The mediating role of social capital in the association between neighbourhood income inequality and body mass index

Joreintje D Mackenbach[a]*, Jeroen Lakerveld[a], Yavanna van Oostveen[a], Sofie Compernolle[b], Ilse De Bourdeaudhuij[b], Helga Bárdos[c], Harry Rutter[d], Ketevan Glonti[d], Jean-Michel Oppert[e,f], Helene Charreire[e,g], Johannes Brug[a], Giel Nijpels[h]

[a] Department of Epidemiology & Biostatistics, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, the Netherlands. Address: De Boelelaan 1089a, 1081 HV Amsterdam, the Netherlands.

[b] Department of Movement and Sport Sciences, Ghent University, Ghent, Belgium. Address: Watersportlaan 2
9000 Gent, Belgium.

[c] Department of Preventive Medicine, Faculty of Public Health, University of Debrecen, Hungary. Address: Kassai út 26/b, 4028 Debrecen, Hungary.

[d] ECOHOST – The Centre for Health and Social Change, London School of Hygiene and Tropical Medicine, London, UK. Address: 15-17 Tavistock Place, London WC1H 9SH, United Kingdom.

[e] Equipe de Recherche en Epidémiologie Nutritionnelle (EREN), Centre de Recherche en Epidémiologie et Statistiques, Inserm (U1153), Inra (U1125), Cnam, COMUE Sorbonne Paris Cité, Université Paris 13, Bobigny, France. Address : 74 Rue Marcel Cachin 93017 Bobigny, France.

[f] Sorbonne Universités, Université Pierre et Marie Curie, Université Paris 06; Institute of Cardiometabolism and Nutrition, Department of Nutrition, Pitié-Salpêtrière Hospital, Assistance Publique-Hôpitaux de Paris, Paris, France. Address : 47-83 Boulevard de l'hôpital, 75013 Paris, France.

[g] Paris Est University, Lab-Urba, UPEC, Urban School of Paris, Créteil, France. Address: 61 Avenue du Général de Gaulle,
94010 Créteil Cedex, France.

[h] Department of General Practice and Elderly Care, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, the Netherlands. Address: Van der Boechorststraat 7, 1081 BT Amsterdam, the Netherlands.

* Corresponding author: Address: De Boelelaan 1089a, 1081 HV Amsterdam, Netherlands. E-mail address: j.mackenbach@vumc.nl. Phone number: 0031 20 4448198.

Abstract (236 words)

Background Neighbourhood income inequality may contribute to differences in body weight. We explored whether neighbourhood social capital mediated the association of neighbourhood income inequality with individual body mass index (BMI).

Methods A total of 4,126 adult participants from 48 neighbourhoods in France, Hungary, Netherlands and the UK provided information on their levels of income, perceptions of neighbourhood social capital and BMI. Factor analysis of the 13-item social capital scale revealed two social capital constructs: social networks and social cohesion. Neighbourhood income inequality was defined as the ratio of the amount of income earned by the top 20% and the bottom 20% in a given neighbourhood. Two single mediation analyses –using multilevel linear regression analyses– with neighbourhood social networks and neighbourhood social cohesion as possible mediators- were conducted using MacKinnon's product-of-coefficients method, adjusted for age, gender, education and absolute household income.

Results Higher neighbourhood income inequality was associated with elevated levels of BMI and lower levels of neighbourhood social networks and neighbourhood social cohesion. High levels of neighbourhood social networks were associated with lower BMI. Results stratified by country demonstrated that social networks fully explained the association between income inequality and BMI in France and the Netherlands. Social cohesion was only a significant mediating variable for Dutch participants.

Conclusion The results suggest that in some European urban regions, neighbourhood social capital plays a large role in the association between neighbourhood income inequality and individual BMI.

Keywords: body mass index; Europe; income inequality; social capital; neighbourhood

Introduction (588 words)

Obesity is a major global public health problem.(1–3) Overweight and obesity are unequally distributed across and within societies.(4–6) Low socio-economic status (SES), as indicated by low income, educational level and/or occupational status, is recognized as a risk factor for increased body weight.(5) It has been suggested that income *inequality* rather than low SES per se contributes to this phenomenon, but it remains unclear why this could be the case.(7, 8)

Income inequality is generally defined as the income gap between those with the highest income and those with the lowest income within a given geographical unit (e.g. country or neighbourhood). A number of studies have shown higher average body weight as well as prevalence of overweight/obesity in countries with high income inequality.(7–9)

In studies from Europe, more consistent evidence is available for associations of income inequality with body weight than with other health outcomes.(9–11) It has been suggested that country-(9) or state-level(12) income inequality influences population health via political mechanisms, for example through associations with patterns of state spending on education and welfare.(13) Among more egalitarian countries, such as those in Europe, income inequality at neighbourhood level may be more important than inequalities at national level.(14) Lower levels of health in more unequal neighbourhoods may be related to lower levels of community social capital.(7) Neighbourhoods have emerged as a potentially relevant unit because they provide social and physical resources that are likely to contribute to better health, and because place of residence is often patterned by socioeconomic status.(15)

Neighbourhood social capital can be conceptualised as a collective characteristic through which individuals living in a particular area share behaviour patterns and social norms.(16) Although the study findings are mixed,(17) there is increasing evidence that higher levels of social capital are associated with lower levels of overweight and obesity.(18) Income inequality could affect health via perceptions of place in the social hierarchy.(19) In accordance with neighbourhood disadvantage theories,(20, 21) a perceived low position in the social hierarchy leads to social disconnection (lack of social capital) and social distress(22) which has been associated with risk factors for overweight and obesity such as over-eating(23) and preferences for energy-dense foods(24).

If neighbourhood social capital mediates the association between neighbourhood income inequality and BMI, higher levels of neighbourhood social capital may help to reduce the negative effects of income inequality on BMI. Mediation analysis is one approach that can be used to study such underlying mechanisms. One study has examined if collective efficacy (a measure of social capital) mediated the association between neighbourhood income inequality and obesity in the US, but no such evidence was found.(25)

A review on associations between country-level income inequality and health outcomes outlined methodological requirements for future research.(8) First, analyses should be adjusted for individual income, to ensure that observed associations are due to true income differences and not to the diminishing marginal gains of income at the individual level.(26) That is, each additional unit of income is associated with improvements in a person’s health, but by ever smaller amounts. Second, analyses should be adjusted for educational attainment to take into account residual confounding. Third, studies should focus on the examination of pathways linking income inequality to health; fourth, appropriate geographical scales should be used for analyses.(8)

In a previous study (27), we showed that neighbourhood social capital was associated with weight status.(18) In the present study we studied the association between neighbourhood income inequality and BMI of adults from neighbourhoods in urban regions in Europe, and assessed the mediating role of neighbourhood social capital.

Methods (857 words)

Study design and population

This study was part of the SPOTLIGHT project, conducted in five urban regions in Belgium, France, Hungary, the Netherlands and the United Kingdom. Neighbourhoods were defined according to small scale local administrative boundaries as used in each country except for Hungary, where we used 1 square km areas to represent neighbourhoods. Sampling of neighbourhoods, detailed characteristics of the neighbourhoods and recruitment of participants has been described in detail elsewhere.(27) Neighbourhood sampling was based on a combination of residential density and 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 adults was invited to participate in an online survey that contained questions on demographics, neighbourhood perceptions, social environment, health, motivations and barriers for healthy behaviours, obesity-related behaviours and weight and height. A total of 6,037 (10.8%) individuals participated between February and September 2014. The study was approved by the local ethics committees of participating countries and all participants provided informed consent.

Measures

Dependent variables

BMI, calculated from self-reported weight and height was normally distributed and treated as a continuous variable. In a sensitivity analysis, we present results with weight status (BMI ≥ 25 kg/m^2) as outcome variable.

Independent variables

Participants from France, Hungary, the Netherlands and the United Kingdom provided information on their annual or monthly net household income, according to five categories that represented national quintiles of net household income. Participants from Belgium did not provide information on household income due to country-specific ethical considerations and were excluded.

To calculate the neighbourhood income inequality ratio the sum of the total earnings of the richest 20% of included households was divided by the sum of the total earnings of the poorest 20% of included households resulting in a 20:20 ratio.(28)

Potential mediating variables

Aspects of perceived neighbourhood social capital were measured as described by Beenackers et al.(29) using a reliable 13-item scale (Cronbach’s alpha = 0.86). Responses ranged from 1 (totally disagree) to 5 (totally agree). Factor analysis was performed and identified two reliable constructs, namely ‘social network’ (Cronbach’s alpha =0.83) and ‘social cohesion’ (Cronbach’s alpha =0.79).(18) Supplementary Table 1 describes the item description and rotated factor loadings for the 13 items. The mean of all individual social capital scores were calculated to generates scores for ‘neighbourhood social cohesion’ and a ‘neighbourhood social network’.

Covariates

Covariates included were country of residence, age, gender, education level (higher [i.e. college or university] and lower), household composition (number of children and adults) and absolute monthly net household income.

Statistical analysis

We excluded individuals who could not be allocated to a sampled neighbourhood (n=137), and respondents from Belgium, who did not provide information on household income (n=1,774), leaving a sample of 4,126 participants available for analyses.

Item-nonresponse ranged from 1% (age) to 19% (household income). Missing values for all variables were imputed using Predictive Mean Matching in SPSS version 22.0. All variables described under 'measures' were used as predictors in the imputation model to create 20 imputed datasets, and ´neighbourhood type´ and ´urban region´ were used as auxiliary variables. A sensitivity analysis was carried out using a non-imputed dataset.

To explore the hypothesised mediating roles of the neighbourhood social networks score and the neighbourhood social cohesion score, two single mediation analyses were performed using MacKinnon's product-of-coefficients method(30). A series of linear regression analyses were conducted using a four-step process (Figure 1).

-- Figure 1 about here –

First, we performed multivariable multilevel linear regression analyses to explore the association between neighbourhood income inequality and BMI (path c), taking into account clustering at the neighbourhood level. All covariates were tested as potential effect modifiers, but only country of residence turned out to be a significant effect modifier in the a- and b-paths ($p<0.05$). Covariates that were not effect modifiers were included in the model as confounding variables. Model 1 represents unadjusted analyses and model 2 represents analyses adjusted for age, gender and education. As suggested by Wagstaff and van Doorslaer (2000), we also present a third model in which we adjusted for household composition and household income. This allows for the conclusion that income inequality is associated with BMI regardless of absolute levels of income.(26)

Second, we explored the association between neighbourhood income inequality and neighbourhood social networks (path a_1) and neighbourhood social cohesion (path a_2) using linear regression analyses. Third, the association between neighbourhood social networks (path b_1) and neighbourhood social cohesion (path b_2) and BMI were analysed, adjusted for the independent variable neighbourhood income inequality. The regression coefficients of these multilevel analyses were multiplied to compute the mediating effects (i.e. a_1b_1 *and* a_2b_2) and the statistical significance (Sobel test; z-score). Finally, the proportion of the association between neighbourhood income inequality and BMI that was mediated by neighbourhood social networks and neighbourhood social cohesion (path *c*') was calculated by dividing *ab* by *c*. The statistical analyses were performed using SPSS version 22.0. A p-value <0.05 was considered to be statistically significant.

Results (541 words)

Mean BMI was highest in Hungary, while the highest income inequality ratio was observed in the UK. Neighbourhood level scores of social networks and social cohesion were highest in the Netherlands (Table 1).

---- Table 1 about here ---

The association between neighbourhood income inequality and BMI is shown in Table 2. In the empty model, variances of BMI at the individual and neighbourhood level were 19.58 and 0.99, respectively. After adjustment for age, gender and education (model 2), a 1-point increase in the neighbourhood income inequality ratio was associated with a 0.37 kg/m^2 higher body mass index (95%CI=0.03; 0.70). Further adjustment for absolute household income slightly attenuated the association. In the fully adjusted model, BMI variances at the individual and neighbourhood level were 17.81 and 0.74, respectively. Table S2 displays the results when analyses were additionally adjusted for country of residence, which slightly strengthened the associations.

---- Table 2 about here ---

The results of the two single mediation models are presented in Table 3 (coefficients for covariates are presented in Table S2). Country of residence was an effect modifier in the a- and b-paths, so results are presented for the total sample and stratified by country. In the total sample, neighbourhood income inequality was statistically significantly associated with the neighbourhood social networks score (path a_1) and the neighbourhood social cohesion score (path a_2). A 1-point increase in neighbourhood income inequality was associated with a 0.56 point lower neighbourhood social networks score, and a 0.79 point lower neighbourhood social cohesion score. A 1-point higher neighbourhood social networks score was associated with a 0.35kg/m2 lower BMI (path b_1). In the total sample, neighbourhood social cohesion was not significantly associated with BMI (path b_2). Stratified results show that income inequality was associated with lower levels of social networks and social cohesion in all four countries, but these associations were strongest in France and the

Netherlands (a-path). In France and the Netherlands, a negative association of social networks with BMI was observed, while a positive association was observed in the UK. Only in the Netherlands, the neighbourhood social cohesion score was significantly associated with a lower BMI.

In the total sample, the Sobel test showed that the association between neighbourhood income inequality and BMI was significantly (p=0.006) mediated by neighbourhood social networks, but not by neighbourhood social cohesion (p=0.24). The proportion of the association between neighbourhood income inequality and BMI that was mediated by neighbourhood social networks was 46%. For participants from France (p=0.04) and the Netherlands (p=0.03), the association between neighbourhood income inequality and BMI was fully mediated by neighbourhood social networks, while this was not the case for participants from Hungary and the UK. Neighbourhood social cohesion was only a significant mediator in the association between income inequality and BMI in the Netherlands (p=0.04).

---- Table 3 about here ---

Tables S3 and S4 show the un-stratified results using non-imputed data. Results were comparable, with a significant (Z-score = 2.73, p=0.006) mediating effect of social network, and a non-significant (Z-score=1.05, p=0.29) mediating effect of social cohesion. Table S3 and S5 show the results using overweight as dependent variable; a 1-point increase in the neighbourhood income inequality ratio was associated with a 1.24 times higher odds of being overweight/obese (95%CI: 1.07. 1.43).

Discussion (1008 words)

Using data from a cross-European survey, we found a mediating role of neighbourhood social capital in the association between neighbourhood income inequality and individual BMI. This suggests that income inequality affects the provision of neighbourhood social resources that are relevant for a healthy body weight.(15)

To our knowledge, this is the first study to provide evidence for an association between neighbourhood income inequality and body weight in Europe. This association was modest in size, with a one point increase in the neighbourhood income inequality ratio (which differed by three points between the least and most unequal neighbourhoods in this sample) associated with 1.24 times higher odds of being overweight/obese. However, the consequences of, and ways of responding to, income inequality may become increasingly important given the rising levels of income inequality in Europe associated with ageing populations, smaller family structures (single-parent families/fewer children in the household), globalised markets, and governmental policies.(31–33)

Higher neighbourhood income inequality was consistently associated with lower levels of neighbourhood social networks and social cohesion. This supports the idea that a certain degree of homogeneity within neighbourhoods is required for neighbourhoods to serve as resources for social connections.(34) These associations were modest overall, but strongest in participants from France. In concordance with findings from previous studies(18, 21, 35), a higher neighbourhood social networks score was associated with lower BMI in French and Dutch participants. The higher social networks and social cohesion scores in the Dutch neighbourhoods are in concordance with previous reports describing relatively high levels of membership belonging, sense of trust and doing voluntary work in the Netherlands compared to other European countries such as Hungary.(36, 37) In French participants, mean BMI was about 2.2 kg/m^2 lower in neighbourhoods with the highest compared to the lowest social network scores. In contrast, mean BMI of UK participants was about 1.5 kg/m^2 higher in neighbourhoods with the highest compared to the lowest social network scores. This may suggest that there are socio-cultural differences in the role of social networks for behaviours that influence weight status.

A number of studies have found social capital to be a mediator in the association between income inequality and mortality or self-rated health (i.e.(20)), but the only study to date (conducted in the US) that examined potential mediation of social capital in the association between income inequality and BMI did not find evidence for such mediation.(38) Following the observed country differences, it may be speculated that in countries like France and the Netherlands social connections generally stimulate healthier behaviours. Alternatively, it may be that social networks are mostly stronger among healthier individuals in the Netherlands and France, while social networks are stronger among unhealthier individuals in the UK.

While reforming tax and benefit policies are considered to be the most direct and powerful instrument for increasing redistributive effects at the national level,(32) it remains unknown how to decrease neighbourhood income inequality without promoting segregation by socio-economic status. The findings from this study also suggest that the potential adverse effects of neighbourhood income inequality may be at least partially addressed via the enhancement of social interactions. On a regional level this could include (re)designing neighbourhoods to promote *active* social interactions, e.g. via the social use of neighbourhood public spaces, community centres or outdoor recreational facilities and more walkable streets. On a national level, policies to prevent discrimination and social exclusion and the promotion of civic participation may contribute to stronger social networks.

Strengths and limitations

Several studies have shown that self-reported height and weight data are valid for identifying relationships in epidemiological studies, but these data may be prone to a degree of reporting bias, such as higher levels of underestimation among heavier men and women.(39, 40) Lack of continuous data on household income prevented us from calculating the Gini coefficient, the most used method for measuring household income inequality. Instead, 20:20 ratios were calculated but this does not provide an absolute measure of income inequality, and it does not include the middle part of the income distribution.(41) On the other hand, the 20:20 ratio is a useful method to measure neighbourhood income inequality since it quantifies the range between the richest and the poorest in an area. It should be noted though, that this measure only measured income inequality among the survey participants, and thus may not be accurately representative of the actual neighbourhood income inequality. Additionally, the neighbourhood income inequality ratios, ranging from 1.7-4.9, were quite small compared to national income inequality statistics, which may imply that the consequences of neighbourhood income inequality in areas with higher neighbourhood income inequalities will be larger in terms of BMI and weight status differences. Further, the cross-sectional data limit the interpretation of mediation effects. The results give an indication of relations between the studied variables, but we were not able to determine the direction of the pathways. Lastly, the response rate in the SPOTLIGHT survey, at about 10%, may have resulted in a selection bias with potentially more highly motivated people participating in the survey, so there is a need for caution when generalising these findings.

This study also benefits from a number of strengths. First, we were able to include a relatively large sample of adults from high and low SES neighbourhood in four European countries. This provided power to conduct multilevel mediation analysis, which resulted in comparable relationships across several countries with different political and social systems. Second, the multilevel approach allowed us to differentiate the possible sources of variability (individual and neighbourhood) and it enabled us to control for clustering effects. Third, we were able to adjust our analysis for a number of relevant covariates such as individual income and educational level, which decreases the likelihood of the observed associations being confounded.

Conclusions

The results from this study suggest that social capital plays a large role in the association between neighbourhood income inequality and individual BMI, especially in France and the Netherlands. Further investigation of the activities done within social networks will help identify potential intervention tools to attenuate the adverse effects of income inequality on BMI in European adults.

Acknowledgements: This work was supported by the Seventh Framework Programme (CORDIS FP7) of the European Commission, HEALTH (FP7-HEALTH-2011-two-stage) [278186]. The content of this article reflects only the authors' views and the European Commission is not liable for any use that may be made of the information contained therein. We would like to thank the participants to the SPOTLIGHT survey for their responses, and our VU Medical Centre colleagues from the bi-weekly DIABOLO meeting for their thoughts on this topic.

Conflicts of interest: none declared.

Key-points:

- Income inequality is consistently associated with lower levels of social networks and social cohesion across urban European regions
- In France and the Netherlands, neighbourhood social networks fully explained the association between neighbourhood income inequality and body mass index
- Actions to reduce socio-economic inequalities in health may benefit from approaches that stimulate healthy behaviours in social networks

References

1. Finucane MM, Stevens G a, Cowan MJ, *et al.* National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants. *Lancet* 2011;377:557–67.

2. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health* 2009;9:88.

3. Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. *Jama* 1999;282:1523–29.

4. Sobal J, Stunkard AJ. Socioeconomic status and obesity: a review of the literature. *Psychol Bull* 1989;105:260–75.

5. Stunkard AJ. Socioeconomic status and obesity. *Ciba Found Symp* 1996;201:174–193.

6. Roskam AJR, Kunst AE, van Oyen H, *et al.* Comparative appraisal of educational inequalities in overweight and obesity among adults in 19 European countries. *Int J Epidemiol* 2010;39:392–404.

7. Wilkinson RG. *The impact of inequality-how to make sick societies healthier*. New York: Penguin New York; 2005.

8. Subramanian SV, Kawachi I. Income Inequality and Health: What Have We Learned So Far? *Epidemiol Rev* 2004;26:78–91.

9. Pickett KE, Kelly S, Brunner E, Lobstein T, Wilkinson RG. Wider income gaps, wider waistbands? An ecological study of obesity and income inequality. *J Epidemiol Community Health* 2005;59:670–674.

10. Hu Y, van Lenthe FJ, Mackenbach JP. Income inequality, life expectancy and cause-specific

mortality in 43 European countries, 1987-2008: a fixed effects study. *Eur J Epidemiol* 2015;30:615–625.

11. Nikolaou A, Nikolaou D. Income-related inequality in the distribution of obesity among Europeans. *J Public Heal* 2008;16:403–411.

12. Diez-Roux a V, Link BG, Northridge ME. A multilevel analysis of income inequality and cardiovascular disease risk factors. *Soc Sci Med* 2000;50:673–87.

13. Kawachi I, Kennedy BP. *The health of nations*. New York, NY: The New Press; 2003.

14. Islam MK, Merlo J, Kawachi I, Lindström M, Gerdtham U-G. Social capital and health: does egalitarianism matter? A literature review. *Int J Equity Health* 2006;5:3.

15. Diez-Roux AV. Neighborhoods and health: where are we and were do we go from here? *Rev Epidemiol Sante Publique* 2007;55:13–21.

16. Kawachi I, Kim D, Coutts A, Subramanian S V. Commentary: Reconciling the three accounts of social capital. *Int J Epidemiol* 2004;33:682–90; discussion 700–4.

17. Glonti K, Mackenbach JD, Ng J, *et al.* Psychosocial environment: definitions, measures and associations with weight status - a systematic review. *Obes Rev* 2016;17:81–95.

18. Mackenbach JD, Lakerveld J, van Lenthe FJ, *et al.* Neighbourhood social capital: measurement issues and associations with health outcomes. *Obes Rev* 2016;17:96–107.

19. Pearce N, Davey Smith G. Is social capital key to inequalities in health? *Am J Public Heal* 2003;93:122–129.

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

21. Wilkinson RG, Marmot MG. *Social determinants of health: the solid facts*. Copenhagen: World Health Organization; 2003.

22. Wilkinson RG. *Unhealthy Societies: The Afflictions of Inequality*. London: Routledge; 1996.

23. Greeno CG, Wing RR. Stress-induced eating. *Psychol Bull* 1994;115:444–64.

24. Oliver G, Wardle J, Gibson EL. Stress and food choice: a laboratory study. *Psychosom Med* 2000;62:853–65.

25. Bjornstrom EE. An examination of the relationship between neighborhood income inequality, social resources, and obesity in Los Angeles county. *Am J Heal Promot* 2011;26:109–115.

26. Wagstaff a, van Doorslaer E. Income inequality and health: what does the literature tell us? *Annu Rev Public Health* 2000;21:543–67.

27. Lakerveld J, Ben-Rebah M, Mackenbach JD, *et al.* Obesity-related behaviours and BMI in five urban regions across Europe: sampling design and results from the SPOTLIGHT cross-sectional survey. *BMJ Open* 2015;5:e008505.

28. Charles-Coll JA. Understanding Income Inequality: Concept, Causes and Measurement. *Int J Econ Manag Scii* 2011;1:17–28.

29. Beenackers MA, Kamphuis CBM, Mackenbach JP, Burdorf A, van Lenthe FJ. Why some walk and others don't: exploring interactions of perceived safety and social neighborhood factors with psychosocial cognitions. *Health Educ Res* 2013;28:220–33.

30. Mackinnon DP, Fairchild AJ, Fritz MS. Mediation Analysis. *Annu Rev Psychol* 2010;58.

31. RAND Europe. *Demography and inequality. How Europe's changing population will impact on income inequality*. 2013.

32. OECD. *An Overview of Growing Income Inequalities in OECD Countries: Main Findings*. 2011.

33. Jaumotte F, Lall S, Papageorgiou C. *Rising Income Inequality: Technology, or Trade and Financial Globalization?* Washington, DC; 2013.

34. Alesina A, La Ferrara E. Who trusts others? *J Public Econ* 2002;85:207–234.

35. Lynch J, Smith GD, Harper S, *et al.* Is income inequality a determinant of population health? Part 1. A systematic review. *Milbank Q* 2004;82:5–99.

36. Adam F. Mapping social capital across Europe: findings, trends and methodological shortcomings of cross-national surveys. *Soc Sci Inf* 2008;47:159–186.

37. European Observatory on the Social Situation. *Social Cohesion , Trust and Participation: Social Capital , Social Policy and Social Cohesion in the European Union and Candidate Countries*. 2007.

38. Kim D, Subramanian S V, Gortmaker SL, Kawachi I. US state- and county-level social capital in relation to obesity and physical inactivity: A multilevel, multivariable analysis. *Soc Sci Med* 2006;63:1045–1059.

39. Yoong SL, Carey ML, D'Este C, Sanson-Fisher RW. Agreement between self-reported and measured weight and height collected in general practice patients: a prospective study. *BMC Med Res Methodol* 2013;13:38.

40. Dekkers JC, van Wier MF, Hendriksen IJ, Twisk JW, van Mechelen W. Accuracy of self-reported body weight, height and waist circumference in a Dutch overweight working population. *BMC Med Res Methodol* 2008;8:69.

41. De Maio FG. Income inequality measures. *J Epidemiol Community Health* 2007;61:849–852.

TABLES

Table 1. Characteristics of the study population

Variable	N total sample[‡]	Characteristics total sample	France (N=835)	Hungary (N=875)	Netherlands (N=1609)	UK (N=824)
Age (mean (SD))	4107	51.4 (16.3)	46.7 (15.8)	48.5 (15.4)	54.9 (15.9)	49.4 (17.4)
Gender (% male)	4116	*42.6%*	*41.5%*	*36.9%*	*46.0%*	*43.2%*
BMI (mean (SD))	3616	25.1 (4.5)	24.5 (4.4)	26.0 (5.12)	25.0 (3.9)	25.1 (4.8)
% overweight	*1610*	*44.5%*	37.9%	52.8%	42.7%	45.6%
Income	3371					
First quintile (%)	*297*	*8.8%*	7.6%	7.4%	8.4%	11.9%
Second quintile (%)	*589*	*17.5%*	20.9%	10.6%	21.6%	12.7%
Third quintile (%)	*625*	*18.5%*	21.5%	13.8%	21.8%	13.9%
Fourth quintile (%)	*727*	*21.6%*	20.6%	20.4%	25.3%	16.4%
Fifth quintile (%)	*1133*	*33.6%*	29.3%	47.7%	22.9%	45.1%
Neighbourhood income inequality ratio (median, range)	4126	3.0 (1.5-4.9)	2.8 (1.7-3.4)	2.9 (1.5-3.6)	3.0 (1.9-4.8)	3.7 (1.9-4.9)
Educational level (% higher)	3746	*43.1%*	*64.7%*	*49.6%*	*56.4%*	*58.1%*
Household composition (median, range)	3732	2 (1-10)	2.0 (1.0-8.0)	2.0 (1.0-8.0)	2.0 (1.0-8.0)	2.0 (1.0-10.0)
Social networks sum score (median, range)	3818	10.3 (4-20)	10.6 (8.7-11.7)	9.3 (7.9-10.8)	11.4 (8.9-12.6)	10.1 (8.3-11.0)
Social cohesion sum score (median, range)	3799	17.3 (5-25)	16.7 (14.8-18.4)	17.4 (14.9-18.0)	18.8 (14.8-19.6)	16.5 (14.8-18.8)

[†] The Randstad comprises a conurbation including Amsterdam, Rotterdam, the Hague and Utrecht

[‡] N varies due to missing data

Table 2. Multilevel linear regression coefficients of the association between neighbourhood income inequality and individual body mass index (N=4126).

	Model 1	Model 2	Model 3
	B (95%CI)	B (95%CI)	B (95%CI)
Neighbourhood income inequality†	0.33 (-0.05; 0.71)	0.37 (0.03; 0.70)*	0.35 (0.01; 0.69)*

† This ratio reflects the neighbourhood income inequality between the poorest and the richest quintiles

Model 1 crude model.

Model 2 adjusted for age, gender, education.

Model 3 adjusted for age, gender, education, household composition and income.

*P value <0.05

B = coefficient, 95%CI = 95% confidence interval

Table 3. Linear regression coefficients (path *a*) and multilevel linear regression coefficients (path *b* and *c*) of the mediation analysis with neighbourhood social networks and neighbourhood social cohesion

	Path *a* (B, 95%CI)	Path *b* (B, 95%CI)	Path *c* (B, 95%CI)	Path *c'* (B, 95%CI)	Sobel test (z-score)	Proportion mediated
Neighbourhood social networks score – total sample	-0.56 (-0.61; -0.51)*	-0.35 (-0.61; -0.09)*	0.35 (0.01; 0.69)*	0.19 (-0.16; 0.53)	2.75*	46%
France	*-0.81 (-0.89; -0.74)**	*-0.73 (-0.81; -0.66)**	*0.25 (-0.29; 0.80)*	*-0.20 (-0.89; 0.49)*	*2.10**	*100%*
Hungary	*-0.31 (-0.46; -0.17)**	*0.38 (-0.22; 0.97)*	*1.09 (-0.15; 2.34)*	*1.21 (0.00; 2.41)*	*-1.19*	-
Netherlands	*-0.61 (-0.66; -0.55)**	*-0.32 (-0.60; -0.03)**	*0.19 (-0.21; 0.59)*	*-0.02 (-0.39; 0.36)*	*2.21**	*100%*
United Kingdom	*-0.33 (-0.40; -0.27)**	*0.56 (0.00; 1.12)**	*0.36 (-0.19; 0.92)*	*0.49 (-0.04; 1.01)*	*-1.93*	-
Neighbourhood social cohesion score – total sample	-0.79 (-0.85; -0.73)*	-0.13 (-0.38; 0.12)	0.35 (0.01; 0.69)*	0.26 (-0.18; 0.70)	1.18	-
France	*-1.61 (-1.66; -1.55)**	*-0.04 (-0.78; 0.69)*	*0.25 (-0.29; 0.80)*	*0.19 (-1.14; 1.51)*	*0.11*	-
Hungary	*-0.82 (-0.99; -0.64)**	*0.09 (-0.44; 0.61)*	*1.09 (-0.15; 2.34)*	*1.16 (-0.16; 2.49)*	*-0.34*	-
Netherlands	*-0.84 (-0.91; -0.77)**	*-0.24 (-0.47; -0.01)**	*0.19 (-0.21; 0.59)*	*-0.03 (-0.42; 0.36)*	*2.03**	*100%*

United Kingdom	*-0.73 (-0.81; -0.66)**	*0.15 (-0.36; 0.67)*	*0.36 (-0.19; 0.92)*	*0.46 (-0.19; 1.12)*	*-0.56*	-

Path a represents the association between the neighbourhood income inequality ratio and neighbourhood social networks/cohesion. Path b represents the association between neighbourhood social networks/cohesion and body mass index. Path c represents the direct association between the neighbourhood income inequality ratio and body mass index. Path c' represents the indirect association between the neighbourhood income inequality ratio and body mass index.

Associations are adjusted for age, gender, education, household composition and income.

*P value <0.05

B = coefficient, 95%CI = 95% confidence interval

Figure 1. Overview of the analyses that were conducted