Title: The differential impact of subjective and objective aspects of social engagement on cardiovascular risk factors

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INTRODUCTION

The study of the social determinants of health is a relatively new area of scientific enquiry. A plethora of different conceptualisations and measurements of the key social characteristics of people's lives have been developed and deployed in surveys. Both cross-sectional and, more interestingly, longitudinal studies, have yielded evidence of a link between various aspects of 'social engagement' (an umbrella term used here to denote one or more aspects of the social existence of study participants) and mortality/morbidity (Berkman & Syme, 1979; Berkman, Leo-Summers & Horwitz, 1992; House, Robbins & Metzner, 1982; Kaplan, Cohn, Cohen, & Guralnik, 1988; Orth-Gomer & Johnson, 1987; Seeman, Mendes de Leon, Berkman & Ostfeld, 1993; Welin et al., 1985). Earlier studies relied in most cases on self-reported health (and some still do); gradually, more objective measurements of health were included in prospective studies; and more recently a range of biomarkers have been incorporated into many longitudinal population studies.

Previous studies (Ford et al., 2006; Loucks et al., 2005; Loucks, Berkman, Gruenewald, & Seeman, 2006; Loucks, Sullivan et al., 2006) examining objective aspects of social engagement (i.e. social participation and social ties) found no consistent association between inflammatory markers (hsCRP and fibrinogen) for older and younger women and younger men. The authors recommended that subjective aspects of social engagement (such as emotional support or demanding aspects of relationships) should be addressed in further studies in order to provide insight into the role of inflammatory markers as biological mediators between social engagement and cardiovascular disease. We expand the previous model by incorporating both objective and subjective measurements of social engagement and by incorporating measurement of a range of relevant validated cardiovascular risk factors not restricted to inflammatory markers.

Using data from the English Longitudinal Study on Ageing (ELSA), a nationally representative panel study, we hypothesized that objective (social participation and social ties) and subjective (emotional support) aspects of social engagement are independently associated with objective measures of CV risk.

In this paper, 'social engagement' refers to a combination of objective and subjective measures of the salient aspects of people's 'social' existence. This definition incorporates social participation (affiliation or membership in religious, voluntary, political, and social associations or activities), social ties (the number of close children, friends and relatives), and emotional support from spouse, children, relatives and friends. These components are based on previous studies of older individuals (L.F. Berkman & Kawachi, 2000). The selected risk factors have well-established associations with cardiovascular diseases: high-density lipoprotein (HDL) (Toth, 2005), hypertension (Benetos, Thomas, Safar, Bean, & L.Guize, 2001), glycosylated hemoglobin (HbA1c) (Khaw et al., 2004; Singer, Nathan, Anderson, Wilson, & Evans, 1992), and two inflammatory markers – fibrinogen (Collaboration et al., 2007; Di Napoli & Singh, 2009), and high sensitivity C-reactive protein (hsCRP) (Aviles et al., 2003; Barzilay et al., 2001; Cao et al., 2003; Puts, Visser, Twisk, Deeg, & Lips, 2005).

High-density lipoprotein (HDL) is known as "good cholesterol" because it removes the excess cholesterol deposited in the blood vessel, returning it to the liver, where it is metabolized to bile acids and salts that are eventually eliminated through the intestine. Studies have shown that for every 1-mg/dL rise in HDL, the risk for developing cardiovascular disease decreases by 2% to 3%, even when the LDL or total cholesterol is well controlled (Toth, 2005). Systolic and diastolic blood pressure are markers of hypertension. Epidemiological studies have shown that both systolic (SBP) and diastolic blood pressure (DBP) are associated with cardiovascular risk (Benetos et al., 2001). Glycated hemoglobin (hbA1c) is a substance in red blood cells formed

when blood sugar (glucose) attaches to hemoglobin. High level of hbA1c means a high level of glucose in the blood, which is an important indicator of a diabetic condition. Prospective population studies have shown the relationship between HbA_{1c} and cardiovascular disease (Singer, 2002; Khaw, 2004). Two inflammatory markers are included: high sensitivity C-reactive protein and Fibrinogen. High sensitivity CRP and Fibrinogen are acute phase reactants (altered as a result of the inflammatory process). CRP is a predictor of frailty (Puts, Visser, Twisk, Deeg & Lips, 2005), is a risk factor for the development of cardiovascular conditons such as arterial fibrillation (Aviles et al., 2003), ischemic stroke (Cao et al., 2003), diabetes (Barzilay et al., 2001), and cognitive decline (Teunissen et al., 2003). Fibrinogen is involved in thrombogenesis and in the stimulation of atherogenenic cell proliferation; thus, elevated levels of fibrinogen are associated with coronary disease and stroke.

METHODS:

Design/participants

The English Longitudinal Study of Ageing (ELSA) is an ongoing panel study of a nationally representative sample of the English population living in households. The original ELSA cohort consists of men and women born on or before 29 February 1952. The sample was drawn from households that have participated in the Health Survey for England (HSE) in 1998, 1999, and 2001. For the present analyses, data from the second wave (2004–2005), which comprised a face-to-face interview and clinical assessment by a nurse, were used. This is the only wave containing the objective health assessment and blood analysis data that is currently available for public use. Overall, 8,688 people participated in wave 2 (2004-05). Of these 7,433 participants had a nurse

visit at which blood data were collected. Valid biological data are available for 5,540 participants. Biological data were missing for participants who did not consent to give blood or were ineligible (participants with clotting and bleeding disorders, or taking anti-coagulant medication). The analysis of the blood data was carried out in the Royal Victoria Infirmary (Newcastle-upon-Tyne, UK). Both the HSE and ELSA employed the same laboratory and the same guidelines and protocols for the blood analysis. Detailed information on the technicalities of the blood analysis are available in the 2004 HSE technical report (Graig, Deverill, & Pickering, 2006). Blood samples were analysed for HDL, HbA1c, hsCRP and fibrinogen. Blood pressure was recorded as the average of three seated blood pressure readings (Omron HEM-907 blood pressure monitor).

Measurements

Cardiovascular variables: Cardiovascular variables were dichotomized. The cut-off for HDL-cholesterol is <1.03 mmol/L for men and <1.29 mmol/L for women (International Diabetes Federation). Hypertension is defined as SBP and DBP ≥140/90 mmHg (Health, 1997) or SBP ≥140 (isolated systolic hypertension) or using hypertensive medication. The cut-off point for HbA1c was ≥ 6% (American Diabetes Association). Elevated hsCRP and fibrinogen were categorized by the highest quartile concentration for each inflammatory marker: CRP >4.1 mg/l and Fibrinogen >3.6g/L, respectively.

Social engagement: Three different dimensions of social engagement were examined. *Social participation* was measured as a count of eight activities in which the respondent reported current membership or participation: (1) political, trade union or environmental group; (2) tenants' groups, residents' groups or neighbourhood watch; (3) church or other religious organization; (4) charitable associations; (5) an education, arts or music group or evening class; (6) social club; (7)

sports club, gym, or exercise class; and (8) any other organisations, clubs or societies. A dichotomous variable was created: no activities (=0) or one or more activities (≥1 = 1). *Social ties* were measured by a count of the number of close children, relatives and friends. The final score was added up and then dichotomized as: zero or one close relationship (=0) versus more two or more close relationships (=1). Emotional support from spouse, children, relatives and friends was measured by the following three questions: a) How much respondents feels their spouse/partner (children/relatives/friends) understand(s) their feelings; b) How much respondents can rely on spouse/partner (children/relatives/friends) if they have a serious problem; and c) How much respondents can open up to their spouse/partner (children/relatives/friends) if they need to talk. The responses for each item range from 0 (not at all) to 3 (a lot). Responses to all three questions are added up to a summary score ranging from 0 (lack of emotional support or no spouse/children/relatives or friends) to 9 (highest possible emotional support).

Demographic and socio-economic variables included age (in years), sex (male as reference category), and educational measured as the highest qualification participants obtained, and categorized into four groups (no education, primary, secondary and tertiary level).

Health behaviours: Body mass index, which is a proxy for physical activity, was dichotomized by cut-off point of BMI≥30kg/m2. Smoking was coded as never smoked and ever smoked (ex-smoker or current smoker).

Co-morbidity: Known cardiovascular disease was assessed by self-reported angina, myocardial infarction, stroke, heart failure, heart murmur, abnormal heart rhythm, diabetes and ischaemic heart disease. Other major chronic diseases include self-reported chronic lung disease, asthma, arthritis, osteoporosis, cancer, Parkinson's disease, and Alzheimer's disease. These variables are

dichotomized into "0 condition" and "≥1 condition". Depression was measured by the 8-item Center for Epidemiologic Studies Depression Scale (CES-D) with a cut-off point of 3 or more depressive symptoms which has been proven to be clinically significant (Steffick, 2000) (<3 = non depressive, ≥3 = depressive). Co-morbid disorders were subsequently corrected for in the adjusted models.

STATISTICAL ANALYSIS:

The effects of social engagement on CV risk factors were examined using logistic regression in three models. The first model was adjusted for socio-demographic factors (age, sex and education). The second model was further adjusted for co-morbidity (depression, cardiovascular and chronic disease). The third model was additionally adjusted for behavioral risk factors (smoking, and BMI). The third model adjusted for variables that may be considered as confounders or as mediators. Cases with hsCRP higher than10 mg/L were excluded from the hsCRP regression analysis because such levels reflect an acute infection or inflammation other than those due to cardiovascular disease (Ridker, 2003). Performing correlation analysis with co-morbidity variables and cardiovascular risk factors, correlation coefficients showed that only diabetes was associated with HbA1c ($r=0.53$, $p=0.0001$). Therefore, participants with diabetes were excluded from Hba1c regression and other pre-existing cardiovascular and chronic diseases were statistically controlled for.

RESULTS

Descriptive statistics for all variables are shown in Table 1. The sample was composed of 53.4% of women and 46.6% of men. The median age was 65 and 66 years for women and men respectively. Sixty nine percent were married, 88.7% had one or more living children, and 40.4 %

have a primary education. Thirty-seven percent reported no social participation and 15.1% of the respondents reported that they did not have close children, relatives or friends.

Correlation coefficients within predictors and outcomes, and correlation of control variables (covariates) and outcomes are discussed below (data not shown).

Examining correlation within outcomes at p=0.0001 level, hsCRP and fibrinogen were correlated (r=0.43). Within predictors, social participation and support by friends (r=0.35), social ties and support from child (r=0.33), relative (r=0.38) and friend (r=0.39) were correlated. Emotional support by relatives was correlated with support by friends (r=0.40).

Tables 2-6 show the odds ratios (OR) and 95% confidence intervals (CIs) from logistic regression for serum HDL, hypertension, HBA1c, fibrinogen, and hsCPR. Adjustment for behavioural factors (model 3), attenuated the results slightly, but the associations remained significant for four of the markers (OR for serum HDL decreased from 0.81 in model 2 to 0.83 in model 3, OR for HbA1c from 0.72 to 0.76; OR for fibrinogen from 0.80 to 0.86, and OR for hsCRP from 0.73 to 0.78). In contrast, for objective hypertension, adjusting for behavioral factors, the association became significant (OR=0.902 from model 2 to OR=0.89 from model 3). The overall trend was robust for social participation even after all the adjustments, indicating that social participation was significantly inversely associated with all of the cardiovascular risk factors (p=0.05). Social ties were associated with hypertension (OR=0.99) (model 3). Emotional support from spouse was associated with HDL (OR=0.98), hypertension (OR=0.98) and HbA1c (OR=0.96) (model 3).

DISCUSSION

In examining the association between social engagement and CVD risk factors, our study expanded from previous studies by incorporating both objective and subjective measurements of social engagement. Within the subjective measurements, by differentiating emotional support by its source (i.e. spouse, children, relatives and friends), only emotional support from spouse was significant associated with HDL, hypertension, and HbA1c, but the effect was very small. Within the objective measurements, social ties were associated with hypertension, but again the effect was extremely small. Social participation was associated with all five cardiovascular risk factors (lower HDL, hypertension, HBA1c, fibrinogen and CRP), and had a moderate to strong effect even after controlling for an extensive set of variables.

A recent study on social participation (Ellaway & Macintyre, 2007) did not find any consistent association with CV risk factors. However, the study compared the mean scores of the CV risk markers by social participation adjusted only for age and social class. Our study adjusted for various indicators of comorbidity and behavioral factors to reduce the likelihood that the observed relationship between social engagement and CV risk factors was a spurious relationship.

Our results indicate that objective and subjective measurements of social engagement may be related to different cardiovascular risk factors and raise the question of why social participation is more protective against CV disease than other measures such as social ties and emotional support.

The findings suggest that participation in social, civic or political activities may have an important effect on lowering risk for CV risk. Previous research has found that social

participation has an impact on physical and mental health (Bassuk, Glass, & Berkman, 1999; Glass, de Leon, Marottol, & Berkman, 1999; Glei et al., 2005), survival at older ages (Cornman, Goldman, Glei, Weinstein, & Chang, 2003) , and is inversely associated with plasma fibrinogen (Helminen, Rankinen, Väisänen, & Rauramaa, 1997; Rosengren et al., 1990). Participation in political, social or civic activities provides social contacts and gives rise to meaningful social roles which in turn provide a sense of value, belonging and attachment in the community (L.F. Berkman & Kawachi, 2000). It may give meaning and purpose to life through the fulfillment of various social roles (Mendes de Leon, Glass, & Berkman, 2003), thus lowering the levels of psychological distress (Cornman et al., 2003). Social participation may facilitate access to health information and services, and may even "facilitate forms of political organization that may be used to improve access to and quality care" (Mendes de Leon, 2004, p.538). In addition, Glei et al. (2005) suggested that social participation had a greater impact on cognitive function than the extent of one's social ties, because social ties can impose demands and negative interactions.

As shown above, correlation tests indicated that the social ties and emotional support from child, relative and friend were correlated. Emotional support from relatives was correlated with support from friends indicating that these the variables should perhaps be combined into a single index. However, when this was done the index lacked explanatory significance. We conclude that it is important to retain the separate variables in the analysis.

We conducted additional analysis (data not shown) using cardiovascular risk factors at wave 2 as a dependent variable with social engagement variables at baseline (wave 1). In line with the argument advanced by Antonucci and Akiyama (Antonucci & Akiyama, 1987), that social networks are stable in old age, there was a little change in the social engagement indicators from

wave 1 to wave 2 and the results did not change what is presented in this article. We also created indices for CVD risk by summing the scores for each one of the five CV risk factors (range 0 to 5) and estimated the relationship between these scores and social engagement using Poisson regression (results not shown but available upon request). The results are again similar to the logistic regression, confirming that the CV disease index is significantly inversely associated with social participation.

This study has both strengths and limitations. Strengths include a large representative sample of the non-institutionalized older population from which the findings can be generalized, the use of three separate indicators of social engagement, and the careful measurement of a range of relevant and previously validated cardiovascular risk factors. The limitations are firstly that , causality cannot be inferred from cross-sectional data analysis (necessitated by the availability, currently, of health measurement and blood data from a single wave of the study) Secondly, although we adjusted for an extensive range of health factors, one could argue that social participation is actually measuring health status in ways not otherwise controlled for. Future analyses of forthcoming panel data will allow us to explore this limitation. For example, the elimination of those who die during the next five years of follow-up would attenuate some of the relationship between health and social participation. It will be possible to make stronger causal inferences from further waves.

Table 1: Distribution of explanatory variables

Variable	Percent/Mean (SD)
Demographic and socio-economic variables	
Age (%)	
50-60	31.9
60-70	31.7
70-80	25.1
80+	11.3
Mean Age	
Currently married (%)	66.7
Male (%)	53.7
Education: levels of education attained	
terciary	22.9
secondary	27.9
primary	40.4
no education	8.7
Social engagement	
No social participation (%)	37.41
No social ties (%)	15.05
No emotional support from	
Spouse	36.5
Children	23.0
Relatives	23.4
Friends	15.9
Co-morbidity	
Have Depression (8 item CES-D)	22.9
Body Mass Index (>30 kg/m2)	29.0
No chronic disease*	59.6
No CVD**	22.8
Health Behaviours	
Smoking	82.5
Cardiovascular variables	
Systolic and diastolic blood pressure	
Mean systolic BP (mmHg)	135.4(19.0)
Mean diastolic BP (mmHg)	74.9 (11.3)
Hypertension (%)(>=140/90 mmHg or antihypertensive medication)	38.8
Mean total HDL cholesterol	1.5 (0.4)
HDL <1.0 mmol/L in men and <1.3 mmol/L in women	14.57
Mean HbA1c level (%)	5.6 (0.7)
HbA1c > 6.0 %	6.7
Mean hsCRP (mg/l)	3.6 (4.8)
hsCRP>4.1 mg/l	26.13
Mean Fibrinogen (g/l)	3.2 (0.7)
Fibrinogen >3.6 g/l	28.4

Note: For HDL HbA1c, hsCRP and fibrinogen, n=5897. For all other variables, n=7662

*chronic lung disease, asthma, arthritis, osteoporosis, cancer, Parkinson's disease, and Alzheimer's disease

**angina, myocardial infection, stroke, heart failure, heart murmur, abnormal heart rhythm, valvular heart disease, ischaemic heart disease

Table 2 Logistic regression models for social engagement and lower serum HDL

	Model 1 OR (95 % CI)	Model 2 OR (95 % CI)	Model 3 OR (95 % CI)
social participation	0.761(0.646 - 0.897)**	0.806 (0.682 - 0.952)*	0.829 (0.700 - 0.982)*
social ties	1.003 (0.989 - 1.017)	1.004 (0.990 - 1.018)	1.003 (0.989 - 1.018)
emotional support from			
spouse	0.971 (0.951 - 0.992)**	0.973 (0.953 - 0.995)*	0.977 (0.956 - 0.999)*
children	1.023 (0.997 - 1.050)	1.022 (0.995 - 1.049)	1.015 (0.988 - 1.042)
relatives	0.971 (0.946 - 0.996)*	0.973 (0.948 - 0.999)*	0.974 (0.949 - 1.000)
friends	1.002 (0.973 - 1.032)	1.003 (0.974 - 1.033)	1.001 (0.972 - 1.031)

*statistically significant at P<0.05; **statistically significant at p<0.01

Model 1 adjusted for age, gender, and education.

Model 2 contains all adjustments from Model 1 with addition of comorbidity (depression, chronic conditions and cardiovascular disease)

Model 3 contains further adjustment from Model 2 with addition of health behaviour risk factors (smoking, BMI)

Table 3 Logistic regression models for social engagement and hypertension

	Model 1 OR (95 % CI)	Model 2 OR (95 % CI)	Model 3 OR (95 % CI)
social participation	0.914 (0.817 - 1.022)	0.902 (0.808 - 1.007)	0.892 (0.793 - 1.003)*
social ties	0.992 (0.982 - 1.002)	0.993 (0.984 - 1.003)	0.99 (0.981 - 1.000)*
emotional support from			
spouse	0.983 (0.969 - 0.997)*	0.982 (0.968 - 0.995)**	0.977 (0.963 - 0.992)**
children	1.008 (0.991 - 1.025)	1.008 (0.992 - 1.025)	1.005 (0.988 - 1.024)
relatives	1.012 (0.995 - 1.030)	1.01 (0.993 - 1.027)	1.012 (0.995 - 1.031)
friends	0.991 (0.972 - 1.011)	0.995 (0.976 - 1.014)	0.992 (0.972 - 1.014)

*statistically significant at P<0.05; **statistically significant at p<0.01

Model 1 adjusted for age, gender, and education.

Model 2 contains all adjustments from Model 1 with addition of comorbidity (depression, chronic conditions and cardiovascular disease)

Model 3 contains further adjustment from Model 2 with addition of health behaviour risk factors (smoking, BMI)

Table 4 Logistic regression models for social engagement and elevated HbA1c

	Model 1 OR (95 % CI)	Model 2 OR (95 % CI)	Model 3 OR (95 % CI)
social participation	0.661 (0.474 - 0.922)*	0.72 (0.545 - 0.951)*	0.761 (0.573 - 1.012)*
social ties	1.022 (1.002 - 1.043)*	1.018 (1.000 - 1.038)	1.018 (0.999 - 1.038)
emotional support from			
spouse	0.957 (0.917 - 0.999)*	0.966 (0.932 - 1.002)	0.96 (0.926 - 0.996)*
children	0.998 (0.948 - 1.050)	1.008 (0.966 - 1.053)	1.007 (0.963 - 1.052)
relatives	1.007 (0.955 - 1.063)	0.991 (0.949 - 1.035)	0.99 (0.947 - 1.035)
friends	0.954 (0.899 - 1.012)	0.977 (0.931 - 1.026)	0.973 (0.926 - 1.022)

*statistically significant at P<0.05; **statistically significant at p<0.01

Model 1 adjusted for age, gender, and education.

Model 2 contains all adjustments from Model 1 with addition of comorbidity (depression, chronic conditions and cardiovascular disease)

Model 3 contains further adjustment from Model 2 with addition of health behaviour risk factors (smoking, BMI)

Table 5 Logistic regression models for social engagement and elevated fibrinogen

	Model 1 OR (95 % CI)	Model 2 OR (95 % CI)	Model 3 OR (95 % CI)
social participation	0.786 (0.687 - 0.900)**	0.802 (0.700 - 0.920)**	0.86 (0.748 - 0.989)*
social ties	0.99 (0.978 - 1.003)	0.991 (0.979 - 1.003)	0.988 (0.975 - 1.001)
emotional support from			
spouse	0.991 (0.974 - 1.008)	0.996 (0.978 - 1.013)	1.005 (0.987 - 1.023)
children	1.004 (0.984 - 1.026)	1.005 (0.984 - 1.026)	1.003 (0.982 - 1.025)
relatives	0.982 (0.961 - 1.003)	0.982 (0.961 - 1.003)	0.984 (0.963 - 1.006)
friends	1.019 (0.994 - 1.044)	1.02 (0.995 - 1.045)	1.013 (0.988 - 1.039)

*statistically significant at P<0.05; **statistically significant at p<0.01

Model 1 adjusted for age, gender, and education.

Model 2 contains all adjustments from Model 1 with addition of comorbidity (depression, chronic conditions and cardiovascular disease)

Model 3 contains further adjustment from Model 2 with addition of health behaviour risk factors (smoking, BMI)

Table 6 Logistic regression models for social engagement and elevated hsCRP

	Model 1 OR (95 % CI)	Model 2 OR (95 % CI)	Model 3 OR (95 % CI)
social participation	0.708 (0.618 - 0.811)**	0.73 (0.636 - 0.838)**	0.779 (0.676 - 0.897)**
social ties	1.002 (0.990 - 1.013)	1.003 (0.991 - 1.014)	0.999 (0.987 - 1.012)
emotional support from			
spouse	0.976 (0.959 - 0.993)**	0.982 0.964 - 0.999)*	0.985 (0.967 - 1.003)
children	1.013 (0.992 - 1.035)	1.014 (0.992 - 1.036)	1.01 (0.988 - 1.032)
relatives	1.00 (0.979 - 1.022)	1.001 (0.979 - 1.023)	1.004 (0.982 - 1.026)
friends	0.986 (0.963 - 1.011)	0.987 (0.963 - 1.012)	0.981 (0.957 - 1.006)

*statistically significant at P<0.05; **statistically significant at p<0.01

Model 1 adjusted for age, gender, and education.

Model 2 contains all adjustments from Model 1 with addition of comorbidity (depression, chronic conditions and cardiovascular disease)

Model 3 contains further adjustment from Model 2 with addition of health behaviour risk factors (smoking, BMI)

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