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Diversity, integration, and variability of intergenerational relationships in old age: New insights from personal network research

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ABSTRACT

Relationships between family members from different generations have long been described as a source of solidarity and support in aging populations and, more recently, as a potential risk factor for COVID-19 contagion. Personal or egocentric network research offers a powerful kit of conceptual and methodological tools to study these relationships, but this has not yet been employed to its full potential in the literature. We investigate the heterogeneity, social integration, and individual correlates of intergenerational relationships in old age analyzing highly granular data on the personal networks of 230 older adults (2747 social ties) from a local survey in one of the areas of the world at the forefront of global aging trends (northern Italy). Using information on different layers in broad egocentric networks and on the structure of connectivity among the social contacts of aging people, we propose multiple conceptualizations and measures of intergenerational connectedness. Results show that intergenerational relationships are strongly integrated, but also highly diverse and variable, in older adults' social networks. Different types of intergenerational ties exist in different network layers, with various relational roles, degrees of tie strength, and patterns of association with individual and tie characteristics. We discuss how new and existing personal network data can be leveraged to consider novel questions and hypotheses about intergenerational relationships in contemporary aging families.

Population aging is one of the defining trends of the contemporary world. Individuals aged 65 or over account for approximately 10% of the global population, a share that doubled since 1950 and is projected to increase to about 17% by 2050 (U.N. Department of Economic and Social Affairs, 2023). Europe is especially affected by this transformation. Seven of the ten countries of the world with the highest share of 65-or-older residents are in Europe (Eurostat, 2022b). The top European nation in this ranking is Italy: the Italian population has the oldest age structure in the European Union by most measures (Eurostat, 2022b), including median age (47.6), the share of people aged 65 or more (23.5%), and the old-age dependency ratio (37%). Aging-related issues in Italian society and politics are increasingly studied as precursors of future scenarios in the European continent and the broader Western world (Mazzola et al., 2016).

One such issue is the growing prominence of intergenerational (IG) relationships between older adults and younger relatives, which have become a key feature of family life and social organization in Western countries. Research on this topic has particularly focused

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on parent-child relationships, documenting their critical role as a source of solidarity and support for both aging people and their adult children (Kalmijn and De Vries, 2009; Lye, 1996; Seltzer and Bianchi, 2013). In-depth knowledge about IG relationships, scholars have argued, will be necessary for a full understanding of family in the near future, but it requires rich, granular data on social ties beyond what can be found in existing large-scale national and cross-national surveys (Fingerman et al., 2020). Indeed, often missing in the literature is a consideration of the broader personal networks in which IG ties are embedded, including older adults' extended family, neighbors, friends, co-workers, and other acquaintances. Concepts and methods from social and personal network analysis (McCarty et al., 2019; Perry et al., 2018), which were specifically conceived for the study of social relationships, their antecedents, and their consequences, have yet to be fully deployed in this area of research.

This article adopts methods from personal network research to offer a new look at intergenerational family relationships and their diversity, integration, and variability in aging communities. A major goal is to demonstrate how these methods can generate new insights, enable the test of novel hypotheses, and foster theoretical advancement in the field. We study characteristics and correlates of different types of IG relationships in the personal networks of aging people, analyzing tie-level information about their social contacts in different network layers and the structure of connectivity among these contacts. The analyses are based on new, extensive personal network data, collected in a leading region for population aging in Italy and the Western world. Findings show that IG ties are both widespread in the elderly population under study and highly integrated in its social life in terms of frequency of contact and centrality in network structures. Nonetheless, IG relationships are also diverse and highly variable: they exist in different layers of personal networks, and different types of IG ties show different features and patterns of association with aging people's sociodemographic and health-related characteristics. We reflect on the originality of the evidence about IG relationships generated by the personal network approach, on how this approach can be pursued with new and existing data, and on what it can contribute to theoretical progress in the field.

1. An ego-network perspective on intergenerational relationships: Questions and contributions

A personal (or egocentric) network is defined as the set of social contacts ("alters" in network analysis terminology) known to a focal individual (the "ego"), and the ties among them (McCarty et al., 2019). Personal networks form around recurrent social contexts or foci of interaction (Feld, 1981) – such as family life, work, the neighborhood, or places of worship – and comprise concentric layers of varying tie strength (Roberts et al., 2009): from the core network of the closest and most intimate ties, to the active layer of the people with whom the ego interacts on a regular basis, to the extended set of weak ties known by name but only seen occasionally. Ego-networks are also characterized by complex structures of connectivity among the ego's contacts, such as patterns of clustering in cohesive subgroups and varying levels of node centrality (McCarty, 2002; Vacca, 2020).

Drawing from insights about interaction foci and layers of tie strength in personal networks, we distinguish three types of IG ties around older adults: IG ties in the immediate family, that is, between aging people and their *adult children*; *active intergenerational ties*, involving daily or weekly interactions with any younger generation relative in the immediate or extended family[1]; and *all intergenerational ties* within the immediate or extended family at any level of interaction frequency. We also differentiate between *absolute* and *relative* intergenerational connectedness: the first is conceptualized as the absolute amount (count) of IG ties in one's network; the second as a proportion of IG ties relative to the number of all ties in the network layer of interest.

Informed by these distinctions, the paper asks four sets of questions:

1. What is the absolute and relative *prevalence* of the three different types of IG relationships in the personal networks of older adults?
2. What are the main *characteristics of IG ties* in terms of context of relationship, frequency of contact, coresidence, and structural integration in older adults' personal networks? How do these vary between the three types of IG ties?
3. How does intergenerational connectedness, both in absolute and relative terms, vary between older adults with different *sociodemographic and health characteristics*?
4. What is the degree of *concentration* or reliance of older adults' personal networks on IG ties in the immediate family (i.e., with adult children)? How does that vary with different sociodemographic and health characteristics of aging people?

The ego-network perspective proposed in this paper contributes to existing knowledge on IG relationships in multiple ways. First, scholars have repeatedly noted an imbalanced, almost exclusive focus on adult children in most existing literature on IG relationships and social support in old age (Dykstra, 2015; Litwin, 1997). In contrast, we expand the scope of analysis to consider the diversity of *IG ties from different network layers and circles*, including adult children and the extended family, the active network, and the total network of older adults. Second, we propose *different conceptualizations of intergenerational connectedness*, measuring IG relationships both in absolute terms and relative to the size of different network layers. These distinctions are typically hidden in studies based on less granular data, which cannot capture variability between network layers. Third, we study the issue of *concentration* of aging people's personal networks on ties with children – that is, the extent to which children represent most or all of the relationships and network resources available to an older person for social engagement and support. This is a new conceptualization of IG connectedness and a potentially important dimension of vulnerability in aging families, as it may engender excessive reliance or dependency on adult

[1] Here we use the term *active relationships* (or active network layer) with a somewhat stricter meaning compared to other literature, which often terms as "active" the set of contacts with whom a person has interacted at least once recently (e.g., in the last year); see Marsden and Hollstein (2022).

children for older parents, as well as overload for children in informal support roles. Fourth, we examine the *structure of connectivity* among older people's social contacts. In contrast with most previous literature, this allows us to obtain novel structural measures for the integration of IG ties in the social life of aging adults. Finally, in a line of literature often relying on the same, few survey datasets, we heed recent calls to test existing hypotheses on IG relationships with new data collected with different research designs (Dykstra, 2018; Emery and Mudrazija, 2015).

2. Intergenerational relationships and social support in old age: background and hypotheses

Intergenerational relationships have been the subject of a long line of scholarship in sociology, demography, and social gerontology. Most of this work has examined aging people's ties with adult children, their role as a source of support (e.g., financial transfers, assistance with everyday chores, child care, emotional support, etc.) for both older and younger generations, and, in fewer cases, other forms of contact, interaction, and proximity within them (Antonucci et al., 2007; Dykstra, 2015; Hank, 2007). The COVID-19 pandemic has renewed scholarly and public interest in the topic: IG relationships have been studied as a risk factor exposing the elderly to COVID-19 contagion (Arpino et al., 2020; Dowd et al., 2020), but they have also been described as critical in providing health-protective behavioral guidance to older adults during the pandemic (Arpino et al., 2023).

A dominant framework in the study of IG relationships and social support in old age has been the convoy model (Kahn and Antonucci, 1980). It depicts the individual as part of a dynamic network of relations that accompany, protect, and support him or her through the life course. The relational convoy changes over time, both in composition and size, as a result of life transitions and events. Some of these shifts take place during old age, when family ties tend to become relatively more prevalent in one's personal network and IG ties grow more intense and supportive (Kalmijn, 2019; Shaw et al., 2007; Umberson, 1992; van Tilburg, 1998). The support older adults receive from their relational convoy is not uniform and homogenous, however, but diverse and specialized, with different types of relationships being called upon for different kinds of assistance (Messeri et al., 1993; Wellman and Wortley, 1990). Diversity also characterizes the direction of support exchanges in aging people's social ties: older adults do not just receive help, they also give it – including to younger family members (Attias-Donfut et al., 2005; Lowenstein et al., 2007; Shaw et al., 2007). Support is reciprocal especially in parent-child relationships, in which older people tend to give more (e.g., in terms of financial transfers and grandchild care) than they receive (Albertini et al., 2007), at least until a certain age (Kalmijn, 2019).

Attempting to capture the variety of relationships and exchanges in older adults' support networks, certain literature has adopted the construct of "social network types" (Shiovitz-Ezra and Litwin, 2015; Suanet and Antonucci, 2017). Scholars in this line of research have identified typologies of social networks by applying cluster analysis techniques to composite collections of summary measures describing older adults' social relationships and activities. Results have revealed the existence of recurrent types of social networks among older adults, characterized by different capacities for aid and support: from more extensive and diverse to more limited and restricted types, from networks focused on family ties to those heavily oriented to religious association or friendships (Shiovitz-Ezra and Litwin, 2015). These social network types are associated both with socioeconomic characteristics (Litwin and Shiovitz-Ezra, 2011) and with different health and wellbeing outcomes for the focal older individuals (Litwin and Stoeckel, 2014; Shiovitz-Ezra and Litwin, 2015). Studies of network types have made critical contributions to our understanding of family relationships and social support in old age, but they have been limited by their reliance on proxy or summary measures of network characteristics and a general lack of engagement with richer data and more advanced methods of personal network research.

In general, most literature in the field has depended on data from a few major survey projects, such as the Longitudinal Study of Generations (LSOG), the Family Exchanges Study (FES), the Within-Family Differences Study (WFDS), the National Social Life, Health, and Aging Project (NSHAP), and the Survey of Health, Aging and Retirement in Europe (SHARE). These have provided essential insights about older adults' sources of support, values and orientations, and parent-child relationships. However, their results have been more limited regarding the broader personal networks in which aging people and their IG ties are embedded. NSHAP and SHARE do include some personal network information, with data about respondents' core networks, certain tie-level variables (e.g., frequency of contact between ego and alter) and, only for NSHAP, alter-alter ties among core social contacts (i.e., the way core network alters are connected with each other). Both surveys, however, lack information on wider network layers beyond the core. The Dutch Longitudinal Amsterdam Study on Ageing (LASA) is the only aging study, to the best of our knowledge, that collects tie-level data on extended personal network layers, allowing for the study of IG relationships beyond immediate family and core ties. Like SHARE, however, LASA data do not contain information about alter-alter ties. Such limitations are understandable given the large scale of these surveys, the cross-national and longitudinal nature of some of them, the quality of their data in other domains, and the cost per respondent of granular data about single social relationships.

One consequence of the limited incorporation of personal network methods in research on IG relationships and support has been the disregard for connectivity structures – such as patterns of structural cohesion, network subgroups, and alter centrality (McCarty, 2002; Mollenhorst et al., 2011; Vacca, 2020) – in the ego-networks of older adults. Multiple aspects of these structures, however, are germane to questions about the significance and integration of IG ties in the social life of aging people. We focus on one of them: the centrality of alters in personal networks. This paper considers first the most basic dimension of alter centrality, degree: an alter's number of connections to other alters in the ego-network. High values of degree for alter a mean that a knows many other social contacts of the ego's: in other words, a and the ego are part of a high number of closed triads and potentially, depending on whether their mutual contacts also know each other, of larger network cliques (Martí et al., 2017; Mollenhorst et al., 2011). This structural position rich in mutual contacts and network closure reflects high integration of a in the ego's social life, in different senses. First, network closure is typically associated with a stronger tie between a and the ego, one characterized by trust and overlap of multiple contexts of socialization, social roles, and types of exchange (Coleman, 1990; Mollenhorst et al., 2011). Second, high degree centrality

in the ego-network increases *a*'s ability to provide support to the ego (Wellman and Frank, 2001) as well as to coordinate with others to influence the ego's beliefs and behaviors (DiMaggio and Garip, 2012). Finally, and related to the latter point, high degree of *a* is associated both with diminished autonomy of the ego from *a* (Burt, 1992) and with greater levels of monitoring and constraint from others on the relationship between *a* and the ego (Krackhardt, 1998; Portes and Sensenbrenner, 1993). We also consider the betweenness dimension of alter centrality, which captures the extent to which an alter is connected to multiple, separate social circles in the ego's network (McCarty, 2002).

2.1. Research hypotheses

A recurrent aim in previous literature has been the comparison between different countries in terms of the prevalence and salience of IG relationships. In such comparisons, Italy consistently ranks at the top, with high levels of support exchanges and interpersonal contact between generations (Bordone et al., 2017; Hank, 2007; Kalmijn and De Vries, 2009; Tomassini et al., 2004a,b). This is thought to stem from cultural, demographic, and policy-related characteristics of the Italian context: the dominance of familialistic attitudes and values (Dalla Zuanna, 2001; Kalmijn and Saraceno, 2008; Reher, 1998); the tendency to residential proximity and coresidence between generations, with late exit of young adults from the parental home (Hank, 2007; Santarelli and Cottone, 2009); and a family-oriented welfare regime in which scarce public or market-based provision of services is supplemented by higher intergenerational support within the family (Dykstra, 2018; Kalmijn and Saraceno, 2008; Naldini and Saraceno, 2008).

In light of this literature, we expect IG ties to be well integrated in the social life of older adults in our data, in terms of both frequency of interaction and structural position in personal networks. First, we hypothesize that older adults in our study tend to maintain frequent (daily or weekly) interactions with their contacts in younger generations, especially with adult children (**H1**). Second, drawing from the literature on network centrality and closure referenced in the previous section, we argue that ego-network centrality is another important dimension of intergenerational integration. We expect younger generation kin to be on average highly central in older adults' personal networks, and more central than other alters (**H2**). Furthermore, we hypothesize this effect to be higher for adult children than for other types of IG relationships. At the same time, we emphasize the distinction between social integration of IG ties and multigenerational coresidence. While residential proximity and coresidence between generations are more common in Italy than in other Western countries, only a minority of Italians aged 65 or more live in multigenerational households (Arpino et al., 2020; Kalmijn and Saraceno, 2008; Tomassini et al., 2004a). Hence, we hypothesize that intergenerational family ties are associated with a lower likelihood of the ego and the alter living in the same dwelling: in other words, younger generation family members are less likely than same-generation contacts to live together with the ego (**H3**). This issue is not novel and has been investigated in the past with multiple data sources. Our hypothesis, however, serves to highlight that personal network data (e.g., about frequency of interaction in a social tie and alter centrality) may reveal a level of social integration of IG relationships in aging populations much higher than what emerges from data about household age structure and multigenerational coresidence.

The growing importance of IG relationships as a source of support and social engagement does not mean that IG connectedness is uniformly high across all segments of the population. In fact, much research has underscored heterogeneity and identified significant dimensions of variation in the degree to which older adults maintain IG ties. *Age* is one such dimension. As people get older, they tend to favor contacts who are more intimate, are family members, and provide regular support (Carstensen et al., 2003; Cornwell et al., 2008; Shaw et al., 2007). These preferences, together with increasing support needs, explain the evidence that, with advancing age, older adult's ties with children become more supportive (Kalmijn, 2019; Kalmijn and Saraceno, 2008; Silverstein et al., 2002; Umberson, 1992) and are characterized by more frequent interaction (Hank, 2007; Umberson, 1992). Consistently, we hypothesize that, within the older age range considered in this study, age is positively associated with the count and percentage of IG relatives in older adults' total and active network, as well as with the concentration of their network on adult children (**H4**).

We also hypothesize that *women* are surrounded by more IG relationships, both in absolute terms and as a percentage of all ties (**H5**). Over the life course, women are more likely to occupy kinkeeper and caregiving roles (Lye, 1996; Rosenthal, 1985). Compared to men, women in the U.S. consistently report greater access to social support through family and less access to support through friends (Verdery and Campbell, 2019). These tendencies create more opportunity among women for long-lasting ties with younger relatives, including adult children and grandchildren. Indeed, existing evidence shows that older women, compared to men, are more likely to receive support from adult children, see them more frequently, and coreside with them (Hank, 2007; Kalmijn, 2019; Silverstein et al., 2002; Umberson, 1992). Theoretical arguments and evidence in previous literature, however, do not necessarily suggest higher levels of concentration of older women's networks on adult children.

Socioeconomic status (SES) also influences IG relationships in decisive ways. Across different countries and age brackets, individuals with lower education are embedded in personal networks with higher prevalence of family ties (Drouhot, 2017) and report more social support from family and less support from friends (Verdery and Campbell, 2019) – two conditions that facilitate the emergence and maintenance of IG ties. Furthermore, older parents and adult children tend to be spatially closer and to have more frequent contact in families with lower education (Goldman and Cornwell, 2018; Hank, 2007; Kalmijn and De Vries, 2009; Tomassini et al., 2004b) and less wealth (Swartz, 2009; Umberson, 1992). This association between SES and IG relationships seems stronger in more familialistic countries like Italy (Kalmijn and Saraceno, 2008). Explanations of this effect point to the heightened importance of kin ties as a source of material support and welfare in low-SES groups (Seltzer and Bianchi, 2013; Swartz, 2009) and to the greater geographic mobility of adult children in high-SES families (Drouhot, 2017; Kalmijn, 2006; Schafer and Sun, 2021). From these arguments we derive the hypotheses that older adults maintain more IG and IG active ties (both in absolute and relative terms), and their networks are more concentrated on adult children, when they are in lower educational levels (**H6**) and in lower-status occupational categories (**H7**).

Finally, *physical, cognitive, and mental health* also shape the development of IG relationships. Poorer health increases the need of

social support for older adults, activating stronger interactions and assistance from younger family members (Eggebeen and Davey, 1998; Haberkern et al., 2015; Hank, 2007; Schafer and Upenieks, 2021), especially in more familialistic societies (Kalmijn and Saraceno, 2008). Consistently, we expect older adults' poorer physical health to be associated with higher counts and proportions of IG family ties in personal networks, including in the active network layer, and with higher network concentration on children (**H8**). In contrast, we hypothesize absolute and relative IG connectedness, both in the total and active network, to be lower among older adults with depression (**H9**) and dementia (**H10**), due to mutually reinforcing causal links in both directions: less social interaction and engagement are among the determinants of depression (Santini et al., 2015) and cognitive decline (Piolatto et al., 2022) in old age; while depression and cognitive impairment, in turn, may lead older adults to disengage from social ties (Aartsen et al., 2004; Almquist et al., 2017). At the same time, depression and dementia in older adults may activate emergency support from the immediate family, so we do not expect these two conditions to be associated with lower (or higher) concentration of the network on adult children.

3. Materials and methods

We use data obtained as part of the SOCIABLE project, a study of social relationships and health among older adults in Brescia, Italy (Bianchi et al., 2023). Brescia is the second most populous city in the northern Italian region of Lombardy, and among the top ten cities in northern Italy by the same measure. Northern Italy is one of the few European regions where more than one in four residents are 65 or older, and it includes some of the communities with the oldest age structure in the country (Eurostat, 2020; ISTAT, 2021). Lombardy, in particular, has one of the highest percentages of 65-or-older residents in Europe (22.9% in 2021; Eurostat, 2022a). In Brescia itself, 21.9% of the population was 65 or older in 2021, with a 34.1% old-age dependency ratio (ISTAT, 2021).

The population of interest for the SOCIABLE project consisted of all adults aged 75 years and over from three major neighborhoods of Brescia, characterized by different area-level sociodemographic profiles. The entire list of these individuals (4248 residents) was used as a sampling frame, from which a simple random sample of 851 individuals was extracted. Of these, 107 respondents completed the survey (12.6% response rate). An additional, referral-based sample of 123 individuals was recruited with assistance from local community organizations, resulting in a total sample size of 230 individuals. All analyses in this paper are replicated on both the full sample (main article) and the random sample (Supplementary Materials), emphasizing points of convergence and divergence between the two sets of results. The questionnaire was administered by a team of six trained interviewers. Most interviews (84%) were conducted face-to-face in 2019, while the remainder were conducted via telephone at the outset of the COVID-19 emergency in early 2020.

3.1. Social ties and intergenerational relationships

The survey included standard questions about sociodemographic characteristics, a module on health outcomes, and a component on personal networks. Similar to other personal network studies among older adults (e.g., Bilecen and Vacca, 2021; van Tilburg and van Groenou, 2002), ego-network members were elicited via multiple questions – eight name generators in total (Table S1 in Supplementary Materials) – which asked about personal contacts from various interaction foci, including the respondent's household, households of adult children, neighborhood, current or former workplace, and voluntary associations. While their wording prioritized "important" alters with whom the respondent had frequent contact, the name generators elicited a substantial variety of network members in terms of relational role (e.g., immediate family, extended family, non-kin), contact frequency (from daily to yearly), and focus of interaction (see Table 2).

Subsequent questions elicited information about each alter's gender, role and focus, and time frequency of interaction with the respondent. Although the survey did not directly register the age of each alter, it asked about his or her detailed role or position in the family and type of relationship with the respondent (an open-ended question). We used this information to infer the generation of each social contact, classifying as *intergenerational* any alter in the generation of the respondent's children or grandchildren. An important strength of these data is their ability to capture the variety of IG ties in different layers of personal networks. We account for this diversity by distinguishing (1) IG ties in the immediate family, that is, with *adult children*; (2) IG ties with family members in the active network layers, i.e., who maintain a daily or weekly frequency of interaction with the respondent (henceforth *IG active ties*); and (3) all IG ties with any immediate or extended family member (henceforth simply called *IG ties*). Ties in categories (1) and (2) are both subsets of all IG ties (category 3), but they overlap only partially: 25% of ties with adult children are *not* active, and over a third (34%) of IG active ties are *not* with adult children. For simplicity, all relationships other than IG ties are called same-generation or non-IG (although a small minority of them are with non-kin in younger generations).

Fig. 1 illustrates these data, exemplifying some of the observed variation in the level and types of intergenerational connectedness: different absolute and relative numbers of IG ties, heterogeneity in their interaction frequency with the ego, and the varying levels of concentration of the personal network on adult children. We analyze this variation by calculating counts and proportions of IG ties in the ego-networks. Counts capture an individual's *absolute* amount of IG relationships, but they co-vary with total network size: people who are socially more active and embedded in larger networks are likely to maintain more IG ties overall. In contrast, proportions of IG ties (over the size of the relevant network layer) measure a person's *relative* tendency, exposure to, or opportunity for IG relationships, holding constant the size of her or his network. We therefore consider four dependent variables: counts of all IG ties and of IG active ties (also called *IG counts* in the text); and proportions of all IG ties and of IG active ties (also called *IG network proportions*).[2] A fifth response

[2] The proportion of IG ties is calculated using the number of all alters as denominator. The proportion of IG active ties is calculated as the number of IG active ties relative to the number of active ties.

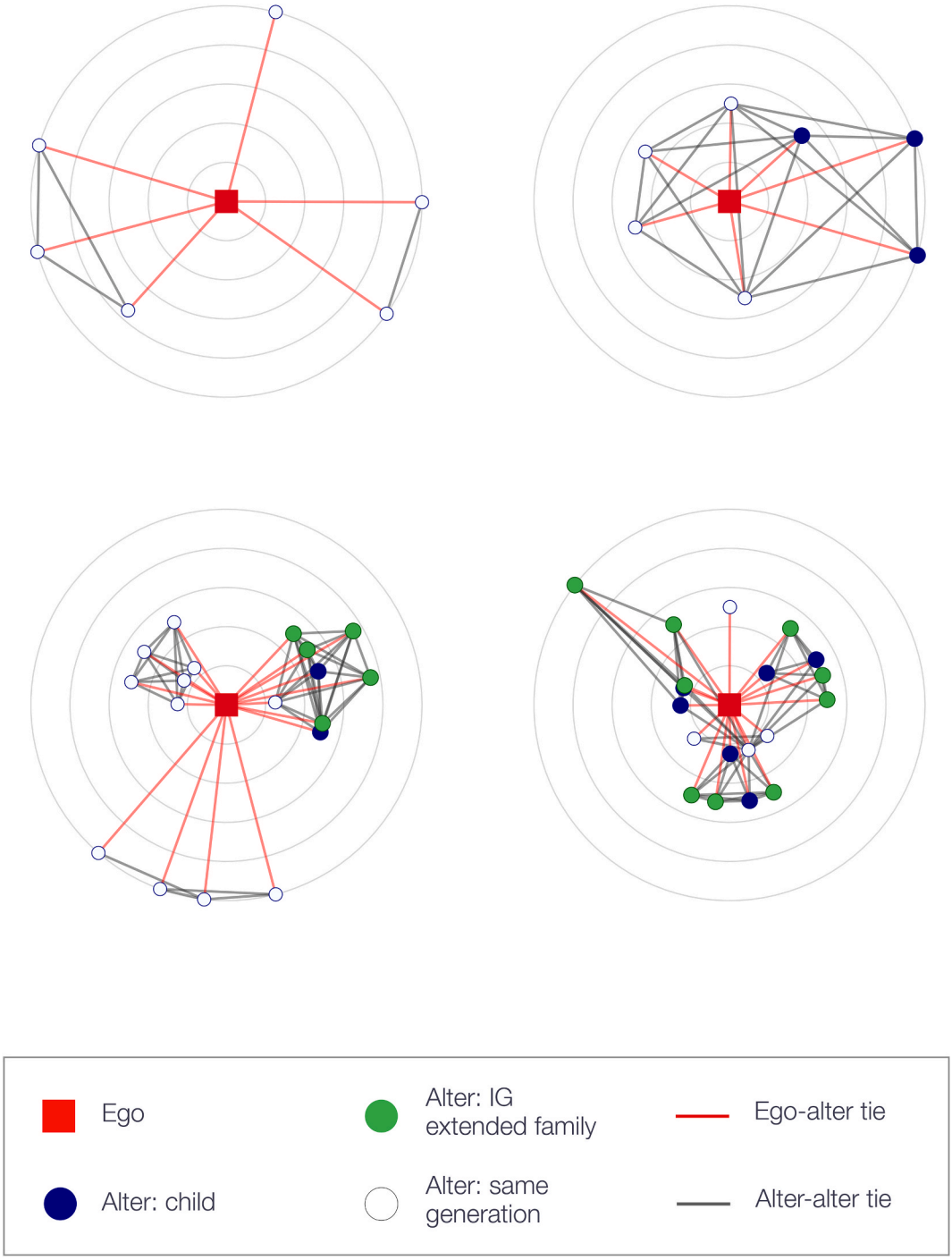

Fig. 1. Four examples of personal networks in the data. IG = Intergenerational. Concentric circles around Ego represent frequency of interaction categories (Yearly, Monthly, Weekly, Daily): circle closer to Ego = more frequent interaction between ego and alter.

variable, the proportion of adult children relative to all social contacts, measures the concentration of a personal network on the respondent's children (also called *concentration* on children henceforth).

As shown in Fig. 1, the survey also collected information about alter-alter ties, which allows us to reconstruct the connectivity structure of each personal network. Here, a tie between two alters indicates that they both know each other and interact with each other, even without the ego (the respondent) being present. We use this information to measure *centrality of alters* in personal networks, with three indexes: (1) the proportion of all social contacts of the ego who are known to alter *a*, that is, *a*'s degree centrality as a

proportion of ego-network size (proportion network known or *p*); (2) *a*'s degree centrality relative to the maximum degree centrality of any alter in the same ego-network (relative degree or *d*); (3) *a*'s betweenness centrality relative to the maximum betweenness centrality of any alter in the same ego-network (relative betweenness or *b*).

3.2. Sociodemographic and health-related characteristics of older adults

Data on sociodemographic characteristics of respondents include *age*, *gender*, *marital status*, *education*, and *type of occupation* (before retirement). Section 2 and Table S2 in the Supplementary Materials provide more details and show categories and descriptive statistics for these variables. Respondents' physical health is described with the following measures:

i) *Number of physical diseases*, obtained from questions asking respondents to indicate their current illnesses in a list of common geriatric physical diseases.
ii) *Limited ADL*, a binary variable indicating whether the respondent is seriously limited in any of the six areas of Katz's (1983) Activities of Daily Living (ADL) instrument (ambulation, feeding, dressing, personal hygiene, continence, toileting).
iii) *Number of recent health care event types*, constructed from questions asking whether the respondent has used any of three main health care services in the previous three months: primary care clinic, emergency room, hospitalization at an in-patient facility.

In addition, a binary variable indicates if the respondent has been diagnosed with *dementia*.[3] Finally, depression is measured via the common five-item *Geriatric Depression Scale* (GDS) (Rinaldi et al., 2003), whose score indicates the number of answers suggesting depression (scores higher than 1 are considered indicative of depressive symptoms).[4] Missing values in all variables were imputed via multiple imputation with chained equations using the *mice* R package (Buuren and Groothuis-Oudshoorn, 2011).

3.3. Analyses

After describing alter and tie characteristics among different types of IG and non-IG relationships, we model IG connectedness as a function of older adults' sociodemographic and health-related features. We use Zero-Inflated Negative Binomial (ZINB) models for IG counts and standard binomial logit models for IG network proportions (more details about models and coefficient interpretation are in Section 3 of the Supplementary Materials).

We also use multilevel logistic models to answer questions about tie- or alter-level characteristics of IG relationships. Here, the probability of a tie being IG, IG active, or an adult child is modeled as a function of characteristics of alters and social relationships, while controlling for respondent-level clustering and effects. This approach is commonly used in personal network analysis to account for the multilevel structure of egocentric data (Vacca, 2018). Treating measures of a social contact's age and family role (e.g., whether a tie is IG or an adult child) as "dependent variables" in regression models may appear counterintuitive, because an alter's age and family role precede in time, and cannot be "caused" by, other tie characteristics. Our multilevel regressions, however, have the descriptive goal of detecting features that, among a battery of potential predictors, tend to be recurrent with or typical of different types of IG ties (vis-à-vis non-IG ties), while taking into account other characteristics of social ties and the individuals they connect, as well as the clustered structure of the data. This is similar to the use of multilevel modeling in other personal network research to identify the most salient characteristics of specific types of ties – e.g., ties that are interethnic (de Miguel Luken and Tranmer, 2010) or supportive (Vacca et al., 2019) – and should not be interpreted as presupposing a causal nature of the modeled relationships.

All regression models control for whether the respondent currently lives in an assisted living facility and for interview mode (in person or telephone). A link to the code and data to reproduce the analyses is provided in the Supplementary Materials (Section 5).

4. Results

4.1. Characteristics and integration of intergenerational relationships

The vast majority of older adults in our data (87.8%) have at least one IG social tie (Table 1), in most cases (79.5%) one they see daily or weekly, and nominated at least one adult child in their personal network (77.3%). The average network comprises almost 5 IG relationships (sd = 3.6), with daily or weekly interaction occurring in 3 IG ties (sd = 2.8). For the average respondent, substantial proportions of both the total personal network and its active layer are intergenerational – 42% in both cases (sd = 26% and 31%, respectively). Importantly, while children represent about a quarter of the personal network for the average older adult (26%, sd = 22%), IG ties are not exclusively with children: 43% of them come from the extended family of grandchildren, nephews, and nieces (Table 2). This statistic confirms the importance of broadening the conceptualization of IG ties in aging populations beyond parent-child relationships. As expected in *hypothesis H1*, most IG ties (63%) involve frequent interactions occurring weekly (45%, a

[3] For respondents who were diagnosed with dementia (26 out of 230, see Table S2), interviews were conducted with the assistance of their primary caregiver.

[4] Internal consistency reliability for GDS on our sample was estimated as 0.71 (0.81 in the random sub-sample). The estimate is obtained as Omega asymptotic, following recent recommendations for cases in which the essentially tau-equivalence and unidimensionality assumptions for the scale are not realistic (Dunn et al., 2014; Trizano-Hermosilla et al., 2021).

Table 1
Counts, proportions, and centrality of IG social ties. Full sample (N = 230). All statistics are ego-level: mean, standard deviation and range across egos (respondents); N and % of egos (respondents). IG = Intergenerational. Active = Daily/weekly contact.

	Mean (SD)	Range
Counts of alters in personal network		
All	12 (6.6)	0–29
Family	7.2 (4.8)	0–26
Active	7.5 (4.6)	0–23
IG	4.9 (3.6)	0–17
IG active	3 (2.8)	0–14
Adult children	2.8 (2.1)	0–10
Proportions of personal network		
IG	0.42 (0.26)	0–1
IG active	0.42 (0.31)	0–1
Adult children	0.26 (0.22)	0–1
Max centrality of an IG alter in personal network		
Max proportion network known (*p*)	0.61 (0.27)	0–1
Max relative degree (*d*)	0.82 (0.25)	0–1
Max relative betweenness (*b*)	0.38 (0.46)	0–1
	N (%)	
Ego has IG ties	201 (87.8)	
Ego has IG active ties	182 (79.5)	
Ego has adult children in network	177 (77.3)	
IG alter knows all network members	42 (18.5)	
IG alter has highest degree	114 (50.4)	
IG alter has highest betweenness	42 (18.3)	

Table 2
Characteristics of IG and same-generation social ties. Full sample (N respondents = 230, N ties = 2747). *Difference between IG and same-generation ties in variable distribution is significant at 5% (chi square test for categorical variables, clustered Wilcoxon test for continuous variables). IG = Intergenerational.

	IG ties	Same-generation ties	All ties
N (row %)	1115 (41)	1632 (59)	2747 (100)
		N (column %)	
Alter gender			
Male	533 (48)	716 (44)	1249 (45)
Female	582 (52)	916 (56)	1498 (55)
Alter role*			
Immediate family	640 (57)	329 (20)	969 (36)
Extended family	475 (43)	203 (13)	678 (25)
Non-family	0 (0)	1081 (67)	1081 (40)
Frequency of contact*			
Daily	197 (18)	396 (24)	593 (22)
Weekly	502 (45)	626 (38)	1128 (41)
Monthly	307 (28)	418 (26)	725 (26)
Yearly	109 (10)	192 (12)	301 (11)
Coresident*			
No	1090 (98)	1507 (92)	2597 (95)
Yes	25 (2)	125 (8)	150 (5)
		Mean (SD)	
Alter centrality			
Proportion network known (*p*)*	0.57 (0.25)	0.34 (0.27)	0.44 (0.28)
Relative degree (*d*)*	0.74 (0.26)	0.52 (0.34)	0.61 (0.33)
Relative betweenness (*b*)	0.13 (0.31)	0.13 (0.31)	0.13 (0.31)
Top 5 alter roles	Other family, Child, Child-in-law	Friend, Religious/voluntary group, Sibling, Neighbor, Sibling-in-law	Other family, Friend, Child, Religious/voluntary group, Child-in-law

significantly higher proportion compared to same-generation ties) or daily (18%, significantly lower than for same-generation ties). All these results are substantively confirmed in analyses of the random sample (Tables S6 and S7).

Alter centrality measures reveal a remarkable level of social integration of IG contacts in older adults' personal networks, supporting *hypothesis H2*. For the average respondent (Table 1), a family member from younger generations knows 61% of all other social contacts; and for 18.5% of respondents, a younger generation relative knows *all* other network members. IG ties display some of the highest values of degree centrality (82% of the maximum in the average network) and, for about half of respondents (50.4%), an IG tie

has the highest degree centrality among all contacts. On average, compared with other relationships (Table 2), alters in IG ties know significantly greater proportions of the personal network (mean $p = 57\%$ vis-à-vis 34% for same-generation ties) and have significantly higher relative degree centrality (but the same relative betweenness centrality). At the same time, as posited in *hypothesis H3*, younger generation alters are less likely to coreside with the respondent (only 2% are coresident) compared to non-IG ties (8% coresident). These findings about IG alter centrality and coresidence remain substantively unaltered in random sample analyses (Tables S6 and S7).

Additional insights on hypotheses H1–H3 come from multilevel regressions (Fig. 2 and Table S5). Coresidence with the ego, network centrality, and frequency of contact are all significant correlates of IG ties in these models. Providing more support for *hypothesis H1*, social ties that involve daily interaction are significantly more likely to be adult children (but less likely to be IG relationships in general), while those that only involve monthly contact are less likely to be adult children. In line with *hypothesis H2*, network centrality (measured as proportion of network known, p) emerges as the strongest correlate of IG relationships – and not limited to ties with adult children. Alters in more degree-central network positions are much more likely to be children, active IG ties and, even more strongly, IG ties of any type. For example, an increase by 10 percentage points of the proportion of other contacts known by an alter a is associated with 93% higher odds of a being from a younger generation ($\exp(0.1 \times 6.56) = 1.93$). Notably, different types of IG ties show different patterns of integration in older adults' social networks: for example, adult children are the most likely to interact with aging people on a daily basis (as expected in hypothesis H1), whereas the centrality effect is strongest for all IG ties rather than for children (in contrast with hypothesis H2). As expected with *hypothesis H3*, social contacts who reside in the same dwelling as the ego are much less likely to be from younger generations.

4.2. Sociodemographic and health correlates of intergenerational connectedness

Bivariate associations (Fig. 3) and regression results (Fig. 4) point to significant differences between aging population subgroups in terms of intergenerational connectedness, and to important predictors of IG relationships among sociodemographic and health-related characteristics of older adults. As proposed in *hypothesis H4*, within the age range under consideration, age is significantly and positively associated with IG relationships and network concentration on children.[5] According to unadjusted correlations (Fig. 3), people with more years of age are embedded in personal networks with significantly higher percentages of IG ties, IG active ties, and adult children (but not with higher IG counts). When holding equal other respondent characteristics in regression models, age is positively associated with all measures of IG connectedness, except for the count of active IG ties (Fig. 4). Ten additional years of age, for example, are associated with about 39% more IG relationships ($\exp[10 \times 0.033] = 1.39$) and with the proportion of IG ties in the network (relative to the proportion of non-IG ties) increasing by 88% ($\exp[10 \times 0.063] = 1.88$) (Tables S3–S4). With other characteristics being equal, 85-year-old women are expected to have almost two more IG ties than 75-year-old women (Fig. S1A in Supplementary Materials); more than 55% of an 85-year-old man's personal network is predicted to be intergenerational, compared to about 40% for a 75-year-old man (Fig. S1D). Interestingly, the age coefficient estimate is higher for the proportion of all IG ties than it is for the proportion of adult children, suggesting that IG relationships with extended family members may be associated with age even more strongly than those with children. These results are reproduced by models estimated on the random sample (Fig. S3).

In regression results, women tend to have significantly more IG ties than men, but not more IG active ties or higher IG network proportions, and actually lower concentration of the network on children. Furthermore, the positive association with the count of IG ties is not reproduced in random sample analyses (Fig. S3), suggesting insufficient support for *hypothesis H5*. Here again, different patterns emerge for different types of IG connectedness: the negative, significant association between ego's female gender and network concentration on children (replicated in the random sample) is in contrast with a positive, non-significant association between the same characteristic and the proportion of all IG ties (not replicated in the random sample).

Results describe an overall negative relationship between IG connectedness and SES (*hypotheses H6* and *H7*) in both the full and random samples. First, considering unadjusted associations (Fig. 3 and Fig. S2), older adults in lower educational categories (primary and middle school) tend to have more IG ties in their total and active networks, in both absolute and relative terms, as well as higher network concentration on children. Adjusting for other characteristics in regression models (Fig. 4 and Fig. S3), those with only middle-school education exhibit significantly higher IG counts, as well as higher IG proportions in random sample analyses, but not higher network concentration on children. For example, men with middle-school education are predicted to have about two more IG active ties than their high school graduate counterparts (holding occupation constant to the elementary/menial category, Fig. S1B). At the same time, IG proportions and network concentration on children are generally lower among high school and university graduates (although confidence intervals cross the zero line for three out of the six relevant coefficient estimates).

Second, along the occupational dimension, bivariate statistics show that respondents in the lowest occupational category (1-Elementary/menial jobs) tend to be surrounded by significantly larger IG and IG active networks and higher percentages of IG ties and adult children (in both full and random sample analyses). Consistently, adjusted results from regressions, both in the full and random samples, show lower IG active counts, IG proportions, and network concentration on children in higher occupational categories (especially 2-Skilled crafts/trades and 4-Professional/self-employed categories), although effects do not uniformly reach the conventional 5% significance threshold for all dependent variables.

Concerning the relationship between IG ties and physical health (*hypothesis H8*), evidence is more mixed. In bivariate analyses

[5] While, in general, a curvilinear relationship may be expected between age and amount of IG relationships (Hank, 2007; Kalmijn, 2019), our analyses focus on a relatively limited age range (75 years and over), in which a linear trend is sufficient to describe this association. Analyses with a quadratic term for age estimated a coefficient close to zero (results not shown).

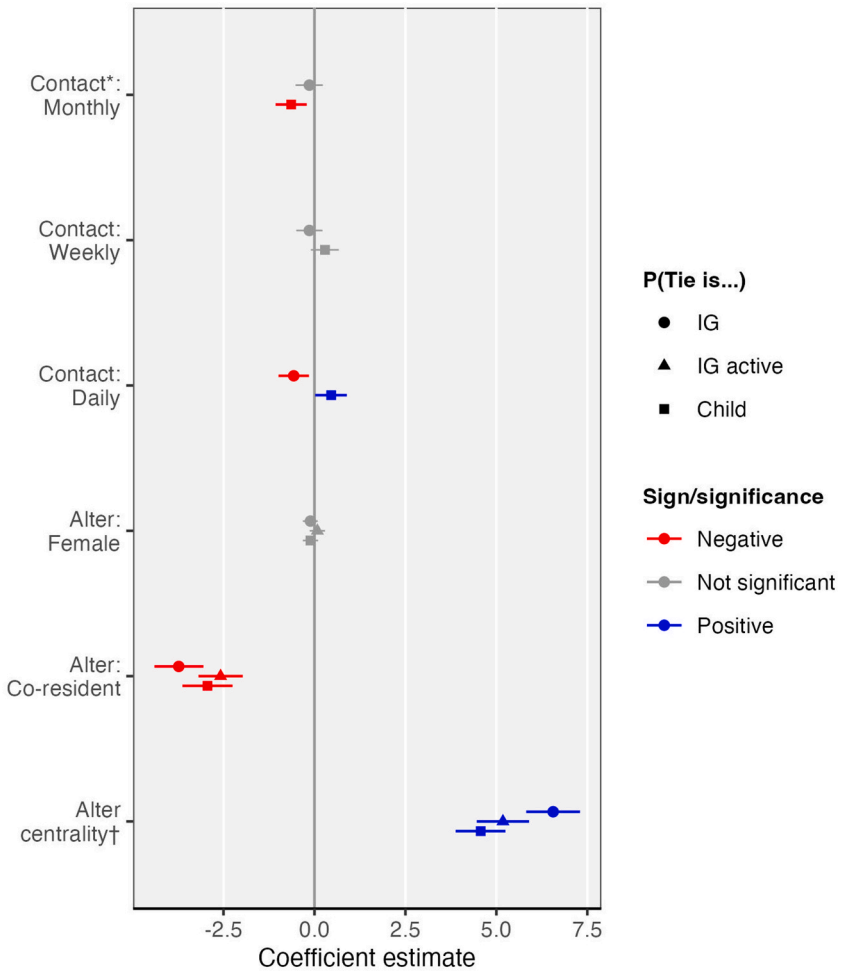

Fig. 2. Coefficients of multilevel logistic models for the probability of a tie being IG, IG active or adult child: point estimates and 95% confidence intervals. N ties (level 1) = 2747, N egos (level 2) = 227. Full results in Table S5. *Reference category: Yearly. †Alter centrality = Proportion network known by alter. Contact frequency is omitted in models for IG active ties because these ties have daily/weekly contact by construction. All models control for the same ego-level variables included in ego-level models (see Fig. 4). IG = Intergenerational. Active = Daily/weekly contact.

(Fig. 3), all measures of IG connectedness are slightly higher among those with one or multiple physical diseases; and people with multiple recent events of health care utilization show higher IG counts on average, but not higher IG proportions (bivariate differences for both health-related predictors, however, do not reach the 5% significance level). In regression models, the number of physical diseases does not show significant effects. However, multiple recent events of health care utilization are associated with higher IG counts (Fig. 4, Figs. S1C and S1F); a positive effect of this predictor on IG network proportions is also detected (but does not reach 5% significance); and no effect of health care utilization is identified for network concentration on adult children. Thus, overall, the personal networks of older adults who have recently received more health care seem to be larger and include more IG ties in absolute terms; but they are not more strongly reliant on IG relationships in relative terms, either with adult children or with extended family members. These results remain substantively unaltered in analyses of the random sample, which also suggest a positive association between having multiple physical diseases and the count of all IG ties (Figs. S2 and S3).

In contrast, in unadjusted statistics (Fig. 3), respondents with limited ADL autonomy exhibit significantly higher IG network proportions and concentration on children, but *lower* counts of IG ties: this suggests that their personal networks are smaller (including fewer contacts overall) and, at the same time, more reliant on IG family relationships. Regression estimates (Fig. 4) depict a positive association between limited ADL autonomy and proportion of IG active ties as well as network concentration on children (but for the latter response variable the corresponding 95% confidence interval crosses the no-effect threshold). Results are similar in random sample analyses (Figs. S2 and S3).

As expected in *hypothesis H9*, the negative association between depression (GDS) and IG connectedness emerges as statistically significant in bivariate and regression results in both the full and random samples. In particular, people with depressive symptoms (GDS >1) have fewer IG ties overall and lower IG network proportions. Notably, however, they do not show lower network concentration on children; in fact, in bivariate results, this measure is higher on average among older adults with depressive symptoms.

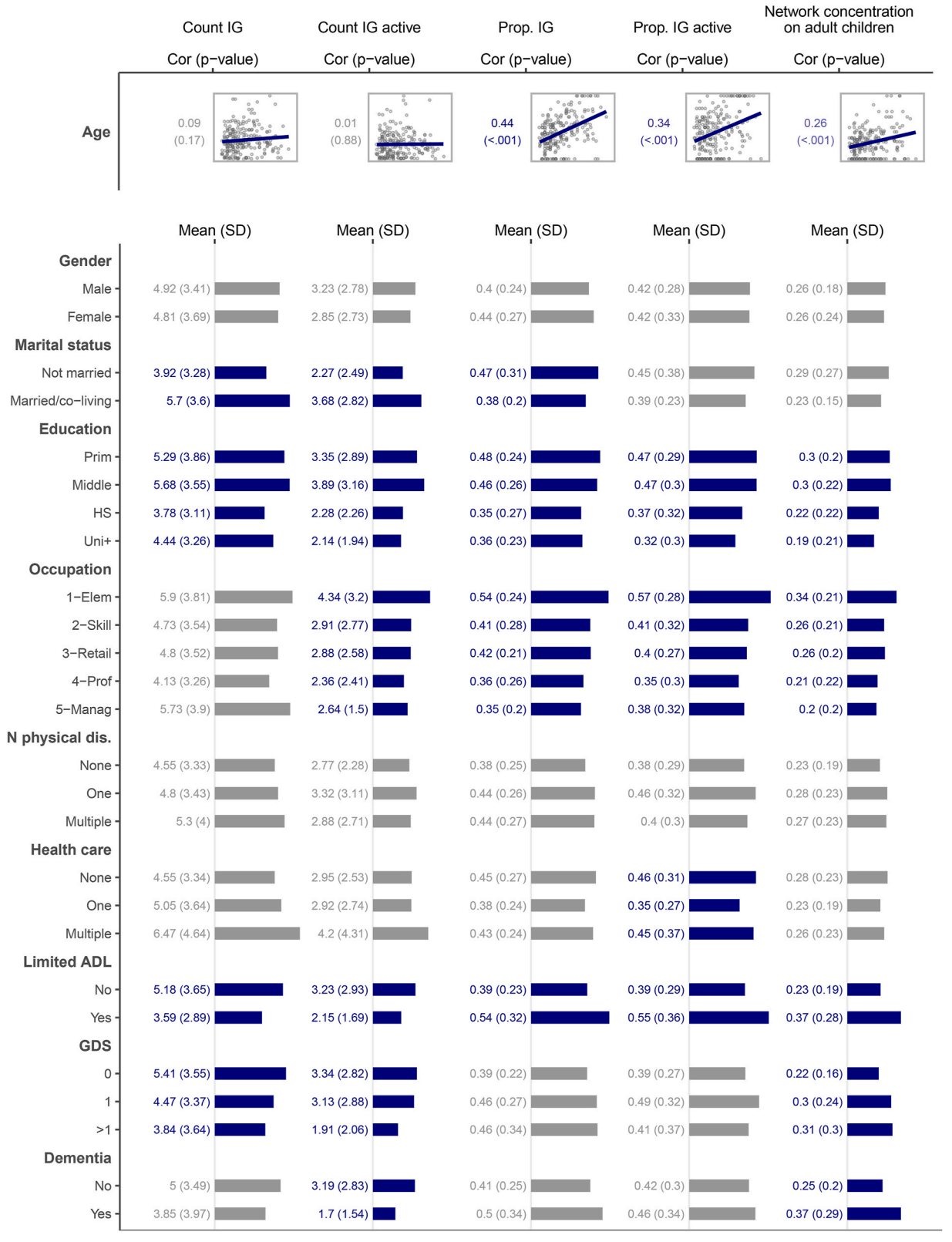

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Fig. 3. Bivariate associations between characteristics of respondents and counts/proportions of IG ties. Full sample (N = 230). Cor = Pearson's correlation. Blue (grey) bars and numbers indicate association is statistically significant (not significant) at 5% level (based on *t*-test, F-test, or Pearson's correlation test). IG = Intergenerational. Active = Daily/weekly contact. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

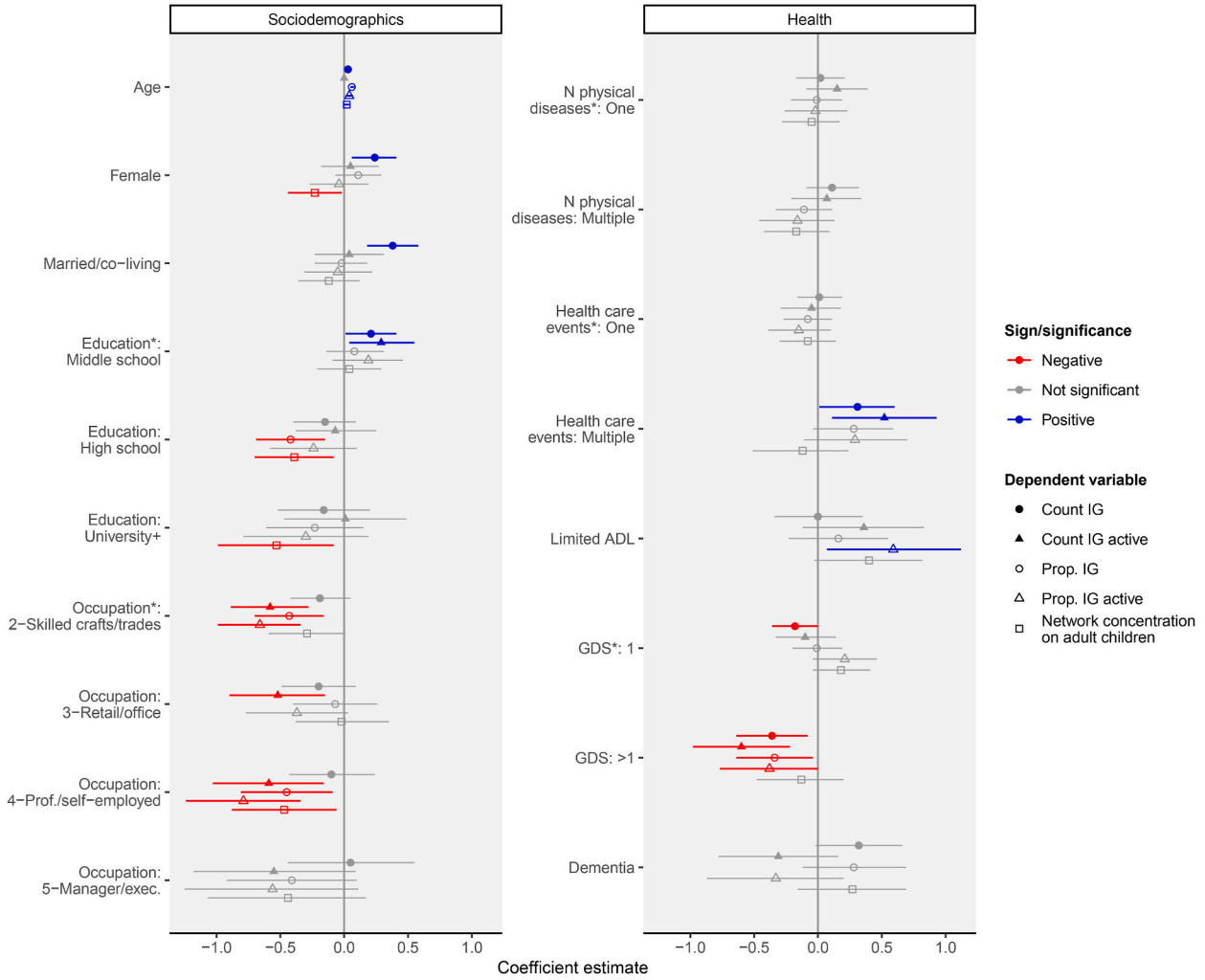

Fig. 4. Coefficients of ZINB/binomial logit models for counts/proportions of IG ties: point estimates and 95% confidence intervals. N = 230 (counts), 227 (proportions). Full results in Tables S3–S4. *Reference categories: Primary school (Education); 1. Elementary/menial (Occupation type); None (Number of physical diseases); None (Recent health care events). All models control for respondent's residence in assisted living facility and interview mode (in person or telephone). IG = Intergenerational. Active = Daily/weekly contact.

Results for dementia are weaker and more ambiguous. They do not indicate general support for *hypothesis H10* but suggest an overall pattern in which the personal networks of people with dementia are more concentrated on adult children.

5. Result summary and discussion

Intergenerational relationships have become a key feature of family and social life in Western societies, with major impacts in domains such as social support, health, and wellbeing of aging people. We have examined the diversity, characteristics, and correlates of IG relationships in an area of the world at the forefront of global aging trends. To do so, we have proposed a novel approach based on egocentric network methods, arguing that the more extensive and granular information it provides – about broad personal networks, specific dyadic relationships, and connectivity structures – generates new insights that would not be possible with other research designs.

Our findings show that IG relationships were prevalent but also highly variable in the population under study. The vast majority of

older adults in our data maintained one or more IG ties with kin, which derived from both the immediate and extended family and represented a substantial percentage of their personal networks across different layers. In addition, younger generation relatives were highly integrated in the social circles of the older adults in our study: they tended to be active participants in their social life, interacting daily or weekly with them and occupying some of the most central positions in their networks. On the other hand, the great majority of IG contacts did not live in the same household as their older relative, suggesting that coresidence between generations captures relatively few (and perhaps atypical) IG relationships. This finding also underscores the limits of proxy measures of IG connectedness based on coresidence between age groups, which have been common in the literature about IG relationships and COVID-19 diffusion (Arpino et al., 2020; Brandén et al., 2020; Dowd et al., 2020).

Our results are consistent with previous findings about both the prevalence of IG relationships and their sociodemographic and health-related variability. As reviewed in Section 2, existing literature indicates that the intensity and importance of IG relationships are positively associated with older adults' age and negatively related to socioeconomic status. It also points to a specific effect of aging adults' poor health, which tends to activate and mobilize more intergenerational solidarity, especially in more familialistic societies. Our results support these claims with novel data and extend them to IG ties with any family member, not just adult children; to IG ties in both the total and active network layers of aging people; and to IG connectedness measured as both absolute number of ties and proportion of one's personal network.

In our findings, IG relationships are indeed more prevalent among the oldest old and in lower socioeconomic groups. We also report some evidence that IG ties are more frequent among older adults with poorer health: more numerous (as measured via tie counts) in the personal networks of those who report more physical diseases and have recently used more health care services, and relatively more frequent (as network proportions) among people with limited ADL autonomy. Here, the distinction between absolute and relative IG connectedness proves useful to discern differential associations between various aspects of health and IG relationships: certain indexes of poor health (recent health care utilization) are associated with IG ties being more numerous in absolute terms but not more prevalent relative to the entire network; while others (limited ADL autonomy) are associated with smaller networks in which IG ties are fewer yet more predominant as a proportion of all social ties.

In assessing these results, a few important limitations of our data should be borne in mind. The data come from a local survey conducted in one city of northern Italy: this setting is of particular interest as located in one of the European areas most affected by population aging, but results about it cannot be generalized to the national population. Furthermore, the relatively smaller sample size of this survey, compared to large-scale national or cross-national studies, may have obscured certain effects and associations due to lower statistical power. Finally, this was a cross-sectional survey, whose data do not allow us to disentangle causal directions behind the observed effects. For example, we are unable to evaluate whether the negative association between GDS and IG connectedness is driven mostly by depression reducing older people's inclination and ability to maintain IG ties; or vice versa, by the lack of IG ties making the emergence of geriatric depression more likely.

6. Conclusions and future directions

A major argument in this paper is that methods of personal network research enable scholars to ask new questions and test novel hypotheses about IG relationships and social support in old age. These methods can be employed by collecting new data similar to those described here or by leveraging existing datasets with rich personal network information – such as the LASA (Huisman et al., 2011) or UCNets (Fischer, 2018) data – for novel analyses.[6] In new data collections, ego-network survey designs different from those adopted in this study should also be considered. These include designs using exchange-based or interactive name generators, those eliciting a fixed number of alters to reduce respondent bias in tie recollection, and those asking name and edge interpreters on just a sub-sample of alters to limit respondent burden (Marsden and Hollstein, 2022; McCarty et al., 2019, p. 72; Peng et al., 2023).

Besides the methodological argument, results in this paper make three main contributions to theoretical advancement in research on IG relationships and social support in aging populations. First, they highlight the *diversity of IG relationships* across different layers and circles in older adults' social life. For example, while the vast majority of previous literature conceptualizes IG ties as parent-child relationships, in our data 43% of aging people's ties with younger generation kin are from the extended family. Moreover, IG relationships in different ego-network layers may have different features and associations with sociodemographic characteristics (and perhaps different consequences). For instance, we observe that alter centrality effects in multilevel models are stronger for all IG ties than they are for adult children, suggesting that younger generation relatives in the extended family may occupy central positions in older adults' ego-networks to an even greater extent than children. Thus, although currently overlooked in most literature and in the dominant datasets in the field, the distinction between personal network layers may lead to more appropriate conceptualizations of IG relationships and more precise hypotheses about their antecedents and consequences.

Second, we document a high level of *structural integration of IG ties* in older adults' social life. Relatives in younger generations were some of the most central alters in the ego-networks we observed. This observation adds a new dimension to the study of IG relationships and opens up a novel way of conceptualizing their importance, power, and constraints in aging families – based on their centrality in network structures. In our multilevel model estimates, common measures of interaction frequency indicate children as the most integrated contacts in their older parents' social life; however, network centrality points to other types of IG ties as the most

[6] The UC Berkeley Social Networks Study (UCNets) collects rich information about extended personal networks, with tie-level questions about alters and alter-alter ties for a subsample of each respondent's social contacts. This study, however, does not focus specifically on aging issues. Its population of interest comprises a young-adult cohort (21–30 years old) and a young-old cohort (50–70 years old).

integrated. This suggests that indexes based on network connectivity capture a different, non-redundant aspect of relational integration and tie strength in IG relationships, which cannot be measured with other data.

Our findings about alter centrality emphasize, more broadly, the importance of considering network structural patterns and effects in the study of IG relationships and support in old age. In addition to centrality, examples include patterns of reciprocity, triadic closure, and cohesive subgroups in ego-networks (Bianchi et al., 2023; McCarty, 2002; Vacca, 2020). The stability (Goldman and Cornwell, 2018) and ambivalence (Fingerman et al., 2004) of IG relationships, for instance, may be influenced by network closure and cohesion, with IG ties being more stable or less conflictual when embedded in closed triads or cohesive cliques. In a similar vein, personal network methods can be used to study patterns of reciprocity (giving and receiving support in the same relationship) and multiplexity (receiving multiple types of support) in IG ties, and how these are influenced by connectivity structures (e.g., whether reciprocity and multiplexity are higher in IG ties embedded in closed triads). Analyses of reciprocity and multiplexity would help to shed further light on the differential roles of older adults as both receivers and providers of support in IG social ties.

Finally, our results point to the issue of *social network concentration on adult children* as an important aspect of IG connectedness. The observed associations between the concentration measure and older adults' sociodemographic and health-related characteristics suggest that this may be an important dimension of vulnerability in aging populations, compounding other disadvantages such as low socioeconomic status, diminishing functional ability, and overall poor health. Previous research has produced some evidence that social network types characterized by excessive reliance on family ties (especially on adult children) are associated with poorer outcomes of health and wellbeing in old age (Fiori et al., 2006; Shiovitz-Ezra and Litwin, 2015). However, the kind of analyses employed in this literature, which aggregate several summary indicators of social activity and support into a single composite typology, do not facilitate the identification of specific dimensions, drivers, and mechanisms behind the described associations. On this and other issues, methods of personal network research enable more precise and valid operationalizations, empirical investigation, and theorization in the study of IG relationships and their diversity, variability, and integration in aging families.

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CRediT authorship contribution statement

Raffaele Vacca: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Federico Bianchi:** Conceptualization, Investigation, Data curation, Writing – original draft, Writing – review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssresearch.2024.102991.

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