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Social network typologies and mortality risk among older people in China, India, and Latin America: A 10/66 Dementia Research Group population-based cohort study

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ABSTRACT

Background: Restricted social networks have been associated with higher mortality in several developed countries but there are no studies on this topic from developing countries. This gap exists despite potentially greater dependence on social networks for support and survival due to various barriers to health care and social protection schemes in this setting. Thus, this study aims to examine how social network type at baseline predicts all-cause mortality among older adults in six Latin American countries, China, and India.

Methods: Population-based surveys were conducted of all individuals aged 65+ years in eight countries (Cuba, Dominican Republic, Peru, Venezuela, Mexico, Puerto Rico, China, and India). Data on mortality were obtained at follow-up (mean 3.8 years after cohort inception). Follow-up data for 13,891 individuals were analysed. Social network types were assessed using Wenger's Practitioner Assessment of Network Type (PANT). Cox proportional hazard models were constructed to estimate the impact of social network type on mortality risk in each country, adjusting for socio-demographics, receipt of pension, disability, medical conditions, and depression. Meta-analysis was performed to obtain pooled estimates.

Results: The prevalence of private network type was 64.4% in urban China and 1.6% in rural China, while the prevalence of locally integrated type was 6.6% in urban China and 86.8% in rural China. The adjusted pooled estimates across (a) all countries and (b) Latin America showed that, compared to the locally integrated social network type, the locally self-contained [(b) HR = 1.24, 95%CI 1.01–1.51], family dependent [(a) HR = 1.13, 95%CI 1.01–1.26; (b) HR = 1.13, 95%CI 1.001–1.28], and private [(a) HR = 1.36, 95%CI 1.06–1.73; (b) HR = 1.45, 95%CI 1.20–1.75] social network types were significantly associated with higher mortality risk.

Conclusion: Survival time is significantly reduced in individuals embedded in restricted social networks (i.e. locally self-contained, family dependent, and private network types). Social care interventions may be enhanced by addressing the needs of those most at risk of neglect and deteriorating health. Health policy makers in developing countries may use this information to plan efficient use of limited resources by targeting those embedded in restricted social networks.

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1. Introduction

Worldwide, the number of people aged 65 years and above will outnumber children under age five by 2016, implying a radical increase in the proportion of old to young (WHO, 2011). Demographic ageing is associated with an increase in the burden of morbidity, disability, and dependency, which in turn will increase the demand on health care services and social costs. This increase in demand may be particularly significant in developing countries, where population ageing is occurring at a faster pace than in developed countries. For example, in 2010, the global population of people aged 60 years and above residing in developing countries was 65%, and this figure is projected to increase to 80% by 2050 (Kinsella and Wan, 2009). Many developing countries do not have the industrial and socio-economic resources to support the increasing health and social care demands associated with an ageing population, and are typically characterised by significant infrastructural barriers to accessing existing social protection schemes (WHO, 2011).

The lack of social protection for older people in developing countries is increasingly becoming recognised as a significant but yet under-prioritised problem in health and human development agendas (Cho et al., 2012; Prince et al., 2008; UN, 2002; UNAIDS, 2010). This is in spite of evidence showing the importance of various socioeconomic factors and vulnerabilities in predicting mortality among older people in developing countries (Ferri et al., 2012). Social networks can be a source of financial, practical and emotional support, and hence represent a key component to social protection. The importance of social networks for health and wellbeing has been extensively demonstrated in high-income countries. In a recent meta-analysis of 20 population-based cohort studies, social network integration, was inversely associated with mortality [HR = 0.91, 95%CI (0.86; 0.97)] (Nyqvist et al., 2014). Another meta-analysis also involving studies mainly in high-income countries found that the effect size for the association of poor social relationships with mortality was comparable to that for excessive drinking, and smoking, and greater than that for obesity, and lack of exercise (Holt-Lunstad et al., 2010). In the case of older people specifically, studies conducted in high-income countries have reported that maintaining social contacts in late life is associated with a reduced risk of psychological distress (Golden et al., 2009; Reich and Zautra, 1991), cognitive decline (Bassuk et al., 1999; Fratiglioni et al., 2000), functional decline (Stuck et al., 1999), disability (Avlund et al., 2004; Escobar-Bravo et al., 2012), institutionalization, and mortality (Steinbach, 1992). For the developing countries involved in the current study, being embedded in restricted social networks has been reported to be positively correlated with loneliness, depression, less happiness, poor health, disability, and need for care (Thiyagarajan et al., 2014). As yet, however, there are no studies specifically on social networks and its effect on mortality in developing country settings.

Using a large multi-country population-based sample, the aim of this study is to assess the association of social network type with all-cause mortality among older people living in India, China, and six Latin American countries. The countries participating in the 10/66 Dementia Research Group's population-based research program were not purposively selected, but rather represent those that chose to join the group in the late 1990s to conduct research into a topic of growing social and public health significance. These were all, at that time, or shortly to become, middle income countries, and are all undergoing particularly rapid population ageing and economic development, with attendant social change. Nevertheless, the countries and sites comprise considerable diversity in culture, sociodemographic and health characteristics. Correlations between social networks and health have been reported previously, at the baseline of these cohorts (Thiyagarajan et al., 2014). For these reasons, all countries with mortality outcomes recorded at follow-up were retained for this analysis. Based on the literature discussed, we hypothesise that more restricted network types will be associated with higher mortality. Harnessing information about how restricted social network types predict increased mortality risk is particularly important in the economic context of low and middle income countries, where resources are limited and people are more likely to depend on their social networks for support and survival. Understanding the association between social network structures and mortality may be relevant in regards to allocating limited resources or establishing public health interventions to improve population health and well-being in developing countries.

2. Methods

2.1. Study design, settings and sample

The baseline for this cohort study is defined by the 10/66 population-based prevalence surveys conducted of residents aged 65 years and above in geographically defined catchment area sites in the subset of eight countries (Cuba, Dominican Republic, Peru, Venezuela, Mexico, Puerto Rico, China, and India) where follow-up assessments of vital status were subsequently carried out. All of these eight countries are still classified as middle-income countries, except for Puerto Rico, which changed its status to high-income between the two surveys.

Details of study methodology and protocols have been described elsewhere (Ferri et al., 2012; Prince et al., 2007). In brief, baseline assessments were carried out between 2003 and 2006 with the exception of Puerto Rico (2007–2009). The 10/66 study questionnaires were translated from the original English into Spanish, Tamil, and Mandarin. The study sites consisted of urban and rural areas. Urban sites which represented the typical predominately lower income or mixed neighbourhoods were purposively selected and consisted of the following sites: Cuba (Havana and Matanzas), Dominican Republic (Santo Domingo), Venezuela (Caracas), Peru (Lima), Mexico (Mexico City), Puerto Rico (Bayamon), China (Xicheng, Beijing) and India (Chennai). Rural sites referred to areas remote from major population centres with agriculture and related trade as the main local industry and included the following: Peru (Cañete Province), Mexico (Morelos State) and China (Daxing, Beijing Province).

The original target sample size for each country was between 2000 and 3000 (see Table 1). The boundaries of each catchment area were precisely defined, and households mapped. Each household was then systematically door-knocked to identify all household members aged 65 years and over who were eligible to participate in the survey. A full assessment (lasting 2–3 h) was conducted for all eligible individuals if they or their kin agreed to participate in the survey. The assessment comprised a background sociodemographic, health and risk factor interview, a structured clinical mental state assessment, and a physical examination. For those with marked communication difficulties arising from dementia, severe mental illness, deafness or mutism, the background interview, which included the social network assessment, was administered to a key informant (Prince et al., 2007).

Each centre had a coordinator who supervised the interviewers. There were between four and ten interviewers for each site, usually non-specialist graduates (apart from Cuba and China where medical doctors were used) extensively trained for the interviews and the main diagnostic assessment. Previous experience was also gained during the dementia diagnostic pilot study. Several meetings for the principal investigators were also conducted before the start of fieldwork, and at regular intervals of six months during the project. A standardised operating procedure manual covering all aspects of the interviews and procedures was also available to all interviewers, who were supervised during the fieldwork until the quality of the

Table 1
Baseline characteristics by country among older adults in eight developing countries.

	Cuba		Dominican Republic		Peru		Venezuela		Mexico		Puerto Rico		China		India	
Baseline response rate (%)	94.0		95.0		82.3		80.0		85.0		93.0		84.2		98.0	
Cohort at baseline	2806		2009		1929		1931		2003		2002		2162		1004	
Vital status ascertained at follow-up	2628	93.7	1704	84.8	1748	90.6	1667	84.5	1844	92.0	1562	78.0	1991	92.1	747	74.4
Mean time of follow-up in years	4.12		4.36		3.06		4.16		2.91		4.13		4.62		2.93	
Person years	10,814		7437		5343		6942		5367		6447		9194		2206	
Deaths (%)	605	23.0	467	27.4	152	8.7	186	11.2	209	11.3	297	19.0	515	25.9	153	20.5
Age (years)																
65–74	1387	52.9	878	51.4	939	54.3	1147	67.8	1026	56.1	727	45.5	1221	62.0	594	68.8
75–84	942	35.9	596	34.9	594	34.2	438	25.9	647	35.4	673	42.1	616	31.3	214	24.8
85+	295	11.2	234	13.7	202	11.8	108	6.4	155	8.5	199	12.5	133	6.8	55	6.4
Gender																
Female	1695	64.5	1134	66.5	1057	60.8	1073	63.3	1170	64.0	1036	65.0	1136	57.6	505	58.9
Male	932	35.5	572	33.5	681	39.2	622	36.7	658	36.0	559	35.1	835	42.4	353	41.1
Marital status																
Not married	1461	55.7	1182	69.7	734	42.4	826	49.9	887	48.6	768	48.2	699	35.5	452	52.4
Married/cohabiting	1162	44.3	514	30.3	996	57.6	831	50.2	938	51.4	826	51.8	1272	64.5	411	47.6
Education																
None	95	3.62	326	19.3	139	8.07	135	8.1	474	25.9	108	6.8	730	37.0	321	37.2
Incomplete primary	606	23.1	871	51.5	243	14.1	364	21.9	769	42.1	301	18.9	254	12.9	225	26.1
Completed primary	864	32.9	313	18.5	623	36.2	846	50.9	329	18.0	338	21.2	497	25.2	173	20.1
Completed secondary	635	24.2	114	6.8	453	26.3	233	14.0	140	7.6	536	33.7	357	18.1	99	11.5
Completed tertiary	423	16.1	66	3.9	265	15.4	83	5	115	6.3	309	19.4	133	6.8	44	5.1
Assets [Mean (SD)][a]	5.6	(1.0)	5.0	(1.4)	5.7	(1.1)	6.2	(1.0)	5.1	(1.7)	6.5	(0.9)	5.6	(1.1)	4.5	(1.6)
Any pension																
No	512	19.5	1172	68.6	628	36.1	699	41.2	925	50.6	739	46.2	993	50.4	680	78.7
Yes	2119	80.5	536	31.4	1110	63.9	996	58.8	903	49.4	860	53.8	978	49.6	184	21.3

Data are N and % unless otherwise stated.
[a] Number of assets ranged from 0 to 7 and corresponded to the total number of assets owned.

interview was deemed satisfactory. Random checks were also carried out during the project. Data were collected onto paper and then extracted, cleaned and processed in SPSS (version 15.0; SPSS, Inc., USA), or directly onto laptops (in Cuba) using computerised questionnaires driven by EpiData (version 2.0; EpiData Software, Denmark). Data were finally checked a number of times (three to four) in London after completion of the interviews (Prince et al., 2007).

Vital status was assessed in the second, incidence wave of the 10/66 survey, in which we sought to trace and re-interview all participants three to four years after the original baseline survey (see Table 1 for mean follow-up time at each site). We first called on their residence at baseline, revisiting on up to four occasions. If the participant had moved away, we sought information regarding their vital status and/or current residence through non-coresident friends or family members for whom information on names and addresses were recorded at baseline. Where a participant had died, we recorded the date of death in the course of a verbal autopsy interview with a suitable key informant.

Response and follow-up rates for all sites are presented in Table 1. In total, 15,901 older persons were interviewed at baseline, of whom 13,891 had vital status ascertained at follow-up. Ethical approval was obtained from local ethical committees and the King's College London Research Ethics Committee. A signed informed consent, or witnessed oral consent in case of illiteracy, or next of kin written agreement in case of incapacity, was obtained from all participants.

2.2. Baseline measures

2.2.1. Social network type

Various ways to measure social networks exist, such as size, density, or contact frequency (Smith and Christakis, 2008). However, a more informative assessment using social network typologies can help to identify separate categories of social network composition, thereby making it possible to capture distinct social environments that may be harmful or beneficial to health. In this study, we used the Practitioner Assessment of Network Type (PANT) to identify five distinct social network types described by Wenger (1991, 1996, 1997); Wenger et al. (2007). The construct validity of Wenger's typology has been supported by the findings of an ecological study in New Zealand (Stephens et al., 2011), and more recently in the countries included in the 10/66 survey (Thiyagarajan et al., 2014). The algorithm used in this study to identify Wenger's (1989, 1991, 1996) five network types was based on the participants' responses to eight questions pertaining to the following:

1) Distance to nearest relative (not spouse). Possible responses were 0 (no relatives); 1 (within 1 mile); (2) 1–5 miles); 3 (6–15 miles); 4 (16–50 miles); 5 (50 + miles).
2) Distance to nearest child. Possible responses were 0 (no children); 1 (within 1 mile); (2) 1–5 miles); 3 (6–15 miles); 4 (16–50 miles); 5 (50 + miles).
3) Distance to nearest sibling. Possible responses were 0 (no sisters or brothers); 1 (within 1 mile); (2) 1–5 miles); 3 (6–15 miles); 4 (16–50 miles); 5 (50 + miles).
4) Contact frequency with children or other relatives. Possible responses were 0 (never/no children or relatives); 1 (daily); 2 (2–3 times per week); 3 (at least weekly); 4 (at least monthly); 5 (less often).
5) Contact frequency with friends in the community/neighbourhood. Possible responses were 0 (never/no friends); 1 (daily); 2 (2–3 times per week); 3 (at least weekly); 4 (at least monthly); 5 (less often).
6) Contact frequency with neighbours. Possible responses were 0 (no contact with neighbours); 1 (daily); 2 (2–3 times per week); 3 (at least weekly); 4 (at least monthly); 5 (less often).
7) Religious involvement. Possible responses were 0 (none); 1 (regularly); 2 (occasionally).
8) Involvement in community or social groups. Possible responses were 0 (none); 1 (regularly); 2 (occasionally).

The exact algorithm used to construct the variable has been described in detail in Wenger (1991). Wenger's network typology is

described as follows:

1. The locally integrated network type includes close involvement with local family members, friends, neighbours, and the community. This type of network is typically larger than other types and provides the optimal level of social support.
2. The locally self-contained network type involves a household-focused lifestyle with arm's-length relationships with kin, and little community activity, though the person may rely considerably on neighbours for support. Community involvement, if any, tends to be very low.
3. The wider community-focused network type refers to a lack of local family members, but involves extensive contact with friends and neighbours, and with relatives such as adult children who live some distance away. Participants with this type of network are generally involved in community voluntary organizations.
4. The family dependent network type is characterised by active involvement with close local family members, but few peripheral friends and little contact with neighbours. This network is often based on a shared household with adult children or siblings, or very near separate households.
5. The private network type can be described as an absence of local family and kin, few nearby local friends and low levels of community contact or involvement.

The analysis utilised social network type as a categorical variable, where the locally integrated type was contrasted to each other network type (1 = locally integrated, 2 = locally self-contained, 3 = wider community focused, 4 = family dependent, 5 = private).

2.2.2. Socio-demographic characteristics

Socio-demographic characteristics included age, sex, marital status, education, wealth (number of assets), and pension. Education was classified as none, incomplete primary, completed primary, completed secondary, and completed tertiary. A variable for household assets was generated by summing up the number of household assets owned (i.e. car, television, refrigerator, telephone, mains electricity, mains water, plumbed toilet). This ranged from 0 to 7. Receipt of any occupational or government pension was a dichotomous variable.

2.2.3. Physical health status, disability, dementia, and depression

Physical health status was assessed through self-report of a list of 11 commonly occurring physical impairments, and was grouped into none, one to two, and three or more. Disability was measured using the psychometrically validated 12-item World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0) (WHO, 2001). Higher scores (on a 0–100 scale) indicate greater disability. Dementia was assessed using the 10/66 Dementia Research Group criteria (Prince et al., 2003). Depression was assessed with the cross-culturally validated EURO-D scale, derived from the Geriatric Mental State examination (Castro-Costa et al., 2007; Guerra et al., 2015; Guerra et al., 2009; Prince et al., 1999). The total score ranges from 0 to 12, with a score of either four and above or five and above (depending on the country) representing the presence of probable depression. This has been identified the optimal cut-point for the EURO-D against the reference criterion of ICD-10 depressive episode specifically regarding the countries included in the 10/66 study (Guerra et al., 2015). Physical health, disability, dementia, and depression were considered as potential confounders as they may lead to higher mortality among older adults (Dewey and Saz, 2001; Fried et al., 1998; Schulz et al., 2000), and because they are also known to be related to social relationships (Avlund et al., 2004; Escobar-Bravo et al., 2012; Kuiper et al., 2015; Santini et al., 2015; Uchino, 2006, 2009). We sought to control for these factors by entering them into the models as covariates. Alcohol consumption was also considered a potential confounder but was later omitted because it did not affect the estimates and did not improve the model fit.

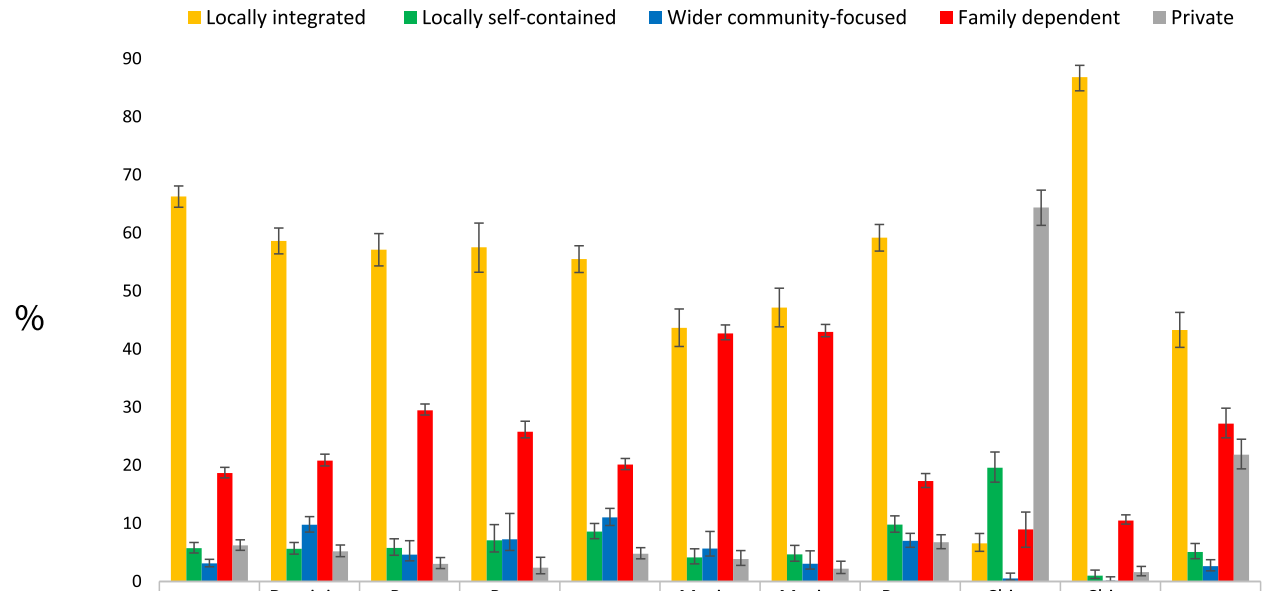
2.3. Statistical analysis

All analyses were conducted using STATA 13.1. For each country, univariate and multivariate Cox proportional hazard models were constructed to estimate the mortality risk as a function of social network types. The start of the risk period was the time of the first survey. Participants were censored either at the date of death, or the date of follow up for those who were traced successfully. There were 1961 participants for whom vital status could not be determined at follow-up. Participants for whom vital status could not be determined at follow-up were not included in the survival analysis. The number (%) of those not traced at follow-up by social network type were: family dependent, 410 (11.6%); locally integrated 906 (10.5%); locally self-contained 215 (18.6%); wider community focused, 164 (19.0%), private 264 (16.3%). The models employed Wenger's 5-level social network type variable (i.e. each type contrasted to locally integrated type) as the main exposure variable of interest.

The multivariate analyses adjusted for age, gender, marital status, education, number of assets, receipt of pension, disability, number of physical impairments, and depression. All covariates were entered as categorical variables, apart from household assets and education, which were entered as categorical variables. Information on the covariates used for adjustment was obtained from the baseline survey. All regression analyses were based on the sample with no missing data. Only <2% of the data were missing for the covariates in the model. For all Cox proportional hazard models, the proportional hazards assumption was tested using the Schoenfeld residuals. A pooled estimate of the effects of network type on mortality was calculated by taking the estimates of each country and combining them into a fixed-effect meta-analysis. The analysis included one pooled analysis across all countries, and one pooled analysis of Latin American countries. The Cochrane Q heterogeneity and Higgin's I^2 were calculated to estimate the degree of heterogeneity. A heterogeneity level of less than 40% was considered to be negligible and 40–60% was considered to indicate moderate heterogeneity (Higgins and Thompson, 2002). Kaplan–Meier cumulative mortality curves were drawn to display the non-adjusted failure probability as a function of social network type using the pooled sample. Hazard ratios (HR) and their 95% confidence intervals (CIs) are reported.

3. Results

Table 1 presents the baseline characteristics of the sample in each country, and Fig. 1 shows the prevalence of the five different social network types across all sites. Participants were generally younger in Venezuela, China and India, while high proportions of the oldest age group were observed in Cuba, Dominican Republic, Peru, and Puerto Rico. Across all sites, urban China had the far lowest prevalence of locally integrated network type (6.6%), while rural China had the highest across all sites (86.8%). The prevalence of this network type was slightly less prevalent in Mexico and India as compared to the remaining sites. Overall, the locally integrated network type was generally the most prevalent and represented around 50% of network types across all sites apart from urban China. The prevalence of private network type was generally lower than the prevalence of other types, except in the case of urban China where this network type was about two thirds (64.4%).



	Cuba	Dominican Republic	Peru (urban)	Peru (rural)	Venezuela	Mexico (urban)	Mexico (rural)	Puerto Rico	China (urban)	China (rural)	India
Locally integrated	66.3	58.6	57.1	57.5	55.5	43.7	47.1	59.2	6.6	86.8	43.3
Locally self-contained	5.7	5.6	5.8	7.1	8.6	4.1	4.7	9.8	19.6	1.0	5.1
Wider community-focused	3.1	9.8	4.6	7.3	11.0	5.7	3.0	7.0	0.5	0.1	2.6
Family dependent	18.7	20.8	29.5	25.8	20.1	42.7	43.0	17.3	9.0	10.5	27.2
Private	6.2	5.2	3.0	2.4	4.8	3.8	2.2	6.7	64.4	1.6	21.8

Fig. 1. Crude prevalence of social network type in eight developing countries. Bars denote 95% confidence intervals. The locally integrated support network includes close relationships with local family, friends and neighbours. The family dependent support network is focused on close family ties, few neighbours and peripheral friends. The locally self-contained support network typically has arms-length relationships or infrequent contact with at least one relative but the primary reliance is on neighbours. The wider community-focused support network is typified by an absence of nearby relatives but active relationships with distant relatives, usually children, and a high salience of friends. The private restricted support network is associated with an absence of local kin, few nearby friends and low levels of community contacts or involvement.

Locally self-contained type was lowest in rural China and highest in urban China. The wider community-focused network type was more prevalent in Latin American countries as compared to the Asian sites. The family dependent network type had the lowest prevalence in both Chinese sites, while the highest were observed in Mexico. Overall, the family dependent type was the second most common network type in almost all sites.

Overall, vital status was ascertained for 13,891 individuals (87.7% of the cohort at baseline). Deaths were recorded for 2584 participants (18.6% of those for whom vital status was ascertained) during the 53,750 person years of follow-up. Fig. 2 presents the crude Kaplan–Meier failure curve by baseline social network type. The family dependent and the private social network types had the highest probability of mortality. Table 2 presents the association between social network type and mortality. In terms of the country-wise adjusted analyses, the locally self-contained social network type was significantly associated with mortality in Venezuela (HR = 1.69, 95%CI 1.07–2.68), while the private social network type significantly predicted mortality in Cuba (HR = 1.56, 95%CI 1.18–2.07), Peru (HR = 2.91, 95%CI 1.21–6.97), and Mexico (HR = 2.08, 95%CI 1.10–3.93). In the adjusted analysis across all countries, family dependent, and private social network types were significantly associated with 1.13 (95%CI [1.01–1.26], $I^2 = 0.0\%$) and 1.36 (95%CI [1.06–1.73], $I^2 = 55.3\%$) times higher mortality risks respectively. In the adjusted pooled analysis for Latin America only, the corresponding figures for each network type were: locally self-contained (HR = 1.24, 95%CI 1.01–1.51, $I^2 = 15.4\%$), family dependent (HR = 1.13, 95%CI 1.001–1.28, $I^2 = 0.0\%$), and private (HR = 1.45, 95%CI 1.20–1.75, $I^2 = 44.5\%$). Because of the great difference in social networks between urban and rural China (Fig. 1), we carried out a sensitivity analysis by re-running the Cox models across the two different centres. The direction of associations between social networks in urban China was different compared to

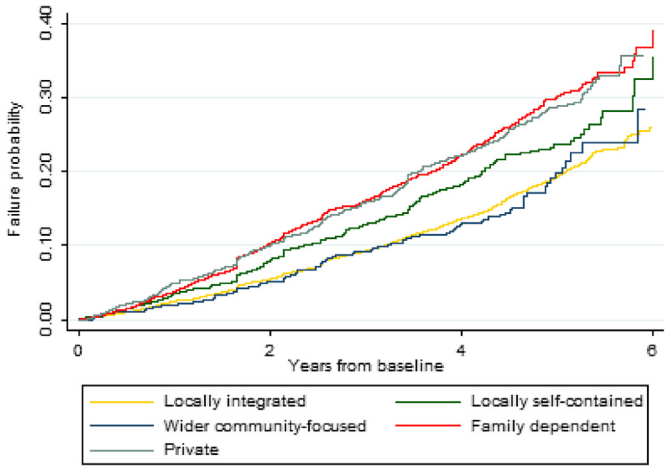


Fig. 2. Crude mortality risk by social network type across eight developing countries. The locally integrated support network includes close relationships with local family, friends and neighbours. The family dependent support network is focused on close family ties, few neighbours and peripheral friends. The locally self-contained support network typically has arms-length relationships or infrequent contact with at least one relative but the primary reliance is on neighbours. The wider community-focused support network is typified by an absence of nearby relatives but active relationships with distant relatives, usually children, and a high salience of friends. The private restricted support network is associated with an absence of local kin, few nearby friends and low levels of community contacts or involvement.

Table 2
Country-wise unadjusted and adjusted hazard ratios and pooled estimates of the effect of social network type (contrasted to the locally integrated type) on all-cause-mortality among older adults in eight developing countries.[a]

Country	Locally self-contained			Wider community-focused			Family dependent			Private		
	HR	95%CI		HR	95%CI		HR	95%CI		HR	95%CI	
Unadjusted model												
Cuba	**1.45**	1.06–1.98		0.63	0.34–1.17		**1.85**	1.53–2.25		**2.24**	1.69–2.97	
Dominican Republic	1.29	0.86–1.95		**1.42**	1.06–1.91		1.21	0.96–1.53		**1.99**	1.40–2.81	
Peru	**2.65**	1.55–4.53		0.59	0.21–1.61		**2.07**	1.48–2.89		**4.57**	2.49–8.38	
Venezuela	**2.22**	1.42–3.47		1.03	0.60–1.76		**1.83**	1.27–2.62		**2.69**	1.62–4.46	
Mexico	1.57	0.80–3.07		1.30	0.62–2.72		**1.85**	1.37–2.48		**3.05**	1.61–5.80	
Puerto Rico	**1.70**	1.13–2.56		1.19	0.75–1.89		**2.51**	1.90–3.30		**2.43**	1.63–3.64	
China	0.78	0.55–1.11		NA[c]	NA[c]		**1.76**	1.37–2.27		0.93	0.75–1.15	
India	0.98	0.42–2.26		0.85	0.27–2.67		**1.79**	1.25–2.56		1.49	0.98–2.27	
Pooled estimate (all countries)[b]	**1.42**	1.22–1.65	$I^2 = 68.2\%$	1.15	0.94–1.40	$I^2 = 23.3\%$	**1.79**	1.62–1.96	$I^2 = 60.0\%$	**1.67**	1.48–1.90	$I^2 = 87.3\%$
Pooled estimate (Latin-America only)	**1.67**	1.40–1.99	$I^2 = 26.1\%$	1.16	0.95–1.42	$I^2 = 33.7\%$	**1.79**	1.61–1.99	$I^2 = 71.4\%$	**2.43**	2.06–2.87	$I^2 = 21.7\%$
Adjusted model[d]												
Cuba	1.12	0.82–1.52		0.68	0.36–1.26		1.00	0.79–1.26		**1.56**	1.18–2.07	
Dominican Republic	0.87	0.57–1.30		1.30	0.96–1.75		1.06	0.82–1.36		1.04	0.68–1.60	
Peru	1.44	0.79–2.64		0.63	0.23–1.71		1.23	0.84–1.81		**2.91**	1.21–6.97	
Venezuela	**1.69**	1.07–2.68		0.67	0.37–1.21		1.24	0.84–1.85		1.82	0.99–3.32	
Mexico	1.64	0.83–3.26		1.19	0.57–2.70		1.31	0.95–1.80		**2.08**	1.10–3.93	
Puerto Rico	1.31	0.82–2.09		1.12	0.70–1.78		1.19	0.84–1.70		0.98	0.59–1.65	
China	0.85	0.55–1.33		NA[c]	NA[c]		0.96	0.69–1.32		0.91	0.67–1.24	
India	1.07	0.47–2.45		0.82	0.25–2.67		1.44	0.96–2.14		1.42	0.92–2.21	
Pooled estimate (all countries)[b]	1.16	0.98–1.36	$I^2 = 14.4\%$	1.03	0.85–1.26	$I^2 = 21.4\%$	**1.13**	1.01–1.26	$I^2 = 0.0\%$	**1.36**	1.06–1.73	$I^2 = 55.3\%$
Pooled estimate (Latin-America only)	**1.24**	1.01–1.51	$I^2 = 15.4\%$	1.04	0.85–1.28	$I^2 = 33.2\%$	**1.13**	1.001–1.28	$I^2 = 0.0\%$	**1.45**	1.20–1.75	$I^2 = 44.5\%$

Results in bold are statistically significant ($p < 0.05$). Heterogeneity tests were performed with Higgin's I^2.

[a] Each network type is contrasted to the locally integrated type. The locally integrated support network includes close relationships with local family, friends and neighbours. The locally self-contained support network typically has arms-length relationships or infrequent contact with at least one relative but the primary reliance is on neighbours. The wider community-focused support network is typified by an absence of nearby relatives but active relationships with distant relatives, usually children, and a high salience of friends. The family dependent support network is focused on close family ties, few neighbours and peripheral friends. The private restricted support network is associated with an absence of local kin, few nearby friends and low levels of community contacts or involvement.

[b] Pooled estimates were obtained by meta-analysis with fixed effects.

[c] Estimates could not be obtained because there were no deaths in this category for China.

[d] The multivariate analysis adjusted for age, gender, marital status, education, number of assets, receipt of pension, disability, number of physical impairments, depression, dementia.

the other centres, but this was not significant, and the meta-analyses pooled estimates remained unaffected. The Schoenfeld residuals confirmed that there were no appreciable violations in the proportional hazard assumption for any of the Cox proportional hazard models.

4. Discussion

In this study, we investigated the association of baseline social network type with all-cause mortality among older adults in urban and rural catchment areas in Latin America, China and India. Overall, our findings demonstrate that having a social network with few friends or community contacts is associated with higher mortality, as compared to those embedded in a more integrated social network. In the pooled analyses, the locally self-contained, family dependent, and private social network types were associated with significantly increased risk of mortality. After adjusting for socio-demographic variables and health status, the associations were considerably attenuated but those for family dependent and private networks remained statistically significant. When the analysis was restricted to Latin America, the effects were mostly stronger and less heterogeneous, given the generally null associations in China. Thus, lack of integration in one's social networks may be detrimental to health, particularly when the network is restricted to family, but not to friends and neighbours.

4.1. Strength and limitations

The strengths of this study include the use of a large, population-based sample with over 50,000 person-years of follow-up. Further, to our knowledge, this is the first multi-country study using standardized questionnaires to assess the direct impact of social networks on mortality risk across a wide range of cultures in developing countries. However, some limitations deserve mentioning. First, our findings may not be generalized beyond the particular catchment areas sites where the study was carried out, and should not be taken to refer to the respective countries as a whole, or urban or rural settings in general within them. Second, social networks were assessed at baseline in late life, with no information regarding either exposures earlier in the life course, or subsequent changes in social networks. These may have been affected by the onset of disability or care dependence, which may have limited access to friends outside of the household, and increased dependence upon family. Moreover, we acknowledge a potential risk of overadjustment, since impaired health, disability, and needs for care are likely to be determinants of 'family dependent' network types, and may mediate the association between other restricted network types and mortality. There were some differences in the distributions of social network types at baseline between those who were and were not part of the second survey. Thus, some level of bias may have been introduced due to these differences. Furthermore, there were some potential confounders such as personality type (Bogg and Roberts, 2004; Weiss and Costa, 2005) that we could not adjust for due to lack of data. Next, area-level contextual variables such as social capital, or neighbourhood crime and violence (as indicators of social disintegration) may be important determinants of mortality risk independent of individual social network exposures (Wilkinson et al., 1998), but our

catchment area study design precluded the examination of these effects due to restricted area-level variance. Finally, the Wenger's social network construct and accompanying assessment tool, originally developed as having meaning, relevance and predictive validity for older people living in North Wales (Wenger, 1991), has not been formally validated in our study setting, although there is evidence at least to support its construct validity (Thiyagarajan et al., 2014). Other studies have highlighted some points of divergence between network typologies described in high income countries (Doubova Dubova et al., 2010).

4.2. Contextualization of findings

We did not find the wider-community focused network type to be associated with increased risk of mortality. This is consistent with a body of research that attests to the salience of friendships and community relationships, rather than family relations, to mental health and wellbeing (Adams and Blieszner, 1995; Chao, 2011), self-reported health (DuPertuis et al., 2001) and survival (Fiori et al., 2006). On the other hand, the family dependent network type carried significant risk. This seems to be in accordance with previous research, and additional factors may exacerbate the risk for this network type. Relationships in which family members are obliged to provide care for an older person can result in caregiver strain, poor relationship quality and patterns of caregiving behaviours that are directly harmful to the health and wellbeing of the older person receiving care (Beach et al., 2005; Christie et al., 2009; Krause and Rook, 2003).

Older people with a private social network type, characterised by having a very restricted network and being socially isolated, were at considerably high risk of mortality. To a lesser degree, this was also the case for the locally self-contained social network type characterised by a focus on household and immediate neighbours with little wider community engagement. Although people with the family dependent network type are at higher risk of mortality, it appears that having a family network is still better than having a very small network or no network at all (consistent with previous research; Fiori et al., 2008). One reason for this finding could be that family support still may serve to promote certain fundamental and preventive behaviours (better diet, health screening, physical activity, etc.). Other research has documented the negative impact of social isolation on morbidity and mortality (Cacioppo and Cacioppo, 2014; Cerhan and Wallace, 1997; Luo et al., 2012; Luo and Waite, 2014; Steptoe et al., 2013). Social isolation means that people will effectively be restricted in terms of fostering relationships with peers, participating in religious services, and being actively involved in the community. According to the broader social networks and social support literature, it is the lack of social integration that negatively influences health (Berkman and Syme, 1979; Krause et al., 1990).

As discussed previously, people in countries with less well-developed social welfare systems may be more reliant than those in high-income countries on informal social networks for social protection, and this may have implications for mortality. Comparing our results with those conducted in high income countries, we find that the risk of mortality associated with the most restricted network type (as compared to the most integrated type) is relatively stronger in our sample (HR = 1.45 for Latin America and HR = 1.36 across all countries) as compared to those results obtained among older adults in the USA (HR = 1.19) (Fiori et al., 2008), (HR = 1.20) (Keller et al., 2003) and among older adults in Israel (HR = 1.32) (Litwin and Shiovitz-Ezra, 2006) (for purposes of comparison, we reversed the hazard ratios reported in these papers because their focus was on protective effects rather than risk). The aforementioned studies did not use the exact same social network typology and did not include as many covariates as our study, with some studies omitting important confounders such as level of disability or number of medical conditions. Therefore, it is possible that the differences observed may not be directly comparable. However, it does serve to at least indicate that social networks may be of particular importance to the health and longevity of older adults in settings where their social protection is not assured.

4.3. Mechanisms, and implications for policy and practices

Social networks have been linked to health and mortality in various ways, including physiological, behavioural, and psychological pathways (Smith and Christakis, 2008; Uchino, 2006, 2009). Physiological pathways may involve metabolic function (Yang et al., 2013) or cardiovascular, neuroendocrine, and immune function (Uchino, 2006). Behavioural pathways to mortality may include suicide (Tsai et al., 2014). Finally, psychological pathways to mortality may involve mental disorders such as depression, which is particularly relevant in the context of perceived social isolation or loneliness (Luo et al., 2012). In order to assess the influence of depression on the association between social networks and mortality, we compared the pooled estimates obtained from the model with and without depression but an appreciable change in the estimates for social networks was not observed, suggesting that depression may not be a significant mediator of this association at least in our study setting.

The relationship between social networks and mortality is probably best understood from a life course perspective, acknowledging that social networks both influence and are influenced by life transitions and changes in health status (Melchior et al., 2003). First, there is evidence that social networks increase in size in early life and then decrease over time as individuals focus selectively on a core of positive long-term relationships (English and Carstensen, 2014). There is likely to be some continuity over time in the ability and propensity of an individual to form and maintain positive relationships. Marriage (Kalmijn, 2003; Mildardo, 1987; Parks et al., 1983), reproduction (Bost et al., 2002) and retirement (van Tilburg, 1992, 2003) are key life course events with the potential transiently to impact upon social networks and relationships. For those that survive into older age, there is, naturally, a loss of some of these long-term core relationships through bereavement (Ha, 2008; Utz et al., 2002). Being embedded in more integrated and diverse network types thus appear to be beneficial for health in various ways such as through psychological and material resources, instrumental and informational support, and social identification with or belongingness to resourceful community groups or social class (Cohen, 2004; Smith and Christakis, 2008).

While there is evidence that social networks and relationships influence mortality across the life course, the critical period or periods for intervention have not been clearly established. Social isolation has been shown to be a predictor of mortality similar to that of well-documented clinical risk factors in terms of associated risk (Pantell et al., 2013). However, although most other factors are generally non-modifiable, this is not the case for social integration. It thus becomes all the more relevant to consider it as an important non-pharmacological approach for public health planning and gerontological interventions to promote the health and wellbeing of the elderly population. Further, the trend of a decline in the size of social networks as people age means that social network integration may be assessed before the transition into old adulthood. Hence, individuals embedded in restricted networks could be identified before serious consequences for health take place.

Many different forms of social networks interventions exist, and are typically designed to 1) enhance existing network linkages

(Heaney, 1991; Sandler et al., 1992; Wing and Jeffery, 1999), 2) develop new network linkages (Helgeson and Gottlieb, 2000), 3) enhance networks through the use of indigenous natural helpers and community health workers (Earp et al., 1997; Kegler and Malcoe, 2004; Krieger et al., 2005), or 4) enhance networks through community capacity building and problem solving (Boutilier et al., 2000; Minkler, 2001). For a detailed review, see Heaney and Israel (2008). In terms of preventing loneliness and promoting social integration among older adults, a literature review assessing social network interventions identified educational and social activity group interventions to be effective, whereas the effectiveness of home visiting and befriending schemes remained unclear (Cattan et al., 2005). In terms of possibilities for clinical practice interventions, Wenger's social network typology has been used as a practical tool in England and Wales as an integral part of gerontological social work practice, reflecting differing risk profiles for mental disorder and differing implications for health care utilization and transition to institutional care. This has also resulted in greater confidence among practitioners, increased understanding of the situations and needs of older people, and more appropriate tailoring of interventions (Wenger and Tucker, 2002).

Our results demonstrate that family dependent and private social network types were associated with mortality risk. The intervention required among older adults embedded in these types of networks would thus be to diversify the network member structure, particularly by incorporating friends and facilitating contact with neighbours and the community. Health and social care practitioners and community organisations can reinforce such networks by promoting social activity group interventions, or a broader community level programme designed specifically to facilitate social interaction. Another intervention perhaps relevant particularly to people embedded in the family dependent network type would be supporting the family caregivers to prevent possible stress or strain that could undermine the quality of the informal care provided and further potentially facilitate harmful caregiver behaviours (Cutrona and Cole, 2000). Enhancing and diversifying networks would not only add new social ties and interpersonal contact to the elderly client, but would also serve to provide respite for the family caregivers.

Future studies may make a more informative assessment of mortality risk by social network type if they also include measures of relationship quality (i.e. positive and negative interactions) (Schuster et al., 1990) or, in the case of informal care relationships, measures of potentially harmful caregiving behaviours (Williamson and Shaffer, 2001) and exemplary care (Dooley et al., 2007). Including such measures could provide more insight into the dynamics involved in the link between social network types and mortality. Finally, a thorough assessment of differences in the impact of social network types on mortality between developed and developing country settings is needed.

5. Conclusion

Our findings present evidence that more restricted networks are related to higher mortality. Specifically, the locally self-contained, the family dependent and the private social network types are associated with considerable risk among older adults in developing countries. Individuals embedded in such restricted social network types in a resource-limited context may suffer serious consequences. This study has demonstrated that Wenger's social network typology may be used as an effective tool to identify older adults who lack the social protection necessary to meet future needs of care. This could inform the development or enhancement of social care interventions in order to address the needs of those most at risk of neglect and deteriorating health. Health policy makers may use this information to plan more efficient use of limited care resources to improve health outcomes by targeting those embedded in restricted social networks. Initiatives could include for example educational and social activity group interventions for such individuals, preferably applied before the transition into older adulthood. Geriatric practitioners may also benefit from addressing older adults' level of social network integration in their assessment of patients.

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