Int J Public Health 54 (2009) 183–192
1661-8556/09/030183-10
DOI 10.1007/s00038-009-7113-x

Original article

Effects of area deprivation on health risks and outcomes: a multilevel, cross-sectional, Australian population study

Robert J. Adams[1], Natasha Howard[2], Graeme Tucker[3], Sarah Appleton[1], Anne W. Taylor[4], Catherine Chittleborough[4], Tiffany Gill[4], Richard E Ruffin[1], David H Wilson[1]

[1] *The Health Observatory, University of Adelaide, The Queen Elizabeth Hospital Campus, Woodville, Australia*
[2] *Nutrition Obesity Lifestyle and Environment (NOBLE) Study, Department of Geographical and Environmental Studies, University of Adelaide, Adelaide, Australia*
[3] *Epidemiology Branch, South Australian Department of Health, Adelaide, Australia*
[4] *Population Research and Outcome Studies Unit, South Australian Department of Health, Adelaide, Australia*

Submitted: 29 November 2007; revised: 15 July 2008, 01 December 2008; accepted: 04 December 2008

Published online first: 13 February 2009

Abstract

Objectives: Our aim was to examine the effect of local area socio-economic disadvantage after accounting for individual socio-economic status (SES), and to determine if these differ between various health and risk factor variables.
Methods: The North West Adelaide Health Study (NWAHS) is a biomedical representative population study of adults. The Index of Relative Socio-Economic Disadvantage (IRSD), produced from the Australian Bureau of Statistics (ABS) Census data at the level of Collector Districts (200 dwellings) was used as an indicator of local area disadvantage. Multi-level modeling techniques examined the effects of IRSD level on a variety of health outcomes and risk factors, after accounting for individual socio-economic factors.
Results: Significant, independent associations were seen between IRSD and obesity, smoking, and health-related quality of life, with 5 % to 7.2 % of the variance located at the neighborhood level. No independent associations were seen between IRSD and estimated cardiovascular disease risk, diabetes, physical activity, or at-risk alcohol use.
Conclusions: Aggregated area-level characteristics make modest, but significant independent contributions to smoking, obesity and quality of life, but not for other health outcomes.

Keywords: Socio-economic disadvantage – Multilevel modeling – Obesity – Health-related quality of life – Social determinants of health.

Introduction

A number of studies have examined the association of local area context as a mediator between income inequality and health[1,2] Pickett and Pearl[3], in a systematic review of multilevel studies of the association of neighbourhood area and health, concluded that there is evidence for an association between area and health outcomes. However, these area associations with health are generally smaller than those seen for individual socioeconomic status (SES) variables (such as age, gender, social class, and employment status). In addition, several studies have shown interactions between area and individual characteristics in predicting health.[4–6]
Findings from the US demonstrate an association between income inequality and self-rated health that persists after adjustment for individual level factors.[7] However, this finding does not seem to be generalisable to other countries where the evidence for any association between income inequality and health outcomes is mixed.[8,9] A potential limitation of these analyses is the focus on income[10] without consideration of other measures of SES such as education which show a strong association with such factors as cardiovascular risk factors in other studies[11].
At smaller levels of geographical analysis in the U.S., multilevel studies have produced mixed findings for health outcomes including self-rated health[12,13] and for mortality[14,15]. A number of studies from the US and Canada have found that the relationship between mortality and income is different for disadvantaged and advantaged neighborhoods[15,16]. These studies have shown excess mortality among those with low individual SES living in high SES neighbourhoods over peo-

ple with low individual SES living in low SES neighbourhoods. Of note, Winkleby et al found there were few differences in baseline lifestyle risk factors between those with low individual SES who were living in low or high SES areas.[15] This suggests that factors other than individual risk were at play in these results. In previous Australian studies, the most deprived neighborhoods were associated with adverse health outcomes, including mortality[17], and chronic diseases[18,19]. However, these studies did not make any adjustments for individual socio-economic status.

Studies examining the association between area and health risks have also produced mixed results. Individuals living in the most deprived neighborhoods have shown an increased risk of being obese, physically inactive and smoking when adjusted for individual status[6]. However, criticism has been made that some of the studies examining links between area and health risks have not adequately controlled for important individual cardiac risk factors, such as smoking[20,21,22]. In Australia, area level disadvantage has been identified as an important risk factor for obesity, after adjusting for individual SES[23]. However this study was limited by a marked over-representation of women, use of self-report BMI measurements, and achieved a low response rate from low SES individuals. This raises the possibility of bias and confounding in the results, as the sample may not have been representative of Australian adults, and may not have accurately assessed the key variable of obesity with self-reported BMI[24].

Therefore, confirmation of an area level association with health risks independent of individual level characteristics in a recent, representative population cohort is important. To examine this question we used data from the North West Adelaide Health Study (NWAHS), a population study of predominantly Caucasian adults from Adelaide, South Australia. The first aim of this study is to analyze in an Australian context whether there is an association between local area socio-economic disadvantage and health that persists after accounting for individual socio-economic status. The second aim is to analyze whether any local area effect varies for different health and risk factor variables. We also examine if any relation between health risk factors and income or education is differential for disadvantaged and advantaged neighborhoods.

Methods

The North West Adelaide Health Study (NWAHS) is a representative biomedical population study of people aged eighteen years or older living in the north western suburbs of Adelaide, South Australia (regional population 0.6 million). The aims of the study were to provide estimates of chronic conditions and associated risk factors and quality of life for the regions. The sample is representative of the community profile of Adelaide[25]. The methods have been described previously in detail[25].

The North West Adelaide Health Study (NWAHS) recruited between 2000 and 2002 with a total of n = 4060 adults participating. The overall response rate of the completed telephone interview, self-completed questionnaire and clinic biomedical assessment (including blood sample) was 50 % (69 % of those interviewed)". Persons aged ≥ 18 years from households selected at random from the electronic white pages directory were eligible. Respondents completed surveys of health status and demographic data and underwent clinic assessment, including measurement of blood pressure, height, weight, waist and hip circumference, fasting glucose and lipid levels. The study was approved by institutional ethics committees of the North West Adelaide Health Service, and all subjects gave written informed consent.

Individual level variables included age, gender, country of birth, marital status, education level, household income, receiving government benefits or pension, employment status.

The Index of Relative Socio-Economic Disadvantage (IRSD) is a measure of area socio-economic position produced from the Australian Bureau of Statistics (ABS) Census data[26] that focuses on low income, relatively lower educational attainment and high unemployment. We used indices developed from 2001 census data to correspond with the timeframe of the NWAHS Study. It is a composite measure derived from the following area attributes of percentages of people with: low household income (< $15 600); families with offspring with parental income < $15 000; unemployment; lower skill workers (those classified as "labourer and related workers", "intermediate production and transport workers", elementary clerical, sales and service workers") tradespersons; people aged 15 and over with no qualifications and/or did not go to school; one parent families with dependent offspring only; people separated or divorced; households renting from government authorities; dwellings with no motor cars; occupied private dwellings with two or more families; people lacking fluency in English. The IRSD is compiled at the Collector's District (CD) level, a census collection unit equivalent to about 200 dwellings in urban areas. The CDs are similar in population size to enumeration districts in the UK. We present results for IRSD scores divided into quintiles for single-level models and per CD level in the multi-level models.

Health states and risk factors definitions are as follows. Smoking was defined as current smoking. Recreational physical activity was assessed to Australian standards using items for the Active Australia Survey[27]. Activity was calculated as the number of times activity was undertaken by average time/

session by (self-perceived) intensity, categorized into sedentary, low, moderate and high exercise[27]. High blood pressure was defined as systolic blood pressure ≥140 mmHg and or diastolic blood pressure ≥90 mmHg. High cholesterol was defined as total blood cholesterol ≥5.5mmol/litre. Intermediate to high alcohol use was defined for males and females. Males: average daily intake of at least 5–8 standard drinks or occasional excess; Females: average daily intake of at least 4 standard drinks or occasionally 9–12 drinks in one day[28]. Obesity was defined as BMI >30 kg/m^2. High waist circumference waist circumference of >102 cm for males / >88 cm for females The metabolic syndrome was defined using the ATP Expert Panel III definition, as 3 or more of the following variables: triglyceride level of >1.7 mmol/L; HDL cholesterol level of <1.0 mmol/L in men or <1.3 mmol/L in women; blood pressure of at least 130/85 mm Hg; fasting glucose level of >6.1 mmol/L; or waist circumference of >102 cm for males / >88 cm for females[29]. For Framingham Heart Study functions of predicted CHD risk we used published criteria[30] based on age, total and HDL cholesterol, blood pressure, diabetes and smoking. We defined high risk for CHD as 10-year risk of >15 % for men and women aged 35–75 years, with no previous history of CHD or stroke. Quality of life was measured using the Short-Form 36 (SF-36) scale, aggregated into the Physical Health Component Summary (PCS) and Mental Health Component Summary (MCS) scores, which is a validated measure of quality of life in Australia[31].

Statistical Analyses

Data for self-report variables was 99 % complete, other than income (95 %) and for measured variables was over 98 % complete. Data obtained were weighted to the 1999 Estimated Residential Population for South Australia[32] by region, age group, gender and probability of selection in the household, to provide population representative estimates. Data were analyzed using the Statistic Package for the Social Sciences (SPSS Version 10.0) and Stata Version 9. Logistic regression was used to examine associations of income, education and Socio-economic Indexes for Areas (SEIFA) IRSD scores with health states, lifestyle factors and quality of life, adjusted for age and gender. The SF-36 was scored using coefficients based on a structural equation model. The summary scores based on the exploratory factor analysis approach of Ware et al.[31] have been questioned in the literature[33], and the structural equation modeling approach has been demonstrated to overcome the problem[34]. The component summary scores are constructed so that the mean for the general population is set at 50 with a standard deviation of 10, and higher scores indicate better quality of life.

The assessment of the significance of area-level effects taking into account the characteristics of individuals is inherently multi-level[10,19]. The data takes the form of persons nested within areas, a two level structure. Multi-level models correct the variance estimates of the coefficients in the fixed part of the model by partitioning the error variance between the levels of the nested effects, thus allowing for the clustering or non-independence of the observations. The IRSD index score was matched to the dataset at the CD level, and quintiles computed. Accordingly analysis was carried out at the CD level. Multi-level models were fit with CD as level 2, with SEIFA index of relative socioeconomic disadvantage quintiles as a predictor in the fixed part of the model. Models were fit using MLwiN version 2.10 beta 4. The analysis was conducted with non-integer weights at level 1 since the data are derived from a survey, with a clinic follow up component. Level 2 weights were calculated as recommended by the MLwiN documentation, the method being credited to Bob Johnson (National Opinion Research Centre, University of Chicago).

For normally distributed dependent models the amount of variance associated with each level of the data hierarchy is the intra-class correlation, and can be read directly from the variance contributions of the fitted model. The situation is more complex for non-linear models, such as logistic regression models. For these models it is necessary to calculate the variance partition coefficient (VPC) from the outputs provided by the model, and the VPC cannot be interpreted as an intra-class correlation. In these models the VPC is dependent on the predictors in the model, and the values of the predictors, and it is different for each case. For each binary dependent variable, a variance components model was fit to produce an indication of the size of the variance partition coefficient at each level. We used the first order Taylor series approximation (Method A) of Goldstein et al[35]. We set the tolerance to 10^{-3} to force a more accurate solution. Binary models were fit using 1st order marginal quasi likelihood (MQL) followed by 2nd order penalised quasi likelihood (PQL) where possible. Since the binary dependent models were fit using quasi likelihood, the likelihood statistic was not accurate. In these models the joint significance of the socioeconomic status quintile dummies was tested using Wald tests.

The adjusted R^2 for the normally distributed models was calculated as one minus the variance of the fitted model divided by the total variance identified in a variance components model. The joint significance of the socioeconomic quintile dummy variables was tested using a likelihood ratio test.

Models were also calculated with IRSD scores for postcode levels, constructed by the ABS computing weighted average scores across all CD's comprising the postcode. No differences were seen in any of the relationships or the significance of any of the results. As age makes a substantial contribution to CHD risk scores, models were also recalculated using

Table 1. Risk factor prevalence (%) within quintiles of the SEIFA Index of relative socio-economic disadvantage among those with different levels of education.

Risk factor *	1st Quintile (n = 839)	2nd Quintile (n = 767)	3rd Quintile (n = 792)	4th Quintile (n = 825)	5th Quintile (n = 836)
Obesity	33.2	28.4	28.2	28.4	21.0
High school	34.1	30.9	31.1	29.5	19.4
Technical †	32.3	28.6	25.8	29.8	20.9
University	30.8	17.7	25.6	18.0	17.2
OR	1.1 (0.6–2.0)	2.5 (1.3–4.7)	1.2 (0.8–2.0)	1.6 (0.9–2.8)	1.0 (0.6-1.6)
Current smoking	30.9	23.0	26.5	19.2	20.3
High school	31.8	18.5	29.8	18.5	18.7
Technical	29.9	33.3	27.7	22.8	23.9
University	29.2	10.1	12.7	7.9	14.4
OR	2.3 (1.1–4.7)	2.3 (1.1–4.7)	3.3 (1.8–5.9)	3.2 (1.5–7.0)	1.8 (0.96-3.2)
P***hysical inactivity***	51.4	49.9	49.4	47.0	39.3
High school	54.2	51.1	52.0	55.0	43.5
Technical	50.2	51.9	50.6	39.6	41.7
University	35.4	39.2	37.6	37.1	23.2
OR	2.2 (1.2–4.1)	1.8 (1.1–3.1)	1.9 (1.2–2.9)	2.3 (1.4–3.8)	2.2 (1.4-3.5)
Risky alcohol use	5.4	5.2	8.6	5.7	5.4
High school	6.3	6.6	9.0	6.6	5.5
Technical	4.7	4.8	10.0	3.9	7.1
University	1.5	1.3	3.4	9.0	0.8
OR	1.6 (0.4–6.9)	3.1 (0.7–14.1)	2.0 (0.7–5.4)	0.8 (0.3–2.0)	2.3 (0.6–8.0)
Met. syndrome	17.7	16.9	13.3	15.6	9.5
High school	18.1	19.2	15.0	15.8	9.6
Technical	17.9	17.7	14.6	17.2	8.9
University	10.8	7.6	6.8	7.9	8.9
OR	1.4 (0.6–3.1)	2.0 (0.9–4.7)	2.5 (1.1–5.4)	1.9 (0.9–4.2)	0.8 (0.4–1.6)
≥2 risk factors	52.7	44.1	45.1	44.9	37.8
High school	55.7	48.2	48.3	47.3	41.8
Technical	49.9	47.2	46.9	45.6	40.5
University	44.6	19.0	29.9	30.7	21.0
OR	1.4 (0.8–2.5)	3.5 (1.9–6.2)	2.3 (1.4–3.6)	2.2 (1.3–3.7)	2.0 (1.3–3.2)

***Obesity:** BMI ≥30 kg/m^2; **Physical inactivity:** <150 min/week moderate activity; **Alcohol risk:** for males - average daily intake of at least 5-8 standard drinks or occasional excess; for females: average daily intake of at least 4 standard drinks or occasionally 9-12 drinks in one day;
Metabolic syndrome: ≥3 of waist circumference >102cm for males, >88cm for females; HDL <1.0 mmol/l for males, <1.3 mmol/l for females; blood pressure ≥130/85; serum triglyceride ≥1.7 mmol/l; fasting plasma glucose ≥6.1 mmol/l. **Multiple risk factors:** ≥2 of obesity, current smoking, insufficient physical activity, high BP, alcohol risk; dyslipidemia. † Technical category includes vocational, technical studies, certificate or diploma.
†Technical category includes vocational, technical studies, certificate or diploma.
‡Odds ratios (95 % CI) are for High school compared with University, adjusted for age and gender.

age-standardised parameters. This did not have a significant effect on any of the associations of IRSD SEIFA and health outcomes.

Results

The prevalence of health risk factors, diabetes and the metabolic syndrome, and quality of life scores in the sample population have been published previously[25]. The prevalence of lifestyle risk factors and health states within quintiles of area relative socio-economic disadvantage and the effect of education level (Tab. 1) and household income (Tab. 2), are shown. When comparing people within quintiles of local area disadvantage, those with the lowest levels of education and income had significantly higher levels of smoking, physical inactivity, hypertension and the presence of 2 or more risk factors than people in the highest group of education and income, after adjusting for age and gender. This effect was seen across all SEIFA IRSD quintiles. Consistent differences were not seen

Int J Public Health 54 (2009) 183–192

Table 2. Risk factor prevalence (%) within quintiles of the SEIFA Index of relative socio-economic disadvantage among those with different levels of income.

Risk factor	1st Quintile (n = 901)	2nd Quintile (n = 713)	3rd Quintile (n = 817)	4th Quintile (n = 882)	5th Quintile (n = 748)
Obesity	33.2	28.0	28.1	27.8	20.7
< $20,000	38.1	27.7	34.4	29.5	32.5
$20,001–$50,000	31.4	33.8	26.3	31.6	16.9
$50,001–$80,000	33.1	23.2	28.7	25.8	21.8
> $80,000	19.6	19.0	22.2	17.9	16.1
OR*	1.7 (0.8–3.9)	1.5 (0.7–3.4)	1.8 (0.97–3.5)	1.1 (0.6–2.1)	1.9 (1.02–3.4)
Current smoking	29.8	23.2	26.8	19.4	20.3
< $20,000	25.8	20.8	18.5	18.8	17.2
$20,001–$50,000	34.1	25.7	32.8	21.5	19.6
$50,001–$80,000	31.5	25.8	25.8	18.1	23.4
> $80,000	16.1	13.6	23.2	16.9	19.9
OR	4.4 (1.7–11.3)	5.3 (2.1–13.3)	2.3 (1.1–4.7)	4.2 (1.9–9.3)	3.2 (1.6–6.5)
Physical inactivity	50.9	48.3	47.9	46.5	38.1
< $20,000	55.5	50.6	50.3	49.4	40.5
$20,001–$50,000	53.9	52.7	51.9	45.3	44.9
$50,001–$80,000	42.1	48.0	44.8	49.0	39.6
> $80,000	33.3	25.9	37.4	41.5	24.8
OR	1.6 (0.8–3.4)	2.7 (1.3–5.4)	1.8 (1.03–3.2)	1.6 (0.9–2.8)	2.1 (1.2–3.6)
Risky alcohol use	5.0	5.3	9.0	5.7	3.7
< $20,000	3.8	2.6	3.9	5.7	6.0
$20,001–$50,000	4.8	6.3	11.5	6.5	7.1
$50,001–$80,000	5.6	7.9	11.9	2.5	5.1
> $80,000	10.7	1.7	4.1	8.5	3.7
OR	0.5 (0.1–1.6)	1.0 (0.2–5.7)	1.3 (0.3–4.6)	2.2 (0.6–7.2)	1.8 (0.6–5.5)
Metabolic Synd.	17.7	16.9	13.3	15.6	9.5
< $20,000	22.4	24.7	17.2	18.2	13.8
$20,001–$50,000	16.1	14.9	14.3	17.9	9.8
$50,001–$80,000	15.7	13.2	10.3	9.6	8.6
> $80,000	10.7	13.6	10.1	15.3	6.8
OR	1.3 (0.5–3.4)	0.8 (0.9–2.0)	1.2 (0.5–2.8)	0.7 (0.4–1.5)	1.0 (0.4–2.3)
≥2 risk factors	51.6	43.3	43.5	44.5	36.5
< $20,000	62.2	50.6	47.4	48.3	50.0
$20,001–$50,000	50.9	45.0	45.5	47.2	37.5
$50,001–$80,000	42.1	41.7	41.8	40.4	37.1
≥ $80,001	30.4	22.0	34.3	38.1	24.8
OR	2.5 (1.2–5.4)	2.9 (1.4–6.0)	1.9 (1.04–3.3)	1.8 (1.02–3.3)	2.2 (1.3–3.7)

*OR (95 % CI) for comparison < $20,000 versus > $80,000, adjusted for age and gender.

for obesity or truncal adiposity, and there were no differences in dyslipidemia or risky alcohol use.

Clear trends were seen across quintiles of SEIFA scores and the prevalence of risk factors and health states. Diabetes, the metabolic syndrome and with physical and mental health quality of life, and the risk factors of obesity, smoking and insufficient recreational physical activity were more common among people residing in lower quintiles of SEIFA scores. Similar patterns were seen for differences of income and education level, with the exceptions of diabetes and education, and the metabolic syndrome and income. Large, statistically significant differences were seen across income categories for both physical and mental health quality of life scores. Similar patterns were seen for education levels and area economic disadvantage but the magnitude of these differences was smaller than that seen for income (Tab. 3).

Differences were seen across SEIFA quintiles within categories of education (Tab. 4) and income (data not shown).

Table 3. Mean (SE) SF-36 Physical Component Summary (PCS) and Mental Component Summary (MCS) scores† in relation to individual and area level socioeconomic factors adjusted for age and gender.

SES indicator	PCS Mean (SE)	MCS Mean (SE)
SEIFA quintile		
1st	47.4* (0.3)	48.9* (0.3)
2nd	49.2 (0.4)	50.0 (0.4)
3rd	48.4* (0.3)	48.9* (0.4)
4th	49.3 (0.3)	50.3 (0.3)
5th	50.2 (0.3)	50.5 (0.4)
Education		
High school	48.1* (0.2)	49.4* (0.2)
Technical†	48.9* (0.2)	49.7 (0.3)
University	51.0 (0.4)	50.7 (0.5)
Income		
<$20,000	45.7* (0.3)	47.0* (0.4)
$20,001–$50,000	49.0* (0.2)	49.8* (0.3)
$50,001–$80,000	50.8* (0.3)	51.4 (0.3)
≥$80,001	52.1 (0.4)	52.4 (0.4)

†SF-36 PCS & MCS scores are constructed so that the mean for the general population is set at 50 with a standard deviation of 10, and higher scores indicate better quality of life.
* $p < 0.05$ versus the highest SES category

Compared with the highest quintile of SEIFA, those living in the lowest quintile had significantly increased odds ratios for obesity, smoking, sedentary recreational physical activity and the metabolic syndrome, at each level of individual education and income. Consistent differences were not seen for hypertension, at-risk alcohol consumption, dyslipidemia, or CVD risk.

Multi-level models

Using multi-level modeling we examined the association of neighborhood using SEIFA IRSD quintiles with health states and risk factors, after adjusting for individual demographic and socio-economic factors. Tab. 5 shows the odds ratios (for dichotomous variables) or linear coefficients (for linear variables) associated with each level of SEIFA for each of the dependent variables, as well as the variance residing at the SEIFA level for each variable (expressed by the variance partition coefficient). Significant, independent associations were seen between local area relative economic disadvantage and obesity, smoking, and health-related quality of life as assessed by the SF-36 Mental Health and Physical Health Com-

Table 4. Odds ratios (95 % CI)* for health risks and outcomes in relation to quintile of SEIFA within each education level.

Risk factor	1st	2nd	3rd	4th	5th
Obesity					
High School	2.3 (1.6–3.5)	1.9 (1.2–3.0)	2.0 (1.3–3.0)	2.0 (1.3–3.0)	1.0
Technical‡	2.0 (1.3–2.9)	1.8 (1.2–2.9)	1.5 (0.9–2.2)	1.7 (1.2–2.6)	1.0
University	2.2 (1.0–4.8)	1.0 (0.4–2.4)	1.5 (1.7–2.8)	0.9 (0.4–1.9)	1.0
Smoking					
High School	1.9 (1.3–2.8)	0.9 (0.6–1.4)	1.6 (1.1–2.3)	0.9 (0.6–1.3)	1.0
Technical	1.3 (0.9–1.8)	1.5 (1.0–2.2)	1.1 (0.8–1.6)	0.9 (0.6–1.3)	1.0
University	2.5 (1.2–5.1)	0.6 (0.3–1.6)	0.9 (0.4–1.8)	0.5 (0.2–1.3)	1.0
Sedentary					
High School	1.8 (1.2–2.5)	2.0 (1.4–2.9)	2.2 (1.5–3.2)	1.6 (1.1–2.2)	1.0
Technical	1.7 (1.2–2.4)	2.1 (1.4–3.1)	1.2 (0.8–1.8)	1.0 (0.7–1.5)	1.0
University	3.5 (1.2–10)	3.2 (1.1–9.3)	3.6 (1.4–9.4)	3.1 (1.1–8.6)	1.0
Hypertension					
High School	1.2 (0.9–1.7)	1.2 (0.9–1.7)	1.3 (0.9–1.9)	1.1 (0.8–1.6)	1.0
Technical.	1.2 (0.9–1.8)	1.3 (0.9–2.0)	1.1 (0.8–1.7)	1.2 (0.8–1.7)	1.0
University	1.4 (0.5–3.8)	1.8 (0.7–4.4)	1.1 (0.5–2.8)	0.8 (0.3–2.1)	1.0
Risky alcohol					
High School	1.1 (0.6–2.0)	1.2 (0.6–2.3)	1.5 (0.8–2.7)	1.1 (0.6–2.0)	1.0
Technical	0.7 (0.3–1.2)	0.7 (0.3–1.4)	1.5 (0.8–2.6)	0.5 (0.3–1.1)	1.0
University	2.2 (0.1–41)	1.3 (0.1–33)	5.9 (0.6–60)	13 (1.4–122)	1.0
Metabolic syndrome					
High School	2.4 (1.5–3.7)	2.4 (1.5–3.8)	2.0 (1.2–3.3)	2.0 (1.3–3.3)	1.0
Technical	2.4 (1.5–3.9)	2.5 (1.5–4.2)	2.0 (1.2–3.3)	2.2 (1.4–3.6)	1.0
University	1.5 (0.5–4.1)	1.0 (0.4–2.9)	0.9 (0.3–2.3)	0.8 (0.3–2.3)	1.0

*Reference category for odds ratios is the 5th or highest level quintile.
‡Technical category includes vocational, technical studies, certificate or diploma.

Int J Public Health 54 (2009) 183–192

Table 5. Odds ratios or linear co-efficients* for the association of various health outcomes and lifestyle risk factors with quintiles of SEIFA Index of Socio-economic Disadvantage in multi-level models, adjusted for individual level factors†.

Dependent variable	SEIFA Quintiles				VPC‡	p-value
	2nd	3rd	4th	5th		
SF-36 MCS*	1.54	–0.10	0.92	0.53	5.0%	0.015
SF-36 PCS*	1.26	0.26	1.09	0.48	5.4%	0.059
Obesity	0.8	0.7	0.5	0.4	5.6%	0.0000
Current smoker	0.9	0.8	0.6	0.6	7.2%	0.005
Framingham 15% risk						
Males	1.0	1.1	1.0	1.5	2.1%	0.72
Females	0.9	0.9	0.7	0.4	3.7%	0.40
Diabetes	0.8	0.7	0.8	0.7	1.2%	0.64
Inadequate exercise	0.9	0.9	1.0	1.0	5.9%	0.95
High alcohol risk	1.8	1.8	0.3	1.7	5.1%	0.11

*Linear co-efficients for SF-36 Physical Component Summary (PCS) & Mental Health Component Summary (MCS), other values are odds-ratios for dichotomous variables.
†Models include age, gender, household income, education level, work status/occupation and ethnicity, and the other variables in the table.
‡ VPC = Variance Partition Coefficient

ponent Summary Scores. No independent associations were seen between SEIFA IRSD quintiles and estimated 10-year cardiovascular disease risk in men or women, diabetes, chronic lung disease symptoms, recreational physical activity, or at-risk alcohol use, after adjustment for individual level SES factors. There were no significant individual-area interaction effects seen in the model.

Discussion

We have demonstrated differences between health risk factors and outcomes in their association with local area disadvantage and individual SES. Consistent with some other studies[11,23], we found modest but significant associations between living in socio-economically disadvantaged areas and smoking and obesity that persist after adjustment for individual SES. An association was also seen with health-related quality of life, in both physical and mental health domains. Although an association was seen between local area disadvantage and the presence of diabetes, the metabolic syndrome, predicted risk of cardiovascular events, and recreational physical activity, these associations did not remain after adjustment for individual SES.

It is unclear why some risk factors such as obesity maintain strong associations with aggregated area-level disadvantage after taking individual SES into account, while other obesity-related metabolic disorders, such as diabetes or the metabolic syndrome, do not. It is possible that a universal health system may successfully ameliorate these adverse metabolic consequences of obesity with effective treatments of, for example hypertension and hypercholesterolemia, so that area level effects are no longer discernable. There is also the possibility that diabetes and the metabolic syndrome may differentially develop over time dependent on area level characteristics. Interactions between individual characteristics and behaviour, such as access to food and food choices, exposure to take-away fast food outlets, and opportunities for physical activity may vary according to area level disadvantage. An association between high neighbourhood deprivation and an absence of protective cardiovascular disease-related health behaviour changes in the past year, but not predicted future CHD risk, independent of individual-level SES has been reported[36].

Previous Australian studies suggest complex relationships between individual characteristics, behaviour and area level influences. Studies have shown inconsistent results regarding whether area disadvantage exerts a major effect on food purchasing decisions[18,37]. A study from another Australian city reported a decreased likelihood of participating in sufficient physical activity in people living in economically disadvantaged areas after adjusting for individual SES[38]. The strongest negative association was seen between local area deprivation and jogging. However, the measure of local area economic disadvantage used only accounted for the proportion of low-income households. This measure may not adequately adjust for confounding for individual factors and this may partly account for the differences in results with our study. It is possible that the characteristics of neighbourhoods that influence particular physical activities, such as jogging, vary substantially between the two cities such that local area effects are seen differentially.

Consequently, the implications of these findings for policy planning are that further work is required that specifically examines these questions. One possibility is pseudo-experimental study designs that could compare intensive efforts at individual risk factor reduction (e.g. blood pressure or cholesterol reduction, exercise classes, education on food choices, smoking cessation counseling) in one area, with public health actions at area level (e.g. subsidized access to food and improved food choices, urban design changes to enhance opportunities for physical activity) in another.

We found significant differences between low and high-SES areas among those at similar individual SES levels for obesity, smoking, sedentary recreational physical activity and the metabolic syndrome. In contrast, Winkelby et al found in the US that people with low SES living in high-SES neighbourhoods had higher mortality rates than other groups that were not explained by differences in baseline characteristics[15]. However, in their population, risk factor prevalence at baseline was similar among those with low-SES living in either high or low-SES neighbourhoods. Others have suggested that the association between smoking and poor health in disadvantaged areas may be due to the low socio-economic status of individuals in these areas[20].

Alternatively, peer acceptance of smoking may play a major part in smoking uptake and continuation[39], and people's perception of their own risk may depend on the people around them[40]. This may help to explain the differences in smoking across levels of area SES in people of similar individual SES in our study. The impact of social networking on obesity has been described and may eclipse the effect of immediate neighbours on weight gain[41]. If close social contacts in lower SES areas are more likely to come from local areas than for people in higher SES areas, this may be a contributing factor to neighbourhood effects on such variables as smoking and obesity. It would also point to interventions that modify the individual's social network as important in modifying behaviour[42, 43].

Local area effect was associated with 5 % of the variance in SF-36 MCS scores, a modest but significant effect. Income differences appeared to have a greater association with MCS scores than education. Previous reports from UK and US data indicated neighbourhood effects on mental health were small, compared with the characteristics of the individuals who live in the area[44]. Propper et al. found that for GHQ-12 scores estimated variance at neighbourhood level was < 1 % in adjusted models and concluded that policy should reflect that consideration. They suggested that in terms of mental health status it is people and their households, rather than place that have the greater influence[44]. Our data suggest that attention to which features of neighbourhoods affect mental health is warranted as these may be more amenable to intervention than such individual characteristics as age, gender and education.

Some authors have suggested that census measures such as IRSD scores do not capture features of the neighbourhoods themselves that may influence health[45]. However, there is little consensus regarding possible pathways linking area of residence to health[46]. We included three measures of individual level SES limiting the likelihood of effects of confounding by unmeasured individual SES. Our study is limited by reliance on subject self-report for some of the health conditions described. However, studies from community populations have found self-reported cardiac events and stroke to be accurate[47]. There was also a potential bias from survey non-response, although our study response rate is very good compared to other similar population studies, and there is no significant non-response bias by low SES groups, by gender or those with chronic diseases or health risk factors[48]. The sampling technique was unbiased other than the need for participants to be living in a household with a telephone, which represents about 97 % of Australian households, and the ability of these methods to achieve an unbiased population-based sample have been described previously. The NWAHS study population covers the full range of economic strata, and there are sufficient numbers at each end of the SES scale to allow for describing differences in local area and individual SES[48]. A major strength of this study is the inclusion of a wide range of CHD and other health risk factors, chronic diseases and quality of life measurements, providing a broad picture of the effect of individual and area SES on health.

We have found individual characteristics and aggregated level characteristics make independent contributions to smoking, obesity and quality of life, but not for other health outcomes. Future work is indicated to examine what neighbourhood features in the Australian context contribute to putting people at risk for these differential adverse health effects.

Acknowledgement

Study funding was provided by the University of Adelaide and the South Australian Department of Health.

References

1. Kawachi I, Kennedy B, Lochner K, et al. Social capital, income inequality, and mortality. Am J Public Health 1997;87:1491–8.

2. Lynch JW, Davey Smith G, Kaplan GA, et al. Income inequality and mortality: importance to health of individual income, psychosocial environment, or material conditions. BMJ 2000;320:1200–4.

3. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. J Epidemiol Community Health 2001;55:111–22.

4. Shouls S, Congdon P, Curtis S. Modelling inequality in reported long term illness in the UK: combining individual and area characteristics. J Epidemiol Community Health 1996;50:366–76.

5. Diez-Roux A, Nieto F, Muntaner C, et al. Neighbourhood environments and coronary heart disease: a multilevel analysis. Am J Epidemiol 1997;146:48–63.

6. Stafford M, Bartley M, Mitchell R, et al. Characteristics of individuals and characteristics of areas: investigating their influence on health in the Whitehall II study. Health Place 2001;7:117–29.

7. Kennedy B, Kawachi I, Glass R, et al. Income distribution, socioeconomic status, and self-rated health in the United States: multilevel analysis. BMJ 1998;317:917–21.

8. Stanistreet D, Scott-Samuel A, Bellis M. Income inequality and mortality in England. J Public Health Med 1999;21:205–7.

9. O'Dea D, Howden-Chapman P. Income and Income Inequality and Health. In: Howden-Chapman P, Tobias M, eds. Social inequalities in health in New Zealand: New Zealand 1999. Wellington, NZ: Ministry of Health, 2000.

10. Blakely T, Atkinson, O'Dea D. No association of income inequality with adult mortality within New Zealand: a multilevel study of 1.4 million 25–64 year olds. J Epidemiol Community Health 2003;57:279–84.

12. Farquhar JW, Foitmarm SP, Flora JA, et al. Effects of communitywide education on cardiovascular disease risk factors: the Stanford Five-City Project. JAMA 1990:264:359–65.

12. Soobader M-J, LeClere F. Aggregation and the measurement of income inequality: effects on morbidity. Soc Sci Med 1999;48:733–44.

13. Blakely T, Lochner K, Kawachi I. Metropolitan area income inequality and self-rated health: a multi-level study. Soc Sci Med 2002;54:65–77.

14. Fiscella K, Franks P. Poverty or income inequality as predictor of mortality: longitudinal cohort study. BMJ 1997;314:1724–8.

15. Winkleby M, Cubbin C, Ahn D. Effect of cross-level interaction between individual and neighborhood socioeconomic status on adult mortality rates. Am J Public Health 2006;96:2145–53.

16. Veugelers PJ, Yip AM, Kephart G, Proximate and contextual socioeconomic determinants of mortality: multilevel approaches in a setting with universal health care coverage. Am J Epidemiol 2001:154:725–32

17. Draper G, Turrell G, Oldenburg B. Health inequalities in Australia: Mortality. Health Inequalities Monitoring Series No. 1. Canberra: Queensland University of Technology and the Australian Institute of Health and Welfare. (AIHW Cat. No. PHE 55).

18. Glover JD, Hetzel DMS, Tennant SK. The socioeconomic gradient and chronic illness and associated risk factors in Australia. Aust NZ Health Policy 2004;1:8.

19. Turrell G, Blakely T, Patterson C, Oldenburg B. A multilevel analysis of socioeconomic (small area) differences in household food purchasing behaviour. J Epidemiol Community Health 2004;58:208–15.

20. Reijneveld SA. The impact of individual and area characteristics on urban socioeconomic differences in health and smoking. Int J Epidemiol 1998;27:33–40.

21. Sundquist J, Malmstrom M, Johansson S-E. Neighbourhood deprivation and incidence of coronary heart disease: a multilevel study of 2.6 million women and men in Sweden. J Epidemiol Community Health 2004;58:71–77.

22. Blakely T, Hunt D, Woodward A. Confounding by socioeconomic position remains after adjusting for neighbourhood deprivation: an example using smoking and mortality. J Epidemiol Community Health 2004;58:1030–31.

23. King T, Kavanagh AM, Jolley D, Turrell G, Crawford D. Weight and place: a multilevel cross-sectional survey of area-level social disadvantage and overweight/obesity in Australia. Int J Obesity 2006;30:281–87.

24. Taylor A, Dal Grande E, Gill T, et al. How valid are self-reported height and weight? A comparison between CATI self-reported and clinic measurements using a large representative cohort study Aust NZ J Pub Health 2006;30:238–46.

25. Grant JF, Chittleborough CR, Taylor AW, et al. The North West Adelaide Health Study: detailed methods and baseline segmentation of a cohort for selected chronic diseases. Epidemiol Perspect Innov 2006;3:4.

26. Australian Bureau of Statistics. National Health Survey: Users guide, Chapter 5 – Health Risk Factors. May 2003, Canberra, Australia. Cat no 4363.0.55.001. (Accessed: Dec 2005 at http://www.absat.sa.gov.au/abs/abs%40.nsf/66f306f503e529a5ca25697e0017661f/e29a33cd6710490bca256d32001cca1b?OpenDocument.

27. Armstrong T, Bauman A, and Davies J Physical activity patterns of Australian adults. Results of the 1999 National Physical Activity Survey. 2000, AIHW: Canberra.

28. National Heart Foundation of Australia. Risk Factor Prevalence Study. 1990. Canberra, Australian Institute of Health. 1989. (Survey Number 3).

29. Adams RJ, Appleton S, Wilson D, et al. Population comparison of two clinical approaches to the metabolic syndrome: Implications of the new International Diabetes Federation Consensus Definition. Diabetes Care 2005;28:2777–9.

30. Wilson PWF, D'Agostino RB, Levy D, Belanger AM, Silbershatz H, Kannel WB. Prediction of coronary heart disease using risk factor categories. Circulation 1998;97:1837–47.

31. McCallum J. The SF-36 in an Australian sample: validation. Aust J Public Health 1995; 19:166.

32. Australian Bureau of Statistics. Estimated residential population by age and sex. Canberra: Australian Bureau of Statistics; 1999.

33. Taft, C, Karlsson J, Sullivan M. Do SF-36 summary component scores accurately summarize subscale scores? Qual Life Res 2001;10:395–404.

34. Wilson D, Parsons J, Tucker G. The SF-36 Summary Scales: Problems and Solutions. Soc Prevent Med 2000;45: 239–46.

35. Goldstein H, Rasbash J. Improved approximations for multilevel models with binary responses. J R Statist Soc A 1996;159:505–13.

36. Cubbin C, Winkleby MA. Protective and harmful effects of neighbourhood-level deprivation on individual-level health knowledge, behaviour changes, and risk of coronary heart disease. Am J Epidemiol 2005;162:559–68.

37. Turrell G, Kavanagh AM. 2006. Socio-economic pathways to diet: modelling the association between socio-economic position and food purchasing behaviour. Pub Health Nutr 2006;9:375–83.

38. Kavanagh AM, Goller JL, King T, Jolley D, Crawford D, Turrell G. Urban area disadvantage and physical activity: a multilevel study in Melbourne, Australia. J Epidemiol Community Health 2005;59:934–40.

39. Andrews JA, Tildesley E, Hops H, Li F. The influence of peers on young adult substance use. Health Psychol 2002;21:349–57.

40. Montgomery GH, Erblich J, DiLorenzo R, Bovbjerg DH. Family and friends with disease: their impact on perceived risk. Prev Med 2003;37:242–49.

41. Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. N Eng J Med 2007;357:370–79

42. Wing RR, Jeffery RW. Benefits of recruiting participants with friends and increasing social support for weight loss and maintenance. J Consult Clin Psychol 1999;67:132–38.

43. Malchodi CS, Oncken C, Dornelas EA, Caramanica L, Gregonis E, Curry SL. The effects of peer counseling on smoking cessation and reduction. Obstet Gynecol 2003;101:504–10.

44. Propper C, Jones K, Bolster A, Burgess S, Johnston R, Sarker R. Local neighbourhood and mental health: evidence from the UK. Bristol, 2004. (CMPO Working Paper Series No. 04/099).

45. Cummins S, Stafford M, Macintyre S, Marmot M, Ellaway A. Neighbourhood environment and its association with self-rated health: evidence from Scotland and England. J Epidemiol Community Health 2005;59:207–13.

46. Macintyre S, Ellaway A, Cummins S. Place effects on health: how can we conceptualise, operationalise and measure them? Soc Sci Med 2002;55:125–39.

47. Okura Y, Urban LH, Mahoney DW, Jacobsen SJ, Rodeheffer RJ. Agreement between self-report questionnaires and medical record data was substantial for diabetes, hypertension, myocardial infarction and stroke but not for heart failure. J Clin Epidemiol. 2004;57:1096–1103.

48. Taylor AW, Dal Grande E, Gill TK, et al. Do people with risky behaviours participate in biomedical cohort studies BMC Public Health 2006;6:11.

Address for correspondence

Prof. Robert Adams
Discipline of Medicine
University of Adelaide,
The Queen Elizabeth Hospital Campus
Woodville, SA, 5011
Australia
Tel: +618 82227638
Fax: +618 82226042
E-mail: robert.adams@adelaide.edu.au