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## The contextual effects of social capital on health: a cross-national instrumental variable analysis

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### Abstract

Past observational studies of the associations of area-level/contextual social capital with health have revealed conflicting findings. However, interpreting this rapidly growing literature is difficult because estimates using conventional regression are prone to major sources of bias including residual confounding and reverse causation. Instrumental variable (IV) analysis can reduce such bias. Using data on up to 167 344 adults in 64 nations in the European and World Values Surveys and applying IV and ordinary least squares (OLS) regression, we estimated the contextual effects of country-level social trust on individual self-rated health. We further explored whether these associations varied by gender and individual levels of trust. Using OLS regression, we found higher average country-level trust to be associated with better self-rated health in both women and men. Instrumental variable analysis yielded qualitatively similar results, although the estimates were more than double in size in women and men using country population density and corruption as instruments. The estimated health effects of raising the percentage of a country's population that trusts others by 10 percentage points were at least as large as the estimated health effects of an individual developing trust in others. These findings were robust to alternative model specifications and instruments. Conventional regression and to a lesser extent IV analysis suggested that these associations are more salient in women and in women reporting social trust. In a large cross-national study, our findings, including those using instrumental variables, support the presence of beneficial effects of higher country-level trust on self-rated health. Past findings for contextual social capital using traditional regression may have underestimated the true associations. Given the close linkages between self-rated health and all-cause mortality, the public health gains from raising social capital within countries may be large.

### Keywords

social capital; social determinants of health; social environment; causal inference; instrumental variables; contextual; self-rated health

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## Introduction

The notion of societal conditions and the social environment as fundamental causes of health and disease is not new, dating back more than a century to the works of Durkheim and Virchow (Link & Phelan, 1995; Cassel, 1976; Durkheim, 1897; Virchow, 1848). Social capital, a major attribute of the social environment, has garnered scientific and government attention over the last decade as a plausible broad determinant of population health, educational outcomes, and economic growth (Kawachi, Subramanian, & Kim, 2007). While social capital may be a property of contexts/collectives *or* individuals (Kawachi, Subramanian, & Kim, 2007; Kim & Kawachi, 2007; Kim et al., 2006; Kawachi & Berkman, 2000), and has a strong tradition of being conceptualized as the resources embedded within an individual's social network (Bourdieu, 1977; Lin, 2001; Flap 1991), its novelty lies at the former collective level (Kim & Kawachi, 2007; Kawachi et al., 2004), where it has been defined, according to some scholars, as the features of social organisation, including trust, civic participation, and reciprocity norms facilitating cooperation for mutual benefit (Kim & Kawachi, 2007; Putnam, 2000; Kawachi et al., 1997). At the area or contextual level, social capital may serve as a “public good”, with positive spillover effects onto the health of members of broader society (Putnam, 2000). For example, collective action across a country may mobilise to enact health-promoting policies with potential benefits to all citizens. Comparative work by the political scientist Robert Putnam favors such a policy-related mechanism. In his book *Making Democracy Work: Civic Traditions in Modern Italy* (Putnam, Leonardi, & Nanetti, 1993), Putnam ascribes the strong social bonds and high civic engagement in selected regions in Italy as the driving force behind the presence of smoothly functioning democracies. Leveraging social capital may therefore be a powerful means to improve population health. Furthermore, the adverse effects of income inequality have been posited to take place, at least in part, through the erosion of social capital/cohesion (Kondo et al., 2009; Kawachi, I., 2000; Marmot & Wilkinson, 2001; Pickett & Wilkinson, 2010; Kim et al., 2008). At the individual level, social capital may yield beneficial private health returns to personal investments (Kawachi & Berkman, 2000)—for instance, participation in a civic group boosting one's health through psychosocial processes such as social support (Kim & Kawachi, 2006).

Although multiple studies have investigated the relations between social capital at a contextual level (i.e., at the level of entire countries, states, or neighbourhoods/communities) and general health and disease-specific outcomes (e.g., cardiovascular disease, cancer), findings have been conflicting to date (Lynch et al., 2001; Kennelly, O'Shea, & Garvey, 2003; Mansyur et al., 2008; Helliwell & Putnam, 2004; Gundelach & Kreiner, 2004; Kim, Subramanian, & Kawachi. 2007; Almedom & Glandon D, 2007). A systematic literature review (Kim, Subramanian, & Kawachi, 2007) found that multilevel studies showed weaker, modest associations for contextual trust than individual-level trust, and that the former estimates became attenuated to non-significance after controlling for individual levels of trust.

Few studies have explored associations between social capital measured at the country level and individual self-rated health (Helliwell & Putnam, 2004; Mansyur et al., 2008; Poortinga, 2006; Rostila, 2007). For example, Helliwell & Putnam (2004) and Mansyur et al. (2008) examined average country levels of social trust in relation to individual self-rated health using data from 49 and 45 countries respectively in the European and World Values Surveys. Based on least squares regression models, these studies found that higher country-level social trust was associated and not associated with better self-rated health, respectively (Helliwell & Putnam, 2004; Mansyur et al., 2008).

While the findings to date would appear to discount the utility of leveraging contextual social capital to improve population health, their interpretation is challenged by a fundamental concern which plagues this burgeoning literature: all of these studies, which have been observational in design, have relied on conventional regression estimates, and are prone to bias because the exposure (social capital) does not randomly vary—a problem referred to as “endogeneity”. For instance, endogeneity bias may occur if one estimates country-level associations of social capital with health, but fails to account for unobserved country characteristics correlated/co-varying with social capital, leading to a spurious statistical relationship. By isolating the random variation in exposures, instrumental variables can overcome such bias and can yield more valid effect estimates (Wooldridge, 2008). This technique has proven useful in addressing confounding and reverse causation issues to better quantify the causal roles of other factors in medicine and public health, including obesity and neighborhood conditions (Davey Smith et al., 2009; Kamstrup et al., 2009; Fish et al., 2010).

Our goal was to estimate the causal association between average country levels of social trust and individual self-rated health using instrumental variables (IV), and to compare these findings with those derived using conventional methods. Given the few studies of social capital at the country level, our analyses tested the prior claims that country-level social capital is beneficial to health. In light of past evidence of stronger associations for contextual social capital in women (versus men) (Kim & Kawachi, 2006; Kim & Kawachi, 2007) and individuals with higher (versus lower) levels of social capital (Poortinga, 2006), we further explored whether country-level trust might relate variably to health across selected population sub-groups. Using these new effect estimates, we then quantified the numbers of deaths that might be avoided by elevating average social trust across nations. To our knowledge, this represents the first study to apply IV analysis to estimate the contextual effects of social capital on health, and to project the absolute population health benefits from raising social trust.

## Methods

### Study sample

We used data on social trust and self-rated health from the European and World Values Surveys. These are repeated cross-sectional surveys (1981–1984, 1990–1993, 1995–1997, and 1999–2004) of nationally representative samples (ranging in size between 500 and 2000 individuals, conducted through stratified random sampling) of the general population aged 18 years across countries on all six inhabited continents (World Values Survey Group, 2009).

### Outcome variable

Individual self-rated health was measured on a five-point ordinal scale, ranging from “very poor” to “very good” health. In prospective studies, global self-rated health has independently predicted morbidity and mortality, with a graded relationship between successive categorical ratings of health and probability of mortality (Idler & Benyamini, 1997; DeSalvo et al., 2005). Self-rated health was treated as a continuous measure in all models.

### Predictor variable

Social trust was measured using the following item which has been incorporated into past major social surveys (General Social Surveys, 2007; The Roper Center for Public Opinion Research, 2002), and has exhibited more robust associations with health outcomes than other social capital measures e.g., associational memberships (Kim, Subramanian, &

Kawachi. 2007): “Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?...most people can be trusted/can't be too careful.” These responses were aggregated as the percentage of the country sample reporting that most people can be trusted. Model coefficient estimates were scaled to reflect the absolute change in the measure of self-rated health associated with a 10 percentage point increase in average country-level trust.

### Covariates

We adjusted all models for individually-reported social trust (dichotomous), age, gender, marital status, family income, education, and employment status. Country-level covariates consisted of real Gross Domestic Product (GDP) per capita (Heston, Summers, & Aten, 2009), logarithm of total population size (Census Bureau, 2009), total health expenditures per capita (World Health Organisation, 2009), ethnic heterogeneity (reflecting the probability of two randomly selected persons belonging to disparate ethnic and language groups) (Alesina et al., 2003); and the Gini coefficient (a measure of income inequality, with values ranging from 0 for perfect equality to 1 for perfect inequality) (World Institute for Development Economics Research, 2005). As previously described, we used standardised criteria for the Gini coefficient (Kim et al., 2008). Due to political and economic changes and/or instabilities in eastern bloc countries and Germany, Hungary, and Poland in the early 1990s, we excluded Gini coefficients for these countries prior to 1995. Aside from GDP per capita (categorised into tertiles), all country-level covariates were modeled as continuous.

### Instrumental variables

To provide consistent estimates (i.e., convergent estimates in large samples) of causal associations, IV analysis requires both ‘relevant’ and valid/exogenous’ instruments. To be ‘relevant’, such instruments must be correlated with the endogenous exposure, in order to capture adequate variation in it. To be valid or ‘exogenous’, the instruments must have no direct effect on the outcome, to pick up only *random* variation in the endogenous exposure (Wooldridge, 2008; Martens et al., 2006; Angrist & Krueger, 2001). Hence, for our study, each instrumental variable had to be closely associated with country-level social trust, and to be unassociated with self-rated health except indirectly through its association with social trust.

We used the following pairs of country factors as joint instruments of country trust in separate analyses: corruption and logarithm of population density; and religious fractionalisation and logarithm of population density. Both theoretical grounding and empirical evidence support each of these instruments as a determinant of social trust.

Public institutions arguably play pivotal roles in facilitating interpersonal trust (Levi, 1996; Yamagishi & Yamagishi, 1994). Corruption in public institutions may diminish public trust because the costs of trust may increase when there is a greater perceived risk of being cheated (You, 2005). In a cross-national study, higher perceived country corruption predicted lower individual trust (You, 2005). Using structural equation models, the standardised coefficient estimate for one's level of confidence in government (conceptually inversely related to the level of corruption) as a predictor of individual trust was six times larger than the estimated relation in the reverse direction (Brehm & Rahn, 1997). This evidence is in keeping with one's confidence in government (and by relation, perceived lack of corruption) raising one's level of trust, as opposed to an association in the opposite direction i.e., one's level of trust leading to greater confidence in government.

Higher population densities plausibly create public distrust because “dense” social environments may incite individuals to draw inward out of the need for privacy. Empirical

evidence supports this relation (Brueckner & Largey, 2006; Pew Research Center, 2007; Collier, 1998). For instance, in behavioral experiments in US cities, lower population density has been associated with acts of helpfulness (a concept related to reciprocity and social trust) shown by local residents to strangers (Levine et al., 1994).

Religious fractionalization, corresponding to the degree of heterogeneity in religious group affiliations, has been independently linked to a lower risk of civil conflict (Collier & Hoeffler, 2004). One possible mechanism for this relation is that in more fractionalised societies, the heterogeneity may serve to foster stronger forms of trust and social capital of the bridging kind (i.e., stronger ties between individuals who differ by religious affiliation) (Kawachi et al., 2004; Kim, Subramanian, & Kawachi, 2006), and to facilitate greater tolerance of religious differences.

Country population density data for 1990 were taken from the International Database of the US Census Bureau (Census Bureau, 2009). Corruption was measured using the 1999 Corruption Perceptions Index (CPI) (Transparency International, 2009) for perceived country corruption among public officials/politicians in the previous three years according to multiple international sources; values ranged from 0 (very corrupt) to 10 (very honest). Religious fractionalisation was measured using an index reflecting the probability of two randomly selected persons belonging to different religious groups. This index was previously constructed by collapsing country religious affiliation data from the early 1980s (Barrett, 1982) into nine categories (Collier, 2008): Catholic, Protestant, Muslim, Jew, Hindu, Buddhist, Eastern Religion (other than Buddhist), and no affiliation. All instrumental variables were modeled as continuous.

### Statistical analyses

We used ordinary least squares (OLS; linear regression) analysis to estimate the effects of average country social trust on individual self-rated health. In the first set of models (based on 43 countries; Country Set A), country trust was adjusted for country- and individual-level covariates and survey wave and World Bank regional fixed effects. In the second set (based on 64 countries; Country Set B), we excluded the Gini coefficient, thereby adding 21 countries with missing/omitted income inequality data. A third set of models resembled the first set of models but was additionally limited to countries with religious fractionalisation data (40 countries; Country Set C). For each set of countries, we also tested for an interaction between country- and individual-level trust.

We then used IV analysis to estimate the associations using the hypothetical equivalent of two stages (with software packages deriving the IV estimators in a single step rather than explicitly performing two regression stages, to obtain correct standard errors). In the first stage (simplified Equation 1 shown below), country trust was regressed using OLS on the two instruments and covariates (for this example: Covariate1, Covariate2); assuming instrument validity, the predicted value of country trust ( $\widehat{Trust}_i$ ) corresponds to the exogenous (randomly varying) part of  $Trust_i$ .

$$Trust_i = \pi_0 + \pi_1 Instrument1_i + \pi_2 Instrument2_i + \pi_3 Covariate1_i + \pi_4 Covariate2_i + e_i \quad (1)$$

In the second stage using OLS (Equation 2 below), self-rated health ( $SRH_i$ ) was regressed on the predicted value of country social trust ( $\widehat{Trust}_i$ ) and covariates (as in Equation 1). Our reported IV estimate for country trust is algebraically equivalent to the coefficient on country trust in the second stage regression (Wooldridge, 2008; Baum, 2006).

$$SRH_i = \beta_0 + \beta_1 \widehat{Trust}_i + \beta_2 Covariate1_i + \beta_3 Covariate2_i + u_i \quad (2)$$

The first set of models was based on Country Set A and jointly applied the Corruption Perceptions Index and logarithm of population density as instruments for country trust. The second set of models excluded the Gini coefficient as a covariate and was estimated for Country Set B. The third set was based on Country Set C and employed both religious fractionalisation and the logarithm of population density as instruments.

The interaction between an endogenous variable (country-level social trust) and another variable (gender, individual social trust) will also be endogenous. Consequently, for the interaction models (in which interactions between country-level trust and gender or individual trust were tested separately), we incorporated additional instruments: the interactions between gender/individual trust and the original instrumental variables (Wooldridge, 2008). These additional instruments would be correlated with the interaction between country-level trust and gender/individual trust (relevance), and were hypothesized to be associated with self-rated health only through their associations with these interactions (validity/exogeneity).

Standard errors were adjusted for correlations on self-rated health within the same country and survey wave. We stratified all analyses by gender due to stronger observed main effects in women. In unstratified ordinary least squares (OLS) analyses based on Country Sets A and C, coefficient estimates for the interaction between higher country trust and being female were 0.014 (P=0.02) and 0.012 (P=0.06), respectively; corresponding IV estimates were 0.022 (P=0.02) and 0.074 (P=0.01). Thus, in both OLS and IV analyses, the main associations for country-level social trust were significantly stronger in women than men.

We evaluated both the relevance and validity/exogeneity of the instrumental variables. The Kleibergen-Paap rank LM test was used to assess instrument relevance under the null hypothesis that the instruments were uncorrelated with country-level trust (Kleibergen & Paap, 2006; Baum, Schaffer, & Stillman, 2007). Hansen's J test examined for instrument validity/exogeneity under the null hypothesis that the instruments were jointly exogenous (Baum et al., 2007; Hayashi, 2000). The C statistic evaluated the exogeneity of each instrument individually. The Durbin-Wu-Hausman endogeneity test was used to test the endogeneity of country trust (Baum et al., 2007; Hayashi, 2000).

In analyses that used either the logarithm of country population density or corruption/religious fractionalisation index as an instrument while adding the other variable as a covariate, no direct association with self-rated health was seen for any variable when modeled as a covariate ( $p > 0.65$  for the association with the logarithm of country population density, corruption index, and religious fractionalization index when each variable was modeled in turn as a covariate, Country Sets A and C).

In sensitivity analyses, we repeated the IV analysis using the World Bank Control of Corruption Worldwide Governance Indicator (mean of 1996 and 1998 estimates) in place of the Corruption Perceptions Index (Kaufmann, Kraay, & Mastruzzi, 2003). This measure draws on perceived corruption from a slightly different set of data sources, and was derived using a distinct aggregation method (Kaufmann, Kraay, & Mastruzzi, 2003).

Finally, we estimated the population attributable fraction for mortality for countries with available mortality data, and calculated the hypothetical annual number of deaths avoided by raising country social trust. First, based on our results from IV analysis, we estimated the change in individual self-rated health on a five-point scale associated with raising a

country's percentage of the population that trusts others by 10 percentage points (in countries reporting 30–40% average country levels of social trust in the latest survey wave) or 20 percentage points (in countries with >30% country trust). Drawing on findings from a recent meta-analysis (of 1.92 times higher risk of mortality associated with moving across a four-point scale of self-rated health) (DeSalvo et al., 2005), we estimated the corresponding reduction in individual risk of mortality. The population attributable risk (PAR) for mortality was then calculated using the formula  $PAR = P_e (RR_e - 1) / 1 + P_e (RR_e - 1)$ , where  $P_e$  represents the prevalence of exposure (= 100%, assuming the entire general population is “exposed” to varying levels of social trust (Kondo et al., 2009; Wilkinson & Pickett, 2009)), and  $RR_e$  is the relative risk of mortality with exposure. Last, we used the latest available country age-specific mortality data from the WHO (World Health Organisation, 2009) to estimate the annual number of deaths that might be avoided by raising country trust among those aged 15–74 years in nations with trust levels >40%.

All analyses were performed using Stata (Statacorp, TX, USA, 2005). We applied a 5% significance level for all statistical tests.

This study was approved by the Institutional Review Board of the RAND Corporation in Santa Monica, California.

## Results

The Electronic Appendix Table (available with the online version of this paper [**INSERT LINK TO ONLINE CONTENT HERE**]) lists countries by survey wave for each country set. Table 1 shows the data sources, years, and descriptive characteristics of country variables. The percentage of a country sample reporting that most people can be trusted ranged widely, from 2.8% in Brazil to >55% in Finland and other Nordic countries.

Figure 1 plots country life expectancy (for 2005; OECD Health Data, 2010) against average social trust (based on the latest WVS wave for each country, ranging in years from 1990 to 2004) for 30 OECD nations. The correlation was strong and statistically significant ( $r = 0.59$ ;  $p = 0.001$ ), providing some empirical support for linkages between social capital and all-cause mortality/life expectancy.

### Ordinary least squares analysis

Tables 2 and 3 show results from the OLS regression of individual self-rated health on average country trust among women and men, respectively. For Country Set A, a positive relation was seen in women, and was 34% larger than the relation in men (Model 1a: in women,  $\beta=0.051$ , 95% confidence interval (CI)=0.011 to 0.091,  $P=0.01$ ; in men,  $\beta=0.038$ , 95% CI=0.0002 to 0.077,  $P=0.049$ ). There was a stronger association for country trust in the presence of high individual trust among women (Model 1b). Similar results were found for Country Sets B (Models 2a, 2b) and C (Models 3a, 3b), except that the country- and individual-level trust cross-level interaction was also observed in men for Country Set B.

### Instrumental variable analysis

Tables 4 and 5 present IV estimates in women and men, respectively. For Country Set A, a positive association was found between country trust and self-rated health in women, and was only marginally (3% relatively) larger than the association in men (Model 1a: in women,  $\beta=0.119$ , 95% CI=0.028 to 0.209,  $P=0.01$ ; in men,  $\beta=0.115$ , 95% CI=0.025 to 0.204,  $P=0.01$ ). Country trust effect estimates were larger than those for high individual trust in both sexes. Country-level trust and individual-level trust showed a positive interaction in women only (Model 1b). Similar main effects and interactions were seen for Country Set B

(Models 2a, 2b), but with a relatively larger (19%) main effect in women. For Country Set C, the main effects (Model 3a: in women,  $\beta=0.131$ , 95% CI=0.006 to 0.257,  $P=0.04$ ; in men,  $\beta=0.128$ , 95% CI=0.008 to 0.248,  $P=0.04$ ) were larger than those seen for the other country sets, while there was no cross-level interaction.

When the Control of Corruption measure replaced the Corruption Perceptions Index as an instrument, country trust point estimates were relatively unchanged (Model 1a: in women,  $\beta=0.104$ ,  $P=0.047$ ; in men,  $\beta=0.109$ ,  $P=0.04$ ). Similarly, when the logarithm of population density was used as the sole instrument, country trust estimates were only marginally attenuated in women and unchanged in men but with 36% larger standard errors (Country Set A, Model 1a: in women,  $\beta=0.108$ ,  $P=0.09$ ; in men,  $\beta=0.115$ ,  $P=0.06$ ).

Instrumental variables showed evidence of relevance and validity in all models except cross-level interaction models for Country Set C, for which relevance was less clear (Tables 4 and 5). Based on first-stage regression results (data not shown), each instrument was associated in the hypothesized direction with average social trust (at the 0.10 significance level for the religious fractionalization index, and at the 0.05 significance level for the corruption index and the logarithm of population density), controlling for country- and individual-level covariates. The validity of each instrument was supported by the C test statistic (data not shown). In addition, there was some evidence that country trust was at the margin of being endogenous (Tables 4 and 5).

## Discussion

### Principal findings

Our OLS findings are consistent with the hypothesis that increases in average country-level social trust lead to improved self-rated health in both sexes. Our IV analyses, which were performed to reduce endogeneity bias, produced qualitatively similar results, although the sizes of the estimated effects were more than twice as large as those obtained using OLS. Critically, these findings suggest that the true sizes of the effects of country-level social capital on self-rated health may be grossly underestimated using conventional methods. The estimated health effects of raising the percentage of a country's population that trusts others by 10 percentage points were at least as large as the estimated health effects of an individual developing trust in others. Furthermore, results from both conventional and IV analyses suggest that the effects of country social trust on health may be stronger in women than men, and that among women, the health of trusting individuals may particularly benefit.

### Comparisons with prior studies

Our OLS findings showed mixed agreement with those from past cross-national studies of country social trust and individual self-rated health (Mansyur et al., 2008; Poortinga, 2006; Rostila, 2007; Helliwell & Putnam, 2004;).

In a multilevel linear regression analysis of 70,493 respondents in 45 countries participating in the second and third waves of the Values Surveys, Mansyur et al. (2008) determined that country trust was positively though non-significantly related to better individual self-rated health (for 10% higher trust,  $\beta=0.054$ ,  $P=0.32$ ). Likewise, two multilevel studies of nations in the European Social Survey found positive, non-significant associations between higher country social trust and good or very good individual self-rated health (Poortinga, 2006; Rostila, 2007).

By contrast, in an OLS analysis of 83,520 individuals in 49 countries from the first three waves, Helliwell & Putnam (2004) found that higher average levels of country trust were significantly associated with better individual self-rated health (for 10% higher trust:

$\beta=0.104$ ,  $P<0.01$ ). Because these estimates were markedly larger than our estimates, in a supplemental analysis, we restricted our data to the vast majority of shared countries and first three waves. This produced a more comparable although still smaller estimate ( $\beta=0.076$ ;  $P<0.001$ ). When we used the logarithm of population density and corruption as instruments, the estimate more than doubled in size ( $\beta=0.171$ ;  $P<0.001$ ).

Compared to past studies, our OLS analysis incorporated data from a more recent Values Survey wave and encompassed a wider set of countries. We further accounted for unobserved time-invariant regional factors and time trends by applying regional and survey wave fixed effects. The inclusion of slightly different covariates at the country and individual levels could also partially account for the discrepancies.

### Instrument validity and robustness of findings

Our instrumental variables generally met key validity criteria across multiple tests. Furthermore, our findings were robust to alternative specifications and instruments. The similar results after adding a number of countries (primarily eastern bloc nations) suggest that their omission was an unlikely source of substantial bias. Our findings were also robust to the choice of corruption indicator. In addition, we identified qualitatively similar and some quantitatively stronger results when religious fractionalisation was used (jointly with country population density) as an instrument instead of corruption, and found comparable although less precise results when population density was the sole instrument.

### Population health benefits and approaches

Seminal work by the epidemiologist Geoffrey Rose showed that a small favorable shift in a population's exposure level may reap small individual benefits yet produce large public health gains—a key concept in public health known as the “prevention paradox” (Rose, 1985). Based on our IV analysis results, raising the percentage of a country's population that trusts others by 20 percentage points (equivalent to the difference in average trust levels separating Austria and Canada in the mid-1980s) could roughly improve individual self-rated health by 0.25 points on a five-point scale. Findings from a recent meta-analysis (DeSalvo et al., 2005) suggest that this change would translate into an approximately 5.6% lower individual risk of mortality. In turn, this finding would signify a population attributable fraction of 5.3%.

The Electronic Appendix Table [INSERT LINK TO ONLINE CONTENT HERE] shows the estimated annual number of preventable deaths by raising country trust. Among those aged 15–74 years in 40 nations with country trust levels 40%, increasing country percentages of social trust by 20 percentage points in countries with 30% average country trust in the latest survey wave and by 10 percentage points in countries with 30–40% average country trust might avert more than 287 000 deaths per year (226 000 deaths per year in the former countries, 61 000 deaths per year in the latter countries).

Two general approaches may be undertaken to raise social capital/trust, commonly referred to as “top-down” and “bottom-up” strategies. In a top-down approach, policies to modify the macroeconomic, social, and/or political determinants of social capital would be implemented. For instance, based on the theoretical grounding and empirical evidence provided in this paper, reducing corruption within federal and regional governments could be used to leverage social capital. In a bottom-up approach, social capital could in theory be generated through grassroots actions of civil society groups that encourage investments and subsidies in neighbourhood associations, thereby fostering social interactions, trust, and reciprocity among neighbours. By effectively building social participation and social capital at local levels across major regions, average levels of country social capital may be elevated.

## Interactions

Our findings suggest that health may more closely tied to country-level trust among women than among men. A similar pattern has been observed in other studies in the social capital literature (Kim & Kawachi, 2006; Kim & Kawachi, 2007), as well as studies of neighbourhood socioeconomic associations with health behaviours (Wang et al., 2007) and chronic disease outcomes (Diez Roux et al., 2001; Sundquist, Malmstrom, & Johannson, 2004; Kim et al., 2010). While plausible explanations for these gender differences exist (for example, a higher responsiveness in women due to gender-related perceptions of social/socioeconomic environments) (Kim et al., 2010), this pattern was less consistently found in our IV analysis, and warrants confirmation in other studies. The apparent cross-level interaction in women between trust at the country level and at the individual level is also in keeping with past findings (Poortinga, 2006). Underlying mechanisms for this apparent synergism should be explored.

## Study limitations

Our study had several key limitations. First, we did not account for aggregate social trust at more proximal, sub-national levels (e.g., the neighbourhood level), which may have contributed to residual confounding. Arguably though, any true effect of country trust on health may be mediated in part by trust at more local levels. Second, not all countries participated across survey waves, and survey response rates may have varied across participating countries. Bias in the associations in either direction may have been present if associations were different in non-participating countries. There may have also been survey non-respondent bias, although we were unable to perform a related sensitivity analysis because most countries did not report response rates (Inglehart et al., 2000). However, given that our main results were relatively robust across country sets, neither country non-participation nor survey non-response is likely to have principally accounted for the observed patterns. Third, measures of self-rated health and social trust were not validated across countries. Nonetheless, to the extent that any cross-country differences in associations may be due to regional cross-cultural variations or varying levels of economic development, related biases should have been reduced by our inclusion of regional fixed effects and country-level indicators/correlates of development. Fourth, although corruption data (unlike religious fractionalisation data) did not generally precede trust measures, country relative ranks on corruption are unlikely to have changed substantially over time. Finally, the presence of a direct effect of an instrumental variable on the outcome is a potential pitfall to any IV analysis, and could introduce bias (Angrist & Krueger, 2001). While we found no empirical evidence for direct effects of the instrumental variables on health and the results were robust across multiple combinations of instruments, such direct effects cannot be entirely ruled out. At the same time, the stronger associations with the use of instrumental variables could partly be due to the instrumental variables' ability to reduce measurement error in country-level trust (Wooldridge, 2008; Angrist & Krueger, 2001).

## Conclusions

In a large cross-national study, our findings, including those using instrumental variables to reduce endogeneity bias, support the presence of beneficial effects of higher country-level social trust on individual self-rated health. Past observational findings for contextual social capital using conventional regression may have underestimated the true associations. Given the close linkages between self-rated health and all-cause mortality, the public health gains from elevating social capital within countries may be large. In light of the recent WHO Commission on the Social Determinants of Health report (Commission on Social Determinants of Health, 2008) and commissioned national reports in England (The Marmot Review, 2010) and the United States (Robert Wood Johnson Foundation Commission to Build a Healthier America, 2009) that emphasise social contextual factors including social

capital as fundamental causes of health and disease, similar efforts to improve effect estimates may better inform policymaking decisions to promote population health and reduce health inequities.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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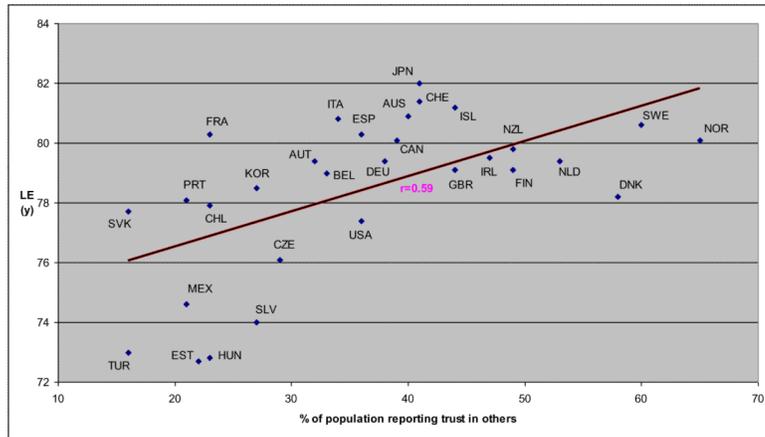
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**Highlights**

- Past research on the associations of area-level/contextual social capital with health outcomes has produced conflicting findings
- Interpreting this growing literature is difficult because estimates using conventional regression are prone to major sources of bias including residual confounding and reverse causation
- Our findings using both instrumental variable analysis to reduce bias and traditional regression support the presence of beneficial effects of higher average levels of country social trust on individual self-rated health
- Estimates from instrumental variable analysis were substantially larger in magnitude, suggesting that past findings for contextual social capital may have underestimated the true associations
- Based on the population attributable fraction (5.3%), greater than 286 000 deaths per year across 40 nations might be avoided by raising the percentage of a country's population that trusts others by 10–20 percentage points



**Figure 1.** Plot of life expectancy (LE) against average social trust for 30 OECD nations

Table 1

Data sources and descriptive characteristics of country-level variables

	Data source (Years)	Country Set A (n=43 countries)			Country Set B (n=64 countries)			Country Set C (n=40 countries)		
		Mean	Std. dev.	Range	Mean	Std. Dev.	Range	Mean	Std. dev.	Range
<b>Social trust (percentage of population reporting trust in others)</b>	Values Surveys (1981–84, 1990–93, 1995–97, 1999–2004)	29	17	3 to 66	28	15	3 to 66	30	16	3 to 65
<b>Gini coefficient</b>	World Income Inequality Database (1975–2000)	0.42	0.12	0.24 to 0.73	-	-	-	0.41	0.13	0.23 to 0.73
<b>Corruption index</b>	Transparency International (1999)	5.3	2.5	1.6 to 9.8	4.9	2.5	1.6 to 10.0	-	-	-
<b>Population density (persons/km<sup>2</sup>)</b>	International Database of US Census Bureau (1990)	106	114	2 to 441	102	100	2 to 441	106	117	2 to 441
<b>Religious fractionalisation index</b>	Collier & Hoeffler (1982)	-	-	-	-	-	-	0.33	0.24	0 to 0.70
<b>Population size (<math>\times 10^6</math>)</b>	International Database of US Census Bureau (1990)	68	179	2 to 1148	66	177	0.2 to 1148	72	182	3 to 1148
<b>Ethnic heterogeneity</b>	Alesina et al. (1981–2001)	0.36	0.26	0.002 to 0.93	0.35	0.23	0.002 to 0.93	0.34	0.25	0.002 to 0.93
<b>Total health expenditures per capita (\$)</b>	WHO Statistical Information System (1999)	1083	1016	48 to 4335	791	962	23 to 4335	1151	1009	48 to 4335
<b>Gross Domestic Product (GDP) per capita (\$)</b>	Penn World Table (1990)	10 888	8489	709 to 27 447	10 283	8058	498 to 27 447	11 370	8452	709 to 27 447

Descriptive statistics for social trust and Gini coefficient taken from latest available survey wave

**Table 2**

Coefficient estimates from ordinary least squares analysis for outcome of better self-rated health—women

	Country Set A (n = 43 countries, 56 240 women)				Country Set B (n = 64 countries, 86 006 women)		Country Set C (n = 40 countries, 54 614 women)	
	Model 1a	Model 1b	Model 2a	Model 2b	Model 3a	Model 3b		
<b>Country level</b>								
Social trust	0.051 (0.01)	0.039 (0.07)	0.050 (0.01)	0.036 (0.08)	0.055 (0.01)	0.044 (0.05)		
95% CI	0.011 to 0.091		0.014 to 0.086		0.014 to 0.095			
<b>Individual level</b>								
Social trust								
High	0.12 (<.001)	0.03 (0.49)	0.13 (<.001)	-0.01 (0.84)	0.13 (<.001)	0.04 (0.33)		
<b>Interactions</b>								
Country trust × individual trust		0.027 (0.02)		0.042 (0.001)	0.13 (<.001)	0.023 (0.047)		

All models also adjusted for individual age, marital status, annual family income, education, employment status, country-level Gini coefficient, ethnic heterogeneity, health expenditures per capita, logarithm of population size, GDP per capita, survey wave, and World Bank region. Standard errors adjusted for country-wave clustering. P values shown in parentheses.

Table 3

Coefficient estimates from ordinary least squares analysis for outcome of better self-rated health—men

	Country Set A (n = 43 countries, 53 855 men)	Country Set B (n = 64 countries, 81 338 men)	Country Set C (n = 40 countries, 52 423 men)
	Model 1a	Model 2a	Model 2b
<b>Country level</b>			
Social trust	0.038 (0.049)	0.033 (0.06)	0.021 (0.27)
95% CI	0.0002 to 0.077	-0.001 to 0.066	0.041 (0.04)
			0.055 (0.11)
			0.0022 to 0.080
<b>Individual level</b>			
Social trust			
High	0.12 (<.001)	0.13 (<.001)	0.01 (0.74)
<b>Interactions</b>			
Country trust × individual trust		0.016 (0.16)	0.033 (0.01)
			0.016 (0.18)

All models also adjusted for individual age, marital status, annual family income, education, employment status, country-level Gini coefficient, ethnic heterogeneity, health expenditures per capita, logarithm of population size, GDP per capita, survey wave, and World Bank region. Standard errors adjusted for country-wave clustering. P values shown in parentheses.

Table 4

Coefficient estimates from instrumental variable analysis for outcome of better self-rated health—women

	Country Set A (n = 43 countries, 56 240 women)	Country Set B (n = 64 countries, 86 006 women)	Country Set C (n = 40 countries, 54 614 women)
	Model 1a	Model 2a	Model 3a
	Model 1b	Model 2b	Model 3b
<b>Country level</b>			
Social trust	0.119 (0.01)	0.120 (0.005)	0.131 (0.04)
95% CI	0.028 to 0.209	0.036 to 0.205	0.006 to 0.257
<b>Individual level</b>			
Social trust			
High	0.10 (<.001)	0.10 (<.001)	0.10 (<.001)
<b>Interactions</b>			
Country trust × individual trust	0.058 (0.001)	0.069 (<.001)	0.006 (0.92)
<b>Instrument tests *</b>			
Rank LM statistic	16.7 (<.001)	20.2 (<.001)	10.9 (0.004)
J statistic	0.06 (0.81)	3.44 (0.33)	0.16 (0.69)
<b>Endogeneity of country trust *</b>			
Endogeneity test statistic	2.74 (0.10)	2.75 (0.10)	1.69 (0.19)

All models also adjusted for individual age, marital status, annual family income, education, employment status, country-level Gini coefficient, ethnic heterogeneity, health expenditures per capita, logarithm of population size, GDP per capita, survey wave, and World Bank region. Standard errors adjusted for country-wave clustering. P values shown in parentheses. Corruption index and logarithm of population density used as instruments of country trust for Country Sets A and B. Religious fractionalisation and logarithm of population density used as instruments of country trust for Country Set C.

\* Null hypothesis corresponds to lack of correlation/relevance for Rank LM statistic; joint instrument exogeneity for J statistic; and exogeneity of country trust for endogeneity test statistic.

**Table 5**

Coefficient estimates from instrumental variable analysis for outcome of better self-rated health—men

	Country Set A (n = 43 countries, 53 855 men)	Country Set B (n = 64 countries, 81 338 men)	Country Set C (n = 40 countries, 52 423 men)
	Model 1a	Model 2a	Model 3a
	Model 1b	Model 2b	Model 3b
<b>Country level predictors</b>			
Social trust	0.115 (0.01)	0.101 (0.02)	0.128 (0.04)
95% CI	0.025 to 0.204	0.019 to 0.183	0.008 to 0.248
<b>Individual level predictors</b>			
Social trust			
High	0.09 (<.001)	0.10 (<.001)	0.09 (0.001)
<b>Interactions</b>			
Country trust × individual trust	0.023 (0.14)	0.055 (0.02)	0.06 (0.73)
<b>Instrument tests *</b>			
Rank LM statistic	16.1 (<.001)	19.0 (<.001)	11.7 (0.003)
J statistic	0.00 (0.99)	0.78 (0.38)	0.04 (0.85)
<b>Endogeneity of country trust *</b>			
Endogeneity test statistic	3.24 (0.07)	2.98 (0.08)	2.36 (0.12)
		1.98 (0.16)	1.25 (0.26)

All models also adjusted for individual age, marital status, annual family income, education, employment status, country-level Gini coefficient, ethnic heterogeneity, health expenditures per capita, logarithm of population size, GDP per capita, survey wave, and World Bank region. Standard errors adjusted for country-wave clustering. P values shown in parentheses. Corruption index and logarithm of population density used as instruments of country trust for Country Sets A and B. Religious fractionalisation and logarithm of population density used as instruments of country trust for Country Set C.

\* Null hypothesis corresponds to lack of correlation/relevance for Rank LM statistic; joint instrument exogeneity for J statistic; and exogeneity of country trust for endogeneity test statistic.