Title: Social engagement and cognitive health in a population-based study of older men and women in rural South Africa

Authors: Guy Harling^{1,2,3,4}, Lindsay Kobayashi⁵, Meagan T. Farrell³, Ryan G. Wagner^{4,6}, Lisa Berkman^{3,4,7}

Address for correspondence: Guy Harling. Institute for Global Health. University College London, Mortimer Market Centre, London, WC1E 6JB. g.harling@ucl.ac.uk

Author affiliations:

1. Institute for Global Health. University College London, United Kingdom
2. Africa Health Research Institute, KwaZulu-Natal, South Africa
3. Harvard Center for Population and Development Studies, Harvard University, Cambridge, MA, USA
4. MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt), School of Public Health, University of the Witwatersrand, Johannesburg, South Africa
5. Lombardi Comprehensive Cancer Center, Georgetown University, Washington, DC, USA
6. Umeå Centre for Global Health Research, Umeå University, Umeå, Sweden
7. Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Cambridge, MA, USA

Keywords: cognition; cognitive impairment; social networks; social support; social engagement; social dis-engagement; gender; South Africa

Acknowledgements

Financial support: This work was supported by the National Institute on Aging at the National Institutes of Health (P01 AG041710), and is nested within the MRC/Wits Rural Public Health & Health Transitions Research Unit (Agincourt), supported by Wellcome Trust (058893/Z/99/A; 069683/Z/02/Z; 085477/Z/08/Z; 085477/B/08/Z), the University of the Witwatersrand, the South African Medical Research Council and the South African Department of Science and Technology (via the South African Population Research Infrastructure Network).

Thanks: The authors would like to thank the HAALSI study team, participants and the Agincourt community.

Disclaimer: The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Authors' contributions: GH conceptualized the study, conducted the analyses, and wrote the first draft of the article in collaboration with LK. LB developed the social network measures; LB and RW were involved in all phases of data collection. All authors contributed to the study design, data analysis and interpretation, and substantive revisions to the written text. All authors approved the final version and agree to be accountable for all aspects of the work.

Data availability: All data underlying this study are publicly available at <https://doi.org/10.7910/DVN/F5YHML>.

Abstract: We investigated how patterns of social engagement and cognitive health in the HAALSI population-based study of over 5000 individuals aged ≥ 40 years in rural South Africa fit with three existing theories of how social engagement and cognitive function are interconnected in older age. We found that respondents with lower cognitive function had smaller, denser social networks that were more local and more kin-based than their peers. Lower cognitive function was associated with receipt of less social support in general, but this difference was stronger for emotional and informational than for financial and physical support. These patterns suggest that cognitively impaired older adults in this setting rely on their core social networks for support, and that theories developed in higher-income and higher-education settings may also apply elsewhere in the world.

Introduction

By 2050, 70% of dementia cases worldwide are projected to occur in low-and-middle income countries (LMICs), such as those in sub-Saharan Africa (Prince et al., 2013). However, the social drivers of cognitive health in older LMIC populations are not well understood (Lekoubou, Echouffo-Tcheugui, & Kengne, 2014; Olayinka & Mbuyi, 2014). Education is perhaps the strongest known protective factor against aging-related cognitive decline and dementia (Clouston, Glymour, & Terrera, 2015; Nguyen et al., 2016; Vemuri et al., 2014). However, in many LMICs, school access and quality are limited, especially for those who are now middle-aged or older (Kenn, 2016; UNESCO, 2018). In the South African context, non-White citizens were systematically excluded from educational opportunities during the Apartheid era of 1948-1994 (Christie & Collins, 1982). Alternative means of developing, maintaining, and promoting cognitive health may therefore be particularly important for the current generation of older non-White South Africans.

Social connectedness is hypothesized to be a key protective mechanism against cognitive decline. Social networks have been theorized to impact health in myriad ways, at macro-social, community and interpersonal levels (Berkman, Glass, Brissette, & Seeman, 2000). One strong hypothesized effect is that greater social stimulation protects against cognitive decline, i.e. the “use it or lose it” hypothesis (Hultsch, Hertzog, Small, & Dixon, 1999). There is substantial longitudinal observational evidence that loneliness and social isolation are associated with incident cognitive decline and dementia (Bassuk, Glass, & Berkman, 1999; Kuiper et al., 2015; Penninkilampi, Casey, Singh, & Brodaty, 2018; Shankar, McMunn, Banks, & Steptoe, 2011). There is also related evidence that higher levels of social engagement are associated with less cognitive decline (Barnes, De Leon, Wilson, Bienias, & Evans, 2004; Ertel, Glymour, & Berkman, 2008; Teresa E Seeman, Lusignolo, Albert, & Berkman, 2001). There is some evidence that these associations are stronger in mid-life compared to older ages (Teresa E. Seeman et al., 2011). Furthermore, a small number of randomized trials have shown the ability of increased social engagement to improve cognitive performance (Hikichi, Kondo, Takeda, & Kawachi, 2017; Mortimer et al., 2012; Pitkala, Routasalo, Kautiainen, Sintonen, & Tilvis, 2011). In this literature, a range of aspects of social engagement have been examined, such as social contact count, frequency of contact with friends or family, levels of emotional support and attendance at religious or community events.

While the substantial literature discussed above links social dis-engagement to subsequent cognitive decline, it is also to be expected that cognitive impairment or dementia following a period of cognitive decline will lead to social dis-engagement. This latter situation may arise due to the impaired individual being less able to engage with others, and others being less able or less motivated to engage with them. Evaluations of this 'reverse' causal process, whereby impaired cognitive function leads to social disengagement, are relatively rare (Aartsen, Smits, Van Tilburg, Knipscheer, & Deeg, 2002; Hosking, Jiang, Sargent-Cox, & Anstey, 2017; Small, Dixon, McArdle, & Grimm, 2012). In practice, the association is likely to be a virtuous circle, whereby better cognitive health promotes ability to engage in stimulating social relationships and activities which further promote cognitive health in older age, or a vicious one in which low social engagement and poor cognitive function negatively impact one-another (Bosma et al., 2002; Hultsch et al., 1999). This divergence is likely to be exacerbated by perceived loss of cognitive capacity, e.g. through reduced word recall, which can lead to greater disengagement independent of measured cognitive ability (Farrell et al., 2014).

At the same time, a third social process might be expected, whereby older adults experiencing cognitive decline begin to receive more care-related support. This support is likely to be primarily instrumental, including physical and financial assistance, but may also include emotional support as and if those with cognitive decline become disorientated or afraid. Social contacts may also decide to shift from providing emotional support to providing instrumental or financial support, as they notice cognitive decline.

Importantly, this shedding of social connections and accretion of care receipt is likely to be non-random. Following the Convoy Model (Antonucci & Akiyama, 1995), the closest social connections are most likely to be maintained as cognitive capacity declines, while peripheral ties are shed (Clay, Roth, Wadley, & Haley, 2008). Caregiving is likely to be performed most often by those who are geographically close, and by those for whom there is an expected intertemporal reciprocity, i.e. offspring and other kin (Schulz & Martire, 2004). These close social ties are likely to be strongly interconnected. A recent cross-sectional comparison of US individuals with normal cognitive function, mild cognitive impairment, and mild Alzheimer's disease showed a progressive shift towards smaller, denser and more kin-focused social networks with greater symptomology (Perry et al., 2017).

Existing research on all of these causal processes has largely been conducted in higher-income countries and among relatively highly educated populations. The role of social engagement in later-life cognitive health in low-income settings is less well examined, and it is not clear how context-specific any buffering effects of social engagement might be. Observation of older Spanish adults educated prior to World War II showed that both having few social contacts and non-participation in social activities were associated with subsequent cognitive decline (Zunzunegui, Alvarado, Del Ser, & Otero, 2003). Within Africa, two studies in Nigeria showed a cross-sectional positive association of social engagement and cognitive function (Ejechi, 2015), and a longitudinal association between social non-engagement and incident dementia (Gureje, Ogunniyi, Kola, & Abiona, 2011). We are not aware of any previous work exploring whether cognitive decline leads to loss of social connections or increases in care receipt in LMICs.

Analytic hypotheses

We therefore analyzed the first round of data collected for a South African rural cohort of middle-aged and older adults, to determine whether the patterns of social engagement seen in this population were consistent with the three causal processes described above. Specifically, we hypothesized that individuals with cognitive impairment will have:

1. Fewer social contacts, due either to cognitive decline having led to reduced contacts, or limited contacts having led to cognitive decline;
2. More kin-focused, geographically proximate and densely connected social contact groups, as peripheral ties are shed and support is drawn from individual's closest contacts;
3. Lower levels of social support of all kinds, due to having shed social contacts, offset in the case of physical and financial support by an increased need for instrumental assistance.

Our cross-sectional data source does not allow us to disentangle these effects, particularly those running from social engagement to cognitive function, and those from cognitive function to social engagement. However, we are able to provide an initial picture of how social factors and cognitive capacity are patterned in this setting, and generate hypotheses to test with future longitudinal data.

Methods

Setting and sample

Our sample comprises the baseline responses in the Health and Aging in Africa: a Longitudinal Study of an INDEPTH community in South Africa (HAALSI) cohort (Gómez-Olivé et al., 2018). HAALSI is a population-based cohort of middle-aged and older males and females aged 40 and above, and is a Health and Retirement Study (HRS) sister study. The baseline sample consists of a random sample of adults aged ≥ 40 in the MRC/Wits Rural Public Health and Health Transitions Research Unit site in Mpumalanga Province, South Africa (hereafter, “Agincourt”) (Kahn et al., 2012). The Agincourt area is rural and, while improvements have occurred since the end of Apartheid, it continues to have limited access to basic services including healthcare. HAALSI interviews were conducted in-home by trained interviewers in the local Shangaan language between November 2014 and November 2015.

Measurement of key variables

Cognitive health

Cognitive functioning was assessed in two ways based on a battery of cognitive measures adapted from validated measures in the U.S. HRS and adapted for local cultural relevance and language in Agincourt. The battery consisted of questions assessing: orientation in time (ability to state the correct date, month, year, and South African President; 4 items total); immediate and delayed recall of 10 words read out loud (20 items total); and ability to count forward from 1 to 20 (1 item) and complete a number pattern (2, 4, 6, ?; 1 item). First, we generated a latent cognitive Z-score with a mean of 0 and standard deviation (SD) of 1, based on confirmatory factor analysis from all measures in the battery (Kobayashi et al., 2017). Second, we generated a binary variable identifying those with cognitive impairment: those who scored ≤ 1.5 SD below the mean on the sum of values for time orientation and immediate and delayed word recall, which are believed to reflect most closely aging-related cognitive impairment, or who required a proxy respondent and were reported to have “fair” or “poor” memory (Kobayashi et al., 2019).

Social engagement

We used a range of measures of social engagement based on a social network name generator: “Please tell me the names of [up to] 6 adults with whom you have been in communication

either in person or by phone or by internet in the past six months, starting with the person who is most important to you for any reason.” If the respondent was married and living with their spouse, the spouse’s name was added to the list of contacts (“alters”) if not otherwise named. For each named alter, sociodemographic information (age, sex, kinship and residential location) was elicited, alongside frequency of communication and how frequently the alter provided emotional, informational, physical and financial support (Harling, Morris, Manderson, Perkins, & Berkman, 2018). Finally, respondents were asked how frequently they believed each named alter communicated with each other alter.

We measured level of social contact as the number of contact names provided and the estimated number of days per month in which an alter had had contact with a respondent, summed across all named alters (i.e., a maximum of $30 * 7 = 210$ contact-days). We measured social support as the number of support-days received per month in same manner, but specific to each support type. To evaluate our hypotheses regarding kinship and physical proximity, we categorized alters as either kin or non-kin, and as living in the same household, same village, within the Agincourt site or elsewhere in South Africa. Finally, we measured the effective size of each respondent egocentric network as a respondent’s alter count, minus the average number of ties that each alter has to other alters (Burt, 1992). Effective size reflects the breadth of independent sources of input respondents have available to them.

Covariates

In addition to age (in decades) and gender, we considered three sets of covariates. First, those reflecting early life experiences: country of origin (a substantial minority of the local population migrated from Mozambique in the 1980s); educational attainment; self-reported literacy; self-rated childhood health and father’s occupation. Second, those reflecting current sociodemographic characteristics: marital status; household size; employment status and household wealth. Third, current physical health: self-reported current health and any reported limitation in basic activities of daily living (ADLs).

Statistical analysis

We included for analysis all respondents providing complete data on all relevant variables. After describing exposures and outcomes, we conducted multivariable regression using linear models for cognitive function Z-scores and Poisson models with robust variance structure for cognitive impairment (yes vs. no). All models were hierarchical, nesting respondents in

interviewers, and adjusted for month of interview, since interviewer identity and interview month have previously been shown to systematically affect HAALSI social network responses (Harling, Perkins, et al., 2018). We began by assessing the association between binary cognitive impairment and monthly communication event count, first adjusting for respondents' age and gender, and then adding in turn: early life variables; current sociodemographics; and finally current health status. We then repeated the fully adjusted models for each combination of outcome and social engagement variable.

To assess for effect-modification of the social engagement and cognition relationship, we added in turn interaction terms for social engagement and: respondent age; gender; and household size to our cognitive impairment models. Additionally, we assessed the composition of communication events and social support by comparing proportions of these exposures in cognitively normal and impaired individuals and by adding an interaction term for these variables and relationship type to the relevant cognitive impairment models.

Results

A total of 5059 eligible respondents completed HAALSI baseline questionnaires (85.9% response rate), of whom 5019 had a valid response for the cognitive impairment variable and 4927 had a valid cognitive Z-score. Forty-eight individuals were missing covariate values, of whom two were also missing cognitive impairment status and nine missing cognitive Z-scores.

For cognitive impairment, 416 (8.3%) of respondents scored ≤ 1.5 SD below the mean or required a proxy interview with 'fair' or 'poor' proxy-reported memory. Mean cognitive Z-scores declined, and the likelihood of cognitive impairment rose, with age; women had worse cognitive function than did men, especially after age 70 (Figure 1).

Respondents were, by design, roughly equally male and female (Table 1). Three-quarters were unemployed, educational attainment and literacy was limited and the great majority lived in households of three or more people. Almost one-third were migrants from Mozambique and almost all were or had previously been married. One in ten reported a current ADL limitation while around one-third reported being in moderate or worse health.

Respondents assessed as having cognitive impairment were older and more likely to be female – notably among those aged over 80. Reflecting this age and gender pattern, cognitive

impairment was positively associated with unemployment, living alone, lower household wealth, less education and illiteracy, being a migrant, being widowed and worse childhood and current health status.

Figure 1. Cognition outcomes in HAALSI baseline by age and gender

Table 1. Descriptive statistics by cognitive impairment status

	All respondents	No impairment	Cognitive impairment
N	5059	4603	416
Named contacts (count; median (IQR))	3 (2, 4)	3 (2, 4)	2 (1, 3)
Male 40-49	8.3%	8.6%	3.8%
50-59	12.3%	12.8%	6.3%
60-69	12.7%	13.1%	8.4%
70-79	8.8%	8.7%	10.3%
80+	4.2%	3.7%	10.3%
Female 40-49	9.9%	10.7%	1.0%
50-59	15.5%	16.4%	7.0%
60-69	13.1%	13.4%	10.3%
70-79	8.5%	7.8%	15.9%
80+	6.6%	4.8%	26.7%
Employment status			
Not working	73.5%	72.2%	88.9%
Employed (part or full time)	15.9%	17.1%	3.4%
Homemaker	10.3%	10.6%	7.7%
Household size			
Living alone	10.6%	10.1%	16.3%
Living with one other person	10.6%	10.3%	14.9%
Living with 2-5 others	48.2%	48.6%	43.8%
Living with 6+ others	30.6%	31.1%	25.0%
Household asset level			
Lowest quintile	20.7%	19.6%	32.0%
Second lowest quintile	19.8%	19.4%	24.8%
Middle quintile	19.6%	19.8%	17.1%
Second highest quintile	19.9%	20.2%	17.5%
Highest quintile	20.0%	21.1%	8.7%
Educational attainment			
No formal education	45.6%	42.2%	85.0%
Some primary (1-7 years)	33.9%	36.0%	12.6%
Some secondary (8-11 years)	11.3%	12.3%	1.2%
Secondary or more (12+ years)	8.8%	9.6%	1.2%
Country of origin:			
Mozambique/other not South Africa	30.2%	28.5%	48.0%
Marital status			
Never married	5.7%	5.5%	8.4%
Separated/divorced	12.8%	13.0%	11.8%
Widowed	30.4%	28.2%	54.6%
Currently married	50.9%	53.3%	25.2%
Can vs. cannot read or write	58.3%	62.8%	9.6%
Father's occupation			
Skilled	49.0%	50.3%	36.1%
Unskilled	28.6%	28.5%	29.9%
Other	11.4%	11.4%	11.3%
Don't know	10.8%	9.7%	22.7%
Childhood self-rated health:			
Good/very good vs. moderate/bad/very bad	87.6%	88.3%	81.4%
Any report of ADL limitation	9.0%	7.1%	29.8%
Current self-rated health:			
Good/very good vs. moderate/bad/very bad	68.0%	70.2%	45.7%

Notes: Differences between those with and without cognitive impairment statistically significant ($p < 0.001$) for all variables shown based on Kruskal–Wallis tests (Rank-Sum test for ordinal variable). Forty-eight individuals missing at least one covariate: employment status, $n=10$; education level, $n=17$; country of origin, $n=5$; marital status, $n=4$; literacy, $n=3$; paternal occupation, $n=12$; childhood health, $n=4$; current self-rated health, $n=3$.

In age and gender-adjusted regressions, a one-SD increase in communication with social contacts per month (38 additional contacts) was associated with 0.58 (95% confidence interval (CI): 0.48, 0.69) times lower risk of having cognitive impairment (Model 1, Table 2). This is equivalent to individuals reporting 22 total communication events per month (one SD below the mean) had an adjusted probability of 25.6% of cognitive impairment, compared to 8.5% for those reporting 99 events (one SD above the mean). When we added covariates relating to early life (Model 2), we saw that illiteracy was strongly correlated with greater cognitive impairment, but that none of these variables substantially changed the association of communication level with impairment. This pattern was similar when including current sociodemographic characteristics (Model 3): currently being married was associated with less cognitive impairment, but this association had little impact on the communication-impairment association. Finally, current physical health was associated with cognition (Model 4), but again only slightly attenuated the communication-impairment association. In the final model, a one-SD increase in communication was associated with 0.74 (95%CI: 0.63, 0.87) times reduction in cognitive impairment.

Table 2. Regression models for cognitive impairment and monthly communication event count

	Model 1		Model 2		Model 3		Model 4	
Communication events per month (SD)	0.58	[0.48, 0.69]	0.64	[0.54, 0.75]	0.71	[0.60, 0.83]	0.74	[0.63, 0.87]
Age and gender (ref: male 40-49)								
Male 50-59	1.08	[0.45, 2.63]	0.94	[0.47, 1.88]	1.16	[0.58, 2.34]	1.12	[0.54, 2.32]
60-69	1.43	[0.73, 2.81]	0.88	[0.51, 1.52]	1.17	[0.75, 1.84]	1.09	[0.70, 1.71]
70-79	2.50	[1.29, 4.85]	1.36	[0.78, 2.35]	1.88	[1.15, 3.07]	1.70	[1.06, 2.74]
80+	4.81	[2.52, 9.15]	2.05	[1.21, 3.47]	2.72	[1.69, 4.38]	2.17	[1.33, 3.53]
Female 40-49								
50-59	0.99	[0.40, 2.46]	0.62	[0.28, 1.35]	0.82	[0.40, 1.71]	0.78	[0.38, 1.59]
60-69	1.66	[0.76, 3.63]	0.80	[0.42, 1.54]	0.99	[0.55, 1.77]	0.94	[0.53, 1.68]
70-79	3.58	[1.80, 7.14]	1.40	[0.76, 2.58]	1.67	[0.96, 2.90]	1.49	[0.85, 2.59]
80+	7.24	[3.94, 13.3]	2.42	[1.44, 4.08]	2.87	[1.82, 4.53]	2.27	[1.38, 3.72]
Educational attainment (ref: no formal education)								
Some primary (1-7 years)			0.80	[0.62, 1.05]	0.84	[0.63, 1.11]	0.83	[0.64, 1.08]
Some secondary (8-11 years)			0.53	[0.27, 1.04]	0.61	[0.30, 1.20]	0.59	[0.30, 1.19]
Secondary or more (12+ years)			0.86	[0.32, 2.35]	1.16	[0.43, 3.14]	1.12	[0.42, 2.99]
Can vs. cannot read or write			0.15	[0.11, 0.22]	0.17	[0.12, 0.23]	0.17	[0.13, 0.23]
Country of origin: Mozambique/other vs South Africa			1.17	[0.97, 1.42]	1.20	[1.00, 1.46]	1.21	[1.00, 1.47]
Father's occupation (ref: skilled)								
Unskilled			1.24	[0.98, 1.56]	1.20	[0.97, 1.48]	1.22	[0.99, 1.51]
Other			1.33	[0.96, 1.84]	1.27	[0.93, 1.73]	1.25	[0.89, 1.75]
Don't know			1.57	[1.30, 1.89]	1.58	[1.32, 1.90]	1.56	[1.28, 1.89]
Childhood self-rated health:								
Good/very good vs. moderate/bad/very bad			0.73	[0.57, 0.94]	0.78	[0.61, 1.00]	0.83	[0.63, 1.10]
Marital status (ref: currently married)								
Never married					2.47	[1.76, 3.45]	2.44	[1.74, 3.44]
Separated/divorced					1.48	[1.03, 2.14]	1.47	[1.01, 2.12]
Widowed					1.44	[1.08, 1.91]	1.44	[1.07, 1.94]
Employment status (ref: not working)								
Employed (part or full time)					0.59	[0.35, 1.01]	0.64	[0.37, 1.10]
Homemaker					0.72	[0.46, 1.11]	0.79	[0.49, 1.26]
Household size (ref: living alone)								
Living with one other person					1.25	[0.88, 1.78]	1.24	[0.87, 1.78]
Living with 2-5 others					1.07	[0.76, 1.50]	1.04	[0.74, 1.45]
Living with 6+ others					0.93	[0.72, 1.20]	0.91	[0.70, 1.17]

	Model 1	Model 2	Model 3	Model 4
Household asset level (ref: lowest quintile)				
Second lowest quintile			1.00 [0.79, 1.28]	0.99 [0.80, 1.24]
Middle quintile			0.89 [0.72, 1.09]	0.87 [0.71, 1.08]
Second highest quintile			0.97 [0.73, 1.29]	0.98 [0.74, 1.30]
Highest quintile			0.76 [0.54, 1.06]	0.78 [0.56, 1.08]
Any report of ADL limitation vs. none				0.58 [0.45, 0.74]
Current self-rated health:				
Good/very good vs. moderate/bad/very bad				0.84 [0.63, 1.13]
Intraclass correlation coefficient	0.203	0.157	0.168	0.163

Notes: Values presented are incident rate ratios and [95% confidence intervals]. N=4973 for all models. All models are hierarchical (individuals nested in interviewers) and contain fixed effects for month of interview. SD: Standard deviations.

When we repeated the fully adjusted models with each of the social engagement variables, almost all were positively associated with higher cognitive Z-score values and negatively with cognitive impairment (Table 3). Broad social contact was lower among those with cognitive impairment or a low cognitive Z-score. Individuals with lower cognitive status named both fewer kin and fewer non-kin contacts; however, this difference was asymmetric, with lower cognition being associated more strongly with fewer non-kin. As a result, the proportion of all contacts that were kin was lower for those with cognitive impairment.

Similarly, respondents with cognitive impairment had fewer contacts living at all distances, but the differences were greatest for those contacts living outside the same household. The effective social network size of those with lower cognitive scores was non-significantly smaller than that of their peers, indicating a more tightly connected set of social contacts. Individuals with poorer cognitive status also reported that their social contacts provided all kinds of social support less frequently than did their cognitively stronger peers. However, the differences were greater for informational and emotional support than for financial and physical support.

Models of cognitive impairment containing interactions of each social engagement variable and respondent age are shown in Table 4. Younger respondents had stronger associations between most engagement variables and cognitive impairment. This included significantly fewer contacts and less communication, most strongly seen for informational and emotional support, less likelihood of naming non-kin contacts and significantly fewer contacts living in a different household but within the Agincourt area. In contrast, neither respondent gender nor household size modified the association between any of the social engagement variables and cognitive impairment (Supplementary Table 1).

Finally, we considered whether the differences in communication and support for those with and without cognitive impairment was modified by whether the contacts were spouses, other relatives or non-relatives. Respondents with cognitive impairment obtained a significantly smaller proportion of both overall communication and all specific types of support from spouses and non-relations, compensated by a larger proportion from other relatives (Supplementary Table 2). This pattern was reflected in multivariable regression models, although the differences were not significant in most cases (Table 5).

Table 3. Descriptive statistics and adjusted regression models for social engagement variables & cognitive status

Variable (unit of change for regressions)	Mean (SD) or percent	[IQR]	Cognitive impairment *		Standardized cognition score (SD) **	
					GLM	
Named contacts (count)	3.1	[2, 4]	0.75	[0.68, 0.83]	0.03	[0.01, 0.04]
Communication events per month (SD)	60.6 (38.3)	[30, 90]	0.71	[0.60, 0.83]	0.05	[0.02, 0.07]
Contact kinship						
Named kin (count)	2.4	[1, 3]	0.84	[0.77, 0.91]	0.01	[0.00, 0.02]
Any named non-kin (binary)	35.5%		0.55	[0.42, 0.73]	0.07	[0.03, 0.11]
Percent named contacts who are kin (10 %age points) †	79.1	[67, 100]	1.06	[1.02, 1.09]	-0.01	[-0.02, 0.00]
Contact distance ‡						
Same household (count)	0.8	[0, 1]	0.85	[0.75, 0.97]	-0.02	[-0.05, 0.01]
Same village (count)	1.3	[0, 2]	0.70	[0.61, 0.80]	0.03	[0.01, 0.05]
Agincourt area (count)	0.4	[0, 0]	0.75	[0.63, 0.90]	0.06	[0.03, 0.09]
Elsewhere South Africa (count)	0.5	[0, 1]	0.74	[0.64, 0.86]	0.03	[0.01, 0.05]
Egonet effective size						
Effective size (range 1-5.7) †	1.1	[1, 1]	0.87	[0.62, 1.21]	0.04	[0.00, 0.09]
Support types						
Informational, per month (SD)	29.3 (33.1)	[4, 40]	0.73	[0.64, 0.82]	0.05	[0.02, 0.07]
Emotional, per month (SD)	26.5 (32.8)	[4, 35]	0.72	[0.63, 0.82]	0.07	[0.05, 0.10]
Financial, per month (SD)	15.0 (22.2)	[1, 30]	0.87	[0.79, 0.96]	0.02	[0.00, 0.05]
Physical, per month (SD)	24.5 (26.1)	[4, 34]	0.77	[0.70, 0.86]	0.03	[0.00, 0.05]

Each regression coefficient represents results from a different model, with the exception of 'contact distance' models (‡), where all four variables were included in a single regression. All models are hierarchical (individuals nested in interviewers) and are adjusted for age, gender, employment status, household size, household wealth, educational attainment, literacy, marital status, father's occupation, childhood health status and interview month. † Models for percent of contacts who are kin and egonet effective size are also adjusted for the number of contacts named. * N for 'cognitive impairment' models is 4974 and values are prevalence rate ratios (and 95% confidence intervals). ** N for 'cognition score' models is 4888 and values are the difference in standardized cognition score (in SDs) associated with a one-unit higher value of the variables as shown in the first column. IQR: Interquartile range; SD: Standard deviation.

Table 4. Multivariable regression models for social engagement variables & cognitive impairment including interaction terms for age

	Respondent age				χ^2	p
	< 60		≥ 60			
Named contacts (count)	0.65	[0.53, 0.79]	0.80	[0.73, 0.87]	5.15	0.02
Communication events per month (SD)	0.50	[0.36, 0.69]	0.80	[0.68, 0.93]	8.89	0.003
Contact kinship						
Named kin (count)	0.79	[0.63, 0.99]	0.86	[0.80, 0.93]	0.70	0.40
Percent named contacts who are kin (10%age points) †	1.05	[0.94, 1.17]	1.06	[1.02, 1.09]	0.00	0.97
Any named non-kin (binary)	0.46	[0.22, 0.98]	0.62	[0.47, 0.81]	0.50	0.48
Contact distance ‡						
Same household (count)	0.90	[0.61, 1.32]	0.88	[0.78, 0.99]	0.02	0.90
Same village (count)	0.56	[0.42, 0.73]	0.76	[0.67, 0.87]	5.19	0.02
Agincourt area (count)	0.44	[0.29, 0.67]	0.83	[0.71, 0.97]	10.0	0.002
Elsewhere South Africa (count)	0.74	[0.57, 0.94]	0.76	[0.65, 0.89]	0.05	0.82
Egonet effective size						
Effective size (range 1-5.7) †	0.96	[0.42, 2.20]	0.84	[0.60, 1.18]	0.08	0.77
Support types						
Information support per month (SD)	0.60	[0.35, 1.02]	0.76	[0.68, 0.86]	0.77	0.38
Emotional support per month (SD)	0.62	[0.41, 0.95]	0.75	[0.66, 0.85]	0.72	0.40
Financial support per month (SD)	0.93	[0.68, 1.27]	0.86	[0.78, 0.95]	0.23	0.63
Physical support per month (SD)	0.67	[0.39, 1.14]	0.79	[0.70, 0.88]	0.32	0.57

Each row of regression coefficients represents results from a different model, with the exception of ‘contact distance’ models (‡), where all four variables were included in a single regression. All models are hierarchical (individuals nested in interviewers) and are adjusted for age, gender, employment status, household size, household wealth, educational attainment, literacy, marital status, father’s occupation, childhood health status and interview month. † Models for percent of contacts who are kin and egonet effective size are also adjusted for the number of contacts named. N for all models is 4973 and values are prevalence rate ratios (and 95% confidence intervals) associated with a one-unit higher value of the variables as shown in the first column. χ^2 tests test the difference between each pair of regression coefficients (i.e., significance of interaction) and have one degree of freedom. SD: Standard deviation.

**Table 5. Multivariable regression models for social engagement variables & cognitive impairment
including interaction terms for relationship type of contact**

	Spouse		Other relation		Non-relation		Spouse vs other relation		Non-relation vs other relation	
							χ^2	p	χ^2	p
Communication events per month	0.70	[0.57, 0.87]	0.84	[0.74, 0.95]	0.70	[0.58, 0.85]	1.63	0.20	4.00	0.05
Information support per month	0.80	[0.65, 0.99]	0.85	[0.77, 0.95]	0.78	[0.66, 0.91]	0.24	0.63	0.70	0.40
Emotional support per month	0.91	[0.74, 1.10]	0.83	[0.74, 0.92]	0.77	[0.66, 0.91]	0.44	0.51	0.48	0.49
Financial support per month	0.82	[0.68, 1.00]	0.97	[0.89, 1.05]	0.89	[0.81, 0.98]	1.69	0.19	1.40	0.24
Physical support per month	0.77	[0.66, 0.89]	0.89	[0.82, 0.97]	0.78	[0.66, 0.92]	2.40	0.12	1.83	0.18

Each row represents results from a different regression model. All models are hierarchical (individuals nested in interviewers) and adjust for interview month; multivariable models additionally are adjusted for age, gender, employment status, household size, household wealth, educational attainment, literacy, marital status, father's occupation and childhood health status. N for all models is 4973 and values are prevalence rate ratios (and 95% confidence intervals) associated with a one-standard deviation higher value of the variables shown in the first column.

Discussion

In a rural population of middle-aged and older South Africans, we find striking associations between two measures of cognitive impairment and a range of measures of social engagement, which together provide support for our three *a priori* analytic hypotheses. First, and most broadly, we found that individuals with impaired cognition reported smaller core social networks of important others, and reported less communication with these contacts. This association is agnostic as to causal mechanism. Less social engagement may reflect contacts lowering engagement due to the increased difficulty of interaction, or respondents with impairment finding engagement increasingly difficult to maintain, or those with more engagement being better able to maintain their cognitive capacity.

Second, we saw a smaller number of both kin and non-kin ties among respondents with worse cognition, but the latter was substantially lower than the former – leading to the social networks of those with worse cognition having a larger proportion of kin vs non-kin, despite those with impairment being substantially less likely to be married. This reflects the fact that non-spousal relations had the most-similar levels of social engagement across cognition levels; even amongst married individuals, spousal communication and physical support was significantly lower for those with cognitive impairment, but spousal emotional support was close to equal across the two groups. Non-spousal kin thus appear to be key sources of social engagement amongst those with cognitive impairment.

Linked to these kin findings, HAALSI participants with cognitive impairment had fewer ties with people in all geographic locations, but the difference was less for contacts living in the same household than for others. These kin and geographic findings highlight that engagement with individuals not bound by reciprocal familial obligations were more infrequent for those with cognitive impairment. Additionally, we found a non-significant association between greater connectedness between contacts and lower cognitive scores. This suggests that the contacts not present for respondents with cognitive impairment were more peripheral to their lives. All of this paints a picture of a core support network being retained by those with cognitive impairment.

Third, when we separate out the support being provided to respondents, we found lower levels of all support types for those with lower cognitive scores. However, once again the difference

was not the same for all types. Specifically, those with lower cognitive scores had the greatest difference in support for informational and emotional support, a moderate difference for physical support and the least difference for financial support. This pattern of findings amounts to a general decline in social connectivity – as described above – offset to some extent for financial and physical support, which we might expect to rise as care needs rise for those with cognitive impairment.

Finally, we find that while the patterns described above do not differ substantially by the gender of the respondent or their household size, we do find differences by respondent age. Specifically, compared to those aged over 60, younger respondents with cognitive impairment have significantly less communication and fewer contacts living outside their home but within Agincourt. They also receive non-significantly less informational, emotional and physical support. This pattern reflects past findings in this cohort that younger HAALSI respondents report more unmet need for Activities of Daily Living care (Harling et al., 2019), and suggests that middle-aged adults with cognitive impairment in this population may not have their support needs recognized.

While we cannot prove causality, our findings suggest that further exploration of these patterns in longitudinal data are warranted, including the use of methods that can separate out the two possible causal directions and multiple potential mechanisms responsible for the associations shown. Our findings add to existing evidence of a positive association of social engagement and cognition in populations with limited educational attainment (Ejechi, 2015; Gureje et al., 2011; Zunzunegui et al., 2003). This growing literature suggests that there may be a benefit to social engagement for older adults in terms of protecting cognition, and possibly an impact of declining cognition on social engagement.

Limitations

The most significant limitation of this work is the cross-sectional nature of the data analysed. Given the high likelihood of bi-directional causality between the key variables, we are not able to prove that impairment causes reduced social engagement, or vice versa, at this time. However, we have provided evidence of a very particular pattern of associations between different measures of social engagement, social support and cognitive impairment. This pattern appears consistent with both impairment leading to changes in social connectivity, and changes in social connectivity leading to impairment.

Another important issue to consider is generalizability. This study was conducted in a rural part of South Africa that was substantially impoverished under the Apartheid regime, limiting educational opportunities, affecting social relationships and family bonds and potentially affecting cognitive capacity through workplace and home-based environmental exposures. Our findings should be applicable to other rural South African settings, and potentially to urban populations within the country too. It is less clear how they might apply in other African and LMIC nations, and it will be important to evaluate this in other datasets in the future.

Third, much of the data we are considering is self-reported, and thus potentially open to social desirability and recall bias. While the cognitive measures are less susceptible due to their indirect approach to measuring cognition (i.e. the respondents were not directly asked if they felt they had cognitive impairment), social support and engagement measures did rely on self-report. Insofar as these self-reports may have been differential by cognitive level, this may bias our associational measures. While a possible increased reporting effort required by those with cognitive impairment may temper our interpretation of the overall lower level of social engagement in this group, it is harder to see how this could have led to the differential associations seen by kin, geography and support type.

Conclusions

In our cross-sectional analysis of over 5000 middle-aged and older adults in rural South Africa, we found respondents with lower cognitive function had smaller, denser social networks that were more home- and kin-based than their peers. These cognitively impaired individuals received less social support in general, but less so for instrumental support. These patterns suggest that cognitively impaired older adults in this setting rely on their core social networks for support, and that theories developed in higher-income and higher-education settings may also apply here.

References

- Aartsen, M. J., Smits, C. H., Van Tilburg, T., Knipscheer, K. C., & Deeg, D. J. (2002). Activity in older adults: cause or consequence of cognitive functioning? A longitudinal study on everyday activities and cognitive performance in older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 57(2), P153-P162.
- Antonucci, T. C., & Akiyama, H. (1995). Convoys of social relations: Family and friendships within a life span context. In R. Blieszner & V. H. Bedford (Eds.), *Handbook of Aging and the Family* (pp. 355-371). Westport, CT: Greenwood Press.
- Barnes, L. L., De Leon, C. M., Wilson, R. S., Bienias, J. L., & Evans, D. A. (2004). Social resources and cognitive decline in a population of older African Americans and whites. *Neurology*, 63(12), 2322-2326.
- Bassuk, S. S., Glass, T. A., & Berkman, L. F. (1999). Social disengagement and incident cognitive decline in community-dwelling elderly persons. *Annals of Internal Medicine*, 131(3), 165-173.
- Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2000). From social integration to health: Durkheim in the new millennium. *Social Science and Medicine*, 51(6), 843-857.
- Bosma, H., van Boxtel, M. P., Ponds, R., Jelicic, M., Houx, P., Metsemakers, J., & Jolles, J. (2002). Engaged lifestyle and cognitive function in middle and old-aged, non-demented persons: a reciprocal association? *Zeitschrift fur Gerontologie und Geriatrie*, 35(6), 575-581.
- Burt, R. S. (1992). *Structural Holes: The Social Structure of Competition*. Cambridge, MA: Harvard University Press.
- Christie, P., & Collins, C. (1982). Bantu Education: apartheid ideology or labour reproduction? *Comparative Education*, 18(1), 59-75. doi:10.1080/0305006820180107
- Clay, O. J., Roth, D. L., Wadley, V. G., & Haley, W. E. (2008). Changes in social support and their impact on psychosocial outcome over a 5-year period for African American and White dementia caregivers. *International Journal of Geriatric Psychiatry*, 23(8), 857-862.
- Clouston, S. A., Glymour, M. M., & Terrera, G. M. (2015). Educational inequalities in aging-related declines in fluid cognition and the onset of cognitive pathology. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring*, 1(3), 303-310.
- Ejechi, E. O. (2015). Comparative assessment of social engagement, cognitive function and their relationship in rural-and urban-dwelling elderly Nigerians. *IFE Psychologia: An International Journal*, 23(2), 13-21.
- Ertel, K. A., Glymour, M. M., & Berkman, L. F. (2008). Effects of social integration on preserving memory function in a nationally representative US elderly population. *American Journal of Public Health*, 98(7), 1215-1220. doi:10.2105/AJPH.2007.113654
- Farrell, M. T., Zahodne, L. B., Stern, Y., Dorrejo, J., Yeung, P., & Cosentino, S. (2014). Subjective word-finding difficulty reduces engagement in social leisure activities in Alzheimer's disease. *Journal of the American Geriatrics Society*, 62(6), 1056-1063.

- Gómez-Olivé, F. X., Montana, L., Wagner, R. G., Kabudula, C. W., Rohr, J. K., Kahn, K., . . . Gaziano, T. (2018). Cohort Profile: Health and Ageing in Africa: a Longitudinal Study of an INDEPTH Community in South Africa (HAALSI). *International Journal of Epidemiology*, 47(3), 689–690j. doi:10.1093/ije/dyx247
- Gureje, O., Ogunniyi, A., Kola, L., & Abiona, T. (2011). Incidence of and risk factors for dementia in the Ibadan study of aging. *Journal of the American Geriatrics Society*, 59(5), 869-874.
- Harling, G., Morris, K. A., Manderson, L., Perkins, J. M., & Berkman, L. (2018). Age and Gender Differences in Social Network Composition and Social Support Among Older Rural South Africans: Findings From the HAALSI Study. *The Journals of Gerontology: Series B*, Epub ahead of print. doi:10.1093/geronb/gby013
- Harling, G., Payne, C. F., Davies, J. I., Gomez-Olive, F. X., Kahn, K., Manderson, L., . . . Witham, M. D. (2019). Impairment in Activities of Daily Living, Care Receipt, and Unmet Needs in a Middle-Aged and Older Rural South African Population: Findings From the HAALSI Study. *Journal of Aging and Health*, epub ahead of print. doi:10.1177/0898264318821220
- Harling, G., Perkins, J. M., Gómez-Olivé, F. X., Morris, K. A., Wagner, R. G., Montana, L., . . . Berkman, L. F. (2018). Interviewer-driven variability in social network reporting: results from Health and Aging in Africa: a Longitudinal Study of an INDEPTH community (HAALSI) in South Africa. *Field methods*, 30(2), 140-154.
- Hikichi, H., Kondo, K., Takeda, T., & Kawachi, I. (2017). Social interaction and cognitive decline: Results of a 7-year community intervention. *Alzheimer's & Dementia: Translational Research & Clinical Interventions*, 3(1), 23-32. doi:<https://doi.org/10.1016/j.trci.2016.11.003>
- Hosking, D. E., Jiang, D., Sargent-Cox, K. A., & Anstey, K. J. (2017). Informant-Reported Cognitive Decline and Activity Engagement across Four Years in a Community Sample. *Gerontology*, 63(5), 469-478.
- Hultsch, D. F., Hertzog, C., Small, B. J., & Dixon, R. A. (1999). Use it or lose it: engaged lifestyle as a buffer of cognitive decline in aging? *Psychology and Aging*, 14(2), 245.
- Kahn, K., Collinson, M. A., Gómez-Olivé, F. X., Mokoena, O., Twine, R., Mee, P., . . . Khosa, A. (2012). Profile: Agincourt health and socio-demographic surveillance system. *International Journal of Epidemiology*, 41(4), 988-1001. doi:10.1093/ije/dys115
- Kenn, G. C. (2016). *Education, Skills, and Decent Work in Low and Middle Income countries: Trends and Results from an Adult Skills Survey*. Retrieved from
- Kobayashi, L. C., Glymour, M. M., Kahn, K., Payne, C. F., Wagner, R. G., Montana, L., . . . Berkman, L. F. (2017). Childhood deprivation and later-life cognitive function in a population-based study of older rural South Africans. *Social Science and Medicine*, 190, 20-28. doi:10.1016/j.socscimed.2017.08.009
- Kobayashi, L. C., Mateen, F. J., Montana, L., Wagner, R. G., Kahn, K., Tollman, S. M., & Berkman, L. F. (2019). Cognitive Function and Impairment in Older, Rural South African Adults: Evidence from “Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in Rural South Africa”. *Neuroepidemiology*, 52(1-2), 32-40. doi:10.1159/000493483

- Kuiper, J. S., Zuidersma, M., Voshaar, R. C. O., Zuidema, S. U., van den Heuvel, E. R., Stolk, R. P., & Smidt, N. (2015). Social relationships and risk of dementia: a systematic review and meta-analysis of longitudinal cohort studies. *Ageing Research Reviews*, 22, 39-57. doi:10.1016/j.arr.2015.04.00
- Lekoubou, A., Echouffo-Tcheugui, J. B., & Kengne, A. P. (2014). Epidemiology of neurodegenerative diseases in sub-Saharan Africa: a systematic review. *BMC Public Health*, 14(1), 653.
- Mortimer, J. A., Ding, D., Borenstein, A. R., DeCarli, C., Guo, Q., Wu, Y., . . . Chu, S. (2012). Changes in brain volume and cognition in a randomized trial of exercise and social interaction in a community-based sample of non-demented Chinese elders. *Journal of Alzheimer's Disease*, 30(4), 757-766.
- Nguyen, T. T., Tchetgen, E. J. T., Kawachi, I., Gilman, S. E., Walter, S., Liu, S. Y., . . . Glymour, M. M. (2016). Instrumental variable approaches to identifying the causal effect of educational attainment on dementia risk. *Annals of Epidemiology*, 26(1), 71-76. e73.
- Olayinka, O. O., & Mbuyi, N. N. (2014). Epidemiology of dementia among the elderly in Sub-Saharan Africa. *International Journal of Alzheimer's disease*, 2014.
- Penninkilampi, R., Casey, A.-N., Singh, M. F., & Brodaty, H. (2018). The Association between Social Engagement, Loneliness, and Risk of Dementia: A Systematic Review and Meta-Analysis. *Journal of Alzheimer's Disease*, Epub ahead of print.
- Perry, B. L., McConnell, W., Finley, E., Duran, T., Pescosolido, B., Unverzagt, F. W., . . . Saykin, A. J. (2017). Social networks and cognitive performance in older adults with normal cognition, mild cognitive impairment, and mild Alzheimer's disease. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*, 13(7), P505-P506.
- Pitkala, K. H., Routasalo, P., Kautiainen, H., Sintonen, H., & Tilvis, R. S. (2011). Effects of socially stimulating group intervention on lonely, older people's cognition: a randomized, controlled trial. *The American Journal of Geriatric Psychiatry*, 19(7), 654-663.
- Prince, M., Bryce, R., Albanese, E., Wimo, A., Ribeiro, W., & Ferri, C. P. (2013). The global prevalence of dementia: a systematic review and metaanalysis. *Alzheimer's & Dementia*, 9(1), 63-75. e62.
- Schulz, R., & Martire, L. M. (2004). Family caregiving of persons with dementia: prevalence, health effects, and support strategies. *American Journal of Geriatric Psychiatry*, 12(3), 240-249.
- Seeman, T. E., Lusignolo, T. M., Albert, M., & Berkman, L. (2001). Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur studies of successful aging. *Health Psychology*, 20(4), 243.
- Seeman, T. E., Miller-Martinez, D. M., Stein Merkin, S., Lachman, M. E., Tun, P. A., & Karlamangla, A. S. (2011). Histories of Social Engagement and Adult Cognition: Midlife in the U.S. Study. *The Journals of Gerontology: Series B*, 66B(Suppl 1), i141-i152. doi:10.1093/geronb/gbq091
- Shankar, A., McMunn, A., Banks, J., & Steptoe, A. (2011). Loneliness, social isolation, and behavioral and biological health indicators in older adults. *Health Psychology*, 30(4), 377.

- Small, B. J., Dixon, R. A., McArdle, J. J., & Grimm, K. J. (2012). Do changes in lifestyle engagement moderate cognitive decline in normal aging? Evidence from the Victoria Longitudinal Study. *Neuropsychology*, 26(2), 144.
- UNESCO. (2018). *Global Education Monitoring Report 2017/18: Accountability in education: Meeting our commitments*. Retrieved from Paris, France:
- Vemuri, P., Lesnick, T. G., Przybelski, S. A., Machulda, M., Knopman, D. S., Mielke, M. M., . . . Petersen, R. C. (2014). Association of lifetime intellectual enrichment with cognitive decline in the older population. *JAMA neurology*, 71(8), 1017-1024.
- Zunzunegui, M.-V., Alvarado, B. E., Del Ser, T., & Otero, A. (2003). Social networks, social integration, and social engagement determine cognitive decline in community-dwelling Spanish older adults. *The Journals of Gerontology: Series B*, 58(2), S93-S100.

Supplementary Materials

Supplementary Table 1. Multivariable regression models for social engagement variables & cognitive impairment including interaction terms for respondent gender or household size

	Respondent gender						Household size					
	Male		Female		χ^2	p	1-2 members		≥ 3 members		χ^2	p
Named contacts (count)	0.74	[0.65, 0.84]	0.79	[0.72, 0.88]	1.16	0.28	0.77	[0.68, 0.87]	0.77	[0.70, 0.85]	0.00	0.99
Communication events per month (SD)	0.72	[0.56, 0.93]	0.76	[0.64, 0.90]	0.12	0.73	0.70	[0.57, 0.87]	0.76	[0.64, 0.90]	0.52	0.47
Contact kinship												
Named kin (count)	0.86	[0.77, 0.95]	0.85	[0.77, 0.94]	0.02	0.87	0.85	[0.74, 0.97]	0.86	[0.79, 0.93]	0.02	0.88
Percent named contacts who are kin (10%age points) [†]	1.07	[1.00, 1.14]	1.04	[1.01, 1.08]	0.45	0.50	1.07	[0.99, 1.15]	1.05	[1.01, 1.09]	0.12	0.73
Any named non-kin (binary)	0.48	[0.29, 0.81]	0.66	[0.54, 0.79]	1.78	0.18	0.59	[0.35, 1.02]	0.57	[0.41, 0.79]	0.01	0.90
Contact distance[‡]												
Same household (count)	1.00	[1.00, 1.00]	1.00	[1.00, 1.00]	0.84	0.36	0.86	[0.70, 1.06]	0.89	[0.78, 1.01]	0.07	0.79
Same village (count)	0.80	[0.58, 1.09]	0.93	[0.83, 1.05]	0.13	0.72	0.74	[0.63, 0.88]	0.71	[0.63, 0.81]	0.29	0.59
Agincourt area (count)	0.71	[0.60, 0.84]	0.73	[0.64, 0.84]	0.88	0.35	0.82	[0.64, 1.04]	0.75	[0.61, 0.93]	0.26	0.61
Elsewhere South Africa (count)	0.84	[0.65, 1.08]	0.73	[0.61, 0.89]	0.10	0.75	0.73	[0.60, 0.89]	0.78	[0.67, 0.89]	0.58	0.45
Egonet effective size												
Effective size (range 1-5.7) [†]	0.83	[0.48, 1.44]	0.91	[0.62, 1.34]	0.07	0.80	1.02	[0.61, 1.71]	0.78	[0.49, 1.22]	0.61	0.44
Support types												
Information support per month (SD)	0.73	[0.55, 0.98]	0.74	[0.67, 0.82]	0.01	0.93	0.77	[0.62, 0.96]	0.73	[0.64, 0.83]	0.27	0.60
Emotional support per month (SD)	0.74	[0.59, 0.91]	0.73	[0.65, 0.82]	0.01	0.92	0.74	[0.62, 0.89]	0.73	[0.64, 0.83]	0.03	0.86
Financial support per month (SD)	0.85	[0.71, 1.01]	0.89	[0.81, 0.98]	0.31	0.58	0.87	[0.70, 1.08]	0.87	[0.80, 0.96]	0.00	0.94
Physical support per month (SD)	0.75	[0.59, 0.95]	0.78	[0.67, 0.91]	0.07	0.78	0.77	[0.65, 0.92]	0.77	[0.69, 0.86]	0.01	0.94

Each pair of regression coefficients (e.g. male/female on one row) represents results from a different model, with the exception of 'contact distance' models ([‡]), where all four variables were included in a single regression. All models are hierarchical (individuals nested in interviewers) and are adjusted for age, gender, employment status, household size, household wealth, educational attainment, literacy, marital status, father's occupation, childhood health status and interview month. [†] Models for percent of contacts who are kin and egonet effective size are also adjusted for the number of contacts named. N for all models is 4973 and values are prevalence rate ratios (and 95% confidence intervals) associated with a one-unit higher value of the variables as shown in the first column. χ^2 tests test the difference between each pair of regression coefficients (i.e., significance of interaction) and have one degree of freedom. SD: Standard deviation.

Supplementary Table 2. Relationship type composition of provision of monthly social engagement, stratified by cognitive impairment status

	N	Spouse		Other relation		Non-relation	
Communication events							
Normal cognition	4,437	25.1%	[24.2%, 26.0%]	54.0%	[52.9%, 55.2%]	20.8%	[19.9%, 21.8%]
Cognitively impaired	320	13.4%	[10.5%, 16.3%]	73.5%	[69.5%, 77.5%]	13.1%	[10.0%, 16.2%]
Z-score		8.0		-9.1		5.3	
Information support							
Normal cognition	4,241	29.0%	[28.0%, 30.1%]	52.3%	[51.0%, 53.5%]	18.7%	[17.8%, 19.7%]
Cognitively impaired	293	16.4%	[12.9%, 19.9%]	72.0%	[67.5%, 76.4%]	11.6%	[8.4%, 14.8%]
Z-score		7.2		-8.4		5.1	
Emotional support							
Normal cognition	4,159	27.1%	[26.1%, 28.1%]	52.6%	[51.4%, 53.9%]	20.3%	[19.3%, 21.2%]
Cognitively impaired	281	16.5%	[12.9%, 20.1%]	70.0%	[65.4%, 74.6%]	13.5%	[10.1%, 16.9%]
Z-score		6.6		-7.3		4.3	
Financial support							
Normal cognition	4,136	34.9%	[33.7%, 36.1%]	47.5%	[46.2%, 48.8%]	17.6%	[16.6%, 18.5%]
Cognitively impaired	282	18.0%	[14.1%, 22.0%]	71.0%	[66.2%, 75.7%]	11.0%	[7.7%, 14.3%]
Z-score		7.6		-8.9		4.8	
Physical support							
Normal cognition	3,717	38.4%	[37.1%, 39.8%]	45.8%	[44.4%, 47.2%]	15.8%	[14.8%, 16.8%]
Cognitively impaired	254	19.0%	[14.7%, 23.2%]	69.6%	[64.5%, 74.7%]	11.5%	[8.0%, 15.0%]
Z-score		7.4		-8.0		3.5	

Each row sums to 100%. Z-score is the result of a Wilcoxon rank-sum test for a difference in value between the two proportions above each score. All values have p-values <0.001. N for communication/type of support varies due to exclusion of respondents receiving none of the relevant type of social engagement.