Neighbourhood social capital: measurement issues and associations with health outcomes

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Abbreviations:

SES	-	socioeconomic status
VAS	-	visual analogue scale
BMI	-	body mass index
IPAQ	-	international physical activity questionnaire
OR	-	odds ratio
95%CI	-	95% confidence interval
ICC	-	Intra class coefficient

ABSTRACT

Background We compared ecometric neighbourhood scores of social capital (contextual variation) to mean neighbourhood scores (individual and contextual variation), using several health-related outcomes (i.e. self-rated health, weight status and obesity-related behaviours).

Methods Data were analysed from 5,900 participants in the European SPOTLIGHT survey. Factor analysis of the 13-item social capital scale revealed two social capital constructs: social networks and social cohesion. The associations of ecometric and mean neighbourhood-level scores of these constructs with self-rated health, weight status and obesity-related behaviours were analysed using multilevel regression analyses, adjusted for key covariates.

Results Analyses using ecometric and mean neighbourhood scores, but not mean neighbourhood scores adjusted for individual scores, yielded similar regression coefficients. Higher levels of social network and social cohesion were associated with better self-rated health, lower odds of obesity and higher fruit consumption, but also with prolonged sitting and less transport-related physical activity. Only associations with transport-related physical activity and sedentary behaviours were associated with mean neighbourhood scores adjusted for individual scores.

Conclusions As analyses using ecometric scores generated the same results as using mean neighbourhood scores, but different results when using mean neighbourhood scores adjusted for individual scores, this suggests that the theoretical advantage of the ecometric approach (i.e. teasing out individual and contextual variation) may not be achieved in practice. The different operationalisations of social network and social cohesion were associated with several health outcomes, but the constructs that appeared to represent the contextual variation best were only associated with two of the outcomes.

INTRODUCTION

Social capital has been defined by Putnam as 'the resources accessed through social networks, including trust, norms of reciprocity, and the ability to undertake collective action'[1]. However, social capital is a complex contextual construct and this definition may require further refinement. Conceptualized as a collective characteristic through which individuals living in a particular area share behaviour patterns and social norms[2,3], social capital has been linked to health and weight status[4–6]. Suggested pathways for this association include (1) through the enforcement of norms related to health-related behaviours, (2) through collective efficacy to promote increased access to (health) services and (3) through the provision of psychosocial support[7]. Yet, whereas associations of social capital with general health seem relatively consistent[4,5], studies reporting on associations with other health outcomes such obesity[6,8–16] or obesity-related behaviours[17–25] are mixed.

The quantitative operationalisation of social capital as a contextual construct remains a challenge. Whereas compositional effects arise from the varying distribution of types of individuals whose characteristics influence their health, contextual effects refer to the context (space and place) individuals live in[2]. Contextual variables are rarely directly observed at the collective level, for example by observing social interactions between residents[26]. Therefore, assessments of neighbourhood social capital are often based on individuals' perceptions of reciprocity, trust and engagement in civic participation[27]. Individual reports of several individuals are then combined into a neighbourhood construct. The advantage of this approach is that neighbourhoods are characterized by merging information from several raters[28,29]. But aggregate neighbourhood measures also suffer from a number of limitations[30]. First, the reliability of the contextual variable differs as the number of respondents differs per neighbourhood. Second, the items that form the social capital scale are not independent of each other, but nested within respondents. Third, the individual perceptions of community social capital are likely to be influenced by characteristics of the respondents. That is, any observed differences between neighbourhoods could be confounded by the characteristics of the individuals living in these neighbourhoods. Without adjustment for individual-level variation, neighbourhood level variables may act partially or entirely as proxies for individual attributes[31,32]. Although adjustment of aggregate neighbourhood social capital scores for individual scores could help tease out the contextual variation of social capital, this is rarely applied[16].

As such, there may be a need for an approach that accounts for all three limitations of the aggregation of individual responses. The extent to which aggregate measures are able to differentiate true differences among communities being studied from variation among the individuals that populate them is a classic multi-level problem. Raudenbusch and Sampson proposed the multilevel 'ecometric' approach to describe the properties of neighbourhoods and to differentiate them from the properties of individuals, measured by psychometrics[28]. This is done by adjusting for individual characteristics that may be associated with the perception of social capital and taking into account the clustering of response patterns within individuals[33]. By differentiating between individual and contextual sources of variation in social capital, this ecometric

approach permits for the identification of whether the variability in area-level measures of social capital is predominantly a contextual function, a characteristic of individuals who live in the same area, or both[27–29]. Theoretically, the ecometric approach may thus be superior to the aggregation of individual level scores.

Ecometrics is an extension of the traditional psychometric evaluation of scales (based on internal consistency of scale item responses within individuals) by including a third level (scale items nested within individuals who are nested within neighbourhoods)[34]. The generated reliability coefficient is comparable to the Cronbach's alpha used for psychometrics; it not only refers to how consistently individuals respond to different component items of a scale, but also refers to what extent individuals living in the same neighbourhood rate their neighbourhood similarly[34]. Although there are some examples of the application of ecometrics to social capital research[29,30,35,36] it remains unclear whether this is a reliable method to tease out contextual and individual variation in social capital. And if so, whether it generates different results compared to using aggregate measures of social capital. Using data from the cross-European SPOTLIGHT project, we aimed to assess the reliability of ecometric measures of neighbourhood social capital, by comparing ecometric and aggregate measures in relation to self-rated health, weight status and obesity-related behaviours.

METHODS

Study design and sampling

This study was part of the SPOTLIGHT project[37], conducted in five urban regions in Belgium, France, Hungary, the Netherlands and the United Kingdom. Sampling of neighbourhoods and recruitment of participants has been described in detail elsewhere[38]. Briefly, neighbourhood sampling was based on a combination of residential density and socio-economic status (SES) data at neighbourhood level. This resulted in four types of neighbourhoods: low SES/low residential density, low SES/high residential density, high SES/low residential density and high SES/high residential density. In each country, three neighbourhoods of each type were randomly sampled (i.e.12 neighbourhoods per country, 60 neighbourhoods in total). Subsequently, a random sample of adult inhabitants was invited to participate in an online survey. The survey contained questions on demographics, neighbourhood perceptions, social environmental factors, health, motivations and barriers for healthy behaviour, obesity-related behaviours and weight and height. A total of 6,037 (10.8%, out of 55,893) individuals participated in the study between February and September 2014. The study was approved by the corresponding local ethics committees of participating countries and all participants to the survey provided informed consent.

Measures

Social capital

Aspects of neighbourhood social capital were measured as previously proposed by Beenackers et al. using a reliable 13-item scale (Cronbach's alpha = 0.86)[39]. Items captured interactions and relationships in the neighbourhood such as "the people in my neighbourhood get along with each other well". Responses ranged from 1 (totally disagree) to 5 (totally agree). Factor analysis was performed and reliabilities of the three identified constructs were α=0.83 for 'social network', α=0.79 for 'social cohesion' and α=0.58 for 'place attachment/sense of belonging'. Based on the Cronbach's alpha, only social cohesion and social network were considered to be reliable social capital factors. Summary scores of social cohesion and social network were calculated for each individual, with values ranging between 5-25 and 4-20 respectively. Detailed methodology of the factor analysis is described in Supplementary File 1. The individual items used to assess social capital, their means, standard deviations and factor loadings can be found in Supplementary Table 1.

Ecometric neighbourhood scores

We employed an ecometric approach to construct contextual social capital variables[27,28]. This approach assessed the reliability of the neighbourhood social capital constructs and if so, ensured that the differences in social capital were attributable to differences at the neighbourhood level as opposed to differences between individuals. The variation present in the data was decomposed into a hierarchy of sources: contextual, individual, item and residual. The 13 individual items of the social capital scale constituted the dependent variables and the dataset was restructured from wide to long, with a dummy variable indicating the item number. Next, a linear three-level multilevel model was built with neighbourhoods, individuals and items as levels. The within-neighbourhood intra-class correlation coefficient quantifies the extent to which participants agree in their assessment of social capital in a given neighbourhood using three-level multilevel models (items nested within participants nested within neighbourhoods)[13,40]. By adjusting the model for individual characteristics that may be associated with the perception of social capital (age, gender, education, length of residency in the neighbourhood, and country) the derived contextual variables consist of the variance that cannot be attributed to individual response patterns[33]. The ecometric variables were constructed in a separate dataset and saved as variables in the original dataset using STATA 12.0[27].

The reliability of the ecometric scales is derived from the variance across neighbourhoods divided by the total variance, i.e. from the intraclass coefficient (ICC)[33]. The total variance consists of the variance in responses between neighbourhoods; variance between respondents within a neighbourhood (taking into account the number of participants in a neighbourhood); and variance between particular responses (taking into account the number of items per scale). The interpretation of the reliability coefficient is comparable to the Cronbach's alpha coefficient[28]: values ranging between zero and one, with higher scores representing a more reliable scale. Quartiles of the ecometric neighbourhood scores of social capital were generated to allow for comparison with the neighbourhood mean measures.

Neighbourhood mean scores

The second method we employed to create contextual social capital variables, encompassed the aggregation of individual scores to the neighbourhood level. These scores represent mean social network/cohesion scores of all individual respondents in the neighbourhood. Quartiles of the neighbourhood mean scores of social capital were generated to allow for comparison with the ecometric neighbourhood scores.

As neighbourhood mean scores represent both individual and neighbourhood variation[27], adjustment for (continuous) individual social network/social cohesion scores should make neighbourhood mean scores and ecometric neighbourhood scores comparable.

Self-rated health and weight status

Self-rated health was measured using a single-item Visual Analogue Scale (VAS)[41,42]. Values along a continuous line with two end-points ranged from 0 (worst) to 100 (best) and participants were asked to indicate how their rated their general health by placing a mark on the line. The VAS has proven to be a valid, reliable and feasible method of obtaining information on self-rated health[41,42]. Self-rated health was dichotomized at the median (score of 73 or higher). BMI was calculated as body weight (kg) divided by height (m) squared as obtained from the survey. Overweight was defined as a BMI ≥ 25 and obesity as BMI ≥ 30 in accordance with WHO guidelines[43].

Obesity-related behaviours

We used physical activity[44], sedentary behaviours[45], and consumption of fruit[46], vegetables[46], fish[47,48], sweets[49], sugar-sweetened beverages[50] and fast food[51] as obesity-related behaviours. Questions about leisure time physical activity (weekly minutes) and transport-related physical activity (weekly minutes) were adapted from the validated International Physical Activity Questionnaire (IPAQ)[52]. Sedentary behaviours were measured using the validated Marshall questionnaire[53], which assesses different types of sedentary behaviours. The variable used was 'average daily minutes of sitting'. Frequency of fruit and of vegetable consumption per week were each measured with a 1-item question as a proxy for diet quality. As assumptions of normality were violated for the obesity-related behaviours, we dichotomized outcome variables at the median consumption per week: fruit < 7 times, vegetables < 7, fish < 2 times, sweets ≥ 3 times, sugar-sweetened beverages ≥ 2 glasses, fast food ≥ 2 times. Leisure time physical activity and transport-related physical activity were dichotomised at less than 25 minutes per day.

General information

Information was obtained on age, gender, employment status, length of residency, smoking, household composition and educational attainment.

Analyses

We excluded individuals that could not be allocated to one of the 60 selected neighbourhoods (n=137). This resulted in a sample of 5,900 participants available for analyses. Descriptive statistics (percentages, median

with range and mean with standard deviation) were used to summarize participant characteristics. Given our sampling design, we assessed differences in social network and social cohesion scores between neighbourhood types (based on SES and residential density) using ANOVA tests.

Item-nonresponse ranged from 1% (age) to 22% (self-rated health). Assuming that data were missing at random, missing values for all variables were imputed using Predictive Mean Matching in SPSS version 22.0. All variables described in the methods section were used as predictors in the imputation model to create 20 imputed datasets. A sensitivity analysis was carried out using a non-imputed dataset.

Given the hierarchical structure of the data, multiple multilevel logistic regression analyses with the two contextual social capital (social network/social cohesion) constructs as independent variables and self-rated health, overweight and obesity, and obesity-related behaviours as dependent variables were carried out, with random intercepts for neighbourhoods. First, an 'empty' model (which included only the random intercept for neighbourhoods) was created, and the ICC was reported. Secondly, we adjusted the models for neighbourhood type (based on SES and residential density), country, education, employment status, household composition, length of residency and smoking status (smoking only in models where weight status was a dependent variable). We present adjusted Odds Ratios (ORs) with 95% Confidence Intervals (Cis) and ICCs of the adjusted models. We compared different operationalisations of contextual social capital: ecometric neighbourhood scores, mean neighbourhood scores of social network and social cohesion; and mean neighbourhood scores, additionally adjusted for individual scores. To assess the relevance of the social capital variables, we compared the effect size of the social capital measures to the effect size of neighbourhood SES, adjusting for the same key covariates.

Lastly, we performed stratified analyses to view whether the association between social capital and health outcomes differed between urban regions. Significance was interpreted as a two-sided p-value of <0.05. Multilevel analyses were performed using STATA version 12.0.

RESULTS

Mean age of the participants was 52 years and 56% were women. Descriptive statistics are presented in Table 1.

[*Table 1 about here*]

Neighbourhood variance, individual variance and item variance was 0.07, 0.61 and 0.80 for the ecometric social network measure and 0.09, 0.33 and 0.43 for the ecometric social cohesion measure, respectively. This resulted in reliability scores of alpha=0.25 for social network and alpha=0.48 for social cohesion. Mean and ecometric neighbourhood social network and social cohesion scores differed between neighbourhood types (p-value for all four variables <0.001). Levels of social network and social cohesion were highest in high SES/low residential density neighbourhoods, and lowest in low SES/high residential density neighbourhoods. For

example, the mean neighbourhood social network score was 11.0 in high SES/low residential density neighbourhoods and 9.7 in low SES/high residential density neighbourhoods (F=466.4, p<0.001).

In general, using ecometric and mean neighbourhood scores resulted in similar coefficients for each of the health outcomes. Adjusting the mean neighbourhood scores for individual social capital scores attenuated the associations, and this attenuation was for most health outcomes stronger for the social cohesion than for the social network measures. Exceptions were the associations with high levels of transport-related physical activity and high levels of sedentary behaviours as outcome; adjusting the mean neighbourhood scores for individual social capital scores strengthened these associations.

Individuals living in neighbourhoods in the highest quartile of social networks (ecometric measure) had a 33% higher odds of having a good self-rated health (≥ 73) than individuals living in neighbourhoods in the lowest quartile of social networks (OR=1.33, 95%CI=1.07; 1.66) (Table 2a). Results using mean neighbourhood scores yielded similar results: individuals living in neighbourhoods in the highest quartile of social networks had 32% higher odds of good self-rated health than individuals living in neighbourhoods in the lowest quartile of social networks (95%CI=1.06; 1.65). After adjustment for individual social network scores, this OR attenuated to 1.22 (95%CI=0.98; 1.53). Similar associations with social cohesion as an independent variable were observed, although ORs for mean neighbourhood scores of social cohesion were much more attenuated by the inclusion of individual social cohesion scores.

A similar pattern was shown with obesity as a dependent variable (Table 2b). Individuals in the highest quartile of social networks or social cohesion had approximately 30% lower odds of obesity than individuals in the lowest quartile, regardless of how neighbourhood scores were estimated. Adjustment for individual social network scores attenuated the coefficients of the mean neighbourhood scores. Results with overweight as an outcome were less clear.

Table 2c shows that higher levels of social network and social cohesion were associated with higher odds of eating fruit at least 7 times a week, although ORs in the models that were adjusted for individual social network scores attenuated to non-significance.

Table 2d shows that social network and social cohesion were not associated with odds of eating vegetables at least 7 times a week.

Table 2e shows that individuals in the highest quartile of social cohesion had a higher likelihood of sitting more than 530 minutes a day, but this was only significant once mean neighbourhood scores were adjusted for individual scores. The same tendency was observed with social networks as independent variable.

Table 2f shows that social networks and social cohesion were not associated with leisure time physical activity.

Table 2g shows some evidence that individuals living in neighbourhoods with the highest levels of social network and social cohesion had approximately 30% lower odds of spending more than 25 minutes per day on

transport-related physical activity. Associations with mean neighbourhood scores were not attenuated by the inclusion of individual scores.

[*Table 2a-g about here*]

As comparison, living in a low SES neighbourhood was associated with a 44% higher odds of being obese (95%CI = 1.21; 1.73); a 15% lower chance of having a high self-rated health (95%CI = 0.74; 0.98); a 16% lower chance of having a high fruit consumption (95%CI = 0.75; 0.95); a 19% lower chance of having high vegetable consumption (95%CI = 0.70; 0.94); a (non-significant) 12% lower chance of having high levels of leisure time physical activity (95%CI=0.77; 0.99); a 13% higher chance of having high levels of transport-related physical activity (95%CI = 0.77; 0.99); and a 88% lower chance of having high levels of sedentary behaviour.

Analyses stratified by country showed broadly comparable patterns. Supplementary Tables 2a-g present results with non-imputed (complete case) data. These results were comparable to the results in main Tables 2a-g, although associations with self-rated health were weaker.

DISCUSSION

Using data from a cross-European survey, this study builds on and adds to the existing literature in two main ways. First, it indicates that, in practice, there are limits to employing an ecometric approach to the operationalisation of contextual social capital. Second, it provides further evidence that supports a link between high social capital and better health [5,54].

The first issue relates to the methodology. We assessed the reliability of ecometric measures of neighbourhood social capital, by comparing ecometric and aggregate measures in relation to self-rated health, weight status and obesity-related behaviours. The reliability of both the social network and the social cohesion measure was low[55] which has probably arisen from an incomplete separation of individual and neighbourhood level variance. This was supported by the results from the multilevel analyses using different health outcomes: the results using ecometric measures – which were supposed to represent just contextual level variation – were in most cases comparable to the results using aggregate measures (representing both individual and contextual variation), and not comparable to the results using aggregate measures that were adjusted for individual scores (representing only contextual variation).

Reliability of ecometric measures will be high when (1) the between-neighbourhood variance is large relative to the within-neighbourhood variance; (2) the number of items in a scale is large and (3) when the number of sampled neighbourhoods is large[28]. As small ICCs are a common finding in multilevel research[27,56], good ecometric properties are likely to rely on the heterogeneity *within* neighbourhoods[57]. This corresponds with the findings from a previous study[27], which reported the ecometric measures to be reliable despite a small between-neighbourhood variability. In the present study, between-neighbourhood variance was not exceptionally low, but the number of sampled neighbourhoods (60) was relatively low compared to the studies

by Mohnen et al.[30] and Schölmerich et al.[36] who used 3,273 and 3,495 neighbourhoods, respectively. They found reliable ecometric properties of their social capital scale (alpha = 0.62 in the study of Mohnen et al.[30] and alpha = 0.60 in the study of Schölmerich et al.[36]).

Whilst it has been suggested that the ecometric approach is, at least in theory, superior to aggregated measures, in practice the results obtained differed little. Consequently, the theoretical advantages of the ecometric approach may not be achieved in practice. Much less is known about the properties of ecological settings such as neighbourhoods than about the properties of individual measurements[29]. Therefore, a thorough examination of the conditions needed for the construction of reliable ecometric measures is warranted. In case researchers want to tease out neighbourhood level variance of social capital in a setting with little between-neighbourhood variance, adjusting mean neighbourhood scores for individual scores may be the best alternative[16]. However, it is worth exploring more in detail whether, despite its limitations[30], using aggregate neighbourhood scores would generate similar results as using (reliable) ecometric measures.

Turning to the second issue, we found that the different operationalisations of social network and social cohesion were associated with several health outcomes. Although we aimed to study the contextual effects of social capital, the measures used mainly represented *compositional* effects Still, this is the first study to relate social capital to weight status in an urban European context, and results are in line with some studies from North America[9,58]. The associations between social capital and health-related behaviours found in this study are complex and not always consistent with other studies [17–23]. One explanation relates to the many-layered nature of social capital, so that some issues, such as dietary behaviour, may be influenced more by characteristics of the family rather than neighbourhood environment. This emphasizes the difficulty of selecting the right groups or 'levels' for social capital research [59].

Although our results stress the importance of taking into account social environmental determinants of health and health behaviours, only associations with transport-related physical activity and sedentary behaviours could be attributed to the *contextual* (neighbourhood) effects of social capital. The finding that higher levels of neighbourhood social capital were associated with more sitting, a risk factor for obesity, is intriguing, but one possible explanation is that stronger social cohesion may stimulate social sedentary behaviours such as socialising with friends. The fact that the effect sizes of the neighbourhood social capital variables were comparable to the effect sizes of the neighbourhood SES variable suggests that the observed associations with neighbourhood social capital are relevant for health. A potential area for future research may examine the extent to which social capital and SES are synergetic (in which case higher levels of social capital mainly have positive health effects in those with high SES) or competitive factors (in which case higher levels of social capital mainly have positive health effects in those with low SES). However, this study was conducted in an urban environment only, and differences may arise when social capital is studied in rural areas, where norms and availability of institutional support services may be different[60]. Finally, it should be noted that neither the aggregation approach nor the ecometric approach captures social cohesion and social network as fluid and dynamic aspects[61].

Evaluation of data and methods

Strengths of the present study include the large population-based sample from five European urban zones; the harmonized data collection across heterogeneous neighbourhoods; the representation of both high and low SES groups; and multiple relevant outcome measures. Limitations include the cross-sectional nature of the study which does not allow for causal inference, and the study population, with about 10% of eligible respondents participating. Although low response rates are now common in large surveys among the general population, generalisation of findings should be done with caution as selection bias may have occurred. Second, despite sampling neighbourhoods that were heterogeneous in SES and housing density, neighbourhood level variation of social capital was relatively low (in comparison to individual-level variation in social capital). Third, the questionnaires used to assess obesity related behaviours have known or suspected limitations[52,53] which may have led to biased estimates of behaviours.

Conclusions

Our findings based on data collected in five large European urban regions show that different operationalisations of neighbourhood level social capital measures were associated with self-rated health, weight status and obesity related behaviours. The results emphasize the importance of area-level social capital as a resource for health and well-being - or conversely that health and wellbeing are important resources for social capital in Europe. The comparable findings using different methods of operationalising neighbourhood social capital constructs suggests that the theoretical advantage of the ecometric approach may not be achieved in practice.

TITLES supplementary files

Supplementary File 1. Factor analysis to identify social capital factors in the SPOTLIGHT survey.

Supplementary Table S1. Results from factor analysis to identify social capital factors in the European SPOTLIGHT project: item description and rotated factor loadings.

Supplementary Tables S2a-g. Multilevel logistic regression coefficients for odds of health outcomes per quartile of neighbourhood social capital in non-imputed data.

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