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Linking social capital and mortality in the elderly: a Swedish national cohort study

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Abstract

Objectives Our objective was to examine the association between neighborhood linking social capital (a concept describing the amount of trust between individuals and societal institutions) and all-cause and cause-specific mortality in the elderly.

Design The entire Swedish population aged 65+, a total of 1,517,336 men and women, was followed from 1 January 2002 until death, emigration, or the end of the study on 31 December 2010. Small geographic units were used to define neighborhoods. The definition of linking social capital was based on neighborhood voting participation rates, categorized into three groups. Multilevel logistic regression was used to estimate odds ratios (ORs) and between-neighborhood variance in three different models.

Results The results showed an overall association between linking social capital and all-cause mortality. The significant OR of 1.53 in the group with low linking social capital decreased, but remained significant (OR = 1.27), after accounting for age, sex, family income, marital status, country of birth, education level, and region of residence. There were also significant associations between linking social capital and cause-specific mortality in coronary heart disease, psychiatric disorders, cancer, stroke, chronic lower respiratory diseases, type 2 diabetes, and suicide.

Conclusion There are associations between low linking social capital and mortality from chronic disorders and suicide in the elderly population. Community support for elderly people living in neighborhoods with low levels of linking social capital may need to be strengthened.

Key words: Elderly, Neighborhood, Mortality, Social capital.

1. Introduction

Social environments encompass multiple dimensions that may influence people's health status (Aida *et al.*, 2013; Fujiwara *et al.*, 2008; Kawachi *et al.*, 1997b; Kobayashi *et al.*, 2013; Zarzar *et al.*, 2012) and mortality risk (Cubbin *et al.*, 2000; Waitzman *et al.*, 1998). One important dimension of the social environment is social capital. During the past decades, there has been an upsurge of interest in the concept social capital and it has been referred to as a societal component that is positively associated with democracy (Putnam, 2000b; Putnam, 1993) and economic wealth (Holzmann *et al.*, 1999; Woolcock *et al.*, 2000). In contrast, lack of social capital has been associated with social disintegration and violent crime (Sampson *et al.*, 1997) as well as adverse health-related outcomes in all ages (Green *et al.*, 2000; Hyyppä *et al.*, 2001; Kawachi *et al.*, 1997a; Sundquist *et al.*, 2006), such as poor self-rated health (Kawachi *et al.*, 1999; Sundquist *et al.*, 2007), poor mental health (Hamano *et al.*, 2010; Lofors *et al.*, 2007), hypertensive status (Hamano *et al.*, 2011a) and coronary heart disease (Sundquist *et al.*, 2006).

Current definitions and measurements of social capital have usually been derived from leading social scientists such as Bourdieu, Coleman and Putnam. For example, Putnam identified social networks and social associations, trust, and norms of reciprocity as key components of social capital (Putnam, 2000a). Putnam described in his 2000 book 'Bowling Alone: The Collapse and Revival of American Community' that the number of people in the U.S. who bowl together had decreased during the last 20 years, although the total number of people who bowl had increased. This example was used as one of many examples of the decline in social capital in the U.S., a decline that may have a negative effect on civic engagement and democracy; if people do not meet, they don't take part in social interaction and civic discussions with other members of the society.

It is important to note that social capital has most frequently been operationalized as a collective, rather than an individual, dimension of the society (Kawachi *et al.*, 2000). Social capital is formed in social relationships and networks that can improve the efficiency of the society by facilitating coordinated actions (Putnam, 1993). While *horizontal* social capital represents bonds and bridges between individuals, *linking* social capital (LSC) includes vertical social trust, which can exist between individuals and societal institutions of any kind. The concept of LSC was introduced at the beginning of the 21st century as a sort of diagonal bridge across power differentials (Szreter *et al.*, 2004).

Elderly people may be particularly vulnerable to low levels of LSC due to their relative powerlessness and dependence on societal support. It was confirmed in a 1997 ecologic study from the U.S that lower state levels of social capital, defined as per capita density of membership in voluntary groups and level of social trust in each state, were associated with higher mortality rates, after accounting for state differences in median income (Kawachi *et al.*, 1997b). Similar findings were found at the neighborhood level: lower neighborhood social capital, measured as civic participation, reciprocity and trust, was associated with higher neighborhood mortality rates in White Americans and, to a less consistent extent, Black Americans in Chicago (Lochner *et al.*, 2003).

Szreter and Woolcock posited three concepts of social capital: bonding, bridging, and linking social capital (Szreter *et al.*, 2004), where LSC refers to trust across authority gradients in the society. Szreter and Woolcock (Szreter *et al.*, 2004) did, however, not suggest any instrument to measure LSC. We chose to define LSC as voting in local government elections. Other research groups have used voting as a proxy for social capital (Islam *et al.*, 2008; Islam *et al.*, 2006). According to Lochner et al., civic participation and engagement is one important aspect of social capital (Lochner *et al.*, 2003) and high voting rates are related to high levels of civic engagement. Researchers on civic engagement have divided civic engagement into three categories: civic, electoral, and political voice (Keeter *et al.*, 2002), where the second category, electoral, refers to, e.g., voting. Putnam (Putnam, 1993) recommended voting as a proxy of political participation. Participation in voting is therefore likely to be a good indicator of LSC and an important component of people's trust in institutionalized political power. For example, surveys of people from Scandinavia, Australia, and the United States have shown that there are strong associations between political action, political interest and measures of trust (Woolcock *et al.*, 2000). Previous studies have shown that LSC is associated with poor mental health, poor self-rated health and coronary heart disease (Lofors *et al.*, 2007; Sundquist *et al.*, 2006; Sundquist *et al.*, 2007). To the best of our knowledge, however, previous studies have not assessed the extent to which LCS may be associated with cause-specific mortality among the elderly.

We hypothesized that low LSC is associated with increased mortality in elderly people. The specific aim was to analyze the association between LSC and cause-specific mortality in all Swedish men and women aged 65+ years. We also assessed whether the hypothesized association between LSC and cause-specific mortality among elderly men and women remained after accounting for potential confounding factors related to individual power in society (age, sex, country of birth, education, marital status, and income).

2. Material and Methods

This population-based study included the entire Swedish population aged 65+ (65 being the normal age of retirement in Sweden), i.e., a total of 647,010 men and 870,326 women. The individuals were followed from 1 January 2002 until death, emigration, or the end of the study (31 December 2010). The study was based on population register data obtained from Statistics Sweden (the Swedish government-owned statistics bureau), including individual-level sociodemographic data collected annually (e.g. age, marital status, and socioeconomic status). Using the unique personal identification numbers assigned to all Swedish residents, we linked the Swedish Population Registry (sociodemographic data) and the Immigration Registry (data on immigration and emigration) to the Cause of Death Register. The latter was delivered to us from the National Board of Health and Welfare. In order to provide anonymity in all the registers, the personal identification numbers were replaced with serial numbers. To examine the effect of the exposure (LSC at the neighborhood level), all individuals were geocoded to their neighborhoods of residence. Small area market statistics (SAMS)—small administrative areas whose average population is 1000 in Sweden as a whole—were used to define neighborhoods. Data on SAMS covering the whole of Sweden (n=9,119) were obtained from Statistics Sweden. The boundaries of SAMS include similar types of housing construction in a neighborhood, meaning that SAMS neighborhoods are comparatively homogeneous in terms of physical and socioeconomic structure.

2.1 Predictor variable

Neighborhood-level variable

Neighborhood LSC was conceptualized as the number of people in the neighborhood (SAMS) who voted in local government elections divided by the number of people in the neighborhood who were entitled to vote. The election boards create the boundaries for the local electoral wards. The division is distributed in detailed maps to Statistics Sweden for determining which individuals are included in each electoral ward based on the individuals' geographic coordinates. Their participation (yes/no) in the local elections is registered at the individual level and then transferred to their respective SAMS area. By this procedure, each individual is linked to their local electoral wards as well as to their respective SAMS area based on their geographic coordinates. Statistics Sweden calculates the percentage voting rates for each SAMS and delivers the neighborhood-level data to us. Neighborhoods were divided into the following three groups based on the proportion of residents aged ≥18 years who voted: (1) low, (2) intermediate, and (3) high LSC. Group 1 comprised the 20% of neighborhoods with the lowest proportions of voters (≤74.0%); group 2 comprised the 60% of neighborhoods with intermediate proportions of voters (74.1–82.0%); and group 3 comprised the 20% of neighborhoods with the highest proportions of voters (>82.0%), based on those individuals who were aged ≥18 years and who were entitled to vote.

Voting in local elections provides a good measure of LSC because of the devolved nature of government in Sweden. In addition, voting patterns are very stable in Sweden. Numbers of people voting in national and local government elections have not been affected by get-out-the-vote campaigns or other actions of interest groups or political parties. As a result, voting in local government elections is a relatively stable variable over time, and rates of participation in local government elections may thus be considered a good indicator of neighborhood LSC.

2.2 Outcome variable

The outcome variable, cause of death, was based on the 10th revision of International Classification of Diseases (ICD-10). Causes of death were determined using the Cause of Death Register. The eight specific outcomes of interest were (1) all-cause (total) mortality and (2) mortality from coronary heart disease (I20-I25), psychiatric disorders (F00-F99), cancer (C00-D48), stroke (I60-I69), chronic lower respiratory diseases (J40-J49), type 2 diabetes (E11-E14), and suicide (X60-X84). The specific outcomes were partly chosen because they represent common chronic disorders in the elderly population.

2.3 Individual-level variables

Age: Age was categorized as follows: 65–69, 70–74, 75–79, 80–84, 85–89, and 90+ years.

Sex: men and women.

Education level: Individual level of education was divided into three groups: Compulsory school or less (≤9 years), practical high school or some theoretical high school (10–11 years), and theoretical high school and/or college/university (≥12 years).

Marital status: Married/cohabiting or never married/widowed/divorced

Country of birth: Categorized as Sweden, Western countries (Western Europe, USA, Canada, Oceania), and Other countries.

Family income: Annual family income divided by the number of people in the family. The final variable was calculated as empirical quartiles from the distribution.

Region of residence: large cities (Stockholm, Gothenburg, and Malmö), Northern Sweden, and Southern Sweden (excluding large cities).

2.4 Statistical methods

Multilevel logistic regression was performed with individuals at the first level and neighborhoods at the second level (Larsen *et al.*, 2000; Snijders *et al.*, 1999). Logistic regression was considered to be a good approximation of Cox's proportional hazard model because we had a large sample size, a relatively low incidence rate, risk ratios of moderate size, and a relatively short follow-up period (Callas *et al.*, 1998). The fixed effects are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The random effects were calculated as the variance between neighborhoods, the explained variance and the intra-class correlation (ICC). We created and analyzed three regression models. Model 1 included the neighborhood-level variable; Model 2 also included age and sex; and Model 3 also included the socioeconomic variables. We added age and sex to a second model because these sociodemographic variables are not modifiable, in contrast to most of the other economic and sociodemographic variables that were also added to Model 3.

The logistic model used is given by the formula:

$y_{ij} = \exp(f_{ij} + u_{0j}) / (1 + \exp(f_{ij} + u_{0j})) + e_{0ij}Z_{0ij}$

where f_{ij} denotes the fixed part of the model, u_{0j} denotes the neighborhood random effect, and z_{0ij} denotes the estimated binomial standard variation and equals $\sqrt{[\pi_{ij}(1 - \pi_{ij})]}$. The first-level variance is constrained to unity. These two terms ensure the correct specification of the binomial variance.

Next, we calculated the second-level (i.e. neighborhood-level) intercept variance. The proportion of the second-level variance explained by the different variables was calculated as:

$V_{Explained} = (V_0 - V_1) / V_0 \times 100$

where V_0 is the second-level variance in the initial model and V_1 is the second-level variance in the other models (Snijders *et al.*, 1999).

The ICC expresses the proportion of the total variance that is at a certain level, in this case the neighborhood level. The ICC can be estimated by different procedures in multilevel logistic regression. We used the latent variable method (Snijders *et al.*, 1999):

$ICC = V_n / (V_n + \pi^2 / 3)$

where V_n represents the variance between neighborhoods and $\pi^2 / 3$ is an approximation of the variance between individuals.

Possible cross-level interactions were tested. None were found. We did not test for random slopes or heterogeneity between the SAMS neighborhoods since there was little variance left in the final models. Parameters were estimated by second-order penalized quasi-likelihood. We systematically explored extra-binomial variation in all models and found no evidence of under- or overdispersion. MLwiN software (MLwiN 2.27) was used to perform the analyses (Rasbash *et al.*, 2000).

2.5 Geographic Information Systems (GIS)

Neighborhood LSC and mortality in Malmö, the third largest city in Sweden, are displayed in maps as spatial patterns. The maps were constructed in ArcGIS (v.10, ESRI).

3. Results

The population distribution and number of mortality events by sociodemographic characteristics, as well as age-standardized mortality rates by level of LSC, are presented in Table 1. Of the 1,517,336 individuals aged 65 and older, 26%, 57% and 17% lived in neighborhoods characterized by low, intermediate, and high LSC, respectively. The all-cause mortality rates were higher among men, those in older ages, those with a low income or a low education level, those who were never married/widowed/divorced, and those who lived in neighborhoods with low LSC.

3.1 Fixed effects

Table 2 presents ORs with 95% CIs for the association between LSC and all-cause mortality in individuals aged 65+ years. There was a gradient between LSC and all-cause mortality, with individuals living in neighborhoods with low LSC being more likely to die compared with individuals living in neighborhoods with high LSC, after accounting for age and sex (OR = 1.42, 95% CI = 1.40-1.45, Model 2). Elderly individuals living in neighborhoods with intermediate LSC were also more likely to die prematurely, after taking age and sex into account (OR = 1.21, 95% CI = 1.19-1.23, Model 2). After adjusting for the other sociodemographic variables (Model 3), the ORs in neighborhoods with low and intermediate LSC decreased to 1.27 and 1.12, respectively, but remained significant. There were also associations between most of the individual-level variables and mortality in the elderly. We performed an additional survival analysis; we applied Cox regression models where we used robust standard errors to adjust the 95% CIs for clustering of individuals within neighborhoods. The effect sizes were very similar. In the main multilevel analysis the OR was 1.27 and in the survival analysis the hazard ratio (HR) was 1.20 (CI = 1.19-1.21), which strengthens that our results are robust (data not shown in table).

Table 3 shows ORs with 95% CIs for the associations between LSC and mortality from coronary heart disease, psychiatric disorders, cancer, stroke, chronic lower respiratory diseases, type 2 diabetes, and suicide. There was an inverse gradient between LSC and mortality from the abovementioned diseases in the crude model. The associations with low LSC were strongest for mortality from chronic lower respiratory diseases (OR = 1.66; 95% CI = 1.57-1.76), type 2 diabetes (OR = 1.60; 95% CI = 1.50-1.72), and coronary heart disease (OR = 1.45; 95% CI = 1.41-1.49). After accounting for age, sex, family income, marital status, country of birth, educational level, and region of residence (Model 3), the ORs for low LSC decreased to 1.41, 1.29, and 1.19, for mortality from chronic lower respiratory diseases, type 2 diabetes, and coronary heart disease, respectively.

3.2 Random effects

LSC

The between-neighborhood variance was over 1.96 times the standard error in the crude model (Table 2, Model 1), indicating that there were significant differences in mortality between neighborhoods. After inclusion of age and sex (Model 2) and the other individual-level variables (Model 3), the between-neighborhood variance decreased, but remained significant. The explained variance increased after stepwise inclusion of the individual-level variables, reaching 82% in Model 3. This implies that the neighborhood-level and individual-level variables explained 82% of the between-neighborhood variance in mortality. Model 3 was also calculated without inclusion of LSC. In that model, the explained variance was 77% (data not shown in table). The ICC expresses the proportion of the total variance that is at the neighborhood level and constitutes a conditional approximation. For example, the ICC was 0.008 or 0.8% of the total variance in Model 3 (Table 2).

LSC in Malmö, Southern Sweden

Figure 1 shows the geographic distribution of the population aged 65+, levels of LSC, and age-standardized total mortality rates in Malmö, the third largest city in Sweden. A separate multilevel regression analysis was conducted for the association between LSC and total mortality in residents of Malmö aged 65+ years (in total 46,298 individuals) (Supplementary Table 1). The association between LSC and total mortality was stronger in Malmö than that for Sweden as a whole.

4. Discussion

The main finding of the present study was that low LSC is associated with an increased total mortality rate in the elderly. This average neighborhood effect on total mortality remained significant after inclusion of the individual-level variables. There was also an inverse gradient between LSC and cause-specific mortality from coronary heart disease, psychiatric disorders, cancer, stroke, chronic lower respiratory diseases, type 2 diabetes, and suicide. The ORs for all types of cause-specific mortality remained significant in neighborhoods with low LSC, after adjustment for the individual-level variables, and varied between 1.06 (stroke) and 1.41 (chronic lower respiratory diseases) (fixed effects). The between-neighborhood variance indicated significant differences in total mortality between neighborhoods, and the neighborhood-level and individual-level variables explained 82% of the between-neighborhood variance in mortality (random effects).

The findings of the present study are partly in agreement with previous research. For example, a study from 39 states in the U.S. found that lower state levels of social capital were associated with higher total mortality rates as well as higher rates of coronary heart disease and cancer (Kawachi *et al.*, 1997b). Similar results were observed in Chicago neighborhoods: when the level of neighborhood social capital decreased, the neighborhood rates for total mortality and coronary heart disease mortality increased. However, there was no association between neighborhood social capital and neighborhood cancer mortality (Lochner *et al.*, 2003). This is partly in agreement with the results from the present study of a relatively weak association between LSC and cancer mortality. However, our results are not directly comparable to the U.S. findings; rather, they extend these findings because our study used mortality data linked to each individual, adjusted for individual-level sociodemographic characteristics, rather than using state- or neighborhood-level mortality rates as the outcome variable. In addition, Sweden has relatively high voter turnout compared to the U.S.

The generalizability of our results may be greater in countries with similar political systems and voter turnout rates. The voter turnout varies greatly between different countries. For example, the voter turnout in the beginning of the 2000s was 45.3% in the U.S., 59.4% in the U.K., 60.6% in Japan, 80.1% in Sweden, 81.4% in Italy and 87.1% in Denmark (Pintor *et al.*, 2002). However, a recent study based on data from the European Social Survey of 25 European countries found support for a positive relationship between self-perceived health and social capital and that it acts in both directions (Rocco *et al.*, 2013).

A recent Danish study included 2,863 seventy-five-year-olds and 1,171 eighty-year-olds to analyze the impact of bonding, bridging and LSC on mortality. The results showed an association between mortality and both bridging and LSC in the eighty-year-olds, with hazard ratios of 1.24 and 1.21, respectively (Poulsen *et al.*, 2012). These effect sizes are similar to our effect sizes of 1.27 on all-cause mortality. Although an effect size of 1.27 might appear modest, it roughly means that 27 000 more deaths will occur if 100 000 deaths are "expected". The authors of the Danish study concluded that possible mediators between social capital and mortality in older populations are physical disability and lack of physical activity. However, it is also possible that the association between social capital and mortality is due to terminal decline, i.e., both low levels of LSC and high mortality rates may be due to poor health among elderly people. Other possible mediators between social capital and mortality are psychological distress and hypertension. A study from Japan found that lower social capital, measured by trust, was associated with psychological distress in the elderly (Hamano *et al.*, 2011b), and that systolic blood pressure increased with an increasing perception of lack of fairness, after adjustment for individual confounders in a multilevel framework (Hamano *et al.*, 2011a). Poor self-rated health is associated with increased mortality and it may represent another potential mediator between social capital and mortality. Bridging social capital (between individuals who are not alike) was associated with good self-rated health in both men and women in Japan, while bonding social capital (between individuals who are alike) had no additional effect on self-rated health (Iwase *et al.*, 2012).

The mechanisms underlying the association between LSC and mortality are most likely of a complex nature and any causal inferences remain to be established. However, neighborhood LSC may reflect how well the society is organized at the local level. Previous research has shown positive associations between the quality of government and other aspects of social capital, such as census response rates and social trust (Knack, 2002). Local governments bear a great deal of power because they have the right to apply taxes and are responsible for health care, elderly care, and city planning. Local politicians distribute key services to their elderly population, i.e., part of their voters. They must build community trust via repeated interaction with people, and many of them have face-to-face contact with potential voters in the local community. Although the present study has shown associations between LSC and mortality rates in the elderly population, the potential causality between the predictor variable and the outcome variable remains to be established. In addition, if investments in social capital are to be made by local politicians, it is hard to know at what time point in the life course that such investments would provide the most benefits in people's health.

Limitations and strengths

This study has some important limitations. The nature of social capital is complex and we operationalized LSC as neighborhood voting rates as a way to assess this multidimensional concept. However, a consensus has not yet been established as to which measurement of social capital is the most "accurate". We argue that measuring social capital in multiple different ways is the most appropriate strategy as this approach can broaden its multidimensional conceptualization. Neighborhood voting rates may be a good proxy of current levels of LSC. However, they may also reflect foregone elections and levels of LSC or regional social relationships rather than trust across authority gradients in the society. We included individuals aged 65 and over because this is the normal age at retirement in Sweden; the retirement age of 67 is optional but most Swedes retire at 65. Some retired individuals may work part-time after retirement but we do not have access to such data. We had no access to smoking rates. Poor health behaviors, such as smoking, may impact individuals through their social networks and socioeconomic status (Lutfey *et al.*, 2005). Although we accounted for socioeconomic status in the analyses, some residual confounding most likely exists in the measurement of socioeconomic conditions. For example, years of education are not equal to quality of education (Kaufman *et al.*, 1997).

These limitations are balanced by certain key strengths. Few previous studies have analyzed, in the elderly, the association between the amount of vertical trust between individuals and societal institutions (i.e., LSC, measured as neighborhood voting rates) and mortality from specific chronic disorders, i.e., coronary heart disease, psychiatric disorders, cancer, stroke, chronic lower respiratory diseases, and type 2 diabetes as well as suicide. In addition, this is the first large-scale multilevel study to examine the potential effect of low LSC on mortality in elderly people, after accounting for a comprehensive set of individual-level sociodemographic factors. The availability of almost 100% complete sociodemographic and mortality data allowed us to perform a comprehensive assessment of the association between LSC and mortality from a broad spectrum of chronic disorders. Our study was based on the entire Swedish population aged 65+ years, a total of 647,010 men and 870,326 women living in small neighborhoods, each with around 1000 residents. The use of small neighborhoods is an advantage according to a recent review of social capital (Whitley *et al.*, 2005). Some research suggests that the immediate neighborhood to a high extent contributes to poor mental health (Boydell *et al.*, 2002), which may impact mortality risk. Furthermore, by using a multilevel model we could take into account the hierarchical structure of the data and consider both fixed and random effects in the analyses.

Finally, our outcome variables and exposure variable were collected from two different sources. The neighborhood variable (voting rates) and the individual-level outcome (mortality) were collected from different data sources, which eliminates spurious associations due to same-source bias. Previous studies have often been hampered by same-source bias, where the neighborhood variable has been constructed by aggregating individual-level survey responses. Problems with same-source bias may occur if people can't vote due to illness. Our definition of social capital eliminated same-source bias because it was based on objective measures and not aggregated individual-level responses from surveys (Poortinga, 2006; Veenstra *et al.*, 2005).

Conclusions

In summary, these findings from a large national cohort study show that low LSC are associated with total and cause-specific mortality among elderly men and women. Decision-makers should take into account the potentially negative effect of LSC on health in the elderly regarding sites of primary health care centers and other kinds of community support for elderly people with chronic disorders.

Highlights:

- Population-based study of linking social capital and mortality in Sweden
- Linking social capital associated with all-cause mortality in elderly people
- Linking social capital associated with cause-specific mortality
- Linking social capital associated with suicide
- Most associations remain after adjustment for individual-level characteristics

Conflicts of interest declaration: None

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Figure legends

Figure 1. Neighborhood linking social capital and mortality in the urban area of Malmö, Sweden.

References

Aida J, Kondo K, Kawachi I, Subramanian SV, Ichida Y, Hirai H*, et al.* (2013). Does social capital affect the incidence of functional disability in older Japanese? A prospective population-based cohort study. *J Epidemiol Community Health* 67**:** 42-47.

Boydell J, McKenzie K, van Os J, Murray R (2002). The social causes of schizophrenia: An investigation into the influence of social cohesion and social hostility. Report of a pilot study. *Schizophrenia Res* 53**:** 264.

Callas PW, Pastides H, Hosmer DW (1998). Empirical comparisons of proportional hazards, poisson, and logistic regression modeling of occupational cohort data. *Am J Ind Med* 33**:** 33-47.

Cubbin C, LeClere FB, Smith GS (2000). Socioeconomic status and injury mortality: individual and neighbourhood determinants. *J Epidemiol Community Health* 54**:** 517-524.

Fujiwara T, Kawachi I (2008). Social capital and health. A study of adult twins in the U.S. *Am J Prev Med* 35**:** 139-144.

Green G, Grimsley M, Suokas A, Prescott M, Jowitt T, R L (2000). *Social capital, health and economy in South Yorkshire Coalfield Communities*. Sheffield: Center for Regional Economic and Social Research.

Hamano T, Fujisawa Y, Ishida Y, Subramanian SV, Kawachi I, Shiwaku K (2010). Social capital and mental health in Japan: a multilevel analysis. *PLoS One* 5**:** e13214.

Hamano T, Fujisawa Y, Yamasaki M, Ito K, Nabika T, Shiwaku K (2011a). Contributions of social context to blood pressure: findings from a multilevel analysis of social capital and systolic blood pressure. *Am J Hypertens* 24**:** 643-646.

Hamano T, Yamasaki M, Fujisawa Y, Ito K, Nabika T, Shiwaku K (2011b). Social capital and psychological distress of elderly in Japanese rural communities. *Stress and Health* 27**:** 163-169.

Holzmann R, Jorgensen S (1999). *Social protection as social risk management. Social protection discussion paper 9904.* Washington DC: Social Protection Team, Human Development Network, World Bank.

Hyyppä MT, Mäki J (2001). Why do Swedish-speaking Finns have longer active life? An area for social capital research. *Health Promot Int* 16**:** 55-64.

Islam MK, Gerdtham UG, Gullberg B, Lindstrom M, Merlo J (2008). Social capital externalities and mortality in Sweden. *Economics and human biology* 6**:** 19-42.

Islam MK, Merlo J, Kawachi I, Lindstrom M, Burstrom K, Gerdtham UG (2006). Does it really matter where you live? A panel data multilevel analysis of Swedish municipality-level social capital on individual health-related quality of life. *Health economics, policy, and law* 1**:** 209-235.

Iwase T, Suzuki E, Fujiwara T, Takao S, Doi H, Kawachi I (2012). Do bonding and bridging social capital have differential effects on self-rated health? A community based study in Japan. *J Epidemiol Community Health* 66**:** 557-562.

Kaufman JS, Cooper RS, McGee DL (1997). Socioeconomic status and health in blacks and whites: the problem of residual confounding and the resiliency of race. *Epidemiology* 8**:** 621-628.

Kawachi I, Berkman L (2000). *Social epidemiology* edn. Oxford University Press: New York.

Kawachi I, Kennedy B, Lochner K (1997a). Long live community: Social capital as public health 8**:** 56-59.

Kawachi I, Kennedy BP, Glass R (1999). Social capital and self-rated health: a contextual analysis. *Am J Public Health* 89**:** 1187-1193.

Kawachi I, Kennedy BP, Lochner K, Prothrow-Stith D (1997b). Social capital, income inequality, and mortality. *Am J Public Health* 87**:** 1491-1498.

Keeter S, Zukin C, Andolina M, Jenkins K (2002). *The civic and political health of the nation : a generational portrait*. edn. College Park, Md.: Center for Information & Research on Civic Learning & Engagement, MD, USA.

Knack S (2002). Social capital and the quality of government. *Am J of Political Science* 46**:** 772-785.

Kobayashi T, Kawachi I, Iwase T, Suzuki E, Takao S (2013). Individual-level social capital and self-rated health in Japan: an application of the Resource Generator. *Soc Sci Med* 85**:** 32-37.

Larsen K, Petersen JH, Budtz-Jørgensen E, Endahl L (2000). Interpreting parameters in the logistic regression model with random effects. *Biometrics* 56**:** 909-914.

Lochner KA, Kawachi I, Brennan RT, Buka SL (2003). Social capital and neighborhood mortality rates in Chicago. *Soc Sci Med* 56**:** 1797-1805.

Lofors J, Sundquist K (2007). Low-linking social capital as a predictor of mental disorders: a cohort study of 4.5 million Swedes. *Soc Sci Med* 64**:** 21-34.

Lutfey K, Freese J (2005). Toward Some Fundamentals of Fundamental Causality: Socioeconomic Status and Health in the Routine Clinic Visit for Diabetes. *American Journal of Sociology* 110**:** 1326-1372.

Pintor RL, Gratschew M (2002). *Voter Turnout Since 1945: A Global Report*. edn. International Institute for Democracy and Electoral Assistance.

Poortinga W (2006). Perceptions of the environment, physical activity, and obesity. *Soc Sci Med* 63**:** 2835-2846.

Poulsen T, Siersma VD, Lund R, Christensen U, Vass M, Avlund K (2012). Impact of social capital on 8-year mortality among older people in 34 Danish municipalities. *J Aging Health* 24**:** 1203-1222.

Putnam R (2000a). *Bowling Alone. The Collapse and Revival of American Community.* edn. Simon & Schuster: New York, NY.

Putnam R (2000b). *Bowling alone: The collapse and revival of American community*. edn. Simon and Schuster: New York.

Putnam R (1993). *Making democracy work*. edn. Princeton University Press: Princeton.

Rasbash J, Browne W, H G, Yang M, Plewis I, Healy M*, et al.* (2000). *A User's Guide to MLwiN (2nd edition).* edn. Institute of Education, University of London: London.

Rocco L, Fumagalli E, Suhrcke M (2013). From Social Capital to Health - and Back. *Health economics*.

Sampson RJ, Raudenbush SW, Earls F (1997). Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science* 277**:** 918-924.

Snijders T, Bosker R (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. edn. Sage Publications: London.

Sundquist J, Johansson SE, Yang M, Sundquist K (2006). Low linking social capital as a predictor of coronary heart disease in Sweden: A cohort study of 2.8 million people. *Soc Sci Med* 62**:** 954-963.

Sundquist K, Yang M (2007). Linking social capital and self-rated health: a multilevel analysis of 11,175 men and women in Sweden. *Health Place* 13**:** 324-334.

Szreter S, Woolcock M (2004). Health by association? Social capital, social theory, and the political economy of public health. *Int J Epidemiol* 33**:** 650-667.

Veenstra G, Luginaah I, Wakefield S, Birch S, Eyles J, Elliott S (2005). Who you know, where you live: social capital, neighbourhood and health. *Soc Sci Med* 60**:** 2799-2818.

Waitzman NJ, Smith KR (1998). Phantom of the area: poverty-area residence and mortality in the United States. *Am J Public Health* 88**:** 973-976.

Whitley R, McKenzie K (2005). Social capital and psychiatry: review of the literature. *Harv Rev Psychiatry* 13**:** 71-84.

Woolcock M, Narayan D (2000). Social capital: Implications for development theory, research and policy. *World Bank Res Obs* 15**:** 225-249.

Zarzar PM, Ferreira EF, Kawachi I (2012). Can social capital contribute to the improvement of oral health? *Brazilian oral research* 26**:** 388-389.

Table 1. Population distribution, number of mortality events, and age-standardized mortality rates (%) in elderly Swedes by linking social capital

	Population		Mortality events		Linking social capital		
	No.	(%)	No.	%	Low	Moderate	High
Total population (%)	1517336				400310 (26%)	869541 (57%)	247485 (17%)
Total mortality			584088		41.8	38.8	32.0
Coronary heart disease			121886	20.9	8.8	8.1	6.3
Psychiatric disorders			35879	6.1	2.6	2.4	1.9
Cancer			118239	20.2	8.0	7.8	7.4
Stroke			71681	12.3	5.0	4.8	3.9
Chronic lower respiratory diseases			18621	3.2	1.5	1.2	0.9
Type 2 diabetes			12556	2.1	1.0	0.8	0.6
Suicide			1746	0.3	0.1	0.1	0.1
Sex							
Men	647010	42.6	264376	45.3	48.0	44.4	36.4
Women	870326	57.4	319712	54.7	37.6	34.7	28.1
Age (years)							
65-69	377429	24.9	53108	9.1	17.0	13.8	11.3
70-74	352424	23.2	82054	14.0	26.1	23.2	19.5
75-79	320621	21.1	122961	21.1	41.0	38.2	34.2
80-84	258020	17.0	151488	25.9	60.5	58.7	55.4
85-89	140641	9.3	111204	19.0	80.1	79.0	77.3
≥ 90	68201	4.5	63273	10.8	92.9	92.8	92.1
Family income (quartiles)							
Low income	379709	25.0	206081	35.3	44.8	42.8	36.2
Middle–low income	379265	25.0	161006	27.6	43.1	40.2	34.2
Middle–high income	379191	25.0	126633	21.7	40.5	38.0	32.1
High income	379171	25.0	90368	15.5	38.5	35.6	29.5
Marital status							
Married/cohabiting	767724	50.6	229942	39.4	39.7	37.3	30.9
Never married, widowed, or divorced	749612	49.4	354146	60.6	43.9	40.9	34.0
Country of birth							
Sweden	1370175	90.3	538338	92.2	42.1	38.9	32.1
Western Countries	108003	7.1	33689	5.8	41.7	38.5	31.0
Other countries	39158	2.6	12061	2.1	34.8	35.3	29.2
Educational attainment							
≤ 9 years	1162582	76.6	527237	90.3	42.5	39.7	33.0
10–11 years	179366	11.8	30451	5.2	9.2	8.0	7.8
≥ 12 years	175388	11.6	26400	4.5	8.6	7.3	7.3
Region of residence							
Large city	706064	46.5	269141	46.1	41.4	38.0	31.4
Southern Sweden	537845	35.4	207152	35.5	42.0	38.8	32.5
Northern Sweden	273427	18.0	107795	18.5	42.3	40.7	34.1

Table 2. Odds ratios (ORs) and 95% confidence intervals (CIs) for all-cause mortality in elderly Swedes: results from multi-level logistic regression models

	Model 1			Model 2			Model 3			
	OR	95% CI		OR	95% CI		OR	95% CI		P-value
Linking social capital (ref. High linking social capital)										
Moderate	1.31	1.28	1.34	1.21	1.19	1.23	1.12	1.10	1.14	<0.001
Low	1.53	1.49	1.57	1.42	1.40	1.45	1.27	1.25	1.29	<0.001
Sex (ref. Females) males				1.73	1.71	1.74	1.95	1.94	1.97	<0.001
Age (ref. 65-69 years)										
70-74				1.88	1.86	1.90	1.78	1.76	1.80	<0.001
75-79				3.92	3.87	3.97	3.29	3.25	3.34	<0.001
80-84				9.20	9.09	9.31	7.46	7.36	7.57	<0.001
85-89				25.13	24.74	25.53	19.18	18.85	19.52	<0.001
≥ 90				87.79	85.25	90.41	63.69	61.72	65.72	<0.001
Family income (ref. High income)										
Middle-high income							1.17	1.16	1.19	<0.001
Middle-low income							1.31	1.29	1.33	<0.001
Low income							1.53	1.50	1.55	<0.001
Marital status (ref. Married/co-habiting)										
Never married,widowed, divorced							1.19	1.18	1.20	<0.001
Country of birth (ref. Sweden)										
Western countries							1.01	0.86	1.18	0.920
Others							0.75	0.73	0.77	<0.001
Educational attainment (ref. ≥ 12 years)										
≤ 9 years							1.32	1.30	1.34	<0.001
10–11 years							1.16	1.14	1.18	<0.001
Region of residence (ref. Large city)										
Southern Sweden							1.00	0.99	1.01	0.617
Northern Sweden							1.07	1.05	1.08	<0.001
Variance (S.E.)	*0.119 (0.002)*			*0.037 (0.001)*			*0.025 (0.001)*			
Explained variance (%)	*14*			*73*			*82*			
Intra class correlation	*0.035*			*0.011*			*0.008*			

Model 1. Crude model.

Model 2. Adjusted for age and sex.

Model 3. Adjusted for age, sex, family income, marital status, country of birth, education, and region of residence.

Table 3. Odds ratios (ORs) and 95% confidence intervals (CIs) for cause-specific mortality in elderly Swedes: results from multi-level logistic regression models

Specific mortality by linking social capital (Ref. high linking social capital, LSC)	Model 1			Model 2			Model 3			
	OR	95% CI		OR	95% CI		OR	95% CI		P-value
Coronary heart disease										
Low LSC	1.45	1.41	1.49	1.33	1.29	1.36	1.19	1.16	1.22	<0.001
Moderate LSC	1.30	1.27	1.34	1.20	1.17	1.23	1.11	1.08	1.13	<0.001
Psychiatric disorders										
Low LSC	1.38	1.30	1.46	1.14	1.08	1.20	1.08	1.03	1.14	0.003
Moderate LSC	1.23	1.17	1.30	1.07	1.02	1.12	1.03	0.98	1.07	0.271
Cancer										
Low LSC	1.09	1.07	1.11	1.09	1.07	1.11	1.08	1.05	1.10	<0,001
Moderate LSC	1.05	1.03	1.07	1.04	1.02	1.06	1.03	1.02	1.05	0.001
Stroke										
Low LSC	1.31	1.26	1.35	1.14	1.10	1.18	1.06	1.03	1.10	<0,001
Moderate LSC	1.24	1.20	1.28	1.11	1.08	1.14	1.04	1.02	1.07	0.002
Chronic lower respiratory diseases										
Low LSC	1.66	1.57	1.76	1.60	1.51	1.68	1.42	1.35	1.50	<0,001
Moderate LSC	1.28	1.22	1.35	1.23	1.17	1.30	1.16	1.10	1.22	<0,001
Type 2 diabetes										
Low LSC	1.60	1.50	1.72	1.48	1.38	1.59	1.30	1.21	1.39	<0,001
Moderate LSC	1.40	1.31	1.49	1.30	1.22	1.38	1.17	1.10	1.25	<0,001
Suicide										
Low LSC	1.22	1.04	1.42	1.31	1.12	1.54	1.14	0.98	1.34	0.089
Moderate LSC	1.17	1.02	1.35	1.23	1.06	1.41	1.14	0.99	1.31	0.075

Model 1. Crude model.
Model 2. Adjusted for age and sex.
Model 3. Adjusted for age, sex, family income, marital status, country of birth, education, and region of residence.

Supplementary Table 1. Odds ratios (ORs) and 95% confidence intervals (CIs) for all-cause mortality in elderly residents of Malmö; Results from multi-level logistic regression models, N=46,298.

	Model 1			Model 2			Model 3			
	OR	95% CI		OR	95% CI		OR	95% CI		P-value
Linking social capital (ref. High linking social capital)										
Moderate	1.51	1.31	1.74	1.27	1.16	1.40	1.18	1.08	1.29	<0.001
Low	1.86	1.61	2.15	1.69	1.54	1.85	1.50	1.38	1.64	<0.001
Sex (ref. Females): males				1.80	1.73	1.88	2.03	1.93	2.12	<0.001
Age (ref. 65-69 years)										
70-74				1.79	1.67	1.91	1.71	1.59	1.83	<0.001
75-79				3.50	3.28	3.75	2.99	2.77	3.22	<0.001
80-84				7.61	7.09	8.16	6.22	5.75	6.73	<0.001
85-89				20.09	18.39	21.94	15.77	14.32	17.36	<0.001
≥ 90				73.11	62.01	86.20	55.15	46.50	65.40	<0.001
Family income (ref. High income)										
Middle-high income							1.19	1.12	1.27	<0.001
Middle-low income							1.31	1.21	1.42	<0.001
Low income							1.42	1.31	1.55	<0.001
Marital status (ref. Married/co-habiting)										
Never married, widowed, divorced							1.17	1.10	1.25	<0.001
Country of birth (ref. Sweden)										
Western countries							0.92	0.86	0.99	0.028
Others							0.69	0.63	0.76	<0.001
Educational attainment (ref. ≥ 12 years)										
≤ 9 years							1.33	1.22	1.45	<0.001
10–11 years							1.15	1.04	1.28	0.005
Variance (S.E.)	*0.183 (0.019)*			*0.042 (0.007)*			*0.030 (0.006)*			
Explained variance (%)	*25*			*83*			*88*			
Intra class correlation	*0.053*			*0.013*			*0.009*			

Model 1. Crude model.

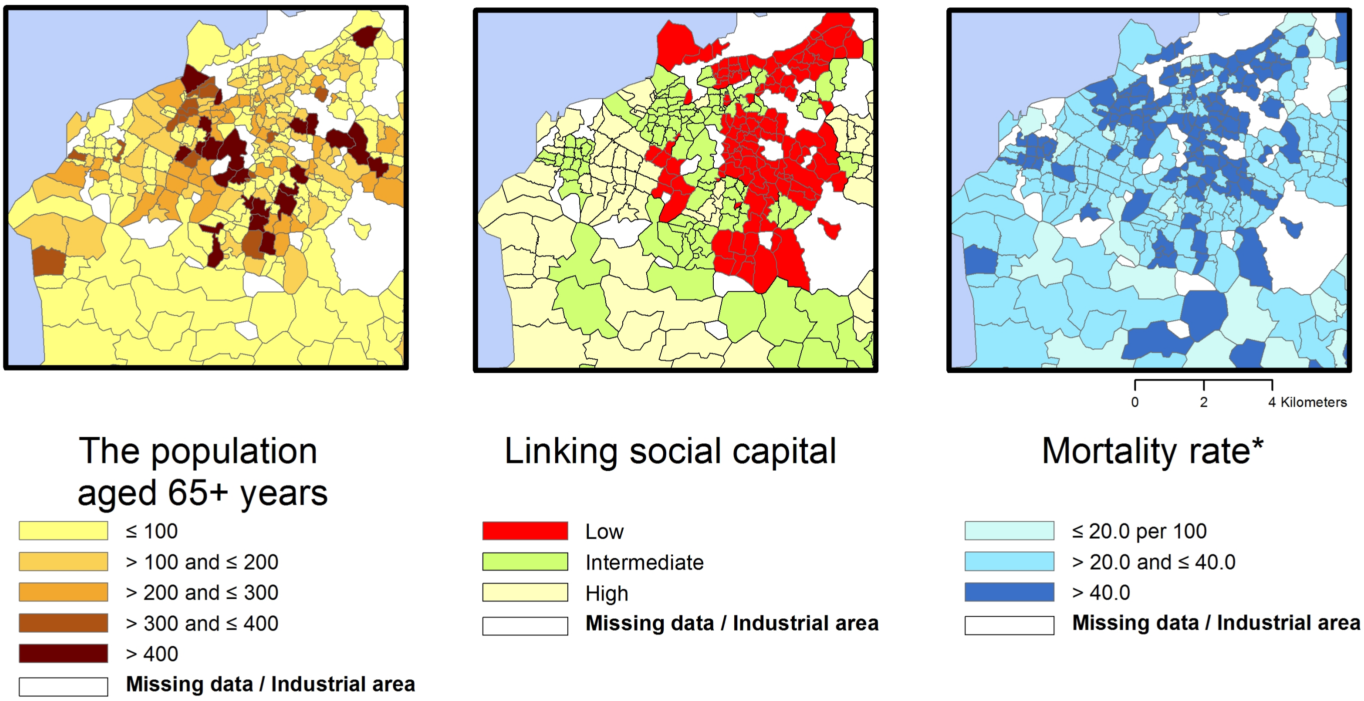
Model 2. Adjusted for age and sex.

Model 3. Adjusted for age, sex, family income, marital status, country of birth, and education.

Supplementary Table 2. Odds ratios (ORs) and 95% confidence intervals (CIs) for disease-specific mortality in elderly residents of Malmö; Results from multi-level logistic regression models, N=46,298.

Specific mortality by linking social capital (Ref. high linking social capital, LSC)	Model 1			Model 2			Model 3			
	OR	95% CI		OR	95% CI		OR	95% CI		P-value
Coronary heart disease										
Low LSC	1.54	1.37	1.74	1.44	1.28	1.63	1.28	1.13	1.43	<0.001
Moderate LSC	1.41	1.24	1.59	1.24	1.11	1.40	1.15	1.02	1.29	0.021
Psychiatric disorders										
Low LSC	1.34	0.97	1.85	0.94	0.74	1.19	0.92	0.72	1.17	0.484
Moderate LSC	1.27	0.92	1.75	0.88	0.69	1.12	0.86	0.67	1.09	0.194
Cancer										
Low LSC	1.16	1.05	1.28	1.19	1.07	1.31	1.16	1.05	1.28	0.005
Moderate LSC	1.12	1.02	1.24	1.13	1.02	1.25	1.10	1.00	1.22	0.057
Stroke										
Low LSC	1.39	1.16	1.67	1.14	0.97	1.33	1.09	0.93	1.27	0.317
Moderate LSC	1.40	1.16	1.68	1.11	0.95	1.29	1.07	0.92	1.26	0.368
Chronic lower respiratory diseases										
Low LSC	2.27	1.76	2.92	2.21	1.72	2.86	1.91	1.47	2.48	<0,001
Moderate LSC	1.79	1.38	2.31	1.68	1.30	2.19	1.51	1.17	1.96	0.002
Type 2 diabetes										
Low LSC	1.67	1.20	2.31	1.61	1.16	2.23	1.31	0.94	1.83	0.110
Moderate LSC	1.20	0.85	1.68	1.12	0.80	1.57	1.02	0.72	1.42	0.920
Suicide										
Low LSC	1.25	0.61	2.56	1.32	0.64	2.72	1.26	0.60	2.66	0.549
Moderate LSC	1.19	0.58	2.46	1.27	0.61	2.64	1.21	0.58	2.51	0.617

Model 1. Crude model.
Model 2. Adjusted for age and sex.
Model 3. Adjusted for age, sex, family income, marital status, country of birth, and education.


0
2
4 Kilometers
The population aged 65+ years
≤ 100
> 100 and ≤ 200
> 200 and ≤ 300
> 300 and ≤ 400
> 400
Missing data / Industrial area
Linking social capital
Low
Intermediate
High
Missing data / Industrial area
Mortality rate*
≤ 20.0 per 100
> 20.0 and ≤ 40.0
> 40.0
Missing data / Industrial area