditions, and lower cognitive scores. Group 5 had the lowest mean baseline IADL (0.44, SD 1.35) and ADL (0.32, SD 1.05) scores.

Weighted descriptive analyses showed the highest functional burden in Group 3. Mean IADL scores across Groups 1–5 were 1.55, 1.21, 3.35, 1.52, and 1.03, respectively, and the corresponding prevalences of any IADL limitation were 26.83%, 24.46%, 48.91%, 28.73%, and 24.01%. Group 3 also had the highest mean ADL score (1.66) and prevalence of any ADL limitation (37.42%). Detailed distributions across severity thresholds are presented in Supplementary Table S8 and Supplementary Figures S2–S3.

In the primary fully adjusted models using trimmed longitudinal weights, all four trajectory groups had higher continuous IADL scores than Group 5. Adjusted mean differences were 0.67 (95% CI 0.46–0.87) for Group 1, 0.28 (0.09–0.48) for Group 2, 0.58 (0.20–0.97) for Group 3, and 0.57 (0.24–0.91) for Group 4; all four contrasts remained statistically supported after Holm correction (Table 2; Supplementary Table S9). Corresponding ADL differences were smaller, and none remained statistically significant after multiplicity correction. Thus, between-trajectory differentiation was substantially more evident for IADL than for ADL.

Table 1
Baseline characteristics of the final analysis sample by trajectory group

Covariate	Category	Group 1 (N = 3,360)	Group 2 (N = 3,929)	Group 3 (N = 1,146)	Group 4 (N = 1,520)	Group 5 (N = 2,814)	Max absolute SMD
Sociodemographic characteristics							
Age	-	55.76(8.10)	56.36(8.22)	67.04(8.89)	57.62(7.59)	59.23(7.94)	1.327
Sex	Male	1512(45.00%)	1929(49.10%)	464(40.49%)	662(43.55%)	1490(52.95%)	0.252
	Female	1848(55.00%)	2000(50.90%)	682(59.51%)	858(56.45%)	1324(47.05%)	
Educational attainment	Less than lower-secondary	2939(87.47%)	3460(88.06%)	1081(94.33%)	1386(91.18%)	2479(88.10%)	0.240
	Upper-secondary/vocational training	363(10.80%)	426(10.84%)	52(4.54%)	121(7.96%)	298(10.59%)	
	Tertiary	58(1.73%)	43(1.09%)	13(1.13%)	13(0.86%)	37(1.31%)	
Rural residence	Urban	1406(41.85%)	1368(34.82%)	431(37.61%)	496(32.63%)	910(32.34%)	0.198
	Rural	1954(58.15%)	2561(65.18%)	715(62.39%)	1024(67.37%)	1904(67.66%)	
Marital status	Not married or partnered	138(4.11%)	188(4.78%)	468(40.84%)	35(2.30%)	527(18.73%)	1.060
	Married or partnered	3222(95.89%)	3741(95.22%)	678(59.16%)	1485(97.70%)	2287(81.27%)	
Family structure and circumstances							
Co-residence with children	No	1075(31.99%)	1245(31.69%)	610(53.23%)	740(48.68%)	1369(48.65%)	0.447
	Yes	2285(68.01%)	2684(68.31%)	536(46.77%)	780(51.32%)	1445(51.35%)	
Number of children	-	2.22(1.33)	2.36(1.26)	3.66(1.59)	2.71(1.19)	2.87(1.25)	0.978
Number of grandchildren cared for	-	0.04(0.21)	0.07(0.28)	0.12(0.40)	0.41(0.64)	0.47(0.65)	0.893
Socioeconomic resources and social health protection							
Employment status	No	1001(29.79%)	1089(27.73%)	656(57.20%)	462(30.37%)	922(32.77%)	0.625
	Yes	2359(70.21%)	2840(72.27%)	490(42.80%)	1058(69.63%)	1892(67.23%)	
Total household income(<i>asinh</i> (<i>x</i>))	-	5.05(5.36)	5.32(5.38)	5.87(5.04)	5.45(5.28)	5.90(5.23)	0.160
Pension income(<i>ln</i> (<i>x</i>))	-	1.52(3.29)	1.46(3.22)	2.77(3.90)	1.68(3.43)	2.17(3.73)	0.368
Public health insurance	No	282(8.39%)	283(7.20%)	107(9.34%)	101(6.64%)	177(6.29%)	0.114
	Yes	3078(91.61%)	3646(92.80%)	1039(90.66%)	1419(93.36%)	2637(93.71%)	
Lifestyle factors							
Smoking history	No	2149(63.97%)	2344(59.65%)	723(63.10%)	962(63.29%)	1585(56.33%)	0.157
	Yes	1211(36.03%)	1585(40.35%)	423(36.90%)	558(36.71%)	1229(43.67%)	
Drinking history	No	2066(61.49%)	2361(60.10%)	764(66.68%)	969(63.77%)	1598(56.80%)	0.204
	Yes	1294(38.51%)	1568(39.90%)	382(33.32%)	551(36.23%)	1216(43.20%)	
Social participation	No	1834(54.58%)	2129(54.18%)	653(57.02%)	820(53.94%)	1382(49.10%)	0.159
	Yes	1526(45.42%)	1800(45.82%)	493(42.98%)	700(46.06%)	1432(50.90%)	
Baseline health status							
Note. Values are presented as mean (SD) for continuous variables and n (%) for categorical variables. SMD, standardized mean difference.							

Covariate	Category	Group 1 (N = 3,360)	Group 2 (N = 3,929)	Group 3 (N = 1,146)	Group 4 (N = 1,520)	Group 5 (N = 2,814)	Max absolute SMD
Sociodemographic characteristics							
IADL	-	0.78(2.25)	0.64(1.88)	1.49(2.87)	0.67(1.79)	0.44(1.35)	0.465
ADL	-	0.37(1.42)	0.38(1.45)	0.82(1.90)	0.35(1.13)	0.32(1.05)	0.324
Depressive symptoms	-	7.85(6.12)	8.02(6.13)	9.70(6.86)	8.61(6.38)	8.68(6.38)	0.284
Cognitive function	-	14.80(4.88)	15.00(4.69)	13.03(4.88)	14.53(4.59)	14.83(4.48)	0.412
Chronic conditions	-	1.17(1.26)	1.27(1.34)	1.62(1.50)	1.34(1.34)	1.42(1.37)	0.326
<i>Note. Values are presented as mean (SD) for continuous variables and n (%) for categorical variables. SMD, standardized mean difference.</i>							

Table 2
Fully adjusted associations of trajectory groups with continuous IADL and ADL scores

Comparison	IADL			ADL		
	adjusted mean difference	P	Holm P	adjusted mean difference	P	Holm P
	(95% CI)			(95% CI)		
Group 1 vs Group 5	0.67 (0.46, 0.87)	< 0.001	< 0.001	0.15 (0.04, 0.27)	0.011	0.111
Group 2 vs Group 5	0.28 (0.09, 0.48)	0.004	0.026	0.03 (-0.09, 0.15)	0.597	1.000
Group 3 vs Group 5	0.58 (0.20, 0.97)	0.003	0.021	0.20 (-0.04, 0.43)	0.103	0.822
Group 4 vs Group 5	0.57 (0.24, 0.91)	< 0.001	0.007	0.13 (-0.03, 0.29)	0.103	0.822
Note. Group 5 is the reference trajectory group. Estimates are from the trimmed-weight, fully adjusted primary specification. IADL, instrumental activities of daily living; ADL, activities of daily living; CI, confidence interval. Holm P values account for multiplicity across trajectory-group contrasts within each outcome.						

3.3 Alternative outcome specifications and pairwise comparisons

Alternative IADL specifications generally supported the primary findings, although consistency varied across groups (Fig. 2; Supplementary Table S10). Group 1 showed the most reproducible pattern relative to Group 5, with ORs of 1.45 (95% CI 1.22–1.73) for any IADL limitation, 1.50 (1.21–1.86) for IADL ≥ 3 , and 1.82 (1.39–2.37) for IADL ≥ 5 , together with a proportional odds ratio of 1.55 (1.30–1.84); all four comparisons remained supported after Holm correction. Group 4 showed a similar but less uniform pattern, with statistically supported differences for any IADL limitation (OR 1.45; Holm P = 0.032), IADL ≥ 3 (OR 1.58; Holm P = 0.036), and ordinal severity (POR 1.53; Holm P = 0.008), whereas the IADL ≥ 5 comparison did not remain supported after correction (OR 1.73; Holm P = 0.133). Findings for Groups 2 and 3 were less consistent across categorical and ordinal specifications. No corresponding ADL contrasts remained statistically supported after Holm correction.

Pairwise comparisons provided an additional distinction beyond comparisons with Group 5 (Fig. 3; Supplementary Table S11). Group 1 had a higher adjusted continuous IADL score than Group 2 after Holm correction, and this Group 1–Group 2 difference was also observed across binary-threshold and ordinal IADL specifications (Supplementary Figure S4). In contrast, no consistent pairwise differences were observed for ADL (Supplementary Figure S5). The most reproducible IADL differences therefore involved Group 1 versus Group 5, Group 4 versus Group 5, and Group 1 versus Group 2, rather than a graded ordering across all five trajectories.

3.4 Sensitivity and robustness analyses

Restriction to participants without baseline functional limitations yielded findings broadly consistent with the primary analyses (Supplementary Tables S12–S13; Supplementary Figure S6). Among participants without baseline IADL limitation, incident IADL limitation was more frequent in Group 1 (RR 1.33, 95% CI 1.17–1.53; Holm P < 0.001) and Group 4 (RR 1.45, 1.19–1.78; Holm P = 0.003) than in Group 5, whereas estimates for Groups 2 and 3 did not remain statistically significant after correction. Logistic and threshold-based analyses showed a similar overall pattern. No corresponding differences in incident ADL limitation remained statistically supported after multiplicity correction.

The findings were also robust to alternative treatment of trajectory-classification uncertainty and longitudinal weighting. Across maximum a posteriori assignment, BCH correction, and posterior probability weighting, all Group 1–4 versus Group 5 estimates for continuous IADL

remained positive and statistically significant (all $P \leq 0.010$), although effect magnitudes varied (Supplementary Table S14). Similarly, all four IADL contrasts remained positive and statistically supported after Holm correction across unweighted, weighted-untrimmed, and weighted-trimmed analyses (Supplementary Table S15). No comparable pattern emerged for ADL.

3.5 Heterogeneity across population subgroups

Associations between trajectory membership and IADL varied most clearly by age and educational attainment (Supplementary Table S16; Supplementary Figure S7). Evidence of interaction was strongest for age (P for interaction = 0.001) and educational attainment (P for interaction < 0.001), with weaker evidence for employment status (P = 0.038) and social participation (P = 0.036).

Age showed the clearest gradient. Relative to Group 5, the adjusted mean difference in IADL for Group 1 increased from 0.19 (95% CI 0.01–0.38) among participants aged 45–59 years to 0.91 (0.47–1.34) among those aged 60–74 years and 3.39 (1.38–5.40) among those aged 75–85 years. Larger between-trajectory differences at older ages were also observed for several other groups. Differences were generally more pronounced among participants who were not working, whereas heterogeneity by social participation was less uniform. No evidence of interaction was observed for sex, rural residence, marital status, co-residence with children, smoking history, alcohol consumption history, or health-insurance status (all P for interaction > 0.05).

For ADL, evidence of heterogeneity was observed by age and educational attainment (both P for interaction < 0.001; Supplementary Figure S8), although stratum-specific patterns were less consistent than for IADL and no clear heterogeneity was observed for the other subgroup factors examined.

4. Discussion

This study identified five longitudinal configurations of intergenerational support that differed in their financial, practical, and relational components. Three findings were most notable. First, between-trajectory differences were substantially more consistent for IADL than for ADL. Second, the most reproducible IADL differences were observed for trajectories characterized by increasing financial exchange accompanied by persistently limited or declining interaction, relative to the high multidimensional exchange–stable interaction trajectory. Third, these patterns were broadly robust to alternative weighting, restriction by baseline functional status, and methods accounting for trajectory-classification uncertainty, although associations varied by age and educational attainment. Together, the findings suggest that intergenerational support may be more informative when considered as an evolving multidimensional configuration rather than as isolated forms of exchange.

4.1 Why were trajectory differences more apparent for IADL than for ADL?

The distinction between IADL and ADL is important because the two domains capture different aspects of functioning. IADL comprises complex activities required for independent community living, whereas ADL reflects basic self-care. Although related, they do not necessarily represent a fixed sequence of decline. IADL performance depends on physical and cognitive capacity as well as environmental accessibility, social resources, and opportunities for participation (Huang & Others, 2024; J. Yu et al., 2024), consistent with the WHO healthy-ageing framework, which views functional ability as arising from interactions between intrinsic capacity and the physical and social environment (Organization, 2020).

This broader dependence on context may help explain why intergenerational-support trajectories were more clearly differentiated for IADL. Regular interaction may coincide with information exchange, recognition of emerging difficulties, accompaniment, and assistance with complex tasks, while reciprocal family roles may help sustain engagement in everyday life. Chinese longitudinal studies have similarly linked social isolation and social capital with functional outcomes, although associations vary across populations and measures (Guo et al., 2021; Man et al., 2024). The relationship between social support and functional trajectories also appears to differ by support type and individual vulnerability (J. Yu et al., 2024). Our exploratory mediation analyses further suggested that cognitive function and employment status may contribute to some of the observed IADL differences across trajectory groups (Supplementary Table S17). These findings should not be interpreted as evidence of causal mediation, but they are consistent with the possibility that family-support configurations capture aspects of the social environment relevant to complex everyday functioning.

This interpretation may be increasingly relevant as independent living becomes more technologically and administratively demanding. Transport, health services, financial transactions, appointments, and communication increasingly involve digital systems, while digital exclusion can create barriers for older adults (Ge et al., 2025). ADL limitations, by contrast, reflect difficulties in basic self-care and often occur at greater levels of functional impairment. The weaker ADL pattern therefore does not imply an absence of association; rather, within this sample and follow-up period, the identified trajectories differentiated subsequent instrumental functioning more consistently than basic self-care. National evidence likewise indicates that different levels of functional dependency in China have distinct burdens and determinants (Gong et al., 2022).

4.2 The configuration of intergenerational support may matter beyond financial exchange alone

The contrasts among Groups 1, 4, and 5 illustrate why financial exchange alone may provide an incomplete representation of intergenerational support. Groups 1 and 4 both showed increasing financial exchange but had the most reproducible higher IADL burden relative to Group 5. What distinguished them was the broader configuration in which financial exchange occurred: Groups 1 and 4 combined increasing transfers with persistently limited or declining nonfinancial interaction, whereas Group 5 maintained comparatively high multidimensional exchange together with stable contact. These contrasts do not show that reduced contact causes functional limitation or that any component of Group 5 is independently protective. They do, however, question the adequacy of financial transfers alone as a proxy for overall intergenerational support. Previous Chinese research similarly suggests that financial and emotional support may have complementary or substitutive associations with parental health (Li & Guo, 2022).

These configurations are also plausible in the context of changing Chinese families. Filial responsibility remains influential, but intergenerational support is increasingly negotiated alongside emotional intimacy, migration, employment, and caregiving obligations (Liu, 2023). Direct interaction and practical assistance may be more constrained by distance and time than financial transfers, while formal and community-based care are expanding alongside continued family involvement (He & Ma, 2023).

The Group 1–Group 2 comparison provides further support for a configuration-based interpretation. Both groups showed increasing financial exchange, but Group 2 also showed increases in caregiving and contact. Group 1 had a higher IADL burden than Group 2 across continuous, binary-threshold, and ordinal specifications, suggesting that the functional meaning of financial exchange may depend partly on the relational and practical context in which it occurs (Li & Guo, 2022; Y. Zhao et al., 2023). Group 2 nevertheless differed modestly from Group 5 in the continuous IADL model, indicating that increasing multidimensional exchange and maintaining consistently high multidimensional exchange may represent different family contexts.

Group 3 warrants a different interpretation. Despite high face-to-face contact and substantial child-to-parent support, it had the greatest descriptive functional burden. This pattern is compatible with need-responsive support, whereby greater assistance may arise partly in response to emerging parental needs rather than preceding them (Kong et al., 2024). Together, these findings argue against treating the five trajectories as a simple hierarchy from “good” to “poor” family support.

4.3 Heterogeneity and broader implications for functional ageing

Heterogeneity was most evident by age and educational attainment. Larger IADL differences at older ages may reflect greater reliance on family and social resources as physical and cognitive reserves decline, although cohort differences, accumulated disadvantage, variation in family availability, and residual confounding may also contribute. Educational differences may similarly reflect variation in health literacy, socioeconomic resources, access to formal services, and the ability to navigate increasingly complex technological environments. Recent CHARLS evidence also suggests that education may modify associations between social participation and physical functioning (Man et al., 2024). Evidence of heterogeneity by employment and social participation was weaker and should therefore be interpreted cautiously.

More broadly, these findings highlight the value of viewing functional ageing within a wider resource context. Intergenerational support may be more informative when considered alongside community, social, and formal care resources rather than as a stand-alone family exposure (N. Wang et al., 2023; L. Zhao, 2023). This perspective is particularly relevant as China moves toward a more mixed system of family, community, and formal support (He & Ma, 2023; Y. Zhao et al., 2023). Smaller families and greater population mobility may constrain sustained practical assistance even when other forms of intergenerational exchange remain feasible (Bao, 2022), while community, rehabilitation, nursing, and long-term-care services may provide complementary resources as functional needs emerge (Zhou et al., 2025). The trajectories identified here should not be interpreted as clinical risk categories or intervention targets; rather, they characterize different family contexts within which functional ageing occurs.

4.4 Strengths and limitations

Strengths of this study include longitudinal characterization of six dimensions of intergenerational exchange, temporal separation between trajectory assessment and subsequent functional outcomes, separate examination of IADL and ADL, and extensive sensitivity analyses addressing attrition, baseline functional status, alternative outcome specifications, and uncertainty in trajectory classification.

Several limitations warrant consideration. First, residual confounding and health-related selection remain possible because functional changes may themselves influence subsequent financial transfers, caregiving, and contact (Li & Guo, 2022; Y. Zhao et al., 2023). Restriction to participants without baseline limitations reduced but did not eliminate concerns regarding reverse relationships and time-varying confounding; the findings should therefore be interpreted as associations rather than causal effects. Second, trajectory models summarize heterogeneous longitudinal patterns into a limited number of latent groups and should not be regarded as naturally discrete family types (Mésidor et al., 2022). Third, support indicators and functional outcomes were largely self-reported. Fourth, although longitudinal weighting improved measured balance, selection related to unmeasured factors may remain. Finally, intergenerational exchange is embedded in cultural and institutional context. Changing filial norms, migration, smaller families, digitalization, and the evolving formal care system may limit direct generalization

beyond China (Bao, 2022; Ge et al., 2025; Liu, 2023). Comparative studies and designs with more frequent assessment of both support and functioning may help clarify which patterns are context-specific and which are shared across ageing societies.

5. Conclusion

Multidimensional trajectories of intergenerational support were more consistently differentiated in IADL than in basic ADL among middle-aged and older adults in China. The clearest differences were observed for trajectories combining increasing financial exchange with limited or declining interaction, compared with sustained multidimensional exchange and stable contact. These findings suggest that the direction, composition, and stability of intergenerational exchange may provide a more informative account of the family context of functional ageing than individual support dimensions considered separately. As family and care arrangements continue to change, understanding how family relationships intersect with other social and formal resources may be important for research on maintaining functional independence in later life.

Declarations

Ethics approval and consent to participate

The CHARLS protocol was approved by the Institutional Review Board of Peking University (IRB00001052-11015), and participants provided written informed consent. The present study was based on a secondary analysis of de-identified CHARLS data and involved no direct contact with participants. All procedures were conducted in accordance with the relevant ethical guidelines and regulations.

Data availability

The CHARLS data used in this study are available to registered users through the official CHARLS data platform, subject to applicable data-use conditions. The data must be obtained directly from CHARLS and cannot be provided by the authors.

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Authors' contributions

Ping Wang conceived and designed the study, conducted the data analysis, managed and visualized the data, and drafted and revised the manuscript. Chunhai Tao contributed to the study conception and methodology, supervised the project, and critically revised the manuscript. All authors reviewed and approved the final version of the manuscript.

Declaration of competing interest

The authors declare that they have no competing interests.

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Figures

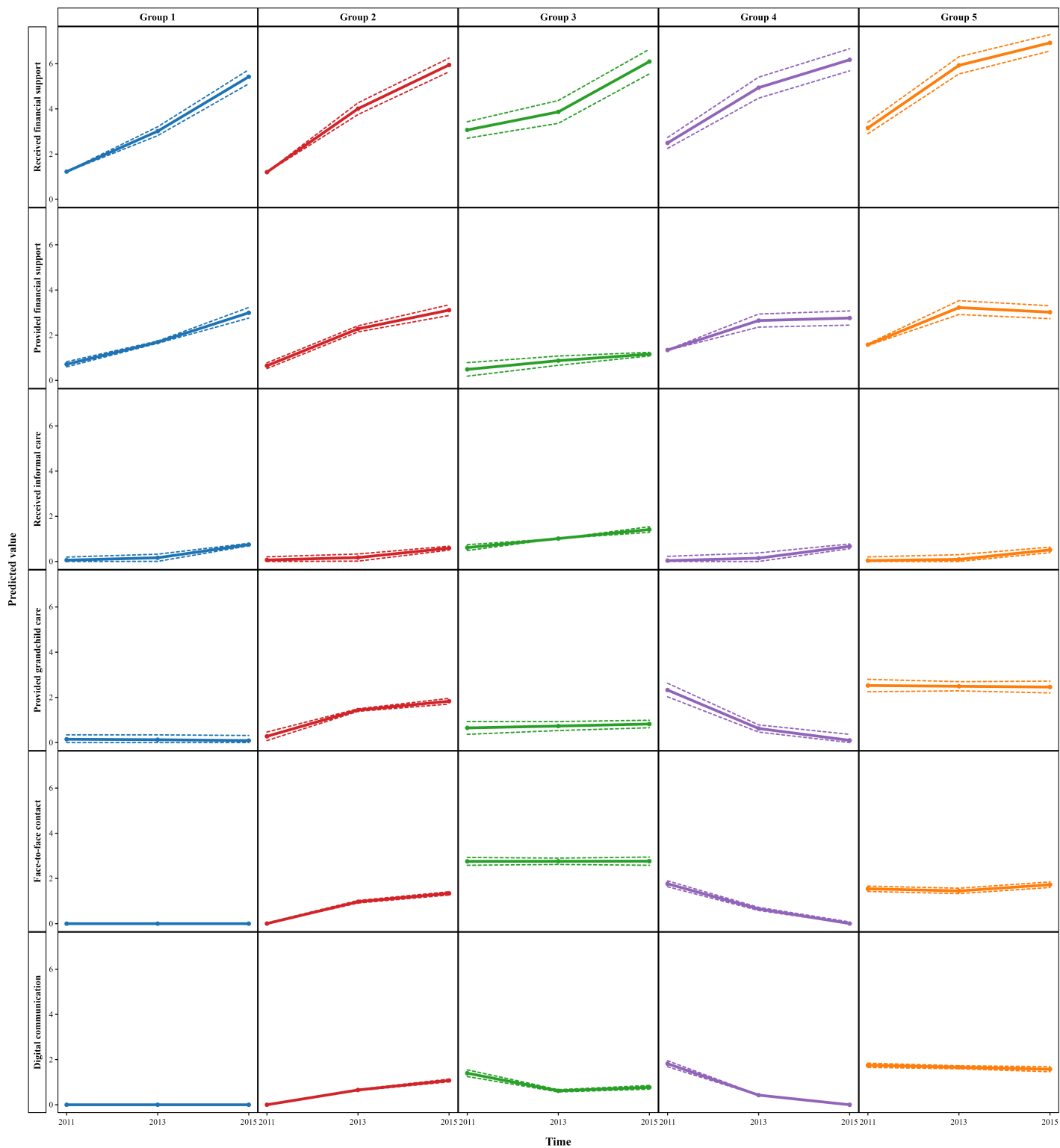


Figure 1

Trajectories of intergenerational exchange across the five groups

Adjusted associations of trajectory groups with IADL and ADL outcomes

Trimmed weighting analysis; Group 5 is the reference trajectory group

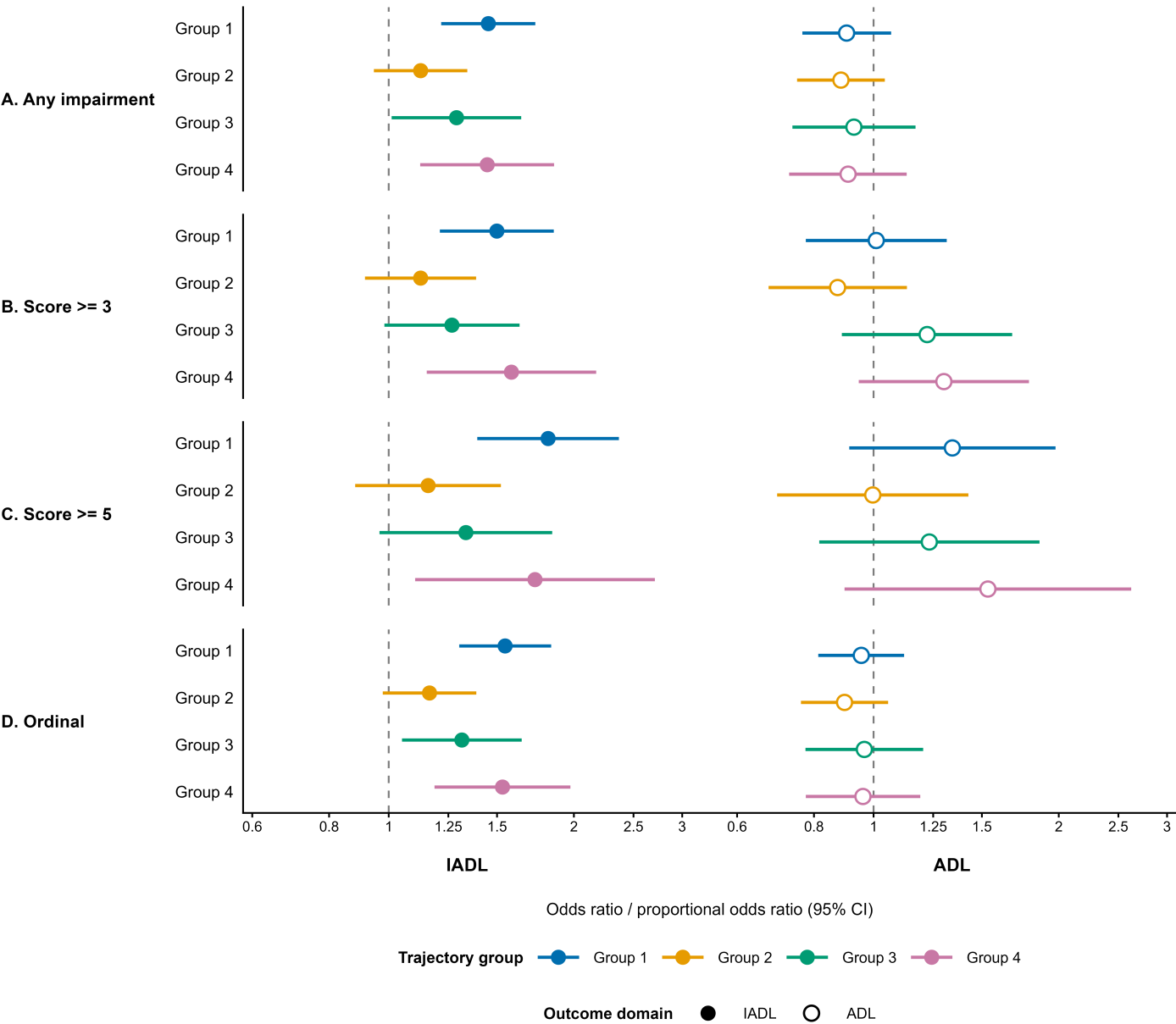
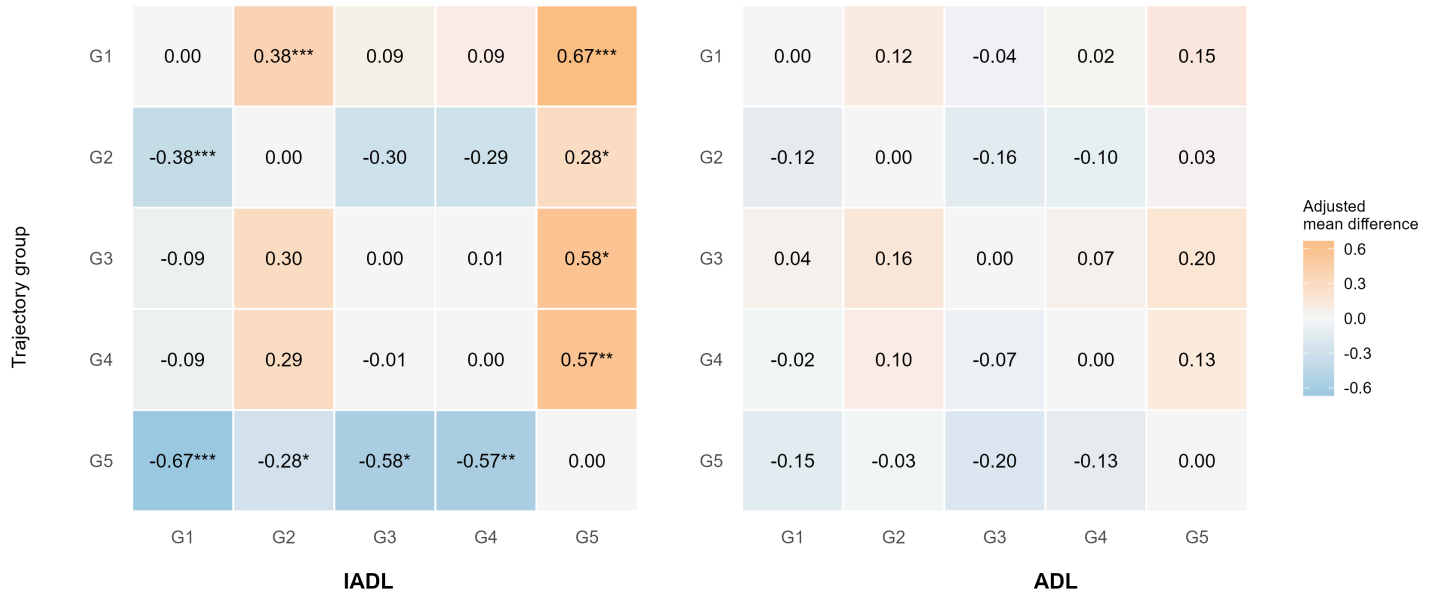


Figure 2

Adjusted associations of trajectory groups with alternative IADL and ADL outcome specifications

Pairwise Comparisons among Five Trajectory Groups

Cell values represent mean differences (row group - column group); statistical significance is based on Holm-adjusted P values



* Holm P < 0.05; ** Holm P < 0.01; *** Holm P < 0.001

Figure 3

Adjusted pairwise comparisons of IADL and ADL across trajectory groups

Supplementary Files

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