Social Capital and Self-rated Health: testing association with longitudinal and multilevel methodologies

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Testing association with longitudinal and multilevel methodologies

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To my wonderful family:
Erika, Alexander,
Sebastian & Peanut

Abstract

Since Durkheim's seminal work over a century ago, research has repeatedly shown that individuals with higher levels of social integration, social networks and social support have better health status. However, the recent introduction of a contextual phenomenon known as *social capital* to the field of public health has sparked lively debate as to how it may also influence the health of individuals, if at all.

Though critics have raised several points of contention regarding reported association between social capital and health over recent years, one outstanding issue remains, the lack of empirical research focusing on causal relationships, due to paucity of adequate longitudinal social capital data.

The overall aim of this thesis is to test association between different social capital proxies and self-rated health (SRH), alongside other well-known health determinants, using multilevel and longitudinal data, whilst employing a variety of study designs and methods. All data used in this thesis come from the United Kingdom's British Household Panel Survey (BHPS) from years 2000, 03, 05, 07 and 08. The underlying premise of this body of work is to investigate temporal (causal) relationships between social capital and health.

All four papers of this thesis demonstrate that *generalised trust* is the most robust of all social capital proxies tested, it maintaining a positive association with SRH over time. Furthermore, results from paper III imply that prior trust levels can predict future SRH, lending weight to the hypothesis that trust is an independent determinant of health. However, debate remains as to whether *generalised trust* solely captures social capital or other, more tangible aspects of social cohesion.

Abreviations

BHPS	British Household Panel Survey
BMI	Body Mass Index
CI	Credible/Confidence interval
GEE	Generalized Estimating Equations
GHB	Good health at baseline
HH	Household
ICC	Intraclass correlation
MCMC	Markov Chain Monte Carlo
OR	Odds ratio
PHB	Poor health at baseline
PSU	Primary Sampling Unit
RGSC	Registrar General's Social Classification
SA	Small area
SRH	Self-rated health
UK	United Kingdom
USA	United States of America
WHO	World Health Organization

Table of Content

List of publications

This thesis is based upon the following four publications, which shall be referred to by their Roman numerals:

Paper I

Giordano, G., and Lindström, M. The impact of changes in different aspects of social capital and material conditions on self-rated health over time: a longitudinal cohort study. Social Science & Medicine, 2010. 70(5): p. 700-10.

Paper II

Giordano, G., Ohlsson, H., and Lindström, M. Social capital and health - purely a question of context? Health & Place, 2011. 17(4): p. 946-53.

Paper III

Giordano, G., Björk, J., and Lindström, M. Social capital and self-rated health – a study of temporal (causal) relationships. Social Science & Medicine, 2012 – In press.

Paper IV

Giordano, G., Merlo, J., Ohlsson, H., Rosvall, M., and Lindström, M. Questioning the validity of association between social capital and health using a family based design – *submitted*

Other publications by GN Giordano

Lazarus, J.V., **Giordano**, **G.N.**, and Matic, S. Male circumcision in HIV prevention: some implementation caveats. HIV Medicine, 2008. 9: p. 327–328.

Giordano G., and Lindström, M. Social capital and change in psychological health over time - a panel study. Social Science & Medicine, 2011. 72(8): p. 1219-1227.

Giordano, G., and Lindström, M. The impact of social capital on changes in smoking behaviour: a longitudinal cohort study. European Journal of Public Health, 2011. 21(3): p. 347-354.

Introduction

The idea that societal phenomena can influence individual health is not new. Since Durkheim's seminal work over a century ago (1), research has repeatedly shown that individuals with higher levels of social integration, social networks and social support have better health status (2-5). However, the relatively recent introduction of a contextual phenomenon known as 'social capital' to the field of public health (6, 7) has sparked lively debate as to how it may also influence the health of individuals, if at all.

Opponents of social capital theory tend to stress the importance of material conditions, access to resources and public welfare policy as major influences over individual health outcomes (8-10). Others hint that social capital is just 'old wine in new bottles' (11), a simple rehashing of well-known and researched associations between *social support* and health (2, 4, 5).

There is also a notable lack of consensus amongst *proponents* of social capital, with several significant points of contention found within this field of research including:

i. how social capital is defined and subsequently conceptualized

ii. how social capital (and its effects) are observed and quantified

iii. how social capital influences health

These three points are inter-connected, as how one defines social capital will influence how one measures and theorizes the effects of social capital on health outcomes.

i) Definition(s) of social capital

There is still no single accepted definition of social capital. Of the contemporary authors in this field, Robert Putnam (12, p.167), defines social capital as '… features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions.' With his definition, Putnam places social capital firmly at the societal level i.e. social capital influences *all* individuals within the collective, equally.

Pierre Bourdieu defines social capital as '…the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network' (13, p.119). i.e. social capital is also conceptualised at the *individual* level.

Another key social capital theorist, James Coleman (14, p.302) defines social capital as '...a variety of different entities [that] facilitate certain actions of individuals who are within the structure'. In his writings, Coleman implies that the stable family unit plays a vital role in social capital creation.

Finally, Portes (15, p.6), who defines social capital as '… the ability of actors to secure benefits by virtue of membership in social networks or other social structures'. Portes' theories, in stark contrast to Putnam's, stress that social capital belongs to, and operates solely at the *individual* level.

The problem is that, without a single definition and one universally accepted social capital theory, any research in this field can be readily opened up to criticism.

Despite this, a large body of empirical social capital research within the public health arena has adopted Putnam's theories and definition above all others. One possible explanation for this is that public health research deals with population health; Putnam's 'macro' view of social capital (compared with the more 'micro'-oriented view of most sociologists) (16) therefore becomes more appealing when attempting to operationalize social capital in public health research. However, despite popular support for Putnam's theories in public health quarters, social capital research still remains heavily contended on theoretical and methodological grounds (16, 17).

ii) Quantifying social capital and its effects

This second point of contention concerns the quantifying of social capital. The vast majority of empirical research in this field relies solely on individual-level data, irrespective of researchers' choice of theory. On the surface, it may seem illogical to use individual-level measures to capture something that is considered by some to be a contextual characteristic (18, p.176). However, by definition, contextual phenomena are difficult to observe or measure directly, so one practical (and commonly accepted) solution in empirical research is to rely on individual-level 'proxy' measures of social capital instead.

As stated previously, public health research often adopts Putnam's 'macro' view of social capital in empirical research. To this end, common social capital proxies utilised within public health include generalised (horizontal) and vertical (institutional) trust, social and civic participation, and measures of reciprocity (12, 19-28).

Though adherence to Bourdieu is commonplace in theoretical texts, his theories are most often cited in empirical social capital research as a possible means to legitimise the inclusion of *social support* variables as indicators of social capital. In this author's opinion, allowing social support to be counted as social capital in this way can only add to the contention surrounding association between social capital and health, as social support has been long established as an independent determinant of health (2, 4, 5).

If researchers wish to consider the *contextual* effects of social capital, individual-level proxies are commonly aggregated to a context of interest, such as a community-, neighbourhood-, or state-level (29-32). However, the process of aggregation is not without its own issues, as any assumption made about individuals based solely on a group mean value may be inherently biased (also known as 'ecological fallacy') (33, p.195). Furthermore, these 'levels' are often chosen more out of convenience and data availability than as accurate representations of individuals' day-to-day social interactions and networks. Noting that social networks are an integral part of any definition of social capital (12, 14, 15, 18), analysis of inappropriate contexts may fail to capture any effects. This point is clearly highlighted by interpretation of the intraclass correlation (ICC), often available in multilevel studies. The ICC expresses the percentage of total variation in the dependent variable (in this thesis' case, self-rated health) attributable to the context being modelled; the higher the ICC, the more important the context is for understanding variation in the individual outcome under investigation (34). In multilevel social capital studies however, it is not uncommon to see that *only* 0–4% of total variation in individual health is attributable to the community, state or county context (for examples see (29, 30, 32, 35)).

iii) How social capital influences individual health

There have been several theories put forward as to how social capital could influence individual health. One theory is that the presence of social capital may reduce the amount of crime in a community (36); crime, especially violent crime, impacts on physical and psychological health, so any reduction in crime levels would be beneficial (7). Social capital is also thought to aid health promotion, influencing behavioural norms more rapidly in communities deemed rich in social capital (for example: promoting more physical exercise and tolerating smoking in public places less) (7, 37). Social capital has also been linked to maintaining and improving access to material resources important for health, through higher civic engagement of individuals within the community (22, 36). Finally, it is theorised that the presence of social capital may reduce sources of psychosocial stress. Chronic exposure to such stressors is considered a precursor to ill health (28, 38), and is one possible explanation as to how social capital could influence the physiology of individuals.

Though the above theories seem feasible, they are still considered contentious by those stressing the greater importance to health of (more equal) access to resources. These are determined for the most part by State-level institutions, egalitarian state policy to redistribute wealth, and the provision of welfare systems (9, 39-41). Such opposition considers 'social capital' as a probable mediator along the pathway from State to health, or even as a proxy for social support, that other well-known health determinant (2, 4, 5).

To address this critique, any empirical social capital research must also consider existing social inequalities when investigating health outcomes. This can be achieved by including socio-economic status (SES) variables in analyses. SES is '… a composite measure that typically incorporates economic status, measured by income; social status, measured by education; and work status, measured by occupation' (42, p.30). To counter the argument that social capital is just 'old wine in new bottles' (11) (i.e. social capital is more akin to *social support*), researchers should also consider measures of social support, such as marital status or frequency of contact with family/friends as confounders in analyses.

iv) Knowledge gaps

Empirical research in the field of social capital has '…drawn significant criticism for theoretical and methodological shortcomings' (17). Paucity of longitudinal data in this field certainly contributes to methodological concerns surrounding social capital research (43, p.184), as lack of adequate longitudinal data means there is limited opportunity to empirically test causality. To highlight this fact, despite the near exponential rise in papers researching social capital and health over the past fifteen years, the vast majority of studies are cross-sectional in design (44). Cross-sectional data are notoriously inadequate when attempting to establish causal relationships; *ipso facto*, any association between social capital and health found in cross-sectional research is prone to reverse-causality bias (33, p.200-1).

To clarify further, though there are nine criteria required to help establish a causal relationship between exposure and disease, temporal relationship is considered the only 'essential criterion'; i.e. if exposure A is theorized to cause disease B, then A must always precede B (45). In order to correctly test temporal relationships adequate longitudinal data are needed, yet as stated above, availability of such social capital data has been lacking (43).

However, over the past three years using British Household Panel Survey (BHPS) raw data, I have created my own unique longitudinal, multilevel social capital dataset. My data cover an eight-year time span (years 2000-08) and are described in detail in the 'Methods' section of this text.

It is also noteworthy that, despite Coleman's (19) theories stressing the importance of families and households for the perpetuation and generation of social capital, this specific context has yet to be investigated in empirical social capital research.

Coleman's ideas are quite plausible, as there is no reason not to believe that the maintenance and ongoing formation of trust in other people, and the propensity to participate in civic and social activities are affected by the close social context of the family and the household in which a person lives. One must therefore speculate that the lack of social capital research at the *household* level is also due to paucity of suitable data; however, one feature of BHPS is that it can be clustered on three levels: the individual-, the household-, and the community-level, making it unique.

It is also important to stress that *all* social capital research to date is based upon classical observational study design, except one (46); *ipso facto*, these studies are all prone to residual confounding by genetic and shared environmental confounds. Even after employing adjustment techniques such as multiple regression modelling and propensity scoring, such bias remains (47). One way to control for this is to employ a family-based study design. By researching populations consisting of individuals, who are either genetically related (twins, full siblings, etc.) and/or share the same environment over time, one can disentangle genetic effects from shared environmental and non-shared individual effects (48). Unfortunately, only about 6% of those sampled in the BHPS are immediate family members (siblings, parents, grandparents) and it is not possible to identify twins with this data. However, that the data are sampled at the household level means that a suitable multilevel, longitudinal study design can adjust for residual confounding of 'shared environment'.

The theories of Putnam (and to a lesser extent Coleman) (12, 14, 19, 22, 49) are tested in this thesis, utilising the following social capital proxies: generalised (interpersonal) trust, active participation in local groups, undertaking of unpaid voluntary work, civic participation (voting), use of informal social networks, and perceived reciprocity and altruistic intentions. The data also contain numerous well-known health determinants as previously discussed (see (iii)), to reduce many sources of confounding, such as multiple SES measures, smoking and marital status. Paper IV addresses the issue of residual confounding by further employing a family-based design.

As per the aims set out in this thesis, papers I, III and IV test temporal (causal) relationships between social capital and self-rated health (SRH), utilising a variety of different designs and methodologies, whilst paper II investigates the household context for the first time in social capital research.

Aims

General aim:

The overall aim of this thesis is to test association between numerous social capital proxies and SRH over time (with a stress on causality) using multilevel and longitudinal data, whilst employing a variety of study designs and methods in a large, randomly selected British adult population.

Specific aims:

- to explore changes in SRH and social capital over time
- to investigate a new context within social capital research - the *household*
- to investigate temporal (causal) relationships between SRH and social capital, by employing a 'lagged' study design
- to test the validity of association between social capital and SRH using a family-based study design

Methods

The data

The data and subsequent research are derived from the British Household Panel Survey (BHPS) raw datasets. The BHPS is a longitudinal survey of randomly selected private households that has been conducted by the United Kingdom's (UK) Economic and Social Research Centre. Since 1991, individuals within selected households have been interviewed annually with a view to identifying social and economic changes within the British population. The original cohort sample was randomly selected by using a two-stage cluster design; the first stage required implicitly stratifying the UK's entire population by geographical region and socio-economic status. From this listing, 250 postal code sectors containing 2500 delivery points (equivalent to postal addresses) were selected as Primary Sampling Units (PSUs). This was done by using a systematic procedure with a random integer start and a systematically applied sampling interval (50). The second stage involved the random sampling of 33 of these 2500 delivery points from each of the 250 PSUs selected at stage one, resulting in a total of 8166 postal addresses around the UK. A total of 10 264 individual interviews were completed in 1991 demonstrating a participation rate of 95% (50). The raw data that have been used for this thesis come from the BHPS individual- and household-level responses in years 2000 (Wave ten), 2003 (Wave thirteen), 2005 (Wave fifteen), 2007 (Wave seventeen) and 2008 (Waves eighteen). The choice of wave was determined by the presence of questions pertinent to social capital research, as this was *not* consistent from year to year.

Within BHPS raw data it is possible to follow individuals over time using their unique personal identity number. This makes it possible to identify all individuals who responded to questions posed at face-to-face interviews across the considered time periods in this body of research. Participation rates at Wave ten (year 2000) compared to the previous year were 94% and, when compared to the original cohort of 1991, were 62%.

Ethical considerations

The Research Centre fully adopted the Ethical Guidelines of the Social Research Association, which conform very closely to those of the International Statistical Institute. Informed consent was obtained from all participants and strict confidentiality protocols were adhered to throughout data collection and

processing procedures. As a precondition of raw data usage, I followed all ethical guidelines provided by the Economic and Social Research Centre regarding its merging, storage, access and security.

Study populations

Paper I: This longitudinal study is based upon the 9303 individuals who participated in face-to-face interviews at Waves ten and fifteen of the BHPS.

Paper II: This cross-sectional, multilevel study is based upon the 10 992 individuals who participated in face-to-face interviews at Wave eighteen of the BHPS.

Paper III: This longitudinal study is based upon the 8114 individuals who participated in face-to-face interviews at Waves ten, thirteen, fifteen and seventeen of the BHPS.

Paper IV: This longitudinal multilevel study is based upon the 6982 individuals who participated in face-to-face interviews at Waves thirteen, fifteen, seventeen and eighteen of the BHPS.

The dependent variable

The dependent variable in all papers of this thesis is the five-point global self-rated health item (SRH). The global SRH item, along with other SRH assessment tools, is considered a valid predictor of morbidity and all-cause mortality (51, 52), even after adjusting for gender, age, ethnicity, marital status and BMI (53). The five-point global SRH item, however, is considered the most reliable for the prediction of poor health in cross-sectional and longitudinal study design (54). This SRH assessment tool also appears to pick up aspects of psychological health, namely perceived stress levels (55, 56), making it a robust subjective indicator of overall health status.

In all four papers, individuals were asked: 'Compared to people your own age, would you say that your health has on the whole been: excellent, good, fair, poor or very poor?' As is standard with this item, the five-point scale was recoded into the dichotomous variable 'good' (excellent, good) and 'poor' (fair, poor, very poor) health, making this outcome suitable for logistic regression analyses.

Independent variables

Paper I

This paper uses the social capital proxies: generalised trust, social participation within the community, use of informal social networks (contact with neighbours) and civic participation (voting). Other explanatory variables include age, gender, household and individual income, social class (derived from the Registrar General's Social Classification of occupations – RGSC), smoking and marital status.

i) Social capital variables

Generalised trust was assessed by asking people: 'Generally speaking, would you say that most people can be trusted, or that you can't be too careful?' Only a positive answer was considered for the reference group ('most people can be trusted') and was given the value 0; the negative answers 'you can't be too careful' and 'it depends' were given the value 1.

Levels of social participation within the community were measured by asking the respondents questions about being *active* members of (i) local community groups, (ii) local voluntary organisations, or (iii) any sports, hobby or leisure group (see appendix for full list). Those who answered positively to any one of these elements were judged to participate.

Use of social networks was established by asking respondents their frequency of 'meeting with friends/family' and 'talking with neighbours'. The possible responses were 'most days, once or twice a week, once or twice a month, less than once a month, or never'. Those who answered 'most days' or 'once or twice a week' were given the value 0 (reference) and assigned the label 'two or more times per week', and those who reported a lower frequency were assigned the value 1.

Civic participation was measured by the respondents answer to the question 'Did you vote in the last general election?' A positive answer was awarded the value 0 and a negative answer the value 1.

ii) Material conditions variables

Household and individual income levels were used as a measure of material conditions and were stratified into quartiles. Household income was weighted according to size using the equivalence scale, by summing the income of all household members and then dividing this sum by the square root of the household size (57). Both household and individual income levels were

expressions of total income (e.g. earned wages, pension, interest on savings, dividends, etc.) net of any taxation.

Those respondents whose answers placed them in the lowest quartile for either household or individual level income were labelled 'lowest income' and assigned the value 1. All others quartiles were assigned the value 0 and considered 'higher income'.

iii) Confounders

Baseline social class derived from the RGSC (see appendix), age, gender, SRH at baseline, smoking and marital status were all considered as confounders in this study. Age was stratified into quartiles, but was kept as a continuous variable in multivariable logistic regression models to reduce any possible residual confounding.

Paper II

This paper uses the social capital proxies: generalised trust, social participation, use of informal social networks, unpaid volunteer work, perceived reciprocity and altruistic intentions. Other explanatory variables include age, gender, highest attained education level, smoking and employment status, and total household income.

i) Social capital variables

Generalised trust was assessed by asking people: 'Generally speaking, would you say that most people can be trusted, or that you can't be too careful?' Those respondents who stated that most people could be trusted were labelled 'can trust' and given the value 0; all other responses (including 'it depends') were labelled 'can't trust' (value 1).

Social participation was measured by asking respondents questions about being *active* members of community groups or any sports, hobby or leisure group activity found locally. Only those who answered positively to any of these were judged to participate (value 0), with all others being labelled 'no participation' (value 1).

Unpaid voluntary work was considered a social capital measure separate to social participation; only those individuals who answered positively to undertaking unpaid voluntary work were judged to volunteer (value 0).

Perceived reciprocity was measured by asking respondents whether they could readily borrow items from neighbours. Those who agreed that they could were labelled 'high reciprocity'; all others were labelled 'low reciprocity' (value 1).

A further proxy for reciprocity, reflecting altruistic intentions at the community level was 'willingness to help improve one's neighbourhood'. Those who were willing were labelled 'willing', all others being labelled 'unwilling' (value 1).

The above individual-level social capital measures were further aggregated to create contextual measures at the household-, and small area-level.

ii) Considered health determinants

Age, gender, education attained, smoking and employment status, and total household income were included as well-known health determinants. Education level was categorised as 'undergraduate or higher', 'year 12', 'year 10' and 'no formal qualifications'. Smoking status was categorised as 'smoker' and 'non-smoker' according to respondents' answer to the question 'Do you smoke cigarettes?' Employment status was categorized as 'employed', 'retired', 'fulltime student' or 'unemployed'. Household income was weighted according to size by summing the income of all household members and dividing this sum by the square root of the household size (57). This item was maintained as a continuous variable per £1000 increase and was an expression of total income, net of any taxation. Age was also kept as a continuous variable to reduce possible residual confounding.

Paper III

This paper uses the social capital proxies: generalised trust, social participation within the community and use of informal social networks (frequency of talking with neighbours). Other explanatory variables include age, gender, highest attained education level, social class (derived from the RGSC), smoking status, total household income, marital status (including cohabitation), and frequency of meeting with friends and family.

i) Social capital variables

Generalised trust was assessed by asking people: 'Generally speaking, would you say that most people can be trusted, or that you can't be too careful?' This variable was dichotomised, with only those respondents stating that most people could be trusted being labelled 'can trust'; all negative responses (including 'it depends') were labelled 'can't trust' (58).

Social participation was measured by asking respondents questions about being active members of listed voluntary community groups or any sports, hobby or leisure group activity found locally (see appendix for full list). Only those who answered positively to any of these were judged to participate, with all others being labelled 'no participation'.

Frequency of talking to neighbours was also considered as a proxy for social capital (22, p.105-6). Possible responses were 'most days, once or twice a week, once or twice a month, less than once a month, or never'. Those answering 'most days' or 'once or twice a week' were assigned the label 'one or more times per week'; the rest were assigned the label 'less often'.

ii) Socio-economic status variables

Social class was determined by the respondents' most recent occupation, derived from the RGSC. The usual six categories (see appendix) were dichotomised into 'higher' (1-3a) and 'lower' (3b-6) social class. Those who had never been employed were labelled 'never worked'. Highest achieved education level was categorised as 'undergraduate or higher', 'year 13' and 'year 11' or 'no formal qualifications'. 'Household income' was weighted according to size by summing the income of all household members and dividing this sum by the square root of the household size (57). This item was maintained as a continuous variable (per £1000 increase) and was an expression of total income, net of any taxation.

iii) Social support variables

Respondents were asked if they were 'married, separated, divorced, widowed or never married'. These five options were recoded into the dichotomous variable 'married' and 'not married' (separated, divorced, widowed or never married). A further variable 'lives alone' ('yes' or 'no') was also used to try to capture more information about those individuals who co-habited.

Frequency of meeting with friends or family was considered as a proxy for social support. Possible responses were 'most days, once or twice a week, once or twice a month, less than once a month, or never'. Those answering 'most days' or 'once or twice a week' were assigned the label 'one or more times per week'; the rest were assigned the label 'less often'.

iv) Confounders

Age, gender, smoking status and time were considered confounders in this study, age being stratified into quintiles. Time (corresponding to the waves of interviews

in years 2000, 2003, 2005 and 2007) was also included as a continuous covariate to adjust for potential trends in SRH and explanatory variables across time.

Smoking status was categorised as 'smoker' and 'non-smoker' according to respondents' answer to the question 'Do you smoke cigarettes?'

All explanatory variables (except gender) were lagged at time (t-1) in reference to SRH at time (t). It was presumed that the presence of social capital, being younger, being married or cohabiting, being a non-smoker, attaining higher education and household income, having greater social support, and being of higher social class at time (t-1) were associated with good SRH at time (t).

Paper IV

This paper uses the social capital proxies: generalised trust and social participation within the community. Other explanatory variables include age, gender, highest attained education level, employment status, smoking status, and total household income.

i) Social capital variables

Two commonly used social capital proxies were investigated in this study: generalised trust and social participation. Generalised trust was assessed by asking people: 'Generally speaking, would you say that most people can be trusted, or that you can't be too careful?' This variable was dichotomized into 'can trust others' and 'can't trust others', with the response 'most people can be trusted' being the reference group (0). Responses 'you can't be too careful' and 'it depends' were combined and given the value 1.

Levels of social participation within the community were measured by asking the respondents questions about being *active* members of (i) local community groups, (ii) local voluntary organizations, or (iii) any sports, hobby or leisure group (see appendix for full list). Only those who answered positively to any of these elements were judged to participate, responses at each wave being dichotomized into 'active participation' (0) and 'no participation' (1).

As the above social capital proxies are time-dependent (i.e. respondents' answers can vary from year to year) we summed the dichotomous (1-0) responses from years 2003, 05 and 07 and re-categorized them to reflect potential changes over time. Taking 'trust' as an example, those who could consistently trust across the three waves (scoring '0' in total) were labelled 'always trusts others'; those who couldn't trust across the three waves (scoring '3' in total) were labelled 'never trusts others'; any respondent scoring '1 or 2' in total (reflecting a change in trust

levels over time) were labelled 'intermittent trust'. This process was repeated for the social capital proxy 'social participation'.

Our summed individual-level social capital proxies were further aggregated to the household level in order to implement our family-based design, deriving two distinct aggregate measures:

i) the '*mean household value'*, a comparison *between different* households sampled, and;

ii) the '*difference from the mean household value*', a comparison of individuals from *within the same* household.

We consider (ii) an individual-level social capital measurement, now *not* confounded by shared environment i.e. sharing the same household over 6 years.

ii) Socio-economic variables

Highest achieved education, employment status and household income were included as measures of SES. Household income was weighted according to its size by summing the income of all household members and dividing this sum by the square root of the household size (57). Income levels were expressions of total income, net of taxation.

As one's education can increase over time, the highest education level was taken from 2007 data and categorized as 'undergraduate or higher', 'year 13', 'year 11' and 'no formal qualifications'. Employment status was categorized as 'employed', 'retired', 'fulltime student' or 'unemployed'. Smoking status was categorized as 'smoker' and 'non-smoker' according to respondents' answer to the question 'Do you smoke cigarettes?' As with our social capital proxies, the responses to smoking and employment status were summed across the three waves (2003-07) to capture change over time.

iii) Confounders

Other variables considered for this study included age and gender, with age being stratified into quintiles for all analyses.

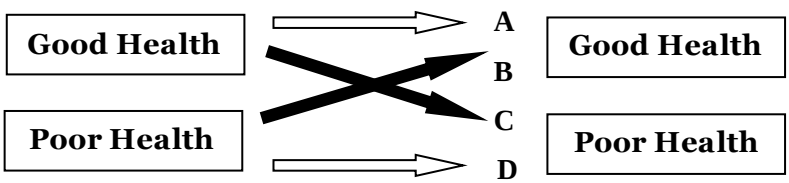
Statistical analyses

In all papers, statistical significance was assumed at $P < 0.05$.

Paper I

All data were disaggregated by baseline health status to create two separate cohorts – 'Good health at baseline' and 'Poor health at baseline'. From this point, the two cohorts were modelled separately. Dichotomised responses from waves ten and fifteen were combined to create new variables demonstrating *change over time*. Taking the dependent variable SRH (good vs. poor health) as one example: combining the responses from the two waves (2000 and 2005) created a new variable that had four potential outcomes: (i) Still good health; (ii) Now good health; (iii) Now poor health; (iv) Still poor health – see figure 1 below.

Figure 1: An illustration of how four outputs (A-D) are created from two sets of dichotomised data derived from 2000 and 2005, using self-rated health as an example



A: Still good health B: Now good health

C: Now poor health D: Still poor health

This process of combining responses was performed for all explanatory variables, except age and gender. We initially performed a bivariate investigation, followed by multiple regression analyses using only those explanatory variables that were statistically significant in bivariate models. All analyses were performed in the statistical software package SPSS 15.0 (59).

Paper II

Individual-level social capital proxies were also aggregated to the household-, and small-area level with a view to investigating social capital effects over all three levels. In total, six multilevel analyses were conducted using the statistical software package MLwiN version 2.21 (60), obtaining both fixed- and random-effect estimates. The fixed effects were converted to odds ratios (OR) with 95%

'credible intervals' (CI) derived from Markov Chain Monte Carlo (MCMC) estimation techniques (61). The variance (random effects) from household-, and small area-levels was used to estimate the intraclass correlation (ICC) using the latent variable method (62). This method assumes that the propensity for the outcome is a continuous latent variable underlying our binary response, which follows a logistic distribution with individual variance equal to 3.29 ($\pi^2 \div 3$).

Model I was 'empty' to ascertain baseline variance of individuals' self-rated health at household-, and small area-levels. Model II contained all considered individual-level health determinants. Model III contained all individual-level social capital proxies. Model IV contained just individual-level items (health determinants and social capital proxies). Model V contained 'contextual level' social capital variables at household- and small area-levels, plus all considered individual-level health determinants. Model VI tested all individual-level and contextual-level variables simultaneously.

Paper III

All data were stratified by baseline (year 2000) SRH to create two distinct 'health' cohorts: 'Good health at baseline' (GHB) and 'Poor health at baseline' (PHB). After this initial disaggregation, the two health cohorts were modelled as separate entities.

Model 1 dealt solely with individuals from the GHB cohort (N = 5689). The outcome of interest in Model 1 was *change* from GHB (0) to poor SRH (1) from year 2000 to 2007. Model 2 dealt solely with individuals from the PHB cohort (N = 2425). The outcome of interest in Model 2 was *change* from PHB (0) to good SRH (1) from year 2000 to 2007.

In order to investigate temporal relationships between exposure and outcome, *all explanatory variables* (except gender) were lagged at time (t-1) in reference to SRH at time (t). For all analyses, we used logistic regression models with random effects.

All explanatory variables were utilised in our two multiple logistic regression models. Model 1 investigated *change* from GHB (0) to poor SRH (1) between years 2000-07; Model 2 investigated *change* from PHB (0) to good SRH (1) between years 2000-07. All analyses were conducted using GLLAMM version 2.3.15 (63), within the statistical software package STATA 11.2 (64). We also performed sensitivity testing to check our assumption that social capital at time point (t-1) influences SRH at time point (t), by including *all* lagged and non-lagged explanatory variables within the same model.

Paper IV

We ran *all* explanatory variables simultaneously against the outcome poor SRH in two separate multiple regression analyses using Generalized Estimating Equations (GEE) (65), with an exchangeable working correlation structure employing the 'sandwich' covariance estimator (66). Our first analysis represents a more traditional longitudinal investigation into association between summed individual-level social capital variables and SRH; our second analysis represents our longitudinal family-based design, investigating association between the summed individual-level social capital variables and SRH, whilst adjusting for shared environment (the household) over time. All analyses were conducted within the statistical software package STATA 11.2 (64). This process of combining responses was performed for all explanatory variables, except age and gender. We initially performed a bivariate investigation, followed by multiple regression analyses using only those explanatory variables that were statistically significant in bivariate models. All analyses were performed in the statistical software package SPSS 15.0 (59).

Results

Paper I

Results

Multivariable analysis – now poor health

As per table 1 (left-hand column), the variables demonstrating the greatest odds ratio (OR) with statistical significance for deteriorating health ($p < 0.001$) are generalised trust, age and smoking status. Only persistently low and 'now lowest' income measures remain associated with deteriorating health.

Regarding social participation, no association remains with deteriorating health. The outcomes 'now meets less often' with friends and 'no longer votes' are associated with an increased risk in deteriorating health. Dissolution of marriage is associated with an increased risk of deteriorating health.

Multivariable analysis – now good health

As per table 1 (right-hand column), the variable 'still trusts others' maintains its association with improving health. All aspects of individual and household income show no significant association with improving health over time. Maintaining levels of social participation and an acquired ability to participate are associated with improving health. Being male, younger in age and remaining a non-smoker are all strongly associated with improving SRH.

Table 1: Odd ratios (OR) with 95% confidence intervals (95% CI) of deteriorated and improved self-rated health between 2000 and 2005 within multivariable logistic regression models containing all significant 'change over time' variables in social capital, material conditions and potential confounders (N_t = 9168 [a])

'Change over time' variable		Change in health status over time	
		Now poor health (N = 6401) [b]	Now good health (N = 2767) [c]
		OR (95% CI)	OR (95% CI)
Age (years)	Continuous	1.019 (1.014 - 1.024) ***	0.979 (0.973 - 0.984) ***
Gender	Male	NA	1.266 (1.071 - 1.497) **
	Female	NA	1.0
Individual income (quartiles)	Still higher income	1.0	1.161 (0.919 - 1.468)
	Now lowest quartile	1.275 (1.029 - 1.581) *	0.902 (0.674 - 1.208)
	Now higher income	1.194 (0.952 - 1.497)	1.120 (0.824 - 1.521)
	Still lowest quartile	1.222 (1.006 - 1.485) *	1.0
Household income - size weighted (quartiles)	Still higher income	1.0	1.082 (0.857 - 1.365)
	Now lowest quartile	1.399 (1.124 - 1.742) **	1.152 (0.847 - 1.567)
	Now higher income	1.101 (0.871 - 1.393)	0.858 (0.634 - 1.160)
	Still lowest quartile	1.292 (1.040 - 1.604) *	1.0
Generalised trust	Still trusts others	1.0	1.369 (1.106 - 1.694) **
	Now can't trust others	1.646 (1.318 - 2.055) ***	1.127 (0.878 - 1.446)
	Now can trust others	1.486 (1.179 - 1.873) **	1.274 (0.978 - 1.660)
	Still can't trust others	1.744 (1.471 - 2.067) ***	1.0
Social participation: Member of local groups, voluntary organisations or	Still a member	1.0	1.560 (1.266 - 1.923) ***
	No longer a member	1.149 (0.924 - 1.430)	1.206 (0.927 - 1.568)
	Now a member	1.131 (0.948 - 1.350)	1.269 (1.032 - 1.561) *

group leisure activities	Still a non-member	1.173 (0.986 - 1.395)	1.0
Social networks: Meets with friends (two or more times per week)	Still meets as often	1.0	NA
	Now meets less often	1.316 (1.046 - 1.657) *	NA
	Now meets more often	0.896 (0.711 - 1.128)	NA
	Still meets less often	1.056 (0.785 - 1.421)	NA
Civic participation (voted in last election)	Still votes	1.0	NA
	No longer votes	1.244 (1.001 - 1.545) *	NA
	Now votes	1.203 (0.965 - 1.500)	NA
	Still doesn't vote	1.072 (0.871 - 1.319)	NA
Marital status	Still married	1.0	0.958 (0.795 - 1.155)
	Now single	1.388 (1.031 - 1.867) *	0.840 (0.586 - 1.204)
	Now married	0.967 (0.717 - 1.304)	1.078 (0.749 - 1.553)
	Still single	1.127 (0.965 - 1.316)	1.0
Smoking status	Still a non-smoker	1.0	1.690 (1.188 - 2.058) ***
	Now a smoker	1.286 (0.859 - 1.924)	1.056 (0.623 - 1.791)
	Now a non-smoker	1.660 (1.274 - 2.163) ***	1.366 (0.970 - 1.925)
	Still a smoker	1.652 (1.397 - 1.954) ***	1.0

Source: The British Household Panel Survey, Waves J & O (2000 and 2005)

* 0.05 significance

** 0.01 significance

*** 0.001 significance

Reference group = 1.0

NA = Not significant in bivariate model

[a] Missing = 132

[b] Missing = 121

[c] Missing = 11

Paper II

Results

Results from all six models are shown in table 2.

Model I (empty)

The intraclass correlation (ICC) estimates indicate that 24.9% of individuals' variation in health is attributed to the household level, and 2.4% to the small area-level.

Model II

Of the considered health determinants, being retired or unemployed, being a smoker and having high school education or less were associated with poor health. The ICC was reduced to 10.5% for households and 1.4% for the small area-level.

Model III

Of the individual-level social capital measures, inability to trust, lack of social participation and unwillingness to improve one's neighbourhood, were associated with poor SRH. The ICC was reduced to 11.6% for households and 2.4% for the small area-level.

Model IV

When individual social capital measures and considered health determinants were tested simultaneously, being retired or unemployed, being a smoker and having no formal qualifications remained associated with poor health. Of the social capital variables, inability to trust, lack of social participation and unwillingness to improve one's neighbourhood, remained associated with poor SRH. The combination of health determinants and individual-level social capital measures reduced the ICC to 9.6% for households and 1.5% for the small area-level.

Model V

When the contextual-level social capital items were modelled alongside considered individual-level health determinants (as potential confounders) inability to trust, lack of social participation and unwillingness to improve one's neighbourhood were all associated with poor SRH at the household level. Only lack of volunteering was associated with poor SRH at the small area-level. The ICC was reduced to 11.0% for households and 1.5% for the small area-level.

Model VI

Of the considered health determinants, being a smoker, being retired or unemployed and having no formal qualifications maintained association with poor SRH in multivariable analysis. Of the individual-level social capital measures, only lack of social participation maintained association with poor SRH. Of the household-level social capital variables, inability to trust others and unwillingness to improve one's neighbourhood maintained association with poor SRH.

Table 2: Models I-VI with estimated fixed effects (odds ratios (OR) and 95% credible intervals (CI)), and random effects (Ω and ICC (standard error) between self-rated health, considered individual-level health determinants and individual and contextual social capital variables (N= 10,992)

		Model I	Model II	Model III	Model IV	Model V	Model VI
Fixed effects			OR (CI)	OR (CI)	OR (CI)	OR (CI)	OR (CI)
i) Considered health determinants							
Age	Cont.		1.02 (1.01-1.02)		1.02 (1.01-1.02)	1.02 (1.01-1.02)	1.02 (1.01-1.02)
Gender	Male		1.0		1.0	1.0	1.0
	Female		0.98 (0.90-1.07)		1.02 (0.93-1.12)	1.00 (0.92-1.09)	1.02 (0.93-1.02)
Smoker	No		1.0		1.0	1.0	1.0
	Yes		1.74 (1.54-1.95)		1.65 (1.47-1.87)	1.65 (1.47-1.85)	1.66 (1.48-1.86)
Education achieved	Undergraduate +		1.0		1.0	1.0	1.0
	Year 12		1.22 (1.05-1.43)		1.15 (1.01-1.34)	1.14 (0.98-1.33)	1.13 (0.97-1.32)
	Year 10		1.22 (1.06-1.41)		1.11 (0.97-1.26)	1.09 (0.95-1.25)	1.08 (0.93-1.26)
	No qualifications		1.95 (1.65-2.25)		1.69 (1.46-1.97)	1.62 (1.38-1.89)	1.61 (1.36-1.92)
Employment status	Employed		1.0		1.0	1.0	1.0
	FT student		0.87 (0.68-1.12)		0.88 (0.68-1.11)	0.90 (0.70-1.15)	0.92 (0.72-1.18)
	Retired		1.22 (1.03-1.45)		1.22 (1.04-1.45)	1.22 (1.04-1.43)	1.22 (1.02-1.45)
	Unemployed		3.03 (2.57-3.54)		2.90 (2.50-3.43)	2.90 (2.49-3.35)	2.95 (2.54-3.47)

Household income (annual) size weighted	Cont.	1.00 (1.00-1.00)		1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Individual-level social capital variables						
Generalised trust	Trusts others		1.0	1.0		1.0
	Can't trust others		1.54 (1.39-1.71)	1.38 (1.24-1.54)		1.11 (0.94-1.31)
Active participation in groups	Participates		1.0	1.0		1.0
	No participation		1.85 (1.65-2.09)	1.38 (1.22-1.57)		1.24 (1.04-1.49)
Voluntary work	Yes		1.0	1.0		1.0
	Never		0.97 (0.86-1.10)	1.02 (0.91-1.17)		0.99 (0.80-1.20)
Perceived reciprocity	Can borrow		1.0	1.0		1.0
	Can't borrow		1.00 (0.90-1.10)	1.01 (0.92-1.12)		1.00 (0.85-1.16)
Willingness to improve neighbourhood	Willing		1.0	1.0		1.0
	Unwilling		1.36 (1.22-1.53)	1.28 (1.15-1.44)		1.12 (0.94-1.34)
ii) Contextual-level social capital variables						
Cannot trust others	HH				1.37 (1.24-1.51)	1.30 (1.12-1.51)
	SA				1.19 (0.95-1.45)	1.18 (0.96-1.46)
Does not participate	HH				1.33 (1.18-1.51)	1.14 (0.95-1.37)
	SA				0.95 (0.72-1.29)	0.92 (0.70-1.24)
No volunteer work	HH				0.99 (0.93-1.06)	0.99 (0.91-1.11)
	SA				1.29 (1.07-1.54)	1.28 (1.07-1.57)

Unwilling to improve neighbourhood	HH					1.30 (1.15-1.47)	1.19 (1.00-1.42)
	SA					1.03 (0.81-1.30)	1.02 (0.79-1.29)
Low perceived reciprocity	HH					1.01 (0.96-1.05)	1.01 (0.94-1.11)
	SA					0.96 (0.82-1.13)	0.97 (0.84-1.15)
Random effects (standard errors)							
Variance Ω (SE)	HH (Ω_u)	0.99 (0.14)	0.33 (0.17)	0.67 (0.10)	0.30 (0.02)	0.35 (0.15)	0.40 (0.17)
	SA (Ω_v)	0.11 (0.02)	0.05 (0.01)	0.09 (0.02)	0.05 (0.02)	0.06 (0.02)	0.06 (0.02)
Intraclass Correlation (%)	HH (Ω_u)	24.9%	10.5%	11.6%	9.6%	11.0%	12.3%
	SA (Ω_v)	2.4 %	1.4%	2.4%	1.5%	1.5%	1.6%

Source: The British Household Panel Survey, 2008

HH - Household level

SA - Small area level

Paper III

Results

Model 1: Multiple regression analysis - GHB cohort

The outcome of interest in Model 1 was change from GHB (0) to poor SRH (1) between 2000 and 2007. As seen in table 3, of the social capital variables, low levels of trust and talking less with neighbours preceded a change from GHB to poor SRH over time (OR = 1.35 and 1.18, respectively).

Of the SES variables, those with low social class or those who had never worked at time (t-1) had increased risk of poor SRH at time (t) (OR = 1.40 and 1.53, respectively). A prior increase in household income seemed to offer some protection against future poor SRH; though significant, the value was close to the reference value of 1.0.

None of the social support variables at (t-1) maintained association with poor SRH at time (t). Of the confounders, smoking at (t-1) and being of older age were associated with poor SRH at time (t).

Model 2: Multiple regression analysis - PHB cohort

The outcome of interest in Model 2 was change from PHB (0) to good (1) SRH between 2000 and 2007. As seen in table 3, of the social capital variables, high levels of trust, participation and talking more often with neighbours at time (t-1) preceded good SRH at time (t) (OR = 1.31, 1.19, and 1.33 respectively).

Of the SES variables, those with higher social class at time (t-1) had good SRH at time (t) (OR = 1.24). Those who had never worked at time (t-1) were likely to remain of poor SRH (OR = 0.61). A prior increase in household income at time (t-1) was associated with good SRH at time (t); though significant, the value was close to the reference value of 1.0.

Of the confounders, being a non-smoker, being male, and being of younger age at time (t-1) were associated with good SRH at time (t).

Sensitivity testing

We tested our hypothesis that social capital at time (t-1) is positively associated with SRH at time (t) by running all explanatory variables at time (t) alongside all lagged (t-1) exploratory variables simultaneously against SRH at time (t). Sensitivity tests were performed for Models 1 and 2 separately. From the GHB cohort, the only lagged (t-1) social capital variable that maintained association with poor SRH at time (t) was lack of trust (OR = 1.25 (1.10-1.42)).

From the PHB cohort, association remained between good SRH at time (t) and the lagged (t-1) social capital variables 'trust' (OR = 1.25 (1.05-1.49)) and 'talks with neighbours' (OR = 1.28 (1.05-1.55)). Association between active social participation at (t-1) and good SRH at time (t) was attenuated after adjusting for participation at time (t). Please refer to paper III for tabulation of sensitivity test results.

Table 3: Odds ratios (OR) with 95% confidence intervals (95% CI) of having good or poor self-rated health at time (t) from baseline (year 2000) health status according to multiple logistic regression analysis of lagged (t-1) explanatory variables in social capital, social support, socio-economic status and confounders (N_T = 8113)

Explanatory variables		Change in self-rated health status from Baseline (2000)	
		Model 1 (N = 5688) [a] Good Health at Baseline Cohort - OR (95% CI) of having PH over time	Model 2 (N = 2425) Poor Health at Baseline Cohort - OR (95% CI) of having GH over time
Social capital variables			
Generalised trust	Trusts others	1.0 [b]	1.31 (1.10-1.56) **
	Can't trust others	1.35 (1.19-1.53) ***	1.0 [b]
Social participation: Active in local groups	Active participation	1.0 [b]	1.19 (1.01-1.39) *
	No participation	1.05 (0.93-1.18)	1.0 [b]
Frequency of talking with neighbours	1+ times/week	1.0 [b]	1.33 (1.10-1.61) **
	Less than this	1.18 (1.02-1.36) *	1.0 [b]
Social support variables			
Marital status	Married	1.0 [b]	1.20 (0.94-1.52)
	Not married	1.00 (0.85-1.19)	1.0 [b]
Living alone	Lives with others	1.0 [b]	0.87 (0.65-1.16)
	Lives alone	1.19 (0.96-1.48)	1.0 [b]

Frequency of meeting with friends or family	1+ times/week	1.0 [b]	1.12 (0.90-1.40)
	Less than this	0.91 (0.77-1.08)	1.0 [b]
Socio-economic variables			
Household income/£1000	Continuous	0.99 (0.98-0.99) ***	1.02 (1.01-1.02) ***
Social class: derived from occupation-based RGSC schema	High SC	1.0 [b]	1.24 (1.02-1.52) *
	Low SC	1.40 (1.22-1.61) ***	1.0 [b]
	Never worked	1.53 (1.13-2.07) **	0.61 (0.40-0.92) *
Education achieved	Undergraduate +	1.0 [b]	0.86 (0.66-1.12)
	Year 13	1.06 (0.88-1.26)	0.73 (0.56-1.01)
	Year 11	1.01 (0.86-1.19)	0.79 (0.60-1.06)
	No qualifications	1.23 (0.84-1.79)	1.0 [b]
Confounders			
Age (years)	16 - 34	1.0 [b]	7.19 (4.90-10.55) ***
	35 - 44	1.12 (0.88-1.42)	2.45 (1.78-3.37) ***
	45 - 54	1.25 (0.98-1.60)	1.27 (0.92-1.75)
	55 - 64	1.30 (0.99-1.68)	1.08 (0.80-1-44)
	65 +	1.84 (1.43-2.37) ***	1.0 [b]
Gender	Male	1.0 [b]	1.37 (1.11-1.69) **
	Female	1.04 (0.91-1.23)	1.0 [b]
Smoking status	Non-smoker	1.0 [b]	1.94 (1.55-2.37) ***
	Smoker	1.68 (1.44-1.97) ***	1.0 [b]

Time (continuous)	1.17 (1.10-1.24) ***	1.01 (0.94-1.10)

Source: The British Household Panel Survey, Waves J, M, O & Q (2000-07)

* 0.05 significance

** 0.01 significance

[a] Missing = 1

[b] Reference

*** 0.001 significance

Paper IV

Results

Model 1- Longitudinal multiple regression analysis

The odds ratios (OR) demonstrating association between social capital (trust and participation) and subsequent poor self-rated health increase as presence of social capital diminishes. There is also association between lack of formal qualifications, being unemployed, smoking (intermittently or full time) and subsequent poor SRH. An increase in household income and being female seems to protect against poor SRH. Please refer to paper IV for the full table of results of the more traditional longitudinal analyses.

Model 2 – Family-based multiple regression analysis

As shown in table 4, having adjusted for shared environment over time (the same household over six years), there are now two OR per social capital proxy: the *mean* value represents association between social capital and subsequent poor SRH when comparing different households with each other (often seen in traditional multilevel designs). However, the *difference from the household mean* value reveals association between trust, social participation and subsequent poor SRH when comparing individuals from *within the same* household (family-based design). The *difference from the household mean* value represents an individual-level social capital measurement, now *not* confounded by the shared environment of the household, and our results show that both trust and participation are now heavily attenuated.

Being a smoker, having no formal qualifications and being unemployed maintain association with subsequent poor SRH. Household income and gender still appear to protect against poor SRH.

Table 4: Odds ratios (OR) with 95% confidence intervals (95% CI) of having poor self-rated health in 2008 according to multiple regression analysis using explanatory variables derived from 2003-07, simultaneously adjusting for *between* and *within* household social capital measures (family-based design, *N* = 6900)

Explanatory variables		Poor self-rated health in 2008 OR (95% CI)
Generalised trust - *between* HHs	Mean value	1.29 (1.21-1.37)
Generalised trust - *within* HHs	Difference from the Mean	1.11 (1.02-1.20)
Social participation - *between* HHs	Mean value	1.07 (0.97-1.18)
Social participation- *within* HHs	Difference from the Mean	0.97 (0.89-1.06)
Age (years)		
	16 - 34	1.0
	35 - 44	1.39 (1.15-1.67)
	45 - 54	1.80 (1.49-2.17)
	55 - 64	1.41 (1.16-1.72)
	65 +	1.48 (1.16-1.88)
Gender	Male	1.0
	Female	0.76 (0.68-0.86)
Household income - size weighted	Per £1000 increase	0.99 (0.99-1.00)

Employment status	Employed	1.0
	Full time student	1.16 (0.97-1.40)
	Retired	1.84 (1.52-2.24)
	Unemployed	3.02 (2.51-3.64)
Education achieved	Undergraduate or higher	1.0
	Year 13	1.11 (0.93-1.32)
	Year 11	1.00 (0.84-1.18)
	No formal qualifications	1.52 (1.26-1.83)
Smoking status	Never a smoker	1.0
	Intermittent smoker	1.47 (1.22-1.76)
	Always a smoker	1.46 (1.26-1.69)

Source: The British Household Panel Survey, Waves M ,O, Q & R (2003, 05, 07 & 08) Reference group = 1.0 HH = Household

Discussion

Main findings

The overall aim of this thesis is to test association between different social capital proxies and SRH, alongside other well-known health determinants, using multilevel and longitudinal data, whilst employing a variety of study designs and methods. The underlying premise being to investigate temporal (causal) relationships between social capital and health, something that has previously been difficult to achieve due to paucity of suitable longitudinal data within this field (43).

The three longitudinal papers of this thesis (I, III, & IV) contribute to the field of social capital and public health research by demonstrating that:

- the social capital proxy 'generalised trust' consistently maintains a positive association with individual SRH *over time*, even after considering numerous well-known socio-economic health determinants and other confounders, such as smoking status, gender and age
- changes in individual SRH are accompanied by changes in levels of social capital
- prior levels of social capital may predict future SRH
- association between social capital and SRH may be confounded by shared environmental factors previously unconsidered by researchers

The only cross-sectional paper in this thesis (paper II) adds to this research field by attempting to identify a more appropriate context within which to measure social capital and its effects; the results reflect aspects of different social capital theories, demonstrating that:

- association between social participation and SRH remains at the individual level; participation is often considered a potential source of social support, an individual-level asset

- association between trust and SRH appears strongest at the household level; this reflects Coleman's theories which highlight the importance of the household when perpetuating social norms, such as trust

- association between volunteering and SRH remains at the community level; this reflects Putnam's theory that individuals who volunteer can influence community health as a whole, by maintaining or increasing access to vital resources needed for better health

Trust matters

The reoccurring theme from all four papers of this thesis is that *trust matters* with respect to individual health outcomes. Whilst papers I, II and III also show positive association with the proxy *social participation*, overall results imply that generalised trust is the more robust proxy, demonstrating a consistently positive association with SRH. Paper III further infers that prior levels in trust predict future SRH, and all four papers add weight to the argument that generalised trust levels can be considered an independent determinant of health (67).

There is a history of public health research adopting Putnam's social capital theories in which *trust* plays a significant role (for examples see: (6, 7, 21, 22, 24, 25)); yet there is still surprisingly little discussion in social capital literature of other disciplines' theories behind the aetiology of generalised trust. As touched upon in the introduction, opponents of social capital theory favour access to resources and public welfare policy as major influences over population health (8-10). Responsibility for such typically lies with State bodies and institutions. Yet these same bodies and institutions are also thought to influence population trust levels (see later), creating uncertainty as to what 'generalised trust' levels truly reflect: social capital or State function. This fact is of greatest relevance when decision-makers (including the World Bank and WHO) choose to develop and implement policy grounded in social capital theory to improve population health (68).

Trust: a measure of 'social capital'

Early social capital literature stresses the importance of two types of trust: *generalised* trust (reserved for strangers) and *particularized* trust (a type of trust reserved for known groups or individuals). Both forms of trust are thought to facilitate actions between individuals or groups (19), i.e. without them, there can be no social capital. Szreter and Woolcock re-emphasize the importance of trust

variants, coining the terms 'bonding', 'bridging', and 'linking' social capital, referring to *particularized*, *generalised* and *vertical* trust, respectively (10).

However, *generalised* trust seems to have become the preferred social capital proxy in public health research. This is most likely due to the works of Robert Putnam (12, 22, 69), and the assumption that individuals are all similarly influenced by the presence (or lack) of community-level social capital (6, 14). This latter aspect, that social capital is a 'public good' (18, p.177), particularly appeals to public health researchers. However, cross-level interactions have shown that this maybe an oversimplification of the situation, as the health of individuals who do not share the social 'norms' (i.e. trust) of the community in which they reside, may be adversely affected (23).

In following Putnam's social capital theory, one assumes (as Putnam does) that trust is a by-product of increased social participation. This assumption implies that trust is just one step along the pathway from participation to health. As to how increased participation influences health could be by potentially increasing an individual's sources of social support e.g. emotional and financial support, or by increasing one's exposure to societal norms that influence health (e.g. the reduced acceptability of smoking in public places). However, the four papers in this thesis suggest that trust (not participation) is the more robust social capital proxy, hinting at other pathways from social capital to health.

Putnam's theory further assumes that these two social capital proxies (trust and participation) are highly correlated. Paper I shows increased social participation to be associated with improved SRH over time, and paper III shows active participation to precede good health, yet both papers also demonstrate that *trust* remains positively associated with SRH.

If trust is correlated with (and is a by-product of) social participation as per Putnam, then one would expect association between trust and health to be attenuated in the presence of 'participation' in regression models. This is evidently not the case here, with papers I, II, III & IV adding to the increasing literature base demonstrating a consistent lack of correlation between these social capital proxies (21, 70, 71).

Conversely, it has been argued that trust is in fact a prerequisite to participation (72). If believed then trust, not participation, must be found at the start of the causal pathway to health. That trust seems the more robust of the two social capital proxies in all four papers of this thesis lends some weight to this hypothesis; however, that participation remains associated with SRH in papers I & III (alongside trust in regression models) lends further weight to the idea that there is more than one pathway from social capital to health.

From 'social capital' to health

There are several theories as to how social capital could influence health, from the better dissemination of health messages to reducing the risk of violent crime (see introduction section also) (7). However, as theorized in paper I, participation and trust may influence health along two separate pathways: active participation could influence health via social support mechanisms, which have been well researched and documented (2); trust levels could influence health directly, via psychosocial pathways initially proposed by Wilkinson (38).

As Wilkinson describes, low generalised trust levels could be a reflection of high levels of perceived social stress and anxiety. Long-term exposure to stressors can, via the hypothalamic–pituitary–adrenal axis, lead to increased levels of blood cortisol over time. Chronically elevated cortisol levels have been linked to such deleterious health outcomes as major depression, type II diabetes, metabolic syndrome, cardio-vascular disease and stroke (73-75). If trust is accepted as an individual proxy of community social capital (49), then it is feasible that those residing in communities with higher levels of social capital may feel less anxious than those living in communities with lower levels. Less anxious individuals may be less susceptible to the negative health outcomes previously mentioned. Though Wilkinson's ideas are considered contentious (76), the psychosocial pathway does remain one plausible mechanism as to how an individual's perceptions of his/her community could translate into physiological changes affecting his/her health.

Trust: a proxy for 'State'

There are theories other than Putnam's within political science as to how the *State* plays a role in population levels of generalised trust. For example, some consider higher levels of generalised trust to reflect the populations' perception of well-functioning State institutions (77); an even more refined hypothesis states that levels of generalised trust reflect the populations' perception of egalitarian State *policies*, rather than the State institutions themselves (78, 79). Others go so far as to imply that the institution of 'Democracy' itself may be a pre-requisite for generalised trust (80). Another theory is that trust in State institutions (*vertical* trust) creates an environment which allows generalised (*horizontal*) trust also to flourish (81, p.198).

All the above are plausible, especially when one compares the low *generalised* trust levels found in populations with corrupt regimes with the much higher trust

levels found in those residing in more egalitarian States (82). Yet empirical evidence consistently shows only weak correlation between *vertical* and *generalised* trust (83, 84), implying that the relationship between State and generalised trust is more complex.

From 'State' to health

One obvious way that State can influence population health is through fair and secure access to resources vital for health; these include education, healthcare, clean water, medicines, etc. Another way could be via State institutions' ability to maintain law and order, and to deal peaceably with conflict resolution. However, it is simplistic to assume that the provision of such institutions is solely a 'top down' process, as the existence of such bodies is considered a product of civic engagement by the population, requiring support for such institutions in the first place (85). In other words, access to resources vital for health may be a product of *social cohesion*.

Social cohesion is a term used to describe the 'togetherness' of a society, in which different domains work, conflict-free towards agreed goals. Societal domains, as described by Forrest and Kearns (86) include common values and a civic culture; social order and control; social capital; and geographical belonging (86). The domains of common values and civic culture, coupled with social order and control contribute to the secure provision of resources previously described, which account for how State may directly influence population health. However, it is noteworthy that social capital is also considered a domain (or subset) of cohesion (18, 86, p.175), implying that social capital and social cohesion are highly correlated. If this is truly the case, then one must ask whether high levels of social capital are a precursor to increased social cohesion, or a product of it.

It should be apparent to readers that *generalised trust* is considered a social capital proxy by some (including me, in this body of work), but also as a proxy for State function by others. This fact alone creates uncertainty as to whether any association found between generalised trust and health reflects efficient functioning of State institutions or the presence of social capital.

This issue is further confounded by the fact that social capital is considered a subset of social cohesion (18), yet social cohesion may also be a precursor to State function (85). Considering this, one can now appreciate how difficult it is for researchers to determine empirically whether social capital is indeed an independent health determinant, or whether it is a mediator between social cohesion, State and population health.

Policy implications

Over the past decade or so, decision makers in the UK (87, 88), along with international development agencies such as the World Bank (89) and WHO (90) have discussed and actively employed aspects of social capital to maintain and improve population health. This trend can be mostly attributed to Putnam's work on civic engagement in Italy and research in the USA.

Though his 1993 work implicitly rules out the health implications of social capital: '…health depends on factors like diet and lifestyle that are beyond the control of any democratic government.' (12, p.66), Putnam does point out that a high level of civic engagement is more likely to 'contribute to the effectiveness and stability of democratic government' (12, p.89).

Yet in 'Bowling Alone', Putnam reverses his opinion, explicitly stating the importance of social capital on health outcomes: 'Of all the domains in which I have traced the consequences of social capital, in none is the importance of social connectedness so well established as in the case of health and well-being' (22, p.326).

As to how State can contribute to health has already been discussed previously in this section; however, that Putnam goes on to say that: '[if]…one wanted to improve one's health, moving to a high-social capital state would do almost as much good as quitting smoking' (22, p.328), raises great concern if policy makers take this statement at face value.

In a nutshell, Putnam's theories imply that if individuals participate more with each other within the community, this will increase community-level social capital and improve population health. It is, therefore, all too easy to cite Putnam's work as an argument for targeting individuals (or even communities) without ever considering the bigger picture of social context within which such individuals and communities exist. Indeed, the 'neo-materialistic' view of victim-blaming can easily detract from the importance of (costly) State institutions, egalitarian policy and welfare provision. Employing Putnam's theories to reduce the role of State responsibility could feasibly lead to ineffectual initiatives and an even greater deterioration of health in certain populations (91, 92). To avoid this, literature must make it quite clear that social capital levels are also intrinsically linked to other macro-level phenomena, such as social cohesion, efficient state institutions, and egalitarian State policy.

Strengths and limitations

A major strength of this thesis is that data are longitudinal and multilevel in nature; this has allowed for causality testing by employing a variety of study designs. As stated before, this has been lacking in social capital research due to paucity of suitable data in the past (43). The fact that the BHPS data are sampled on entire households makes this dataset unique, allowing for clustering at this level, along with more traditional community clusters. The independent variable (the global self-rated health item) is considered a valid predictor of morbidity and future mortality (51, 52, 54). The fact that the data were obtained via interview rather than relying on postal questionnaires contributed to the very high participation rate of around 90%, year on year (50). The data allow for the inclusion of many well-known health determinants (SES, smoking status, gender, etc.) in all papers, which in turn reduces potential confounding. Furthermore, misclassification bias of health and health-determinant variables is kept to a minimum, as all are considered 'mainstream' in format and have been previously validated.

A major limitation of this thesis is that, though its papers utilize differing sample populations, they are all derived from the same source (i.e. from the BHPS). This means that all individuals used in the studies are prone to the same selection bias. By year 2000, only 62.0% of the original cohort members were able to answer the questions posed (50), introducing further selection bias into the studies presented here. Furthermore, the BHPS sample was originally selected to reflect the UK population as a whole and deliberately avoided oversampling of smaller sized communities, i.e. data are not particularly valuable when investigating ethnic diversity or urban vs. rural populations. Paper I uses only two points in time to investigate change in health and social capital; though a novel design in the field of social capital, the use of two time-points is less than the recommended three (or more) required to correctly assess temporal relationships (93, p.9). Paper II, though multilevel in design, is cross-sectional; therefore, no causal inference can be made from its results. As yet, there are no 'gold-standards' available for our social capital proxies, making it difficult to assess their validity and reliability. Furthermore, as presented in the discussion section, there seems valid argument to doubt that generalised trust is as suitable a proxy for social capital, as Putnam presumes (12, 22, 49). This measure of trust may also be a reflection of State and policy effectiveness, which may lead to confounding, as any association in social capital research utilizing *generalised* trust as a proxy may be highlighting its role as mediator between State and population health.

Conclusions

Social capital research is heavily contended on theoretical and methodological grounds (16, 17). Though this thesis attempts to address some of the shortfall in methodologies found within this field, many other issues surrounding social capital theory remain. Without a universally accepted definition of social capital and subsequent agreement on its measurement, all social capital research is still open to criticism. That a plethora of empirical research (including the four papers presented here) consistently shows that 'trust matters' may only be a reflection of the mediator role social capital plays between State and population health.

Appendix

To determine social participation levels, respondents were asked if they were *active* members of any local group or organisation listed below:

Political party, trade union, environmental group, parents'/school association, tenants'/residents' group or neighbourhood watch, church organisation, voluntary service group, pensioners group/organisation, social club/working men's club, sports club or Women's Institute.

The six occupation categories, as per the Registrar General's Social Classification (RGSC) of occupations are:

i) Professional, ii) Managerial/Technical, iiia) Skilled (non-manual), iiib) Skilled (manual), iv) Partly Skilled and v) Unskilled.

Populärvetenskaplig sammanfattning

Socialt kapital är den tillit, reciprocitet och de sociala nätverk som bidrar till samarbete, gemenskap och minskade transaktionskostnader i samhället. Sedan 15 år tillbaka har en snabbt växande internationell litteratur visat att socialt kapital har starka samband med hälsa. Socialt kapital har också betydelse för sociala skillnader i hälsa. Litteraturen bygger emellertid i stor utsträckning på tvärsnittsundersökningar, vilket innebär att man inte kan dra slutsatser om orsakssamband. Eftersom socialt kapital till betydande del handlar om sociala kontexter (sociala sammanhang) har framför allt geografiska kontexter undersökts i flernivåanalyser i litteraturen, däremot är det få studier som har undersökt andra kontexter som till exempel hushållets betydelse för sambandet mellan socialt kapital och hälsa. Ingen studie har undersökt sambandet betydelsen av gemensam miljö (shared environment) för sambandet mellan socialt kapital och hälsa.

Samtliga delarbeten i avhandlingen bygger på analyser av British Household Panel Survey (BHPS). BHPS insamlas återkommande sedan början av 1990-talet genom enkätbaserade intervjuer och är således en paneldataundersökning. Informationen i enkäterna omfattar bland annat basala demografiska uppgifter, individuell inkomst, hushållsinkomst, yrke, utbildning, relation till arbetsmarknaden, olika former av socialt stöd, socialt kapital (generell tillit till andra, socialt deltagande, reciprocitet, kontakt med grannar), en rad andra sociala variabler samt självrapporterad hälsa (SRH5-self rated health med fem svarsalternativ), självrapporterad psykologisk hälsa (GHQ12) och rökning. BHPS liknar med sin paneldatadesign i viss mån ULF (Undersökning om Levnadsförhållanden)-undersökningen (SCB) i Sverige. Den viktigaste skillnaden mellan BHPS och ULF är att medan urvalet i ULF bygger på individer är grunden för urvalet i BHPS hushåll.

I det första delarbetet analyseras olika aspekter av socialt kapital och självrapporterad hälsa. Delarbetet bygger på observationer vid två olika mättillfällen i BHPS. Analysmetoden är logistisk regression i statistikprogrammet SPSS i vilken de olika måtten på socialt kapital vid tidpunkt (t) analyseras mot förändring av självrapporterad hälsa mellan tidpunkt (t) och tidpunkt (t+1). Resultatet visar signifikanta samband mellan socialt kapital i form av bland annat generaliserad tillit till andra människor och självrapporterad hälsa och

förändringen i självrapporterad hälsa även i de multipla regressionsmodellerna i vilka man justerar för confounders som ålder, socioekonomisk status, individuell inkomst, hushållsinkomst, civilstånd och rökning och stratifierar för kön. Design och analys av endast två observationer över tid gör att detta delarbete inte är en fullständig longitudinell paneldatastudie i epidemiologisk och statistisk mening. För detta krävs observationer vid minst tre olika tidpunkter (gärna flera).

Det andra delarbetet är den enda tvärsnittsstudien. Studien är en multipel flernivåanalys i statistikprogrammet MLwiN i tre nivåer med individer (förstanivån), hushåll (andranivån) och geografiskt område (tredjenivån) av sambandet mellan olika mått på socialt kapital på respektive nivå (individnivå samt aggregerade individdata på nivåerna två och tre) och självrapporterad hälsa på individnivå. Resultaten visar att huvuddelen av variansen i självrapporterad hälsa förklaras av socialt kapital på individnivå respektive hushållsnivå, medan endast en mycket liten del av variansen observeras på den geografiska områdesnivån (tredjenivån). Den geografiska nivån har analyserats i många studier på grund av den vanligt förekommande tillgången på geografisk information, medan hushåll som social kontext inte kunnat analyseras av brist på information om denna sociala kontext i enkätbaserade data som samtidigt innehåller information om självrapporterat socialt kapital.

I det tredje delarbetet undersöks sambandet mellan socialt kapital och självrapporterad hälsa i en longitudinell studie med paneldatadesign med fyra observationstillfällen vid olika tidpunkter under perioden 2000-2007. Delarbetet undersöker hur socialt kapital vid tidpunkten (t-1) är relaterad till självrapporterad hälsa vid tidpunkten (t). Alla analyser i delarbetet är genomförda med multipel logistisk regression i GLLAMM version 2.3.15 inom statistiskprogrammet STATA. Resultaten indikerar att framför allt socialt kapital i form av generaliserad tillit till andra människor vid tidpunkten (t-1) har signifikant samband med självrapporterad hälsa vid tidpunkten (t). Vissa statistiskt signifikanta samband observeras också mellan de andra socialt kapital variablerna socialt deltagande respektive samtal med grannar och självrapporterad hälsa, även om inte alla samband är signifikanta för dessa två senare variabler och storleken på de signifikanta sambanden (effektmåtten) är mindre än för tillit. I diskussionen diskuteras med utgångspunkt i samhällsvetenskaplig, folkhälsovetenskaplig och socialmedicinsk litteratur begreppet tillit och dess tänkbara betydelse för hälsa i termer av kausala mekanismer.

Utgångspunkten för det fjärde delararbetet är att det nästan inte finns några studier av socialt kapital och hälsa som kontrollerat för gener och gemensam miljö (shared environment), som också innefattar gemensam social miljö), trots att det

finns mer än tusen empiriska internationella studier av socialt kapital och hälsa. Artikeln undersöker sambandet mellan aspekter av socialt kapital som generaliserad tillit till andra människor respektive socialt deltagande och självrapporterad hälsa i en longitudinell flernivåregressionsanalys med Generalized Estimating Equations (GEE) med kvasiexperimentell familjebaserad design i statiskprogrammet STATA. I delarbetena 1-3 var framför allt sambandet mellan tillit och självrapporterad hälsa starkt både i termer av statistisk signifikans och storleken på effektmåtten. Resultatet av det fjärde delarbetet indikerar att när hänsyn tages till hushåll i analyserna av sambanden mellan tillit och självrapporterad hälsa sjunker oddskvoten för dålig självrapporterad hälsa vid låg tillit från 1,29 (1,21-1,37 95% konfidensintervall) till 1,11 (1,02-1,20 95% konfidensintervall).

Denna avhandling har bidragit till den internationella litteraturen genom analys av fullständiga paneldata med minst tre observationspunkter över tiden, genom att analysera betydelsen av hushåll som en kontext med relevans för sambandet mellan socialt kapital och självrapporterad hälsa i flernivåanalyser och genom en analys av betydelsen av gemensam miljö (shared environment) för sambandet mellan socialt kapital och självrapporterad hälsa. Tillit är den aspekt av socialt kapital som genomgående har signifikant samband med självrapporterad hälsa. Brist på tillit innebär ökad risk för sämre hälsa. När vi tar hänsyn till gemensam miljö försvagas sambandet mellan tillit och självrapporterad hälsa

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The impact of changes in different aspects of social capital and material conditions on self-rated health over time: A longitudinal cohort study

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ABSTRACT

Individual aspects of social capital have been shown to have significant associations with health outcomes. However, research has seldom tested different elements of social capital simultaneously, whilst also adjusting for other well-known health determinants over time. This longitudinal individual-level study investigates how temporal changes in social capital, together with changes in material conditions and other health determinants affect associations with self-rated health over a six year period. We use data from the British Household Panel Survey, a randomly selected cohort which is considered representative of the United Kingdom's population, with the same individuals ($N = 9303$) providing responses to identical questions in 1999 and 2005. Four measures of social capital were used: interpersonal trust, social participation, civic participation and informal social networks. Material conditions were measured by total income (both *individual* and weighted *household* income), net of taxation. Other health determinants included age, gender, smoking, marital status and social class. After the baseline sample was stratified by health status, associations were examined between changes in health status and changes in all other considered variables. Simultaneous adjustment revealed that inability to trust demonstrated a significant association with deteriorating self-rated health, whereas increased levels of social participation were significantly associated with improved health status over time. Low levels of *household* and *individual* income also demonstrated significant associations with deteriorating self-rated health. In conclusion, it seems that interpersonal trust and social participation, considered valid indicators of social capital, appear to be independent predictors of self-rated health, even after adjusting for other well-known health determinants. Understandably, how trust and social participation influence health outcomes may help resolve the debate surrounding the role of social capital within the field of public health.

Introduction

The idea that levels of social cohesion can influence individuals' health status is not new; it was the social scientist Émile Durkheim (1897/1951) who first suggested links between individual health and social cohesion in his study of suicide. It took other social scientists, namely James Coleman (1988, 1990) and Pierre Bourdieu (1998), and the political scientist Robert Putnam (1993a) to bring fresh attention to what is known today as *social capital*, a term defined as "social networks and norms of reciprocity" (Putnam, 2004). Social capital is considered a subset of social cohesion, its indicators being levels of trust, reciprocity and social participation (Berkman & Kawachi, 2000).

Studies by Kawachi et al. (Kawachi, Kennedy, & Glass, 1999; Kawachi, Kennedy, Lochner, & Prothrow-Stith, 1997) placed the concept of social capital squarely within the realm of public health and epidemiological research. Their results demonstrated a quantifiable association between social capital and mortality and morbidity. Suggested causal pathways as to how social capital could influence health included via psychosocial mechanisms, reducing "deviant" behaviours such as drinking, smoking and crime, increased dissemination of positive health messages and behaviours, and maintaining access to local services and amenities (Kawachi et al., 1999). Despite vast amounts of research over the past decade, academic debate surrounding social capital and its association with individual health outcomes has yet to be resolved (Hawe & Shiell, 2000; Muntaner, 2004; Pearce & Davey Smith, 2003; Szreter & Woolcock, 2004). Debate possibly stems from the etymology of the term "social capital" and that the different disciplines of social and political science, public health and epidemiology are all vying for

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plausible explanations of the same phenomenon. It is not surprising, therefore, to still find disagreement among scholars as to how individual attributes of social capital (trust, reciprocity, social networks and participation) contribute to health outcomes.

To expand and clarify, association between social isolation and increased risk of morbidity and mortality has been well researched in the field of social science for over a century (Berkman & Syme, 1979; Durkheim, 1897/1951; Lasker, Egolf, & Wolf, 1994; Pennix et al., 1997), so it stands to reason that attributes of social capital which act to reduce social isolation, such as informal social networks and social participation, must also be considered essential for general well-being. However, lack of distinction between well established social cohesion ideologies and these indicators of social capital generated the "old wine in new bottles" debate (Lochner, Kawachi, & Kennedy, 1999).

Coleman (1990) and Putnam (1993b, 2000) suggested that although trust and social participation were different aspects of social capital, they were somehow correlated. By further postulating that increasing levels of social participation could also increase levels of interpersonal trust, Putnam strived to illustrate how the concept of social capital could contribute something new to current social cohesion hypotheses. One would expect to see strong associations between trust and social participation if this were the case, however, research has shown that the association may be weaker than previously thought (Lindström, 2004a; Stolle, 2001). This reflects elements of Fukuyama's work *The Great Disruption* (1999) and his ideas of "the miniaturisation of community", whereby the distinction is made between the quantity and quality of social participation regarding the generation of interpersonal trust. The hypothesis being that without quality local social participation there can be no gains in interpersonal trust within the community; *ipso facto*, without gains in trust, there is neither an increase in social capital nor any of its potential health benefits. Recent studies conducted in the county of Skåne, southern Sweden seem to support Fukuyama's hypothesis, demonstrating that high levels of social participation, coupled with low levels of interpersonal trust, are significantly associated with poorer health-related behaviours at the individual level, such as high alcohol consumption (Lindström, 2005a, 2005b), smoking tobacco and cannabis (Lindström, 2003, 2004b) and other drug use (Johnell et al., 2006) – the same deviant behaviours high levels of social capital are meant to deter (Kawachi et al., 1999).

Interpersonal trust has been well researched at both the individual and community levels (Kawachi et al., 1997; Kim, Subramanian, Gortmaker, & Kawachi, 2006; Poortinga, 2006). Results demonstrate an independent association between trust and health outcomes, but beg the question as to which causal pathways are at work to achieve this phenomenon.

Another aspect to consider is the standpoint of the "neo-materialist". Social and economic status have long been recognised as important determinants of health (Townsend & Davidson, 1982); it is the belief of neo-materialists that inequalities in health are determined solely by inequalities in access to material resources such as money, food, clean drinking water, safe housing, medicines, healthcare workers, etc. Even in higher income countries with long histories of wealth and stable, egalitarian government this is still considered the case. In the United Kingdom (UK) for example, health gradients exist even when looking at individuals with similar access to material resources well above considered levels of deprivation (Marmot, Bosma, Hemingway, Brunner, & Stansfeld, 1997). One possible reason for the gradient's existence is explained via the psychosocial interpretation using Wilkinson's hypothesis of perception of income inequalities, stress and health outcomes (Wilkinson, 1996, 1999). This hypothesis also allows for the possibility of a link in the causal chain from *perceived* inequality of material conditions to poor health outcomes via depletion of elements of social capital, namely interpersonal trust (Kawachi et al., 1997).

From the above, it is easy to understand why academic debate surrounding social capital's role in health outcomes remains unresolved; indicators of social capital and material indicators all have been successfully argued to influence individual health outcomes. As to how social capital (measured by its constituent parts) stands up to direct comparison with relative material conditions over time while examining health outcomes requires further exploration.

There is also disagreement as to which "level" (community or individual) measurements of social capital should be taken (Macinko & Starfield, 2001). Kawachi et al. (Kawachi et al., 1999; Kawachi et al., 1997) empirically demonstrated that social capital effects measured at the community level were associated with health outcomes and subsequently labelled it an "ecological characteristic" (Lochner et al., 1999). However, there is still disparity as to whether ecological results from the aforementioned research are in fact due to uncontrolled individual-level data, such as levels of generalised trust and social interaction (Poortinga, 2006). This longitudinal study examines individual-level data reflecting the belief that social capital, although a contextual phenomenon, works through – and, therefore, belongs at – the individual level (Bourdieu, 1998; Coleman, 1990; Portes, 1998). This study aims to explore changes in self-rated health, material conditions and indicators of social capital (namely interpersonal trust, informal networks and social and civic participation); these different elements, along with other known health determinants, shall be tested simultaneously in an attempt to further research this field.

Methods

Data collection

The British Household Panel Survey (BHPS) is a longitudinal survey of randomly selected private households conducted by the UK's Economic and Social Research Centre. Since 1991, individuals within selected households have been interviewed annually with a view to identifying social and economic changes within the British population. The original cohort sample was randomly selected by using a two stage cluster design, full details of which can be found online (Taylor, Brice, Buck, & Prentice-Lane, 2007). A total of 8166 private postal addresses around the UK were selected and 10 264 individual interviews were completed in 1991, demonstrating a participation rate of 95%. The Research Centre fully adopted the Ethical Guidelines of the Social Research Association, which conform to those of the International Statistical Institute. Informed consent was obtained from all participants and strict confidentiality protocols were adhered to throughout data collection and processing procedures. The raw data that have been used for this longitudinal study come from BHPS individual-level responses in years 1999 (Wave ten) and 2005 (Wave fifteen). It is possible to track individuals from year to year using their unique personal identity number, thus ensuring that the same individuals have responded to the same questions in both time periods. Participation rates for Wave ten and fifteen compared to the previous year were 93.6% and 93.0%, respectively.

Dependent variable

The dependent variable of this study is change in people's self-rated health status. Self-rated health has been repeatedly found to be a valid predictor of mortality and morbidity (Idler & Benyamini, 1997; Lopez, 2004). In 1999 and 2005, the same individuals were asked: "Would you say that your health has on the whole been

excellent, good, fair, poor or very poor?" This five-point scale was recoded into the dichotomous variable "good" (excellent, good) and "poor" (fair, poor, very poor) health. It was possible to combine responses to create a new variable demonstrating change over time for self-rated health. The newly created variable had four potential outcomes: (i) Still good health; (ii) Now good health; (iii) Now poor health; (iv) Still poor health (see Fig. 1). Change in health status was defined as those whose health had deteriorated over time ("Now poor health") and those whose health had improved ("Now good health").

Independent variables

"Social capital" variables

Interpersonal trust was assessed by asking people: "Generally speaking, would you say that most people can be trusted, or that you can't be too careful?" Those respondents who stated that most people could be trusted were labelled "Can trust others"; all other responses were labelled "Can't trust others".

Levels of social participation within the community were measured by asking the respondents questions about being active members of (i) local community groups, (ii) local voluntary organisations, or (iii) any sports, hobby or leisure group. Those who answered positively to any one of these elements were judged to participate.

Use of informal social networks was established by asking respondents' frequency of "Meeting with friends" and "Talking with neighbours". Possible responses were: "Most days, once or twice a week, once or twice a month, less than once a month, or never". Those answering "most days" or "once or twice a week" were assigned the label "two or more times per week", the rest were assigned the label "less often".

Civic participation was measured by the respondents' answer to the question "Did you vote in the last general election?" Only a positive answer was assigned the label "Yes"; negative answers were labelled "No".

As with self-rated health, responses from 1999 and 2005 were combined to create "change over time" variables for the above measures of social capital.

"Material conditions" variables

Household and individual income levels were used as measures of material conditions and were stratified into quartiles using the software package SPSS version 15.0 (Norusis, 2006). Household income was weighted according to size by summing the income of all household members and dividing this sum by the square root of the household size (Burkhauser, Smeeding, & Merz, 1996). Both household and individual income levels were expressions of total income, net of taxation. Respondents whose answers placed them in the lowest quartile for either household or individual-level income were labelled "lowest income". All other quartiles were considered "higher income". Change over time variables were created by combining answers from the two time frames, as before.

Potential confounders

Baseline social class, derived from the Registrar General's Social Classification of occupations, age, gender, smoking and marital status were considered potential confounders in this study. Age was stratified into quartiles (see Tables 1 and 2), but was kept continuous in multivariate regressions (see Table 3) to reduce possible residual confounding. Change over time variables in smoking and marital status were also created.

Statistical analyses

Table 1 shows frequencies and total percentages of all variables at 1999 baseline, stratified for health status, derived from Wave ten of BHPS. From these data, two separate cohorts were identified, baseline "good health", and baseline "poor health". Those with "good health" in 1999 either remained healthy in 2005 or their health deteriorated. Similarly, those with "poor health" at baseline either remained in poor health or their health improved.

Two separate univariate logistic regression models were run with a view to examining changes in health status over time within these two "health" cohorts (see Table 2). Each independent "change over time" variable was run against the dependent variable "Change in self-rated health" using the statistical software package SPSS 15.0 (Norusis, 2006). The results are presented in Table 2 as prevalence (%) and odds ratios (ORs) with 95% confidence intervals (95% CI). The prevalence percentage demonstrates those individuals whose health status had changed within each outcome investigated.

Two multivariate logistic regression models were also run, adjusting simultaneously for all significant variables using the same statistical software. Non-significant variables from the univariate analyses (i.e. $p \geq 0.05$) were excluded. Results from the multivariate models are presented in Table 3 as ORs with 95% CI. The authors repeated the multivariate analyses having recoded self-rated health as "good" (excellent, good and fair) and "poor" (poor, very poor) to test the sensitivity of the dependent variable and the overall results' robustness.

Results

Univariate analysis – now poor health

The crude unadjusted results in Table 2 reveal that a persistent (1999–2005) inability to trust over time ("Still can't trust

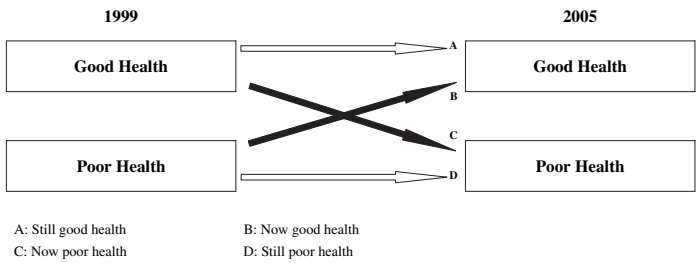

Fig. 1. An illustration of how four outputs (A–D) are created from two sets of dichotomised data derived from 1999 and 2005, using "Self-rated health" as an example.

Table 1
Baseline frequencies of all considered variables expressed as integers and percentages of total ($N_t = 9303$) stratified by self-rated health status in 1999.

	Baseline health status		Total
	Good health	Poor health	
Gender			
Male	3013	1162	4175
	32.4%	12.5%	44.9%
Female	3511	1617	5128
	37.7%	17.4%	55.1%
Total	6524	2779	9303
	70.1%	29.9%	100.0%
Age (years)			
16–34	1454	455	1909
	15.6%	4.9%	20.5%
35–44	1473	482	1955
	15.8%	5.2%	21.0%
45–54	1285	459	1744
	13.8%	4.9%	18.7%
55–64	1043	561	1604
	11.2%	6.0%	17.2%
65+	1269	822	2091
	13.6%	8.8%	22.5%
Total	6524	2779	9303
	70.1%	29.9%	100.0%
Individual income (annual) in quartiles			
£5017 or less	1519	808	2327
	16.3%	8.7%	25.0%
£5018–£10 002	1435	890	2325
	15.4%	9.6%	25.0%
£10 003–£17 024	1689	635	2324
	18.2%	6.8%	25.0%
£17 025 or more	1881	446	2327
	20.2%	4.8%	25.0%
Total	6524	2779	9303
	70.1%	29.9%	100.0%
Household income (annual) in quartiles – equivalence weighted			
£14 376 or less	1319	1006	2325
	14.2%	10.8%	25.0%
£14 377–£25 248	1579	749	2328
	17.0%	8.1%	25.0%
£25 249–£38 148	1750	574	2324
	18.8%	6.2%	25.0%
£38 149 or more	1876	450	2326
	20.2%	4.8%	25.0%
Total	6524	2779	9303
	70.1%	29.9%	100.0%
Trust in others (horizontal)			
Yes, can trust others	2711	834	3545
	29.1%	9.0%	38.1%
No, can't trust others	3813	1945	5758
	41.0%	20.9%	61.9%
Total	6524	2779	9303
	70.1%	29.9%	100.0%
Social class: derived from RGSC occupation-based schema			
SC I professional	300	120	420
	3.2%	1.3%	4.5%
SC II	1869	724	2593
	20.1%	7.8%	27.9%
SC III non-manual	1498	674	2172
	16.1%	7.2%	23.3%
SC III manual	1184	510	1694
	12.7%	5.5%	18.2%
SC IV	1166	526	1692
	12.5%	5.7%	18.2%
SC V unskilled – manual	365	164	529
	3.9%	1.8%	5.7%

(*continued on next page*)

Table 1 (*continued*)

	Baseline health status		Total
	Good health	Poor health	
Total	6382	2718	9100[a]
	68.6%	29.2%	97.8%
Social participation: membership of local groups, voluntary organisations or group leisure activities			
Active participation	3132	1063	4195
	33.7%	11.4%	45.1%
Zero participation	3379	1707	5086
	36.3%	18.3%	54.7%
Total	6511	2770	9281[b]
	70.0%	29.8%	99.8%
Social networks: frequency of meeting with friends			
Two or more times per week	5569	2389	7958
	59.8%	25.7%	85.5%
Less frequent than this	954	389	1343
	10.3%	4.1%	14.4%
Total	6523	2778	9301[c]
	70.1%	29.9%	100.0%
Social networks: frequency of talking with neighbours			
Two or more times per week	5025	2160	7185
	54.0%	23.2%	77.2%
Less frequent than this	492	619	2111
	16.0%	6.7%	22.7%
Total	6517	2779	9296[d]
	70.1%	29.9%	99.9%
Civic participation: voted in the latest general election			
Yes, voted	4758	2036	6794
	51.1%	21.9%	73.0%
No, did not vote	1685	700	2385
	18.1%	7.5%	25.6%
Total	6443	2736	9179[e]
	69.3%	29.4%	98.7%
Marital status			
Married	3811	1578	5389
	41.0%	17.0%	57.9%
Not married	2713	1201	3914
	29.2%	12.9%	42.1%
Total	6524	2779	9303
	70.1%	29.9%	100.0%
Smoking status			
Smoker	1510	897	2407
	16.2%	9.6%	25.9%
Non-smoker	5011	1880	6891
	53.9%	20.2%	74.1%
Total	6521	2777	9298[f]
	70.1%	29.9%	99.9%

Source: the British Household Panel Survey Wave J, 1999.
[a] Missing Value $N = 203$.
[b] Missing Value $N = 22$.
[c] Missing Value $N = 2$.
[d] Missing Value $N = 7$.
[e] Missing Value $N = 124$.
[f] Missing Value $N = 5$.

others'') and an acquired inability to trust over time (''Now can't trust others'') are both strongly associated with an increased risk of deteriorating health. An acquired ability to trust also seems to be associated with an increased risk of deteriorating health.

All outcomes demonstrating ''change over time'' for *household* income are associated with an increased risk of deteriorating self-rated health.

A persistently low *individual* income, and those whose *individual* income had declined to the lowest quartile by 2005, are associated with an increase risk of deteriorating self-rated health.

Regarding social participation, deteriorating health appears to be most strongly associated with those who ''Still do not participate'' in local groups or organisations.

The frequency of talking with one's neighbours and baseline social class show no significant association with deteriorating

Table 2
Prevalence (%) and odd ratios (ORs) with 95% confidence intervals (95% CI) of deteriorating and improved self-rated health between 1999 and 2005 according to univariate analysis of "change over time" variables in social capital, material conditions and potential confounders ($N_t = 9300$).

"Change over time" variables	Change in self-rated health status in 2005			
	Now poor health ($N = 6522$)		Now good health ($N = 2778$)	
	Prevalence (%)	ORs (95% CI)	Prevalence (%)	ORs (95% CI)
Age (years)				
16–34	15.9	1.0	58.2	2.651 (2.095–3.355)***
35–44	15.9	1.000 (0.820–1.219)	47.9	1.750 (1.391–2.201)***
45–54	17.9	1.154 (0.945–1.410)	38.3	1.182 (0.933–1.498)
55–64	16.2	1.025 (0.825–1.273)	37.6	1.146 (0.917–1.433)
65+	28.2	2.075 (1.722–2.500)***	34.5	1.0
Gender				
Male	18.1	1.0	45.7	1.303 (1.119–1.518)**
Female	19.3	1.081 (0.954–1.225)	39.3	1.0
Individual income (quartiles)				
Still higher income	17.0	1.0	44.9	1.451 (1.174–1.793)**
Now lowest quartile	24.8	1.615 (1.323–1.970)***	35.4	0.972 (0.734–1.289)
Now higher income	19.1	1.158 (0.940–1.427)	43.8	1.388 (1.042–1.848)*
Still lowest quartile	23.1	1.468 (1.229–1.754)***	36.0	1.0
Household income – size weighted (quartiles)				
Still higher income	15.8	1.0	46.4	1.704 (1.407–2.062)***
Now lowest quartile	25.5	1.826 (1.496–2.230)***	42.4	1.447 (1.082–1.937)*
Now higher income	20.5	1.373 (1.101–1.712)**	37.1	1.161 (0.878–1.536)
Still lowest quartile	28.9	2.163 (1.821–2.570)***	33.7	1.0
Social class: derived from occupation-based RGSC schema at baseline				
SC I-professional	20.0	1.0[a]	38.3	0.923 (0.570–1.495)
SC II	16.9	0.814 (0.598–1.107)	41.3	1.045 (0.740–1.476)
SC III non-manual	19.3	0.956 (0.701–1.304)	44.5	1.191 (0.842–1.685)
SC III manual	18.8	0.924 (0.672–1.270)	42.9	1.117 (0.781–1.598)
SC IV	19.4	0.962 (0.700–1.322)	40.6	1.014 (0.709–1.449)
SC V unskilled	21.9	1.123 (0.771–1.636)	40.2	1.0[b]
Interpersonal trust				
Still trusts others	12.8	1.0	50.1	1.576 (1.289–1.926)***
Now can't trust others	21.6	1.872 (1.514–2.315)***	41.5	1.114 (0.876–1.416)
Now can trust others	18.4	1.534 (1.227–1.919)***	46.1	1.341 (1.039–1.730)*
Still can't trust others	21.7	1.882 (1.601–2.212)***	38.9	1.0
Social participation: membership of local groups, voluntary organisations or group leisure activities				
Still participates	15.7	1.0[c]	49.3	1.818 (1.496–2.209)***
No longer participates	19.5	1.299 (1.058–1.596)*	43.1	1.414 (1.097–1.821)**
Now participates	18.7	1.232 (1.041–1.457)*	44.2	1.479 (1.214–1.802)***
Still doesn't participate	22.3	1.533 (1.309–1.797)***	34.9	1.0[d]
Social networks: meets with friends (two or more times per week)				
Still meets as often	18.6	1.0[e]	42.4	0.944 (0.667–1.338)
Now meets less often	22.5	1.270 (1.019–1.583)*	40.7	0.881 (0.579–1.342)
Now meets more often	16.8	0.884 (0.708–1.105)	38.9	0.817 (0.536–1.245)
Still meets less often	18.6	1.002 (0.754–1.332)	43.8	1.0[f]
Social networks: talks with neighbours (two or more times per week)				
Still talks as often	19.0	1.0[g]	42.0	0.838 (0.697–1.009)
Now talks less often	20.8	1.126 (0.923–1.374)	38.8	0.852 (0.670–1.082)
Now talks more often	17.4	0.903 (0.743–1.097)	44.9	1.088 (0.871–1.359)
Still talks less often	16.7	0.855 (0.688–1.063)	41.2	1.0[h]
Civic participation: (voted in latest election)				
Still votes	18.2	1.0[i]	40.8	0.909 (0.732–1.129)
No longer votes	21.5	1.231 (1.002–1.512)*	42.5	0.974 (0.724–1.312)
Now votes	18.9	1.048 (0.857–1.281)	47.7	1.199 (0.885–1.626)
Still doesn't vote	18.3	1.011 (0.842–1.214)	43.2	1.0[j]

(*continued on next page*)

Table 2 (*continued*)

"Change over time" variables	Change in self-rated health status in 2005			
	Now poor health ($N = 6522$)		Now good health ($N = 2778$)	
	Prevalence (%)	ORs (95% CI)	Prevalence (%)	ORs (95% CI)
Marital status				
Still married	17.5	1.0[k]	41.7	1.005 (0.855–1.181)
Now unmarried	27.4	1.772 (1.347–2.332)***	37.6	0.846 (0.599–1.195)
Now married	14.0	0.763 (0.574–1.014)	52.0	1.522 (1.080–2.145)*
Still unmarried	20.4	1.205 (1.054–1.377)**	41.6	1.0
Smoking status				
Still a non-smoker	16.8	1.0[l]	44.9	1.513 (1.264–1.811)***
Now a smoker	19.1	1.170 (0.795–1.722)	40.3	1.252 (0.751–2.090)
Now a non-smoker	24.3	1.593 (1.237–2.052)***	40.9	1.282 (0.921–1.784)
Still a smoker	25.2	1.670 (1.433–1.946)***	35.0	1.0[m]

Source: the British Household Panel Survey, Waves J & O (1999 and 2005).
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Reference group = 1.0.
[a] Missing $N = 141$.
[b] Missing $N = 61$.
[c] Missing $N = 13$.
[d] Missing $N = 9$.
[e] Missing $N = 1$.
[f] Missing $N = 1$.
[g] Missing $N = 7$.
[h] Missing $N = 63$.
[i] Missing $N = 103$.
[j] Missing $N = 53$.
[k] Missing $N = 1$.
[l] Missing $N = 3$.
[m] Missing $N = 2$.

health. Regarding the frequency of meeting with friends, only the subgroup "Now meets less often" demonstrates association with deteriorating health. Similarly regarding civic participation, only the subgroup "No longer votes" is associated with an increased risk of deteriorating health.

Univariate analysis – now good health

Regarding trust, "Still trusts others" and "Now can trust others" are significantly associated with improved health.

Those whose *individual* income has increased over time, or remained high demonstrate improved health in 2005. Persistently high *household* income levels and a decrease in *household* income over time are significantly associated with better health in 2005.

Improved health is associated with social participation but not associated with any aspects of use of social networks, civic participation or baseline social class.

Multivariate analysis – now poor health

Following simultaneous adjustment for all significant variables and potential confounders, all ORs are reduced. The variables still demonstrating the greatest ORs with statistical significance for deteriorating health ($p < 0.001$) are interpersonal trust, age and smoking status. ORs are greatly diminished for both measures of *household* and *individual* income, with only persistently low and "Now lowest" income measures remaining significantly associated with deteriorating health.

Regarding "Social participation", no significant associations remain with deteriorating health. The outcome "Now meets less often" with friends is still associated with an increased risk in deteriorating health. Similarly, the association for the outcome "No longer votes" also remains.

Dissolution of marriage is associated with an increased risk of deteriorating health.

Multivariate analysis – now good health

"Still trusts others" maintains its significant association with improved health. All aspects of *individual* and *household* income show no significant association with improved health over time. Maintaining levels of social participation and an acquired ability to participate are significantly associated with improved health.

Being male, younger in age and remaining a non-smoker are all strongly associated with improved self-rated health.

Discussion

The aim of this longitudinal study was to compare any associations that changes in different indicators of social capital, material conditions and other well-known health determinants had on changes in health outcomes over a six year period. Running all significant variables simultaneously within multivariate models revealed that the social capital indicators "Interpersonal trust" and "Social participation" maintained their highly significant association with changes in self-rated health over time. Most other indicators of social capital were rendered insignificant. Persistently low and "Now lowest" *household* and *individual* income also demonstrated a significant association with deteriorating self-rated health.

It is interesting to note that interpersonal trust and social participation seem to affect health outcomes differently; trust is most strongly associated with deteriorating health over time, whereas social participation is only associated with improved health (see Table 3). All other indicators of social capital considered in this study show no association with self-rated health, apart from subgroups "Now meets less often" and "No longer votes". This serves to reiterate the hypothesis of a weaker than expected correlation between differing indicators of social capital (Lindström, 2004a; Stolle, 2001). It also goes some way to explain past difficulties in attempting to understand causal mechanisms involved between measures of social capital and health outcomes. As social capital is usually defined (and

Table 3
Odd ratios (ORs) with 95% confidence intervals (95% CI) of deteriorated and improved self-rated health between 1999 and 2005 within multivariate logistic regression models containing all significant "change over time" variables in social capital, material conditions and potential confounders ($N_t = 9168$[a]).

"Change over time" variable	Change in health status over time	
	Now poor health ($N = 6401$)[b]	Now good health ($N = 2767$)[c]
	ORs (95% CI)	ORs (95% CI)
Age (years)		
Continuous	1.019 (1.014–1.024)***	0.979 (0.973–0.984)***
Gender		
Male	NS	1.266 (1.071–1.497)**
Female	NS	1.0
Individual income (quartiles)		
Still higher income	1.0	1.161 (0.919–1.468)
Now lowest quartile	1.275 (1.029–1.581)*	0.902 (0.674–1.208)
Now higher income	1.194 (0.952–1.497)	1.120 (0.824–1.521)
Still lowest quartile	1.222 (1.006–1.485)*	1.0
Household income – size weighted (quartiles)		
Still higher income	1.0	1.082 (0.857–1.365)
Now lowest quartile	1.399 (1.124–1.742) **	1.152 (0.847–1.567)
Now higher income	1.101 (0.871–1.393)	0.858 (0.634–1.160)
Still lowest quartile	1.292 (1.040–1.604) *	1.0
Interpersonal trust		
Still trusts others	1.0	1.369 (1.106–1.694)**
Now can't trust others	1.646 (1.318–2.055)***	1.127 (0.878–1.446)
Now can trust others	1.486 (1.179–1.873)**	1.274 (0.978–1.660)
Still can't trust others	1.744 (1.471–2.067)***	1.0
Social participation: member of local groups, voluntary organisations or group leisure activities		
Still participates	1.0	1.560 (1.266–1.923)***
No longer participates	1.149 (0.924–1.430)	1.206 (0.927–1.568)
Now participates	1.131 (0.948–1.350)	1.269 (1.032–1.561)*
Still doesn't participate	1.173 (0.986–1.395)	1.0
Social networks: meets with friends (two or more times per week)		
Still meets as often	1.0	NS
Now meets less often	1.316 (1.046–1.657)*	NS
Now meets more often	0.896 (0.711–1.128)	NS
Still meets less often	1.056 (0.785–1.421)	NS
Civic participation: (voted in last election)		
Still votes	1.0	NS
No longer votes	1.244 (1.001–1.545)*	NS
Now votes	1.203 (0.965–1.500)	NS
Still doesn't vote	1.072 (0.871–1.319)	NS
Marital status		
Still married	1.0	0.958 (0.795–1.155)
Now single	1.388 (1.031–1.867)*	0.840 (0.586–1.204)
Now married	0.967 (0.717–1.304)	1.078 (0.749–1.553)
Still single	1.127 (0.965–1.316)	1.0
Smoking status		
Still a non-smoker	1.0	1.690 (1.388–2.058)***
Now a smoker	1.286 (0.859–1.924)	1.056 (0.623–1.791)
Now a non-smoker	1.660 (1.274–2.163)***	1.366 (0.970–1.925)
Still a smoker	1.652 (1.397–1.954)***	1.0

Source: the British Household Panel Survey, Waves J & O (1999 and 2005).
*0.05 significance; **0.01 significance; ***0.001 significance.
Reference group = 1.0.
NS = Not significant in univariate model.
[a] Missing = 132.
[b] Missing = 121.
[c] Missing = 11.

subsequently measured) by many differing components such as variables explored in this study, it has proved prudent to have used longitudinal data within multivariate regression models to weed out those redundant components that seem to have little or no association with change in individual health outcomes over time.

Social capital and health

Previous hypotheses as to how social capital influences health outcomes include proposals by House, Landis, and Umberson (1988) and later by Berkman (1995) that higher levels of trust promote social networks, which in turn influences health; another similar proposal by Anheier and Kendall (2002) states that high trust levels derived from interaction with family and friends enables one to participate more at a social and civic level than those who do not trust, again influencing health. Rothstein and Stolle (2003) go so far as to state that trust is possibly a prerequisite to social participation, as individuals with high levels of interpersonal trust "self-select" into voluntary organisations and groups. Other works, including Putnam's (2000) heavily cited "Bowling Alone" and numerous

studies (Dalgard & Haheim, 1998; Greiner, Li, Kawachi, Hunt, & Ahluwalia, 2004; Lindström, Hanson, & Östergren, 2001) all imply that active participation is strongly associated with positive individual health outcomes.

This study's results also demonstrate that increased and maintained levels of social participation, along with maintained high trust levels, are associated with health improvement. However, that this study further shows low trust levels to be associated with deteriorating health implies that aspects of social capital may act upon different causal pathways in relation to health outcomes.

Our theory as to how this occurs is thus: trust could influence health outcomes the most via psychosocial pathways, whereas social participation could mainly affect health outcomes via social support mechanisms. As to how support mechanisms translate into positive health outcomes has been well researched and documented, however, psychosocial pathways as proposed by Wilkinson (1996) have been considered more contentious (Lynch, Davey Smith, Kaplan, & House, 2000).

Applying Wilkinson's hypothesis, high trust levels could be a reflection of low levels of perceived social stress and anxiety. Long-term exposure to stressors can, via the hypothalamic–pituitary–adrenal axis, lead to increased levels of blood cortisol over time (Shively, Musselman, & Willard, 2009). Chronically elevated cortisol levels have been linked to such deleterious health outcomes as major depression, type 2 diabetes, metabolic syndrome, cardio-vascular disease and stroke (Hemingway & Marmot, 1999; Rosmond & Björntorp, 2000; Watson & Mackin, 2006). If trust is accepted as an individual's expression of their community's level of social capital (Putnam, 2001), then it is feasible that those residing in communities with high levels of social capital may feel less anxious than those living in communities with lower social capital. Less anxious individuals may be less susceptible to the negative health outcomes previously mentioned. Levels of interpersonal trust may be a reflection of the crime rate in an area or could be a reflection of similar attitudes of reciprocation demonstrated by other community members in daily life. In reality, it may not be this simplistic. A multilevel study by Subramanian et al. (2002) concluded that if a community does not reflect an individual's own attitudes regarding trust and reciprocity, this can result in negative health outcomes. However, the psychosocial pathway still seems a plausible mechanism as to how an individual's perceptions of his/her sense of belonging in a community could translate into physiological changes affecting health. The psychosocial pathway could also explain the result that acquired ability to trust over time ("Now can trust") is also associated with deteriorating health (see Table 3). As chronic exposure implies exposure over long periods, this possibly reflects delay between exposure and outcome (i.e. although one has now acquired an ability to trust, health benefits may take much longer to show themselves).

The decline of social capital – a call to action

If trust and participation levels are possible independent predictors of health change, then their decline over the past couple of generations, as reported by Fukuyama and Putnam is indeed cause for concern. In "Bowling Alone", Putnam (2000) theorises that reduced group participation is a possible reason for the decline of individual trust levels across America. Fukuyama (1995, 1999) attributes present day low levels of trust to extreme perceptions of individualism, increased levels of crime, higher divorce rates and the subsequent destruction of the nuclear family.

This study has demonstrated that trust levels are associated with health deterioration and that active social participation is associated with health improvement. With this in mind, decision makers may consider a two-pronged approach when considering social capital's role in health policy; to *improve* the health of a population, social participation levels should be increased, and to *maintain* the good health of a population, individuals must be able to demonstrate high trust levels. There are many initiatives to increase social participation in communities but to build and maintain trust levels, both a top-down and bottom-up approach may be required. The top-down element requires state action to create and commit to policies which ultimately reduce inequalities in *opportunity* as well as wealth, with a view to not just reducing material inequality, a commonly argued cause of health inequality (Davey Smith, 1996) but also *perceived* levels of inequality, via which the psychosocial pathway is presumed to act (Wilkinson, 1996).

The bottom-up element requires individuals to understand how their behaviour and actions can inspire trust in others. The rising level of "individualism", as discussed by Fukuyama (1999), implies that the selfish fail to understand the benefits that simple acts of reciprocity can bring. Reciprocity perceived from a purely economic point of view, as a public good, provides no incentive to be "produced". However, economics also tells us that society places high value in public goods, due to the positive externalities (unintended benefits) they provide. For individuals to willingly contribute to the creation of a public good, they must be made aware that the rewards received exceed the individual costs incurred. One incentive to reciprocity is the generation of higher levels of interpersonal trust and all the positive health benefits this appears to bring.

Strengths and limitations

A major strength of this study is the fact that it is longitudinal, covering a six year time frame with a high number of individual respondents ($N = 9303$). The longitudinal data have allowed the creation of variables that uniquely demonstrate temporal changes in aspects of health, social capital and material conditions. These variables have been examined within multivariate models to enable simultaneous adjustment and comparison with each other whilst researching any associations. The fact that the data were obtained via interview rather than relying on postal questionnaires contributed to the very high participation rate of around 93%, year on year. Self-rated health is considered a valid and reliable indicator of mortality and morbidity. Although it is not possible to validate interpersonal trust, it is considered a proxy of social capital and has been used in numerous social capital research studies. Total income, net of any taxation, was used to assess material conditions; household incomes were weighted according to household size. No consensus as to how to measure social participation has been reached, therefore, simple frequencies of activity were used for this indicator of social capital. The authors' own sensitivity analyses (not published) confirm the robustness of this study's results.

A major limitation of this study is that the BHPS sample was originally selected to reflect the UK population as a whole and deliberately avoided oversampling of smaller communities and minority groups. Therefore, as a data set, it is not particularly valuable when looking at ethnic diversity or urban vs. rural populations. By 1999, only 62.0% of the original cohort members were able to answer the questions posed. The change in cohort composition would have introduced further selection bias into this study. Another limitation is that the data have, in essence, dictated the direction and extent of social capital research possible; many questions pertinent to social capital research (for example: generalised trust and levels of participation) either varied in content depending on the year investigated or were completely absent. This meant that only two waves were

deemed suitable to answer our research question, denying us a possible panel approach to our methodology.

Conclusion

Putnam (1993a) describes reciprocity as being vital for communities to achieve greater goals than would have been possible by the sum of their individual members. Putnam also implies that through repeated acts of reciprocity, interpersonal trust is generated. The results of this study reinforce the importance of interpersonal trust and social participation on health outcomes, but also highlight a possible lack of correlation between differing measures of social capital. That trust directly affects health outcomes and could even be a prerequisite to social participation implies that public health policies solely targeting participation without addressing other root causes of trust's decline, including inequalities of wealth and opportunity, may well be missing their mark.

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Paper II

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Social capital and health—Purely a question of context?

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ABSTRACT

Debate still surrounds which level of analysis (individual vs. contextual) is most appropriate to investigate the effects of social capital on health. Applying multilevel ecometric analyses to British Household Panel Survey data, we estimated fixed and random effects between five individual-, household- and small area-level social capital indicators and general health. We further compared the variance in health attributable to each level using intraclass correlations. Our results demonstrate that association between social capital and health depends on indicator type and level investigated, with one quarter of total individual-level health variance found at the household level. However, individual-level social capital variables and other health determinants appear to influence contextual-level variance the most.

1. Introduction

Having been introduced to the field of public health by Kawachi et al. (1999, 1997), social capital now seems to be an established health determinant. Social capital is theorised to positively influence health independently of other well-known determinants, including socio-economic status and behaviours such as smoking (d'Hombres et al., 2010; Fujiwara and Kawachi, 2008; Giordano and Lindström, 2010; Lochner et al., 2003; Schultz et al., 2008). However, many questions still surround this particular field, with the relevance of social capital on health outcomes often being contested by proponents stressing the importance of material conditions and public welfare policy (Muntaner, 2004; Pearce and Davey Smith, 2003).

To expand and clarify: numerous studies using an array of methodologies, demonstrate association between social capital measures and health (for a review of the literature see Islam et al., 2006). Social capital is considered a contextual phenomenon (Berkman and Kawachi, 2000). It cannot be directly observed or quantified, therefore individual-level proxies are commonly used instead, examples of which include: horizontal and vertical trust, social and civic participation, and perceived reciprocity. These proxies can be grouped into two social capital 'dimensions': a cognitive dimension (trust and norms of reciprocity) and a structural dimension (social networks and participation) (Harpham et al., 2002). As these dimensions are hypothesised to influence health via different pathways (Lindström, 2004; Nummela et al., 2008; Stolle, 2001; Giordano and Lindström, 2010), it is prudent to include at least one proxy from each dimension when investigating social capital and health.

There is, however, disparity among researchers regarding which *context* is most appropriate to investigate effects of social capital on health (Macinko and Starfield, 2001). This disparity stems mainly from lack of consensus regarding how one defines (and therefore conceptualises) social capital. Putnam (1993, p. 167) refers to social capital as 'features of social organisation, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions'. This definition implies that the 'collective level' is most appropriate for investigation of social capital effects. However, Portes (1998, p. 12) defines social capital as 'the capacity of individuals to command scarce resources by virtue of their membership in networks or broader social structures'. This definition justifies investigation of individual-level effects of social capital in health research.

Such diversity within the same field of research has certain repercussions: studies solely measuring individual-level social capital effects face criticism if they ignore potential contextual

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effects; conversely, studies that investigate only aggregated effects may be considered biased if they fail to adjust for individual-level social capital measures.

An obvious solution is to investigate both individual- and contextual-level social capital effects simultaneously (Poortinga, 2006a; Subramanian et al., 2002); however, this is not without its own issues. Individual-level social capital proxies are commonly aggregated to a context of interest, often a community-, state- or country-level. Yet these 'levels' are chosen more out of convenience and data availability than as accurate representations of individuals' day-to-day social interactions and networks. Social networks are an integral part of the definition of social capital (Coleman, 1990; Putnam, 1993; Portes, 1998; Berkman and Kawachi, 2000), so analysis of inappropriate contexts may fail to capture any effects. This point is clearly highlighted by interpretation of the intraclass correlation (ICC), often available in contextual studies. The ICC expresses the percentage of *total* variation in the dependent variable (in this case, self-rated health) attributable to the context being modelled (community, state or country). Similarities between individuals from the same context regarding the propensity for the outcome will result in a high ICC; the higher the ICC, the more important the context is for understanding variation in the individual outcome under investigation (Merlo et al., 2009).

In multilevel social capital studies, it is not uncommon to see that only 0–4% of *total* variation in individual health is attributable to the community, state or country context (for examples, see Fujisawa et al., 2009; Lindström et al., 2004; Poortinga, 2006b; Snelgrove et al., 2009). In response, researchers are seeking more relevant contexts in which to investigate the effects of social capital on health, one such example being the workplace (Oksanen et al., 2010; Suzuki et al., 2010). However, studies at this level can, by definition, only include working adults, and results are not easily extrapolated to general societal contexts.

Historically, generalised trust – considered a key social capital proxy – was often afforded only to individuals recognisable as members of a particular family in which high levels of trust were embedded 'collectively' (Coleman, 1990, p. 185). It has also been suggested that the family, a close proxy for the household in industrial and post-industrial western societies, still plays an important role in the formation of social capital (particularly societal 'norms' of trust and reciprocity) among future generations (Coleman, 1988). Furthermore, as members of the same household are more likely to perpetuate their own societal 'norms' irrespective of differing broader community 'norms' (Coleman, 1990, p. 603), we propose that the 'household' be considered an appropriate context to investigate social capital effects. There is no reason to believe that the maintenance and ongoing formation of trust in other people, trust in societal institutions, and the propensity to participate in civic and social activities are not affected by the close social context of the family and the household in which a person lives.

Though previous research has considered the household context as an influence on individual health, only measures of material conditions have been of interest thus far (for recent examples, see Aittomaki et al., 2010; Minh et al., 2010; Wong et al., 2010; Yang et al., 2009). To our knowledge, social capital measures clustered at the household level have yet to be investigated in health research. Furthermore, considering the debate surrounding the definition and conceptualization of social capital (see earlier), it seems necessary to investigate individual and contextual levels simultaneously. Therefore, the aim of this study is twofold: firstly, to investigate the strength of association (fixed effects) between five different proxies representing the two 'dimensions' of social capital on health at individual- and aggregated-levels, whilst adjusting for other health determinants; and secondly, to determine which context (household vs. small area-level) explains most of the variation (random effects) in individuals' self-rated health. We hypothesise that association between social capital and self-rated health will vary across the three levels investigated depending on the proxy, and that the household context will explain a greater amount of variation in individual-level health than geography alone.

2. Materials and methods

2.1. Data collection

The British Household Panel Survey (BHPS) is a survey of randomly selected private households, conducted by the UK's Economic and Social Research Centre. The raw data used for our study come from the BHPS 'Wave R' in 2008–2009. Datasets were merged to create the multilevel structure necessary for our investigation, and three 'levels' were identified: the individual-level ($N=10{,}992$), the household-level ($N=6201$) and the small area-level ($N=399$). Only household members who were 16 years of age or older could participate and the number of households containing singletons was around 14% ($N=1516$). The small area-level was defined by the postcode sector in which the household was located, one postcode sector typically containing 2500 households. Further details of the selection process, weighting and participation rates can be found on-line in the BHPS User manual (Taylor et al., 2010). The Research Centre fully adopted the Ethical Guidelines of the Social Research Association; informed consent was obtained from all participants and strict confidentiality protocols were adhered to throughout data collection and processing procedures.

2.2. Dependent variable

The dependent variable in this study is self-rated health. Self-rated health has been repeatedly found to be a valid predictor of mortality and morbidity (Idler and Benyamini, 1997). Respondents were asked: 'Compared to people your own age, would you say that your health over the past twelve months has been excellent, good, fair, poor or very poor?' These five outcomes were dichotomised into 'Good' (excellent/good) and 'Poor' (fair/poor/very poor) health. 'Good health' was the reference category (0) and the outcome of interest was 'Poor health' (1).

2.3. Independent variables

2.3.1. Social capital variables

Generalised (horizontal) trust was assessed by asking people: 'Generally speaking, would you say that most people can be trusted, or that you can't be too careful?' Those respondents who stated that most people could be trusted were labelled 'can trust'; all other responses (including 'it depends') were labelled 'can't trust'.

Social participation was measured by asking respondents questions about being *active* members of community groups or any sports, hobby or leisure group activity found locally. Only those who answered positively to any of these were judged to participate, with all others being labelled 'No participation'.

Unpaid voluntary work was considered a social capital measure separate to social participation; individuals who answered positively to undertaking unpaid voluntary work were judged to volunteer.

Perceived reciprocity was measured by asking respondents whether they could readily borrow items from neighbours. Those who agreed that they could were labelled 'high reciprocity'; all others were labelled 'low reciprocity'.

A further proxy for reciprocity, reflecting altruistic intentions at the small area-level was 'willingness to help improve one's neighbourhood'. Those who were willing were labelled 'Willing', all others being labelled 'Unwilling'.

The above individual-level social capital measures were also used to create contextual measures at the household- and small area-level. This was achieved using an ecometric approach, deriving 'shrunken' residuals from each individual social capital proxy for households and small areas (Merlo et al., 2005; Raudenbush and Sampson, 1999). The 'shrunken' residuals were then used as fixed-effect measures of contextual social capital in our multilevel analyses. The ecometric approach was considered superior to standard aggregation methods (on the mean or group mean-centred value) as it considers the number of individuals per cluster; residual values derived from households or small areas containing fewer individuals would be 'shrunk' greatest towards the mean value.

2.3.2. Considered health determinants

Age, gender, education attained, smoking and employment status, and total household income were included as well-known health determinants.

Education level was categorised as 'Undergraduate or higher', 'Year 12', 'Year 10' and 'No formal qualifications'.

Smoking status was categorised as 'smoker' and 'non-smoker' according to respondents' answer to the question 'Do you smoke cigarettes?'

Employment status was categorised as 'Employed', 'Retired', 'Fulltime student' or 'Unemployed'.

Household income was weighted according to size by summing the income of all household members and dividing this sum by the square root of the household size (Burkhauser et al., 1996). This item was maintained as a continuous variable per £1000 increase and was an expression of total income, net of any taxation. Age was also kept as a continuous variable to reduce possible residual confounding.

It was presumed that the presence of social capital, being younger, a non-smoker, attaining higher education and household income, and employment were associated with good self-rated health.

2.3.3. Statistical analyses

All multilevel analyses were conducted using the statistical software package MLwiN version 2.21 (Rasbash et al., 2010), to obtain both fixed- and random-effect estimates.

The fixed effects were converted to odds ratios (OR) with 95% 'credible intervals' (CI) derived from MCMC estimation techniques (Browne, 2009). The variance (random effects) from household- and small area-levels was used to estimate the ICC using the latent variable method (Snijders and Busker, 1999). This method assumes that the propensity for the outcome is a continuous latent variable underlying our binary response. The unobserved individual variable then follows a logistic distribution with individual variance equal to 3.29 ($\pi^2/3$). In a three level model there will be two ICCs calculated as shown below:

ICC for observations within the same household:

$$\frac{(\text{Variance}_{household})+(\text{Variance}_{small\ area})}{(\text{Variance}_{individual})+(\text{Variance}_{household})+(\text{Variance}_{small\ area})}$$

ICC for observations within the same small area but different households:

$$\frac{(\text{Variance}_{small\ area})}{(\text{Variance}_{individual})+(\text{Variance}_{household})+(\text{Variance}_{small\ area})}$$

Model I was 'empty' to ascertain baseline variance of individuals' self-rated health at household- and small area-levels. Model II contained all considered individual-level health determinants. Model III contained all individual-level social capital proxies. Model IV contained just individual-level items (health determinants and social capital proxies). Model V contained 'contextual level' social capital variables at both household- and small area-levels and considered individual-level health determinants. Model VI tested all individual-level and contextual-level variables simultaneously.

3. Results

Table 1a shows frequencies and percentages of all considered individual-level variables stratified by self-rated health. Tables 1b and 1c show the mean values and percentiles of all individual-level variables as distributed across households and small area-levels, respectively. Table 2 presents both fixed and random effects derived from all six models, as previously described.

Model I

As shown in Table 2, the intraclass correlation estimates indicate that 24.9% of individuals' variation in health is attributed to the household level, and 2.4% to the small area-level.

Model II

Of the considered health determinants, being retired or unemployed, being a smoker and having high school education or less were associated with poor health. The ICC was reduced to 10.5% for households and 1.4% for the small area-level.

Model III

Of the individual-level social capital measures, inability to trust, lack of social participation and unwillingness to improve one's neighbourhood, were associated with poor self-rated health. The ICC was reduced to 11.6% for households and 2.4% for the small area-level.

Model IV

When individual social capital measures and considered health determinants were tested simultaneously, being retired or unemployed, being a smoker and having no formal qualifications remained associated with poor health. Of the social capital variables, inability to trust, lack of social participation and unwillingness to improve one's neighbourhood, remained associated with poor self-rated health. The combination of health determinants and individual-level social capital measures reduced the ICC to 9.6% for households and 1.5% for the small area-level.

Model V

When the contextual-level social capital items were modelled alongside considered individual-level health determinants (as potential confounders) inability to trust, lack of social participation and unwillingness to improve one's neighbourhood were all associated with poor health at the household level. Only lack of volunteering was associated with poor health at the small area-level. The ICC was reduced to 11.0% for households and 1.5% for the small area-level.

Model VI

As per Table 2, of the considered health determinants, being a smoker, being retired or unemployed and having no formal qualifications maintained association with poor health in multivariable analysis.

Of the individual-level social capital measures, only lack of social participation maintained association with poor health. Of the household-level social capital variables, inability to trust others and unwillingness to improve one's neighbourhood maintained association with poor health.

Table 1a
Frequencies of all considered variables expressed as integers and percentages (%) of N_T (10,992) stratified by self-rated health.
Source: The British Household Panel Survey Wave R, 2008.

	Self-rated health (SRH)		
	Good health	Poor health	Total (N_T)
Age			
16–34	2579	711	3290
	33.5%	*21.7%*	*29.9%*
35–44	1533	522	2055
	19.9%	*15.9%*	*18.7%*
45–54	1268	586	1854
	16.5%	*17.8%*	*16.9%*
55–64	1070	564	1634
	13.9%	*17.2%*	*14.9%*
65+	1258	901	2159
	16.3%	*27.4%*	*19.6%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*
Gender			
Male	3565	1423	4988
	46.3%	*43.3%*	*45.4%*
Female	4143	1861	6004
	53.7%	*56.7%*	*54.6%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*
Interpersonal trust			
Yes, can trust others	2674	818	3492
	34.7%	*24.9%*	*31.8%*
No, can't trust others	5034	2466	7500
	65.3%	*75.1%*	*68.2%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*
Social participation: local groups, organisations or group leisure activities			
Active participation	2054	530	2584
	26.6%	*16.1%*	*23.5%*
Zero participation	5654	2754	8408
	73.4%	*83.9%*	*76.5%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*
Does unpaid voluntary work			
Yes	1494	548	2042
	19.4%	*16.7%*	*18.6%*
Never	6214	2736	8950
	80.6%	*83.3%*	*81.4%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*
Perceived reciprocity: can borrow things from neighbours			
Agree	3519	1417	4936
	45.7%	*43.1%*	*44.9%*
Disagree	4189	1867	6056
	54.3%	*56.9%*	*55.1%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*
Willing to improve neighbourhood			
Agree	6231	2453	8684
	80.8%	*74.7%*	*79.0%*
Disagree	1477	831	2308
	19.2%	*25.3%*	*21.0%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*
Smoking status			
Smoker	1436	976	2412
	18.6%	*29.7%*	*21.9%*
Non-smoker	6272	2308	8580
	81.4%	*70.3%*	*78.1%*
Total	5946	2048	10992
	100.0%	*100.0%*	*100.0%*
Education achieved[a]			
Undergraduate or higher	2001	500	2501
	26.0%	*15.2%*	*22.8%*
Year 12	1788	577	2365
	23.2%	*17.6%*	*21.5%*
Year 10 or less	2435	932	3367
	31.6%	*28.4%*	*30.6%*
No formal qualifications	1394	1239	2633
	18.1%	*37.7%*	*24.0%*
Total	7708	3284	10866
	100.0%	*100.0%*	*100.0%*
Employment status			
Employed	5025	1417	6442
	65.2%	*43.1%*	*58.6%*
Retired	1411	1012	2423
	18.3%	*30.8%*	*22.0%*
FT student	586	109	695
	7.6%	*3.3%*	*6.3%*
Unemployed	686	746	1432
	8.9%	*22.7%*	*13.0%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*
Household income (annual)—size weighted			
<£12,996	1584	1165	2749
	20.6%	*35.5%*	*25.0%*
£12,997–£20,628	1821	926	2747
	23.6%	*28.2%*	*25.0%*
£20,629–£30,723	2068	681	2749
	26.8%	*20.7%*	*25.0%*
£30,724+	2235	512	2747
	20.3%	*15.6%*	*25.0%*
Total	7708	3284	10992
	100.0%	*100.0%*	*100.0%*

[a] Missing $N=126$.

Lack of unpaid voluntary work was the only small area-level social capital variable to maintain significant association with poor health. Considering all contextual- and individual-level variables simultaneously, the intraclass correlation estimates were reduced from baseline to 12.3% (household-level) and 1.6% (small area-level).

4. Discussion

The purpose of this study was twofold: firstly, to test individual-level social capital proxies alongside household- and small area-level aggregates, to elicit which 'level' revealed association with individual health outcomes; and secondly, to use ICC estimates to compare how much of the total variation in self-rated health was attributable to household- and small area-level contexts. As touched upon in the 'Introduction' section, debate still surrounds the issue of quantifying and measuring the effects of social capital. The multilevel design of this study addresses some of these issues; by using five different proxies to quantify social capital across three different levels, we demonstrate how association (fixed effects) with health outcomes varies with both proxy and level. We also demonstrate that ten times more variation in individual health can be attributed to the household than the small area-level.

Looking at the fixed effects, there is association between individual-level trust and self-rated health in Models II and IV; there is also association between contextual-level measures of trust and health in Model V. Only in Model VI, do we see that individual- and small area-level association was in fact confounded by the household-level effect of trust on health. According to Coleman (1988), it is within the traditional family unit where the social 'norm' of trust is learnt. Though collective trust appears to be of more importance to health, our results infer that

Table 1b
Mean values and percentiles for all considered variables as distributed across households ($N=6201$).
Source: The British Household Panel Survey Wave R (2008–2009).

Variable	Mean	25th percentile	75th percentile
Age Continuous (years)	49	34	63
Self-rated health Good health (0) Poor health (1)	0.31	0.00	0.50
Gender Male (0) Female (1)	0.57	0.50	1.00
Interpersonal trust Trusts others (0) Cant trust (1)	0.68	0.50	1.00
Social participation Participates (0) No participation (1)	0.76	0.50	1.00
Perceived reciprocity Agree (0) Disagree (1)	0.56	0.00	1.00
Willing to improve neighbourhood Agree (1) Disagree (0)	0.21	0.00	1.00
Smoking status Non-smoker (0) Smoker (1)	0.22	0.00	1.00
Education achieved Undergraduate or higher (0) Year 12 (1) Year 10 (2) No qualifications (3)	1.46	1.00	2.40
Employment status Employed (0) Retired (1) FT student (2) Unemployed (3)	0.96	0.00	2.00
Household income (annual) Continuous (£)	22,730	11,818	29,135
Household size	2.47	2.00	3.00

Table 1c
Mean values and percentiles for all considered variables as distributed across the 'small-area' level ($N=399$).
Source: The British Household Panel Survey Wave R (2008–2009).

Variable	Mean	25th percentile	75th percentile
Age continuous (years)	47	43	50
Gender Male (0) Female (1)	0.54	0.50	0.59
Self-rated health Good health (0) Poor health (1)	0.30	0.22	0.38
Interpersonal trust Trusts others (0) Can't trust (1)	0.68	0.60	0.77
Social Participation Participates (0) No participation (1)	0.76	0.69	0.85
Perceived reciprocity Agree (0) Disagree (1)	0.55	0.46	0.65
Willing to improve neighbourhood Agree (1) Disagree (0)	0.21	0.14	0.27
Smoking status Non-smoker (0) Smoker (1)	0.22	0.13	0.30
Education achieved Undergraduate or higher (0) Year 12 (1) Year 10 (2) No qualifications (3)	1.45	1.19	1.74
Employment status Employed (0) Retired (1) FT student (2) Unemployed (3)	0.91	0.71	1.12
Household income (annual) Continuous (£)	23,913	19,975	27,074
Household size	2.80	2.50	3.05

the household level is where association between trust and individual health is statistically significant. If a causal pathway from higher trust levels to better individual health is assumed (Giordano and Lindström, 2010), one of the contexts within which interpersonal trust is generated (i.e. the household) seems also to be where trust's health benefits are most evident.

The reverse seems to be true of 'social participation', with individual-level association between lack of participation and poor health holding in Model VI, with the contextual-level association being completely attenuated.

The differences above reflect the two 'dimensions' described in the 'Introduction' section. Originally considered to mutually enhance one other (Putnam, 1995), our results add to the literature suggesting there is a lack of correlation between these two core aspects of social capital (Lindström, 2004; Nummela et al., 2008; Stolle, 2001; Giordano and Lindström, 2010). The lack of correlation also hints at differing pathways towards health outcomes for each dimension: the 'structural' possibly being linked to pathways associated with social support (Berkman and Syme, 1979), and the 'cognitive', via perceived stressors and the psychosocial pathway (Giordano and Lindström, 2010; Wilkinson, 1996).

Regarding volunteering and health outcomes, it is at the small area-level where association remains (Model VI). This is strikingly different to our other participation proxy, vindicating our decision to keep volunteering separate from other 'structural' measures. Association at this contextual level also implies a differing causal pathway. As volunteer work is strongly associated with increased political involvement (Putnam, 2000) one feasible pathway to health could be via maintaining or increasing community resources (Kawachi et al., 1999). Social capital (as measured by volunteer work) may influence individual health outcomes by maintaining the community's access to important resources via civic engagement of its members.

Only one of our reciprocity proxies maintained association with health in the final model (VI). Considered a 'cognitive' dimension of social capital, reciprocity is seldom researched (Abbott and Freeth, 2008), though if included, proxies have been positively associated with self-rated health (Kawachi et al., 1999; Lochner et al., 2003). Lack of association from our item 'perceived reciprocity' could be due to the inability of a crude proxy to capture such complex behaviour as reciprocity (Blaxter and Poland, 2002).

From the fixed effects results alone, one could interpret that different contextual- and individual-level social capital proxies are positively associated with better health outcomes and subsequently should not be considered mutually exclusive (see also

Table 2
Models I–VI with estimated fixed effects (odds ratios (OR) and 95% credible intervals (CI)), and random effects (Ω and ICC (standard error)) between self-rated health, considered individual-level health determinants and individual and contextual social capital variables.
Source: The British Household Panel Survey, Wave R (2008).

Fixed effects	Model I	Model II OR (CI)	Model III OR (CI)	Model IV OR (CI)	Model V OR (CI)	Model VI OR (CI)
(i) Considered health determinants						
Age						
Cont.		1.02 (1.01–1.02)		1.02 (1.01–1.02)	1.02 (1.01–1.02)	1.02 (1.01–1.02)
Gender						
Male		1.0		1.0	1.0	1.0
Female		0.98 (0.90–1.07)		1.02 (0.93–1.12)	1.00 (0.92–1.09)	1.02 (0.93–1.02)
Smoker						
No		1.0		1.0	1.0	1.0
Yes		1.74 (1.54–1.95)		1.65 (1.47–1.87)	1.65 (1.47–1.85)	1.66 (1.48–1.86)
Education achieved						
Undergraduate or higher		1.0		1.0	1.0	1.0
Year 12		1.22 (1.05–1.43)		1.15 (1.01–1.34)	1.14 (0.98–1.33)	1.13 (0.97–1.32)
Year 10		1.22 (1.06–1.41)		1.11 (0.97–1.26)	1.09 (0.95–1.25)	1.08 (0.93–1.26)
No quals.		1.95 (1.65–2.25)		1.69 (1.46–1.97)	1.62 (1.38–1.89)	1.61 (1.36–1.92)
Employment status						
Employed		1.0		1.0	1.0	1.0
FT student		0.87 (0.68–1.12)		0.88 (0.68–1.11)	0.90 (0.70–1.15)	0.92 (0.72–1.18)
Retired		1.22 (1.03–1.45)		1.22 (1.04–1.45)	1.22 (1.04–1.43)	1.22 (1.02–1.45)
Unemployed		3.03 (2.57–3.54)		2.90 (2.50–3.43)	2.90 (2.49–3.35)	2.95 (2.54–3.47)
Household income (annual) size weighted						
Cont.		1.00 (1.00–1.00)		1.00 (1.00–1.00)	1.00 (1.00–1.00)	1.00 (1.00–1.00)
Individual-level social capital variable						
Generalised trust						
Trusts others			1.0	1.0		1.0
Can't trust others			1.54 (1.39–1.71)	1.38 (1.24–1.54)		1.11 (0.94–1.31)
Active participation in voluntary/leisure groups						
Participates			1.0	1.0		1.0
No participation			1.85 (1.65–2.09)	1.38 (1.22–1.57)		1.24 (1.04–1.49)
Voluntary work						
Yes			1.0	1.0		1.0
Never			0.97 (0.86–1.10)	1.02 (0.91–1.17)		0.99 (0.80–1.20)
Perceived reciprocity						
Can borrow			1.0	1.0		1.0
Can't borrow			1.00 (0.90–1.10)	1.01 (0.92–1.12)		1.00 (0.85–1.16)
Willingness to improve neighbourhood						
Willing			1.0	1.0		1.0
Unwilling			1.36 (1.22–1.53)	1.28 (1.15–1.44)		1.12 (0.94–1.34)
(ii) Contextual-level social capital variable						
Cannot trust others						
HH					1.37 (1.24–1.51)	1.30 (1.12–1.51)
SA					1.19 (0.95–1.45)	1.18 (0.96–1.46)
Does not participate						
HH					1.33 (1.18–1.51)	1.14 (0.95–1.37)
SA					0.95 (0.72–1.29)	0.92 (0.70–1.24)
No volunteer work						
HH					0.99 (0.93–1.06)	0.99 (0.91–1.11)
SA					1.29 (1.07–1.54)	1.28 (1.07–1.57)
Unwilling to improve neighbourhood						
HH					1.30 (1.15–1.47)	1.19 (1.00–1.42)
SA					1.03 (0.81–1.30)	1.02 (0.79–1.29)
Low perceived reciprocity						
HH					1.01 (0.96–1.05)	1.01 (0.94–1.11)
SA					0.96 (0.82–1.13)	0.97 (0.84–1.15)
Random effects (standard errors)						
Variance Ω (SE)						
HH (Ω_u)	0.99 (0.14)	0.33 (0.17)	0.67 (0.10)	0.30 (0.02)	0.35 (0.15)	0.40 (0.17)
SA (Ω_v)	0.11 (0.02)	0.05 (0.01)	0.09 (0.02)	0.05 (0.02)	0.06 (0.02)	0.06 (0.02)
Intraclass correlation (%)						
HH (Ω_u)	24.9%	10.5%	11.6%	9.6%	11.0%	12.3%
SA (Ω_v)	2.4%	1.4%	2.4%	1.5%	1.5%	1.6%

HH—household level
SA—small area-level.

Kawachi, 2006; Subramanian et al., 2003). However, by complementing association with random-effect estimates, we are able to interpret our results further still.

By comparing the ICCs of different models, we can determine which level of analysis is most important for understanding variation in individual health. Only 2.4% of total variance in individual health can be attributed to the small area-level (see Model I). This means that despite the 'volunteering' proxy maintaining its association at this level (see model VI), the influence of small area-level contextual social capital on individual health is slight. This has greatest implication for decision makers who should appreciate that social capital interventions targeting health are unlikely to have a large effect if directed solely at the 'community' level, considering the small variation in health attributable to such a context.

The household context accounted for 24.9% of total variance in individual health (model I). We tested the robustness of this result by removing first singletons, then couples from the sample: the household still accounted for around 22% of total individual variance (24.1% and 20.7%, respectively). The implication is that this context could be more important for understanding variation in individual health than the small area. However, comparison of ICCs reveals that it is predominantly our individual-level health and social capital variables, not aggregated social capital variables that account for the reduction in variation at this level. So in order to support our hypothesis that tangible social networks reveal more about contextual effects of social capital on individual health outcomes than geography alone, further research is needed involving the mapping of individuals' extended social networks, not just household members.

4.1. Strengths and weaknesses

A major strength of this study is its multilevel design. By investigating both fixed and random effects, not only can we demonstrate association between social capital proxies and health, we can also estimate the amount of total variance in our outcome attributable to the contexts under investigation. To our knowledge, this is the first time that social capital has been investigated using household-level clustering, and that household, individual and community contexts have been directly compared. By using 'cognitive' and 'structural' social capital proxies, we are able to demonstrate how these two different dimensions may affect individual health via alternative pathways. Furthermore, by including multiple health determinants as confounders, we reduced bias in any association between social capital proxies and health. The five point measure of self-rated health used as our dependent variable has been repeatedly validated as an excellent proxy of morbidity and mortality (Lopez, 2004). Face to face interviews were carried out with the majority of respondents, which contributed to the very high wave-on-wave participation rate, 95% in the case of wave R (Taylor et al., 2010).

A major limitation is that our study is cross-sectional, so no causal inference can be made from any association reported. However, our social capital proxies' association with self-rated health across the three levels mirror not only just theories within this field (Kawachi et al., 1999) but also associations shown in longitudinal social capital studies where causation can be more readily inferred (for recent examples, see Giordano and Lindström, 2010; Hyyppä et al., 2007). Furthermore, the aim of our study was also to demonstrate the degree of variance (random effects) between different contexts.

It has been argued that the power to detect higher level variance components is influenced by the number of individual observations in each group (Snijders and Busker, 1999). A greater number of higher level groups with relatively few individual observations per group (such as our household level) will yield large standard errors and may have insufficient power to detect a conclusive variance component at this level. However, by taking an ecometric approach (Raudenbush and Sampson, 1999) and using MCMC estimation techniques (Browne, 2009), we have improved the possibility of obtaining correct inferences about the parameter values and their credible intervals. Furthermore, reliability estimates for all household and small area contextual social capital variables derived from the ecometric approach were very close to 1.0 (results not published).

5. Conclusion

Multilevel studies investigating contextual effects of social capital on health have predominantly focused on association found at neighbourhood, state or country contexts. Regardless of strength of association, it appears that only a small percentage of an individual's health outcome can be attributed to such geographic context. Our study has shown that around a quarter of variance in health can be attributable to the household. However, our study also shows that it is individual-level variables that explain most variation at household- and small area-levels. One implication of our findings is that social capital research could be advanced by focusing on contexts based on extended social networks, not just geographic proximity of random individuals. Furthermore, decision makers must now appreciate that social capital interventions targeting health are unlikely to be cost-effective if directed solely at the 'community' level, as only small variations in health are attributable to such a context.

Conflict of interest

None declared.

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Paper III

Social capital and self-rated health – a study of temporal (causal) relationships. Social Science & Medicine. 2012 – In press

Abstract
Despite the vast amount of research over the past fifteen years, there is still lively debate surrounding the role of social capital on individual health outcomes. This seems to stem from a lack of consistency regarding the definition, measurement and plausible theories linking this contextual phenomenon to health. We have further identified a knowledge gap within this field - a distinct lack of research investigating temporal relationships between social capital and health outcomes. To remedy this shortfall, we use four waves of the British Household Panel Survey to follow the same individuals (N = 8114) between years 2000 and 2007. We investigate temporal relationships and association between our outcome variable self-rated health (SRH) and *time-lagged* explanatory variables, including three individual-level social capital proxies and other well-known health determinants. Our results suggest that levels of the social capital proxy 'generalised trust' at time point (t-1) are positively associated with SRH at subsequent time point (t), even after taking into consideration levels of other well-known health determinants (such as smoking status) at time point (t-1). That we investigate temporal relationships at four separate occasions over the seven-year period lends considerable weight to our results and the argument that generalised trust is an independent predictor of individual health. However, lack of consensus across a variety of disciplines as to what generalised trust is believed to measure creates ambiguity when attempting to identify possible pathways from higher trust to better health.

Introduction

Since Durkheim's seminal work over a century ago (Durkheim, 1897; 1951), research has repeatedly shown that individuals with higher levels of social integration, social networks and social support have better health (for examples see: Berkman & Syme, 1979; House et al., 1988; Lasker et al., 1994; Pennix et al., 1997). However, following the introduction of 'social capital' to the field of public health (Kawachi et al., 1999; Kawachi et al., 1997), the debate has continued regarding this contextual phenomenon and how it also independently influences health outcomes (Hawe & Shiell, 2000; Pearce & Davey Smith, 2003; Szreter & Woolcock, 2004).

From social capital literature and research, we have identified three main areas of contention: how one defines (and conceptualizes) social capital, how one measures social capital, and how social capital is theorized to influence health. These issues seem inter-connected, as one's definition of social capital will surely influence how one measures and theorizes the effects of social capital on individual health outcomes.

There is no single accepted definition of social capital, so it is not surprising that there are differences in opinion regarding its conceptualization. Of the contemporary authors in this field, Robert Putnam (1993, p.167), defines social capital as '… features of social organization, such as trust, norms, and networks that can improve the efficiency of society by

facilitating coordinated actions.' With his definition, Putnam places social capital firmly at the societal-level. However, Pierre Bourdieu also conceptualized social capital at the individual level by defining it as '…the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network' (Bourdieu & Wacquant, 1992, p.119).

Another key social capital theorist, James Coleman (1990, p.302) defines social capital as '...a variety of different entities [that] facilitate certain actions of individuals who are within the structure', the family playing a vital role in his theories; and finally Portes (1998 p.6) defines social capital as '… the ability of actors to secure benefits by virtue of membership in social networks or other social structures', stressing the individual-level properties of this phenomenon.

The differences above clearly highlight the lack of consensus between theorists regarding the conceptualisation and ownership of social capital, which leads to our second area of contention: how one measures social capital and its effects on health, at the individual or the collective level (Macinko & Starfield, 2001). This problem is further confounded by the fact that social capital is often considered a contextual phenomenon (Berkman & Kawachi, 2000) that cannot be directly observed or easily quantified. As a result (and irrespective of 'conceptualisation' issues) the vast majority of social capital research relies on individual-level 'proxy' measures. Researchers' choice of proxy often reflects the social capital definition being tested; for example, if investigating Putnam's or Coleman's social capital theory, one would use proxies such as generalised (horizontal) and vertical (institutional) trust, and social and civic participation (for examples see: Coleman, 1988; Hyyppä & Maki, 2001; Lindström, 2004; Putnam, 1993; 2000; Subramanian et al., 2002; Veenstra, 2000).

Researchers wanting to investigate 'group' effects of social capital on individual health may further aggregate individual-level proxies to a context of interest. However, the process of aggregation is not without its own issues, as any assumption made about an individual based solely on a group mean value may be inherently biased (commonly known as 'ecological fallacy'). Furthermore, most multilevel social capital studies have demonstrated that only 0-4% of *total* variation in individual health is attributable to commonly used aggregates, such as community, state or county contexts (for examples see: Fujisawa et al., 2009; Lindström et al., 2004; Poortinga, 2006; Snelgrove et al., 2009).
Conversely, social capital studies maintaining analyses at the individual-level still may face criticism if they do not consider any potential contextual effects. This criticism may be unfounded, however, as one recent multilevel study (simultaneously investigating individual-, household- and community-level contexts) demonstrates that that it is *individual-level* social capital proxies that influence individual health the greatest (Giordano et al., 2011).

The third area of contention (how social capital influences health) has generated lively debate over recent years, as the relevance of social capital on health outcomes has often been contested by proponents stressing the importance of access to material resources and public welfare policy (Muntaner, 2004; Pearce & Davey Smith, 2003). Furthermore, certain social capital proxies (i.e. 'social networks' or 'social participation') could easily be perceived as potential sources of social support, a well-known determinant of individual health (Berkman & Syme, 1979). To address these arguments comprehensively within empirical social capital research, one must consider differing measures of socio-economic status (SES) such as income, education and employment status, along with well-known measures of social support whenever possible. As there is also an increasing literature base suggesting a distinct lack of

correlation between social capital proxies, in turn hinting at several pathways from social capital to health (Giordano & Lindström, 2010; Lindström, 2004; Nummela et al., 2008; Stolle, 2001), it also seems prudent to simultaneously test multiple social capital proxies, if data allow.

We have further identified an apparent shortfall in global social capital research, one that specifically addresses the issue of causality. To clarify: there are nine criteria required to help establish a causal relationship between exposure and disease, including strength, plausibility, and consistency. However, temporal relationship is considered the only 'essential criterion'; i.e., if exposure A is theorized to cause disease B, then A must always precede B (Goodman & Phillips, 2005). In other words, longitudinal data are needed to test causality. This notion is also supported by methodological considerations concerning causal mechanisms within the social sciences (Hedström & Ylikoski, 2010). However, during the near exponential rise in papers researching social capital and health over the past fifteen years, the vast majority of studies have been cross-sectional in design (Islam et al., 2006) and are therefore unable to test temporal relationships. Of the longitudinal studies within the field, a PUBMED search reveals that only one study, investigating association between 'psychological wellbeing' and social capital (Giordano & Lindström, 2011), incorporates the three (or more) time points required to correctly test temporal relationships (Singer & Willet, 2003 p.9). Our study will attempt to address this knowledge gap in social capital research by using the same individuals' responses taken at four different time points between the years 2000 and 2007.

The aim of this longitudinal study is to investigate temporal relationships between self-rated health (SRH) and *lagged* measures of *individual-level* social capital, social support and SES. As our longitudinal data cannot be aggregated, we intend to employ *individual* measures of generalised trust, social participation and contact with neighbours as social capital proxies in our study; the choice of proxy being determined in part by data availability and also our acceptance of Putnam's social capital definitions. We hypothesize that levels of social capital at time (t-1) are positively associated with SRH status at subsequent time point (t), even after adjusting for other well-known health determinants at time (t-1).

Materials and methods

Data collection

The British Household Panel Survey (BHPS) is a longitudinal survey of randomly selected private households conducted by the UK's Economic and Social Research Centre. Since 1991, individuals within selected households have been interviewed annually with a view to identifying social and economic changes within the British population. The original 1991 cohort sample was randomly selected by using a two stage cluster design, resulting in a total of 8166 private postal addresses around the UK. From these addresses 10,264 individual interviews were completed in 1991, demonstrating a participation rate of 95%. Full details of the selection process, weighting and future participation rates can be found on-line in the BHPS user manual (Taylor et al., 2010).

The raw data that have been used for this panel study come from the BHPS individual-level responses in years 2000, 2003, 2005 and 2007. The same individuals (N=8114) were followed across this seven-year time frame; participation rate for year 2000 (as compared to year 1999) was 93.6%, and, compared to the original 1991 cohort, was 62.0%.

The Research Centre fully adopted the Ethical Guidelines of the Social Research Association; informed consent was obtained from all participants and strict confidentiality protocols were adhered to throughout data collection and processing procedures.

Dependent variable

The dependent variable in this study is self-rated health (SRH), considered a valid predictor of morbidity and future mortality (Idler & Benyamini, 1997; Lopez, 2004). The same individuals were asked: 'Compared to people your own age, would you say that your health has on the whole been: excellent, good, fair, poor or very poor?' As is standard with the global SRH item, this five-point scale was recoded into the dichotomous variable 'good' (excellent, good) and 'poor' (fair, poor, very poor) health.

Explanatory variables

Social capital variables

Generalised (horizontal) trust was assessed by asking people: 'Would you say that most people can be trusted, or that you can't be too careful?' This variable was dichotomised, with only those respondents stating that most people could be trusted being labelled 'can trust'; all negative responses (including 'it depends') were labelled 'can't trust' (Uslaner, 2002).

Social participation was measured by asking respondents questions about being active members of listed voluntary community groups or any sports, hobby or leisure group activity found locally (see appendix for full list). Only those who answered positively to any of these were judged to participate, with all others being labelled 'No participation'.

We also considered frequency of talking to neighbours as a proxy for social capital (Putnam, 2000, p.105-6). Possible responses were: 'Most days, once or twice a week, once or twice a month, less than once a month, or never'. Those answering 'most days' or 'once or twice a week' were assigned the label 'One or more times per week'; the rest were assigned the label 'less often'.

Socio-economic status variables

Social class was determined by the respondents' most recent occupation, derived from the Registrar General's Social Classification of occupations. The usual six categories (see appendix) were dichotomised into 'higher' (1-3a) and 'lower' (3b-6) social class. Those who had never been employed were labelled 'never worked'.

Highest achieved education level was categorised as 'Undergraduate or higher', 'Year 13' and 'Year 11' or 'No formal qualifications'.

'Household income' was weighted according to size by summing the income of all household members and dividing this sum by the square root of the household size (Burkhauser et al., 1996). This item was maintained as a continuous variable (per £1000 increase) and was an expression of total income, net of any taxation.

Social support variables

Respondents were asked if they were 'married, separated, divorced, widowed or never married'. These five options were recoded into the dichotomous variable 'married' and 'not married' (separated, divorced, widowed or never married). A further variable 'Lives alone' ('yes' or 'no') was also used to try to capture more information about those individuals who co-habited.

We also considered frequency of meeting with friends or family as a proxy for social support. Possible responses were: 'Most days, once or twice a week, once or twice a month, less than

once a month, or never'. Those answering 'most days' or 'once or twice a week' were assigned the label 'one or more times per week'; the rest were assigned the label 'less often'.

Confounders

Age, gender, smoking status and time were considered confounders in this study, age being stratified into quintiles (see Tables 1 and 2). Time (corresponding to the waves of interviews in years 2000, 2003, 2005 and 2007) was also included as a continuous covariate to adjust for potential trends in SRH and explanatory variables across time. Smoking status was categorised as 'smoker' and 'non-smoker' according to respondents' answer to the question 'Do you smoke cigarettes?'

All explanatory variables (except gender) were lagged at time (t-1) in reference to SRH at time (t). It was presumed that the presence of social capital, being younger, being married or cohabiting, being a non-smoker, attaining higher education and household income, having greater social support, and being of higher social class at time (t-1) were associated with good SRH at time (t).

Statistical analyses

All data were stratified by baseline (year 2000) SRH to create two distinct 'health' cohorts: 'Good health at baseline' (GHB) and 'Poor health at baseline' (PHB). After this initial disaggregation, the two 'health' cohorts were modelled as separate entities: Model 1 dealt solely with individuals from the GHB cohort (N = 5689); the outcome of interest in Model 1 was *change* from 'GHB' (0) to 'poor' SRH (1) from year 2000 to 2007. Model 2 dealt solely with individuals from the PHB cohort (N = 2425); the outcome of interest in Model 2 was *change* from 'PHB' (0) to 'good' SRH (1) from year 2000 to 2007.

In order to investigate temporal relationships between exposure and outcome, *all explanatory variables* (except gender) were lagged at time (t-1) in reference to SRH at time (t). To clarify, when SRH in 2003 was the outcome, only explanatory variables from year 2000 were utilised; when SRH in 2005 was the outcome, only explanatory variables from 2003 were utilised; and when SRH in 2007 was the outcome, only explanatory variables from 2005 were utilised.

Disaggregation by baseline SRH meant we could attribute any association found between our lagged explanatory variables to *change from baseline health status*. Without disaggregation, we could only describe association between lagged explanatory variables and SRH as trends across the timeframe of our study.

Our hypothesis, as stated in the introduction, is that social capital at (t-1) is positively associated with SRH at time (t); however, other temporal pathways may co-exist, confound each other, or even interact with each other. For example: SRH at time (t) could theoretically influence one's ability to maintain social networks at time (t) and/or at (t+1). To address this concern, we also performed sensitivity testing. We ran *all* explanatory variables from time (t), alongside *all* lagged (t-1) exploratory variables, the outcome being SRH at time (t). If association still held at time (t-1) when we considered social capital (and all other explanatory variables) at time (t-1) *and* time (t) simultaneously, this would strengthen our hypothesis that prior levels in social capital are positively associated with subsequent SRH.

For all analyses we used logistic regression models with random effects, as SRH was expected to be more similar *within* the same individual over time than *between* different individuals. The model allowed a random intercept for each individual and we obtained standard errors that were adjusted for the temporal correlation of SRH *within* the same

individual across the time frame of our study. The equations for logistic regression models with random effects are as follows:

$$\text{Log}\,(Y_{ij}) = \beta_{0j} + \beta \mathbf{X}_{i\text{-}1j}$$
$$\beta_{0j} = \beta_0 + \mu_{0j}$$

Where i = time, j = individual, μ_{0j} = the random intercepts (assumed to be independently normally distributed with a common variance), $\mathbf{X}_{i\text{-}1j}$ is a vector of lagged explanatory variables, β_0 is the fixed overall intercept, and β the corresponding vector of coefficients.

All explanatory variables were utilised in our two multiple logistic regression models. Model 1 investigated *change* from GHB (0) to 'poor' SRH (1) between years 2000-07; Model 2 investigated *change* from PHB (0) to 'good' SRH (1) between years 2000-07. All analyses were conducted using GLLAMM version 2.3.15 (Rabe-Hesketh et al., 2005), within the statistical software package STATA 11.2 (StataCorp, 2009).

Results

Table 1a is descriptive, showing frequencies and total percentages of all considered explanatory variables, stratified by self-rated health in year 2000 (baseline). Table 1b is also descriptive, showing the transition of self-rated health over time in each baseline cohort. The results of multiple logistic regression analyses containing all considered explanatory variables are presented in Table 2 as odds ratios (ORs) with 95% confidence intervals (CI). The results of our sensitivity tests are presented in Table 3, also as ORs with 95% CI.

Model 1: Multiple regression analysis - 'GHB' cohort

The outcome of interest in Model 1 was *change* from 'Good Health at Baseline' (0) to 'poor' SRH (1) between 2000 and 2007. As shown in Table 2 (left hand column), of the social capital variables, low levels of trust and talking less with neighbours preceded a change from GHB to poor SRH over time (OR = 1.35 and 1.18, respectively).

Of the SES variables, those with low social class or those who had never worked at time (t-1) had increased risk of poor SRH at time (t) (OR = 1.40 and 1.53, respectively). A prior increase in household income seemed to offer some protection against future poor SRH; though significant, the value was close to the reference value of 1.0.

None of the social support variables at (t-1) maintained association with poor SRH at time (t).

Of the confounders, smoking at (t-1) and being of older age were associated with poor SRH at time (t).

Model 2: Multiple regression analysis - 'PHB' cohort

The outcome of interest in Model 2 was *change* from 'Poor Health at Baseline' (0) to 'good' (1) SRH between 2000 and 2007. As shown in Table 2 (right hand column), of the social capital variables, high levels of trust and participation and talking more often with neighbours at time (t-1) preceded good SRH at time (t) (OR = 1.31, 1.19, and 1.33 respectively).

Of the SES variables, those with higher social class at time (t-1) had good SRH at time (t) (OR = 1.24). Those who had never worked at time (t-1) were likely to remain of poor SRH (OR = 0.61). A prior increase in household income at time (t-1) was associated with good SRH at time (t); though significant, the value was close to the reference value of 1.0.

Of the confounders, being a non-smoker, being male, and being of younger age at time (t-1) were associated with good SRH at time (t).

Sensitivity testing

We tested our hypothesis that social capital at time (t-1) is positively associated with SRH at time (t) by running *all* explanatory variables at time (t) alongside *all* lagged (t-1) exploratory variables simultaneously against SRH at time (t). Sensitivity tests were performed for Models 1 and 2 separately. As shown in Table 3 (left hand column) from the GHB cohort, the only lagged (t-1) social capital variable that maintains association with poor SRH at time (t) is lack of trust (OR = 1.25).

In the right hand column of Table 3 (from the PHB cohort), association remains between good SRH at time (t) and the lagged (t-1) social capital variables 'trust' (OR = 1.25) and 'talks with neighbours' (OR = 1.28). Association between active social participation at (t-1) and good SRH at time (t) was attenuated after adjusting for participation at time (t).

Discussion

The aim of this longitudinal study is to research temporal relationships and association between lagged health determinants (including three social capital proxies) at time point (t-1) and our dependent variable self-rated health (SRH) at subsequent time point (t). The dual 'health' cohort design of the study (see 'Materials and methods' section) further allows causal inference to be made from association between lagged explanatory variables and *changes* from baseline health status over time. All three measures of social capital maintain their positive association with SRH in multiple regression models when tested simultaneously alongside other well known health determinants. Temporal relationships and association imply that *prior* levels in either of these social capital measures seem to independently predict future SRH status, i.e. social capital at time point (t-1) is positively associated with health status at subsequent time point (t), even after taking into consideration levels of other well-known health determinants at time point (t-1).

Of our social capital proxies, frequency of talking with neighbours maintains association with SRH in both models (see Table 2). Though relationships with one's neighbours may be considered a form of 'bonding' social capital (Szreter & Woolcock, 2004), it is also feasible that this source of social capital could become a source of social support, particularly if neighbours become good friends over time (Coleman, 1990, p.178-80). Social participation is only associated with good SRH in Model 2 (see Table 2, right hand column). This result implies that active participation *precedes* good SRH over time. However, our sensitivity tests (see Table 3) hint that it is most likely that good SRH at time (t) influences active participation at time (t). Generalised trust is positively associated with SRH in both Models (see Table 2), i.e. *lack* of trust at time (t-1) precedes poor SRH at time (t) in Model one; conversely, an *ability* to trust at time (t-1) precedes good SRH at time (t) in Model two. This positive association remains after performing our sensitivity test (see Table 3). According to our results, the positive effect of generalized trust at time (t-1) on SRH at time (t) is one third the strength of not smoking at time (t-1).

It is important to appreciate that generalised trust, along with most other explanatory variables in this study, is time–dependent, i.e. one's trust levels may have a different value at any given time. Measures of trust in this study therefore consider not just those individuals who maintain the same trust levels over time, but also those whose trust levels vary over the period of the study. That trust is measured at three lagged time points at (t-1) in relation to the outcome SRH at time (t) adds considerable weight to the assumption that generalised trust is an independent predictor of individual health. Our study is not alone in showing association between generalised trust and SRH (for examples see Giordano & Lindström, 2010; Hyyppä

et al., 2007; Kawachi et al., 1999; Kawachi et al., 1997) but this study is the first of its kind to empirically confirm any temporal relationships, and hence infer causality.

Though 'generalised trust' has been identified and subsequently used as a proxy for social capital in empirical research for over twenty years (Coleman, 1988; 1990; Giordano & Lindström, 2011; Kawachi, 1997; 1999; Lindström, 2004; Putnam, 1993; 2000; Veenstra, 2000), there is surprisingly little discussion regarding what else 'trust' is hypothesised to measure, outside this specific field. To address this issue, we pose (and attempt to answer) three pertinent questions:

1) *Why is generalised trust a proxy for social capital?*
The concept of trust is debated across a variety of disciplines, from social science, philosophy, economics, political science and public health. There is consensus, however, that different forms of trust exist: g*eneralised* (also known as 'horizontal') trust is the form specifically reserved for strangers (vs. *particularized* trust, the form reserved for known individuals or groups). Early social capital literature stresses the importance of both these trust variants to facilitate actions between individuals or groups (Coleman, 1988) i.e., without either form of trust there can be no social capital. Over time, however, *generalised* trust seems to have become the preferred social capital proxy. This is most likely due to the works of Robert Putnam (1993; 1995; 2000), and the assumption that individuals are all similarly influenced by the presence (or lack) of social capital (Coleman, 1990; Kawachi et al., 1997). On the surface this makes sense, as social capital has been described as a public good (Berkman & Kawachi, 2000 p.177) and by definition infers unconditional positive externalities (unintended benefits) to all. However, cross-level interactions have shown that this maybe an oversimplification, as the health of individuals who do not share the social 'norms' (i.e. trust) of the community in which they reside, may be adversely affected (Subramanian et al., 2002). This apparent paradox suggests that joint *particularized* and *generalised* trust measures could provide a more robust social capital proxy in future research.

2) What else could 'generalised trust' measure?
There is contention across disciplines regarding the answer to this question and social capital researchers should carefully consider the implications. From an economic point of view, generalised trust is often considered a *summary measure* of individual experiences, good and bad, the assumption being that generalised trust levels can vary over time (Glaeser et al., 2000). Though this opinion can also be found in political science, others within the field consider that generalised trust is determined in early life, levels being resistant to change irrespective of later-life experiences (Putnam, 2000; Uslaner, 2002). Our longitudinal data reveal that just over half our sample (~ 55%) maintains the same trust levels over the seven year study period, whereas ~ 45% of individuals vary their trust across the same time frame. We therefore can offer only some support for Uslaner's concept of 'moralistic' (stable) trust; furthermore, Putnam's belief that '… all of the decline in social trust since the 1960s is attributable to generational succession' may be inadequate, as it does not explain individual fluctuations in trust over time, as seen in our data (Putnam, 2000, p.140).

Others within political science consider levels of generalised trust to reflect the function of State institutions (Levi, 1998). However, as empirical evidence shows only weak correlation between *vertical* trust (trust in institutions) and generalised trust (Rothstein, 2005; Uslaner, 2003) perhaps a more refined hypothesis is required. One such refinement is the theory that

higher levels of generalised trust reflect State *policies* implemented to reduce inequalities, rather than State *institutions* themselves (Rothstein & Stolle, 2008; Uslaner, 2008).

Putnam implies that generalised trust is created as a by-product of increasing numbers of individuals interacting with each other via membership of community voluntary groups and local organisations (Putnam, 1995). That trust levels - in the USA at least - have declined over the same period that memberships in such local groups have declined is, for the most part, the backbone to Putnam's recent social capital theories (Putnam, 2000). However, it is noteworthy that perceptions of inequality in America have also increased over a similar timeframe; could it be that State policy, not declining voluntary group membership, has inadvertently contributed to the decline in generalised trust in the USA (Uslaner, 2002)?

3) What are possible mechanisms linking trust levels to health?

Mechanisms linking trust to health outcomes must depend on what trust is deemed to measure (see #2 above). If Putnam's ideas are followed, trust is a by-product of increased social participation; therefore, logic dictates that trust is just one step along the pathway from participation to health. As to how participation influences health could therefore be via social support mechanisms, examples of which include instrumental, emotional and financial support. Our results reveal that *high* levels in social participation precede good SRH, lending partial weight to this hypothesis (though attenuated in our sensitivity test – see Table 3). That *low* levels of participation do not precede poor SRH in this study could imply that only longer term reduction in social participation leads to a decline in social support and worse health. Conversely, it has been argued that trust is in fact a prerequisite to participation (Rothstein & Stolle, 2003). If this is the case then it is trust, not participation, at the start of the causal pathway to health.

If higher trust levels are a reflection of efficient State institutions (Levi, 1998), it could be theorised that improved access to resources such as education, healthcare, rule of law, etc. is the real link from trust to health. However, that our data come from the UK, where access to such resources could be considered relatively homogeneous (compared to low- or middle-income countries) implies other mechanisms may also be at work.

If trust levels are considered a measure of egalitarian State *policy* designed to redistribute wealth and reduce inequality (Rothstein & Stolle, 2008; Uslaner, 2008), then maybe the pathway from trust to health is via psychosocial pathways. As described by Giordano et al. (2010), the authors employ Wilkinson's (1996) theories as to how psychosocial pathways are a plausible mechanism from trust to health outcomes. Long term exposure to high levels of chronic stressors (considered by the authors as an indicator of low generalised trust levels) can, via the hypothalamic–pituitary–adrenal axis, lead to increased levels of blood cortisol, which in turn may lead to diseases such as depression and cardio-vascular disease (Shively et al., 2009; Watson & Mackin, 2006). It is feasible that egalitarian State policy could influence health outcomes *directly*, by addressing the negative effects of social stratification on individual heath and *indirectly*, via the reduction of perceived chronic stressors with the creation of higher generalised trust levels.

Strengths and weaknesses

A major strength of this study is the fact that it is longitudinal, tracking the same individuals (N = 8114) at four points in time over seven years. The unique design captures association between *all* lagged (t-1) explanatory variables and changes from baseline SRH at time (t), allowing us to infer causality by temporal relationships (Goodman & Phillips, 2005). To our

knowledge, this is the first time that this has been attempted within the field of social capital. Disaggregation by baseline SRH also enables us to assess association between social capital and health in two large independent cohorts within the same study. Our findings are strengthened by the fact that we see similar patterns (albeit with some differences) for these two cohorts. The fact that the data were obtained via interview rather than relying on postal questionnaires contributed to the very high participation rate of around 90%, year on year (Taylor et al., 2010). By lagging (t-1) *all* explanatory variables, including three different individual-level indicators of social capital, along with multiple SES, social support variables and confounders, we ensured that well-known health determinants were also included in the analyses.

A major limitation of this study is that the BHPS sample was originally selected to reflect the UK population as a whole and deliberately avoided oversampling of smaller sized communities, i.e., data are not particularly valuable when investigating ethnic diversity or urban vs. rural populations. Furthermore, our longitudinal data were unsuitable to perform any meaningful contextual analysis at the household- or community-level. Disaggregation of SRH in year 2000 could introduce bias (misclassification of exposure) at baseline; one way to reduce this potential bias could be to combine SRH responses from 2000 and 2003, however, this would leave just two further points in time to address issues of temporal relationships. As SRH is considered a valid and reliable indicator of morbidity and future mortality (Idler & Benyamini, 1997; Lopez, 2004), we feel that a single baseline measurement is sufficient. By year 2000, only 62.0% of the original cohort members were able to answer the questions posed (Taylor et al., 2010). This would have introduced further selection bias into this study. Marital status was reduced to the dichotomous 'married' and 'not married'; though this method of reduction has been previously validated (Afifi et al., 2006), it may hide more complex pathways regarding cohabitation, common in society today. The 'lives alone' variable was included in an attempt to recapture this detail.
Although temporal relationships are considered 'essential' in establishing causality, it is an oversimplification to assume that causality is proven solely based upon association shown in our results. To address this concern, we performed sensitivity testing – see 'statistical analyses' and 'results' sections for more detail. That association between trust at time (t-1) and SRH at time (t) remained even after considering trust at time (t) serves to strengthen (in part) our hypothesis that levels of social capital at time point A are positively associated with SRH at time point B.

Conclusions

Our longitudinal study is the first of its kind to investigate temporal relationships between individual-level social capital proxies and self-rated health. It appears from our results that generalised trust can be considered an independent predictor of future health status. However, lack of consensus across a variety of disciplines as to what generalised trust could measure creates ambiguity as to which mechanisms link higher trust levels to better health. That 'generalised' trust is only weakly correlated with 'vertical' trust (in State institutions) and social participation implies that higher trust levels could reflect egalitarian State *policy* not State institutions, *per se*. It is feasible that such policies could influence health outcomes directly, through the redistribution of wealth and reduction of inequalities, and indirectly via the creation of higher levels of generalised trust.

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Appendix

To determine social participation levels, respondents were asked if they were *active* members of any local group or organisation listed below:
Political party, trade union, environmental group, parents'/school association, tenants'/residents' group or neighbourhood watch, church organisation, voluntary service group, pensioners group/organisation, social club/working men's club, sports club or Women's Institute.

The six occupation categories, as per the Registrar General's Social Classification of occupations are: i) Professional, ii) Managerial/Technical, iiia) Skilled (non-manual), iiib) Skilled (manual), iv) Partly Skilled and v) Unskilled.

Table 1a: Frequencies of all considered explanatory variables expressed as integers and percentages (%) of N_T (8114) stratified by baseline self-rated health (SRH) in year 2000

Explanatory variables		Baseline self-rated health		
		Good SRH (N= 5689)	Poor SRH (N= 2425)	Total (N_T = 8114)
Age (years)	16-34	1817	600	2417
		32%	*25%*	*30%*
	35-44	1311	426	1737
		23%	*18%*	*21%*
	45-54	1060	472	1532
		19%	*20%*	*19%*
	55-64	740	432	1172
		13%	*18%*	*14%*
	65+	761	495	1256
		13%	*20%*	*16%*
Total		5689	2425	8114
		100%	*100%*	*100%*
Gender	Male	2600	1003	3603
		46%	*41%*	*44%*
	Female	3089	1422	4511
		54%	*59%*	*56%*
Total		5689	2425	8114
		100%	*100%*	*100%*
Generalised trust	Yes, can trust others	2396	726	3125
		42%	*30%*	*39%*
	No, can't trust others	3293	1696	4989
		58%	*70%*	*62%*
Total		5689	2425	8114
		100%	*100%*	*100%*
Social Participation: Local groups, organisations or group leisure activities	Active participation	2469	842	3311
		43%	*35%*	*41%*
	Zero participation	3220	1583	4803
		57%	*65%*	*59%*
Total		5689	2425	8114
		100%	*100%*	*100.0%*
Frequency of talking with neighbours	One or more times/week	4410	1876	6286
		78%	*77%*	*78%*
	Not that often	1279	549	1828
		23%	*23%*	*23%*
Total		5689	2425	8114
		100%	*100%*	*100.0%*
Frequency of meeting with friends	One or more times/week	4872	2081	6953
		86%	*86%*	*86%*
	Not that often	817	344	1161
		14%	*14%*	*14%*

Total		5689	2425	8114
		100%	*100%*	*100%*
Marital status	Married	3370	1411	4781
		59%	*58%*	*59%*
	Not married	2319	1014	3333
		41%	*42%*	*41%*
Total		5689	2425	8114
		100%	*100%*	*100%*
Lives alone	Yes	686	398	1084
		12%	*16%*	*13%*
	No	5003	2027	7030
		88%	*84%*	*87%*
Total		5689	2425	8114
		100%	*100%*	*100%*
Education achieved [a]	Undergraduate or higher	2253	895	3148
		40%	*37%*	*39%*
	Year 13	1654	765	2419
		29%	*32%*	*30%*
	Year 11	1008	461	1469
		18%	*19%*	*18%*
	No qualifications	734	287	1021
		13%	*12%*	*13%*
Total		5649	2408	8057
		100%	*100%*	*100%*
Social class	High	3339	1166	4505
		61%	*51%*	*58%*
	Low	2105	1111	3216
		39%	*49%*	*42%*
	Never worked	245	148	393
		5%	*6%*	*5%*
Total		5689	2425	8114
		100%	*100%*	*100%*
Smoking status	Smoker	1307	787	2094
		23%	*33%*	*26%*
	Non smoker	4382	1638	6020
		77%	*68%*	*74%*
Total		5691	2425	8114
		100%	*100%*	*100%*
Household income (annual) - size weighted	< £9588	1175	855	2030
		21%	*35%*	*25%*
	£9589-£15 055	1367	661	2028
		24%	*27%*	*25%*
	£15 056-£22 493	1515	510	2025
		27%	*21%*	*25%*
	£22 494 +	1632	399	2031
		29%	*17%*	*25%*

Total	5689	2425	8114
	100%	*100%*	*100%*

Source: The British Household Panel Survey Wave J, 2000
[a] Missing N = 57

Table 1b: Transitions of self-rated health status between 2000 and 2007 expressed as integers and percentages (%) of N_T (8114), stratified by health status at baseline

Good health at baseline (year 2000)	Remains in good health	4898	*86%*
	Develops poor health	791	*14%*
Total		5689	*100%*
Poor health at baseline (year 2000)	Remains in poor health	1678	*69%*
	Develops good health	747	*31%*
Total		2425	*100%*

Source: The British Household Panel Survey Wave J, M, O and Q (2000-07)

Table 2: Odds ratios (ORs) with 95% confidence intervals (95% CI) of having 'good' or 'poor' self-rated health at time (t) from baseline (Year 2000) health status according to multiple logistic regression analysis of lagged (t-1) explanatory variables in social capital, social support, socio-economic status and confounders (N_T = 8113)

Explanatory variables		Change in self-rated health status from Baseline (2000)	
		Model 1 (N = 5688) [a] Good Health at Baseline Cohort - ORs (95% CI) of having PH over time	Model 2 (N = 2425) Poor Health at Baseline Cohort - ORs (95% CI) of having GH over time
Social capital variables			
Generalised trust	Trusts others	1.0 [b]	1.31 (1.10-1.56) **
	Can't trust others	1.35 (1.19-1.53) ***	1.0 [b]
Social participation: Active in local groups	Active participation	1.0 [b]	1.19 (1.01-1.39) *
	No participation	1.05 (0.93-1.18)	1.0 [b]
Frequency of talking with neighbours	1+ times/wk	1.0 [b]	1.33 (1.10-1.61) **
	Less than this	1.18 (1.02-1.36) *	1.0 [b]
Social support variables			
Marital status	Married	1.0 [b]	1.20 (0.94-1.52)
	Not married	1.00 (0.85-1.19)	1.0 [b]
Living alone	Lives with others	1.0 [b]	0.87 (0.65-1.16)
	Lives alone	1.19 (0.96-1.48)	1.0 [b]
Frequency of meeting with friends or family	1+ times/wk	1.0 [b]	1.12 (0.90-1.40)
	Less than this	0.91 (0.77-1.08)	1.0 [b]
Socio-economic variables			
Household income/£1000	Continuous	0.99 (0.98-0.99) ***	1.02 (1.01-1.02) ***
Social class: derived from occupation-based RGSC schema	High SC	1.0 [b]	1.24 (1.02-1.52) *
	Low SC	1.40 (1.22-1.61) ***	1.0 [b]
	Never worked	1.53 (1.13-2.07) **	0.61 (0.40-0.92) *

Education achieved	Undergraduate +	1.0 [b]	0.86 (0.66-1.12)
	Year 13	1.06 (0.88-1.26)	0.73 (0.56-1.01)
	Year 11	1.01 (0.86-1.19)	0.79 (0.60-1.06)
	No qualifications	1.23 (0.84-1.79)	1.0 [b]
Confounders			
Age (years)	16 - 34	1.0 [b]	7.19 (4.90-10.55) ***
	35 - 44	1.12 (0.88-1.42)	2.45 (1.78-3.37) ***
	45 - 54	1.25 (0.98-1.60)	1.27 (0.92-1.75)
	55 - 64	1.30 (0.99-1.68)	1.08 (0.80-1-44)
	65 +	1.84 (1.43-2.37) ***	1.0 [b]
Gender	Male	1.0 [b]	1.37 (1.11-1.69) **
	Female	1.04 (0.91-1.23)	1.0 [b]
Smoking status	Non-smoker	1.0 [b]	1.94 (1.55-2.37) ***
	Smoker	1.68 (1.44-1.97) ***	1.0 [b]
Time (continuous)		1.17 (1.10-1.24) ***	1.01 (0.94-1.10)

Source: The British Household Panel Survey, Waves J, M, O & Q (2000-07)

* 0.05 significance

** 0.01 significance

*** 0.001 significance

[a] Missing = 1

[b] Reference group

Table 3: Causal pathway sensitivity testing: odds ratios (ORs) with 95% confidence intervals (95% CI) of having 'good' or 'poor' self-rated health at time (t) according to multiple logistic regression analysis of lagged (t-1) and non-lagged (t) social capital variables, along with all lagged and non-lagged explanatory variables (Note: only social capital variables shown below)

Explanatory variables		Change in self-rated health status from Baseline (2000)	
		Model 1 (N = 5688 [a]) Good Health at Baseline Cohort - ORs (95% CI) of having PH over time	Model 2 (N = 2425) Poor Health at Baseline Cohort - ORs (95% CI) of having GH over time
Social participation: Lagged (t-1)	Active participation	1.0 [b]	1.15 (0.98-1.35)
	No participation	1.00 (0.89-1.13)	1.0 [b]
Social participation: Non-lagged (t)	Active participation	1.0 [b]	1.25 (1.06-1.47) **
	No participation	1.21 (1.07-1.37) **	1.0 [b]
Generalised trust: Lagged (t-1)	Trusts others	1.0 [b]	1.25 (1.05-1.49) *
	Can't trust others	1.25 (1.10-1.42) ***	1.0 [b]
Generalised trust: Non-lagged (t)	Trusts others	1.0 [b]	1.29 (1.08-1.54) **
	Can't trust others	1.45 (1.27-1.64) ***	1.0 [b]
Talks with neighbours: Lagged (t-1)	1+/week	1.13 (0.97-1.31)	1.28 (1.05-1.55) *
	Less than this	1.0 [b]	1.0 [b]
Talks with neighbours: Non-lagged (t)	1+/week	1.13 (0.97-1.31)	1.27 (1.04-1.55) *
	Less than this	1.0 [b]	1.0 [b]

Source: The British Household Panel Survey, Waves J, M, O & Q (2000-07)

* 0.05 significance
** 0.01 significance
*** 0.001 significance

[a] Missing = 1
[b] Reference

PH - Poor SRH
GH - Good SRH

Paper IV

Questioning the validity of association between social capital and health using a family-based design

Abstract

Background
The past decade has seen a vast increase in empirical research investigating association between social capital and health outcomes. Literature reviews reveal 'generalized trust' and 'social participation' to be the most robust of the commonly used social capital proxies, both showing positive association with health outcomes. However, this association could be confounded by unmeasured factors, such as genes or shared environment.

Methods
Using data from the United Kingdom's British Household Panel Survey (Waves thirteen to eighteen), this longitudinal and multilevel study investigates the validity of association between trust, participation and self-rated health using a family-based design (N = 6982). The design attempts to reduce residual confounding bias by adjusting for shared environment over time - the household.

Results
Results show that after adjusting for shared environment over time (the household), association between our two social capital proxies and self-rated health becomes heavily attenuated (odds ratio for 'generalized trust' = 1.11 (1.02-1.20) and 'social participation' = 0.97 (0.89-1.06). Other health determinants such as being a smoker, having no formal qualifications and being unemployed maintain their association with poor self-rated health.

Conclusions
These findings have potentially serious implications within the field of public health and health policy, as 'trust' and 'participation' are frequently researched to demonstrate the independent influence of social capital on health outcomes. The same body of research may have influenced decision makers within the UK, along with international development agencies such as the World Bank, to employ aspects of social capital to maintain and improve population health.

Key words: United Kingdom; social capital; longitudinal; family-based design; self-rated health; trust

Introduction

The works of Kawachi et al (1, 2) and Putnam (3) launched 'social capital' firmly into the field of public health research. Subsequently, the past decade has seen a vast increase in publications investigating association between measures of social capital and health outcomes (for recent reviews see (4, 5)). The same timeframe has also seen fervent critique of social capital research, with questions being asked of its conceptualization, methodologies and its relevance when investigating health outcomes of individuals and populations (6-9).

Disparity amongst researchers has resulted in them employing a variety of differing 'proxies' to operationalise social capital at the individual- or contextual-level. Literature reviews suggest that generalized trust (also known as 'interpersonal trust') and participation seem the proxies most commonly used when investigating social capital and health outcomes (4, 5, 10). Trust appears the more robust of the two, being often touted as an independent predictor of health (11-13).

However, the validity of association between trust, participation and health still needs to be questioned, as it may be confounded by unmeasured factors, such as genes or shared environment. With this in mind, our longitudinal multilevel study will investigate the validity of the association between trust, participation and self-rated health using a family-based design, sampling adults who continually share the same environment (the household) over a six year period.

Materials and methods

Study population

The British Household Panel Survey (BHPS) is a longitudinal survey of randomly selected private households conducted by the UK's Economic and Social Research Centre. Since 1991, individuals within selected households have been interviewed annually with a view to identifying social and economic changes within the British population. The original cohort sample was randomly selected by using a two stage cluster design, full details of which can be found on-line (14).
The Research Centre fully adopted the Ethical Guidelines of the Social Research Association, which conform to those of the International Statistical Institute. Informed consent was obtained from all participants and strict confidentiality protocols were adhered to throughout data collection and processing procedures.
The raw multilevel data for this longitudinal study come from BHPS participants providing responses across the years 2003, 05, 07 and 08 (N=6982), clustered on households (N=4031). Each household contained at least two adult respondents who remained within the same household over the 6 year study period. Attempting

to address issues of reverse causality, we derived all explanatory variables from 2003, 05 and 07 data and our outcome (self-rated health) from 2008. Participation rates for Wave thirteen (2003) compared to the original 1991 sample was 70.2%.

Dependent variable

Our outcome variable is self-rated health, which has been repeatedly found to be a valid predictor of mortality and morbidity (15, 16). In 2008, individuals were asked: 'Compared to people your own age, would you say that your health has on the whole been excellent, good, fair, poor or very poor?' This five-point scale was recoded into the dichotomous variable 'good' (excellent, good) and 'poor' (fair, poor, very poor) health, the outcome of interest being 'poor' health.

Explanatory variables

We used two social capital proxies in this study: generalized trust and social participation. Generalized trust was assessed by asking people: 'Would you say that most people can be trusted, or that you can't be too careful?' This variable was dichotomized into 'can trust others' (0) and 'can't trust others' (1), with the response 'most people can be trusted' being the reference group. Responses 'you can't be too careful' and 'it depends' were combined and given the value 1. Levels of social participation within the community were measured by asking the respondents questions about being active members of (i) local community groups, (ii) local voluntary organizations, or (iii) any sports, hobby or leisure group (see appendix for full list). Only those who answered positively to any of these elements were judged to participate with responses at each wave being dichotomized into 'active participation' (0) and 'no participation' (1).

As the above social capital proxies are time-dependent (i.e. respondents' answers can vary from year to year) we summed the dichotomous (1-0) responses from years 2003, 05 and 07 and re-categorized them to reflect potential changes over time. Taking 'trust' as an example, those who could consistently trust across the three waves (scoring '0' in total) were labelled 'always trusts others'; those who couldn't trust across the three waves (scoring '3' in total) were labelled 'never trusts others'; any respondent scoring '1 or 2' in total (reflecting a change in trust levels over time) were labelled 'intermittent trust'. This process was repeated for the social capital proxy 'social participation'.

Our summed individual-level social capital proxies were further aggregated to the household-level in order to implement our family-based design, deriving two distinct aggregate measures:

i) the 'mean household value', a comparison between the different households sampled, and;

ii) the 'difference from the mean household value', a comparison of individuals from within the same household.

We consider (ii) an individual-level social capital measurement, now not confounded by shared environment i.e. the same household over 6 years.

Highest achieved education, employment status and household income were included as measures of socio-economic position (SEP). Household income was weighted according to size by summing the income of all household members and dividing this sum by the square root of the household size (17). Income levels were expressions of total income, net of taxation.

As education can increase over time, the highest education level achieved was taken from 2007 data and categorized as 'Undergraduate or higher', 'Year 13', 'Year 11' and 'No formal qualifications'. Employment status was categorized as 'Employed', 'Retired', 'Fulltime student' or 'Unemployed'. Smoking status was categorized as 'smoker' and 'non-smoker' according to respondents' answer to the question 'Do you smoke cigarettes?' As with our social capital proxies, the responses to smoking and employment status were summed across the three waves (2003-07) to capture change over time.

Other variables considered for this study included age and gender, with age being stratified into quintiles for all analyses (see tables).

Statistical analyses

We ran all explanatory variables simultaneously against the outcome poor self-rated health in two multiple regression analyses using Generalized Estimating Equations (GEE) (18), with an exchangeable working correlation structure employing the 'sandwich' covariance estimator (19). Our first model (see table 3) represents our longitudinal investigation into association between 'summed' individual-level social capital variables and self-rated health; our second model (table 4) represents our longitudinal family-based design, investigating association between 'summed' individual-level social capital variables and self-rated health, whilst adjusting for shared environment (the household) over time. All analyses were conducted within the statistical software package STATA 11.2 (20).

Results

Table 1 shows frequencies and total percentages of all explanatory variables, stratified by self-rated health in 2008. Table 2a is a '2 x 2' table showing the differences in exposure of generalized trust and self-rated health at the household level ($N_{household} = 4031$); table 2b shows the differences in exposure of social participation and self-rated health, also at the household level.

Model 1

Longitudinal multiple regression analysis

As shown in table 3, the odds ratios (OR) demonstrating association between social capital (trust and participation) and subsequent poor self-rated health increase as presence of social capital diminishes. There is also association between lack of formal qualifications, being unemployed, smoking intermittently or full time and subsequent poor self-rated health. An increase in household income and being female seems to protect against poor self-rated health.

Model 2

'Family-based' multiple regression analysis

As shown in table 4, having adjusted for shared environment over time (the same household over six years), there are now two OR per social capital proxy: the 'mean' value represents association between social capital and subsequent poor self-rated health when comparing different households with each other (often seen in traditional multilevel designs). However, the 'difference from the household mean' value reveals association between trust, social participation and subsequent poor self-rated health when comparing individuals from within the same household (family-based design). The 'difference from the household mean' value represents an individual-level social capital measurement, now not confounded by the shared environment of the household, and our results show that both trust and participation are now heavily attenuated.

Being a smoker, having no formal qualifications and being unemployed maintain association with subsequent poor self-rated health. Household income and gender still appear to protect against poor self-rated health.

Discussion

The aim of our longitudinal multilevel study was to test the validity of association between two commonly used social capital proxies (generalized trust and social

participation) and self-rated health using a family-based design. After adjusting for shared environment over time (the household), we demonstrate that association between our social capital proxies and self-rated health becomes heavily attenuated, hinting at confounding by residuals previously unconsidered by researchers within this field.

These findings have potentially serious public health and policy implications, as decision makers in the UK (21) (22), along with international development agencies such as the World Bank (23) (24) and WHO (25) employ aspects of social capital theory to maintain and improve population health, based in part on past empirical social capital research.

Trust and participation have been considered valid social capital proxies for over a decade (3, 24, 26), and have been extensively used to demonstrate the independent influence of social capital over health outcomes. Reviewing past social capital literature, the association between 'generalized trust' and health appears the more robust (4, 5, 10), resulting in trust being labelled an independent predictor of health (11-13).

Theories as to how trust and participation influence individual health include proposals by House, Landis and Umberson (27) and later by Berkman (28) that higher levels of generalized trust promote participation and more dense social networks, which influence health via social support mechanisms. A similar proposal by Anheier and Kendall (29) states that higher trust levels may stem from frequent interaction with family and friends, which in turn enables greater levels of participation. Rothstein and Stolle (30) consider trust a prerequisite to social participation, the assumption being that individuals with high levels of interpersonal trust 'self-select' into voluntary organizations and groups. More recently, Giordano & Lindström (13) suggest that social support mechanisms and psychosocial pathways (31) play a duel role along the pathway from trust to health.

However, the results of this study suggest that any prior association between trust, participation and self-rated health may have been confounded by shared environmental factors.

It should be noted that our sample contains only adults who cohabitate; we do not claim to adjust for any genetic factors, i.e. a sibling design. The only twin-pair study to date investigating generalized trust, participation and health demonstrates positive association only between trust and health (32). While Fujiwara's and Kawachi's cross-sectional study can rule out personality or early child environment as possible confounders, it '…does not necessarily control for all life course and adult factors on which twins may differ' (33), nor can it tackle issues of reverse causality. Our longitudinal multilevel study design attempts to address

these outstanding issues, sampling adults who share the same environment (the household) over a six year timeframe.

It is important to clarify that the 'mean household value' for trust provides comparison between different households from across the UK in our study. Though this value (OR = 1.29: 1.21, 1.37) maintains significance in our final model (see table 4), this association is confounded by obvious differences between households (for example: by SEP, type of accommodation, lifestyle choices, etc.) and other unmeasured factors. In our opinion, the mean household value holds little relevance regarding our aim to validate association between social capital and self-rated health.

Conversely, the 'difference from the household mean' value is a direct comparison of individuals from within the same household, accounting for a number of previously unmeasured factors, such as the existence of shared genetic and environmental factors, as well as positive assortative mating (34, 35). Within household studies, therefore, produce more valid measures of association than between household analyses, the latter being confounded by unmeasured factors not controllable by traditional multiple regression analyses.

It is noteworthy that the OR derived from the 'difference from the household mean' measure of trust, though now heavily attenuated (compared to individual-level trust measures in Table 3) still remains significant (OR = 1.11:1.02, 1.20). However, one should consider the size of the effect of trust on health in comparison to other well-known health determinants (for example, from our study - 'unemployed': OR = 3.02: 2.51, 3.64).

Our results appear to have strong ramifications within the field of social capital research though they are, of course, data-specific; we therefore welcome continued auditing of the association between social capital and health, using family-based designs.

Strengths and weaknesses

A major strength of our study is that it is longitudinal and multilevel in nature, allowing the implementation of a family-based design, adjusting for the shared environment of the household over time. That adult respondents remain within the same household over six years implies that 'difference from the household mean' values provide a valid and reliable method to compare individuals within the same household, who have differences in exposure and outcome (see tables). We also include other well-known health determinants in our study to reduce potential confounding. All respondents sampled in our data provided face-to-face interviews rather than relying on postal questionnaires across the six year timeframe.

A major limitation of this study is that the BHPS sample was originally selected to reflect
the UK population as a whole, deliberately avoiding oversampling of smaller sized communities. Only 70.2 % of the original cohort sample selected in 1991 was still available by 2003, introducing further selection bias into this study. Though self-rated health is a subjective measure, it is still considered a valid and reliable predictor of mortality and morbidity (15, 16). Though we have stated that our design only considers the shared environment of the household, 9.8% of our sample population (N = 682) are, in fact, directly related (i.e. living with brother, sister or parent).

Conclusion

The results of this study suggest that association between social capital (specifically trust and participation) and self-rated health may be confounded by shared environmental factors previously unconsidered by researchers. Our findings have potentially serious implications within the field of public health and health policy, as social capital research has frequently employed measures of trust and participation to demonstrate its independent influence and importance of social capital on health outcomes. We suggest and welcome continued auditing of the association between social capital and self-rated health, using other family-based designs.

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Conflict of interest: None declared

Appendix

To determine ‘social participation’ levels, respondents were asked if they were members of any group or organization listed below:
Political party, trade union, environmental group, parents' / school association, tenants' / residents' group or neighbourhood watch, church organization, voluntary service group, pensioners group / organization, social club / working men's club, sports club, Women's Institute.

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Table 1: Frequencies of all considered variables (derived from years 2003-2007) expressed as integers and percentages (%) of N_T (6982) stratified by self-rated health in 2008

		Self-rated health		
Explanatory variables		Good	Poor	Total (N_T)
Generalised trust	Always trusts others	1380	330	1710
		28.2%	*15.8%*	*24.5%*
	Intermittent trust	1766	711	2477
		36.1%	*34.1%*	*35.5%*
	Never trusts others	1750	1045	2795
		35.7%	*50.1%*	*40.0%*
Total		4896	2086	6982
		100.0%	*100.0%*	*100.0%*
Social Participation: Active member of local groups, organisations or group leisure activities	Active participation	1341	470	1811
		27.4%	*22.5%*	*25.9%*
	Intermittent participation	2039	840	2879
		41.6%	*40.3%*	*41.2%*
	Zero participation	1516	776	2292
		21.7%	*11.1%*	*32.8%*
Total		4896	2086	6982
		100.0%	*100.0%*	*100.0%*
Gender	Male	2221	942	3163
		45.4%	*45.3%*	*45.3%*
	Female	2675	1144	3819
		54.6%	*54.8%*	*54.7%*
Total		4896	2086	6982
		100.0%	*100.0%*	*100.0%*
Age	16-34	1006	317	1323
		20.5%	*15.2%*	*18.9%*
	35-44	1190	391	1581
		24.3%	*18.7%*	*22.6%*
	45-54	1031	445	1476
		21.1%	*21.3%*	*21.1%*
	55-64	873	412	1285
		17.8%	*19.8%*	*18.4%*

	65+	796	521	1317
		16.3%	*25.0%*	*18.9%*
Total		4896	2086	6982
		100.0%	*100.0%*	*100.0%*
Employment status	Employed	3071	884	3955
		62.7%	*42.4%*	*56.6%*
	Full time student	630	221	851
		12.9%	*10.6%*	*12.2%*
	Retired	849	556	1405
		17.3%	*26.7%*	*20.1%*
	Unemployed	346	425	771
		7.1%	*20.4%*	*11.0%*
Total		4896	2086	6982
		100.0%	*100.0%*	*100.0%*
Highest education achieved [a]	Undergraduate or higher	1304	327	1631
		26.9%	*15.9%*	*23.6%*
	Year 13	1032	364	1396
		21.3%	*17.7%*	*20.2%*
	Year 12	1583	594	2117
		32.7%	*28.8%*	*31.6%*
	No formal qualifications	921	775	1696
		19.0%	*37.6%*	*24.6%*
Total		4840	2060	6900
		100.0%	*100.0%*	*100.0%*
Smoking status	Never smokes	3733	1374	5107
		76.2%	*65.9%*	*73.1%*
	Intermittent smoker	432	233	665
		8.8%	*11.2%*	*9.5%*
	Always smokes	731	479	1210
		14.9%	*23.0%*	*17.3%*
Total		4896	2086	6982
		100.0%	*100.0%*	*100.%*
Household income (annual, size-weighted)	< £ 30,818	110	646	1746
		22.5%	*31.0%*	*25.0%*
	£30,819 - £54,107	1125	620	1745
		23.0%	*29.7%*	*25.0%*

	£54,108- £86,659	1225	490	1745
		25.6%	*23.5%*	*25.0%*
	£86,660 +	1416	330	1746
		28.9%	*15.8%*	*25.0%*
Total		4896	2086	6982
		100.0%	*100.0%*	*100.0%*

Source: The British Household Panel Survey Waves M , O, Q & R (2003, 05, 07 & 08)

[a] Missing N = 82

Table 2a: A 2x2 table showing the differences in exposure of generalised trust and self-rated health at the household level (N= 4031)

	No difference in exposure of trust	Difference in exposure of trust	*Total*
No difference in exposure of SRH	2106	966	3072
	52.2%	*24.0%*	*76.2%*
Difference in exposure of SRH	364	595	959
	9.0%	*14.8%*	*23.8%*
Total	2470	1561	4031
	61.3%	*38.7%*	*100.0%*

Source: The British Household Panel Survey Waves M , O, Q & R

Table 2b: A 2x2 table showing the differences in exposure of social participation and self-rated health at the household level (N= 4031)

	No difference in exposure of participation	Difference in exposure of participation	*Total*
No difference in exposure of SRH	2080	384	2464
	51.6%	*9.5%*	*61.1%*
Difference in exposure of SRH	992	575	1567
	24.6%	*14.3%*	*38.9%*
Total	3072	959	4031
	76.2%	*23.8%*	*100.0%*

Source: The British Household Panel Survey Waves M , O, Q & R

Table 3: Odds ratios (ORs) with 95% confidence intervals (95% CI) of poor self-rated health in 2008 according to multiple regression analysis of explanatory variables derived from 2003-07 (N = 6900)

Explanatory variables		Poor self-rated health in 2008 ORs (95% CI)
Generalised trust	Always trusts others	1.0
	Intermittent trust	1.42 (1.22-1.67)
	Never trusts others	1.87 (1.59-2.19)
Social participation: Membership of local voluntary groups	Always active member	1.0
	Intermittent member	1.11 (0.96-1.28)
	Never active member	1.12 (0.96-1.31)
Age (years)	16 - 34	1.0
	35 - 44	1.37 (1.14-1.65)
	45 - 54	1.77 (1.47-2.13)
	55 - 64	1.37 (1.13-1.67)
	65 +	1.41 (1.12-1.79)
Gender	Male	1.0
	Female	0.76 (0.67-0.85)

Household income -size weighted	Per £1000 increase	1.00 (1.00-1.00)
Employment status	Employed	1.0
	Full time student	1.16 (0.97-1.39)
	Retired	1.85 (1.53-2.25)
	Unemployed	3.07 (2.55-3.69)
Highest education achieved	Undergraduate or higher	1.0
	Year 13	1.13 (0.94-1.35)
	Year 11	1.03 (0.87-1.22)
	No formal qualifications	1.60 (1.33-1.92)
Smoking status	Never a smoker	1.0
	Intermittent smoker	1.49 (1.24-1.80)
	Always a smoker	1.49 (1.29-1.72)

Source: The British Household Panel Survey, Waves M ,O, Q & R (2003, 05, 07 & 08)

Reference group = 1.0

Table 4: Odds ratios (ORs) with 95% confidence intervals (95% CI) of having poor self-rated health in 2008 according to multiple regression analysis using explanatory variables derived from 2003-07, simultaneously adjusting for between and within household social capital measures (family based design, *N* = 6900)

Explanatory variables		Poor self-rated health in 2008 ORs (95% CI)
Generalised trust - between HHs	Mean value	1.29 (1.21-1.37)
Generalised trust - within HHs	Difference from the Mean	1.11 (1.02-1.20)
Social participation - between HHs	Mean value	1.07 (0.97-1.18)
Social participation- within HHs	Difference from the Mean	0.97 (0.89-1.06)
Age (years)	16 - 34	1.0
	35 - 44	1.39 (1.15-1.67)
	45 - 54	1.80 (1.49-2.17)
	55 - 64	1.41 (1.16-1.72)
	65 +	1.48 (1.16-1.88)
Gender	Male	1.0
	Female	0.76 (0.68-0.86)

Household income - size weighted	Per £1000 increase	0.99 (0.99-1.00)
Employment status	Employed	1.0
	Full time student	1.16 (0.97-1.40)
	Retired	1.84 (1.52-2.24)
	Unemployed	3.02 (2.51-3.64)
Education achieved	Undergraduate or higher	1.0
	Year 13	1.11 (0.93-1.32)
	Year 11	1.00 (0.84-1.18)
	No formal qualifications	1.52 (1.26-1.83)
Smoking status	Never a smoker	1.0
	Intermittent smoker	1.47 (1.22-1.76)
	Always a smoker	1.46 (1.26-1.69)

Source: The British Household Panel Survey, Waves M ,O, Q & R (2003, 05, 07 & 08)

Reference group = 1.0
HH = Household