

RESEARCH REPORT

Neighbourhood characteristics, individual level socioeconomic factors, and depressive symptoms in young adults: the CARDIA study

Claire Henderson, Ana V Diez Roux, David R Jacobs Jr, Catarina I Kiefe, Delia West, David R Williams

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Study objective: To investigate the relation between neighbourhood socioeconomic and ethnic characteristics with depressive symptoms in a population based sample.

Design: Cross sectional data from the CARDIA study, including the Center for Epidemiological Studies depression scale score (CES-D). Neighbourhoods were 1990 US census blocks of 1000 people; six census variables reflecting wealth/income, education, and occupation investigated separately and as a summary score; neighbourhood racial composition (percentage white and black) and individual level income and education were also examined.

Setting: Participants recruited in 1985/86 from community lists in Birmingham, AL; Chicago, IL; Minneapolis MN; from a health plan in Oakland, CA.

Participants: 3437 adults aged 28–40 years in 1995/96: 24% white men, 27% white women, 20% black men, 29% black women.

Main results: For each race-sex group, CES-D was inversely related to neighbourhood score and individual income and education. Associations of neighbourhood score with CES-D became weak and inconsistent after adjusting for individual level factors; personal income remained strongly and inversely associated with CES-D. Age adjusted mean differences (standard errors) in CES-D between the lowest and highest income categories were 3.41 (0.62) for white men, 4.57 (0.64) for white women, 5.80 (0.87) for black men, and 5.74 (0.83) for black women. For both black and white participants, CES-D was associated negatively with percentage of white people and positively with percentage of black people in their census block, before, but not after, adjustment for individual and neighbourhood socioeconomic variables.

Conclusions: Neither neighbourhood socioeconomic characteristics nor ethnic density were consistently related to depressive symptoms once individual socioeconomic characteristics were taken into account.

See end of article for authors' affiliations

Correspondence to:
Dr C Henderson, Public Psychiatry Fellowship, room 317, 722 W 168th Street, New York, NY 10032, USA; hendersc@nypdrat.cpmc.columbia.edu

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There has been a resurgence of research into the health effects of residential environments.^{1,2} Broadly, the hypothesis is that contextual features of residential environments may be related to health outcomes even after individual factors are taken into account. These contextual level effects may be modified by individual level factors.

Studies of area effects on mental health have used regions with populations of several million (for example, Weich *et al*³ and Sturm and Gresenz⁴ to neighbourhoods of a few thousand^{5–7} and produced conflicting findings. The effects of community socioeconomic status tend to disappear after adjustment for other community level and individual level factors in some^{8–11} but not all studies.¹²

Area ethnic composition has also been studied in relation to mental health. The ethnic density hypothesis states that for persons of a given ethnicity, rates of mental disorder decrease as the percentage of persons of the same ethnicity living in the community increases.¹³ Protective effects have also been found for occupational^{14,15} and religious density.^{16,17} The effect is proposed to be mediated through increased levels of social support and reduced levels of stress, and has been shown for psychiatric hospitalisation rates,^{18–22} treated rates of psychoses,²³ suicide,⁶ non-fatal self harm,²⁴ and common mental disorder (anxiety and depression).²⁵ Apart from this last study, these studies did not control for individual level socioeconomic factors.

Using data from the coronary artery risk development in young adults (CARDIA) study, we investigated the relation between neighbourhood characteristics and depressive symptoms in a population based sample of young adults. We studied the effects of area socioeconomic characteristics and proportion of black and white people, taking into account individual level factors. We also examined whether these neighbourhood characteristics modify the relation between individual level socioeconomic indicators and depressive symptoms.

METHODS

CARDIA is a cohort study of cardiovascular risk factors in young adults. The sample consists of 5115 adults aged 18–30 years in 1985–86, recruited primarily through telephone contact from community lists in Birmingham, AL; Chicago, IL; and Minneapolis MN; and from membership in a prepaid health plan in Oakland, CA.²⁶ IRB approval for the CARDIA study was obtained at each site. The goal of recruitment was to obtain at each site nearly equal numbers of black and white people, women and men, persons <25 and ≥25 years of age, and persons with high school education or less and more than high school education. Cohort retention at year 10 was 79% of survivors. Year 10 data (1995–1996) were used for

Abbreviations: CARDIA, coronary artery risk development in young adults study; CES-D, Center for Epidemiological Studies depression scale

Table 1 Socioeconomic factors, block group characteristics, and CES-D score by gender and race: the CARDIA study, 1995/96

	White men (n=830)	White women (n=931)	Black men (n=692)	Black women (n=984)
Mean age (SD)	35.5 (3.4)	35.6 (3.4)	34.3 (3.8)	34.4 (3.9)
Income (% distribution)				
<\$16000	7.5	7.5	22.0	28.8
\$16000–\$34999	19.4	21.6	35.0	29.3
\$35000–\$49999	21.2	18.9	17.8	19.2
\$50000–\$74999	23.3	24.6	16.0	15.9
≥\$75000	28.7	27.4	9.2	6.9
Education (% distribution)				
High school diploma or less	21.7	17.2	45.8	36.8
1–3 years college	21.4	20.9	31.6	37.7
4 years college	27.1	31.4	14.6	17.2
Some graduate or professional school	29.8	30.5	7.9	8.3
Block group characteristics median (25th–75th centile)				
Median household income (\$1000s)	37.7 (28.0–51.1)	39.3 (29.6–51.7)	25.5 (18.6–35.1)	25.9 (18.9–34.9)
Median house value (\$1000s)	112.5 (71.3–212.5)	115.4 (77.5–213.5)	67.6 (51.8–125.9)	71.5 (51.4–126.5)
Percentage earning interest income	53 (41–63)	52 (41–63)	28 (15–42)	27 (15–41)
Percentage complete high school	90 (81–95)	90 (82–95)	76 (64–87)	74 (63–85)
Percentage complete college	34 (19–50)	34 (19–51)	16 (8.1–27)	14 (7.5–25)
Percentage executive, managerial occupation	36 (25–48)	36 (25–48)	22 (14–31)	21 (14–31)
Neighbourhood score	4.7 (1.3–8.2)	5.0 (1.7–8.3)	–0.60 (–3.7–2.7)	–0.74 (–3.7–2.3)
Percentage black	2.2 (0.57–6.6)	2.1 (0.74–6.8)	42 (11–81)	48 (12–86)
Percentage white	93 (83–97)	92 (80–96)	42 (11–78)	35 (8–76)
Mean neighbourhood score (SD)	4.8 (4.7)	4.9 (4.5)	–0.3 (4.4)	–0.4 (4.4)
CES-D score mean (SD)	8.9 (6.7)	9.6 (7.5)	11.3 (8.0)	12.9 (9.5)
Percentage 16 or more	13.9	17.7	23.7	31.8

these analyses because earlier addresses were not available for geocoding. Participants were then aged 28–40 years and likely to have completed their education; 68% of participants remained at their original site, with the remaining 32% were dispersed over 45 US states.

Depressive symptoms were assessed using the Center for Epidemiological Studies depression scale (CES-D), an extensively used instrument with well studied psychometric properties²⁷; a higher score indicates more depressive

symptoms, with 16 usually used as cut off point. Item frequency was ascertained over the week preceding the CARDIA year 10 examination.

Key independent variables included individual level socioeconomic indicators and neighbourhood characteristics. Participants were asked to select their total combined family income from a list of categories, and to report the highest grade or year of school completed. We categorised income into five groups (under \$16 000; 16 000–34 999;

Table 2 Age adjusted mean differences in CES-D scores by individual level socioeconomic indicators and neighbourhood summary socioeconomic score

	White men	White women	Black men	Black women
Individual level income†				
<16000			5.80 (0.87)	5.74 (0.83)
16000–34999	3.41 (0.62)	4.57 (0.64)	2.90 (0.78)	3.27 (0.83)
35000–49999	1.80 (0.66)	1.67 (0.71)	1.31 (0.92)	2.17 (0.92)
50000–74999	1.28 (0.64)	1.52 (0.66)	Reference	reference
75000+	Reference	Reference		
p trend across categories*	0.0001	0.0001	0.0001	0.0001
Mean difference per unit increase in income category‡	–1.08 (0.20)	–1.45 (0.20)	–1.86 (0.27)	–1.84 (0.26)
Individual level education				
High school diploma or less	1.59 (0.65)	3.45 (0.73)	4.32 (1.15)	5.48 (1.14)
1–3 years college	0.81 (0.66)	1.26 (0.70)	1.81 (1.19)	2.32 (1.14)
4 years college	–0.16 (0.61)	0.56 (0.62)	–0.24 (1.32)	1.20 (1.25)
Some graduate school	Reference	Reference	Reference	Reference
p trend across categories*	0.0074	0.0001	0.0001	0.0001
Mean difference per unit increase in education category‡	–0.56 (0.21)	–1.05 (0.23)	–1.82 (0.32)	–1.97 (0.32)
Race specific quartiles of neighbourhood score				
Q1: Lowest	1.99 (0.65)	2.88 (0.70)	2.80 (0.85)	2.23 (0.86)
Q2	0.68 (0.66)	1.73 (0.69)	2.33 (0.85)	0.98 (0.86)
Q3	0.60 (0.66)	1.25 (0.68)	1.21 (0.85)	0.12 (0.86)
Q4: Highest	Reference	Reference	reference	reference
p trend across quartiles*	0.0034	0.0001	0.0004	0.0053
Mean difference per unit increase in neighbourhood score	–0.16 (0.05)	–0.21 (0.05)	–0.23 (0.07)	–0.18 (0.07)

*p Values for trend obtained by including categories as an ordinal covariate in regression equations. †Because of differences in the distribution of income in white and black people, the two lower categories are combined in white subjects and the two highest categories are combined in black subjects. ‡Corresponds to average change per unit difference in category. Obtained by including income and education categories in regression equations as ordinal covariates.

35 000–49 999; 50 000–74 999, 75 000 or more). Because of small numbers, the two lowest categories were combined in white participants, and the two highest combined in black participants. Education was categorised as high school diploma or less; one to three years of college, four years of college, some graduate or professional school.

Census defined block groups were used as proxies for neighbourhoods. On average, each block group includes about 1000 people. Study participants' home addresses were linked to their block group by a geocoding firm. Six area variables collected by the US Bureau of the Census in 1990 reflecting wealth/income (median household income, median value of housing units, and percentage of households receiving interest, dividend, or net rental income), education (percentage adults with complete high school, percentage adults with complete college), and occupation (percentage of persons in managerial or professional specialty occupations) were investigated. These variables were also combined into a summary score. Because of their skewed distribution, median household income and median value of housing units were log transformed before the construction of the score. For each of the census variables a Z score was estimated by subtracting the mean and dividing by the standard deviation; Z scores were then summed to get a neighbourhood summary score, with increasing neighbourhood score signifying increasing neighbourhood advantage.²⁸ Neighbourhood scores ranged from -11.4 to 17.4. There were important racial differences in neighbourhood characteristics that would result in little overlap if common categories were used, so block groups were categorised into race specific quartiles of participants based on the block group summary score. Neighbourhood racial composition (percentage white and percentage black) was also investigated.

Of the CARDIA participants who attended the year 10 follow up, 89% (3531) were matched to block group data. Of these, 94 participants were excluded because of missing income or education ($n = 43$) or depression score ($n = 51$), leaving 3437 subjects available for analyses. These participants were distributed in 2451 block groups. About 78% of participants were in block groups with only one participant; only 2% were in block groups with five participants or more.

Statistical methods

Because of important differences in CES-D scores by sex and race, all analyses were stratified by these two variables. Age adjusted mean differences in CES-D scores by individual level socioeconomic indicators and race-specific quartiles of neighbourhood score and racial composition were estimated using linear regression. The p values for trend were obtained by including categories as an ordinal covariate in regression equations. Neighbourhood scores and individual level variables were investigated as both categorical and continuous variables. Interactions between neighbourhood scores and individual level variables were investigated using stratified analyses and tested by including appropriate interaction terms. If no interactions were present, multiple regression was used to estimate mean differences by neighbourhood categories before and after adjustment for personal socioeconomic indicators. This was repeated for each neighbourhood score component. For components reflecting neighbourhood income or education level, multiple regression adjusting only for the individual level equivalent along with age was also performed. Similarly, multiple regression was used to estimate mean difference in CES-D score by categories of neighbourhood ethnic composition before and after adjustment for personal and neighbourhood

Table 3 Age adjusted mean differences in CES-D score per unit increase in neighbourhood score stratified by income and education

	White men	White women
	Mean difference per unit increase in neighbourhood score	Mean difference per unit increase in neighbourhood score
Individual level income		
<\$49999	-0.30 (0.33)	-0.07 (0.34)
≥\$50000	-0.28 (0.30)	-0.94 (0.32)
p value for interaction*	0.96	0.06
	Black men	Black women
	Mean difference per unit increase in neighbourhood score	Mean difference per unit increase in neighbourhood score
Individual level income		
<\$34999	-0.04 (0.37)	-0.34 (0.36)
≥\$35000	-1.07 (0.42)	-0.44 (0.43)
p value for interaction*	0.07	0.86
	White men	White women
	Mean difference per unit increase in neighbourhood score	Mean difference per unit increase in neighbourhood score
Individual level education		
Up to 3 years college	-0.60 (0.33)	-1.21 (0.40)
4 years college or more	-0.43 (0.28)	-0.44 (0.29)
p value for interaction*	0.70	0.12
	Black men	Black women
	Mean difference per unit increase in neighbourhood score	Mean difference per unit increase in neighbourhood score
Individual level education		
High school or less	-0.82 (0.40)	-0.72 (0.45)
Any college or more	-0.60 (0.36)	-0.51 (0.33)
p value for interaction*	0.69	0.71

*Corresponds to interaction between income or education (in two categories as shown) and neighbourhood score.

Table 4 Age adjusted mean differences in CES-D scores by individual level socioeconomic indicators and block group characteristics before and after adjustment for each other. White people

	White men			White women		
	Model with age, neighbourhood score+ education	Model with age, neighbourhood score + income	Model with age, neighbourhood score + income + education	Model with age, neighbourhood score+ education	Model with age, neighbourhood score + income	Model with age, neighbourhood score + income + education
Race specific quartiles of neighbourhood score						
Q1: Lowest	1.64 (0.68)	0.65 (0.71)	0.53 (0.73)	2.08 (0.73)	0.97 (0.76)	0.61 (0.78)
Q2	0.48 (0.67)	-0.23 (0.69)	-0.29 (0.70)	1.16 (0.71)	0.74 (0.71)	0.48 (0.72)
Q3	0.41 (0.67)	0.08 (0.67)	0.02 (0.67)	0.94 (0.69)	0.56 (0.69)	0.42 (0.69)
Q4: Highest	Reference	Reference	Reference	reference	reference	reference
p trend across quartiles*	0.02	0.4	0.6	0.006	0.2	0.4
Individual level income†						
<16000						
16000-34999		3.20 (0.68)	3.12 (0.70)	4.16 (0.71)	3.79 (0.73)	
35000-49999		1.69 (0.71)	1.62 (0.72)	1.36 (0.75)	1.12 (0.76)	
50000-74999		1.21 (0.66)	1.21 (0.69)	1.30 (0.69)	1.20 (0.69)	
75000+		Reference	Reference	reference	Reference	
p trend across categories*		0.0001	0.0001	0.0001	0.0001	0.0001
Individual level education						
High school diploma or less	1.12 (0.68)		0.57 (0.69)	2.80 (0.77)		2.00 (0.77)
1-3 years college	0.47 (0.67)		-0.05 (0.68)	0.78 (0.72)		0.36 (0.71)
4 years college	-0.37 (0.62)		-0.62 (0.62)	0.42 (0.62)		0.34 (0.61)
Some graduate school	Reference		Reference	reference		Reference
p trend across categories*	0.06		0.3	0.0007		0.02

*p Values for trend obtained by including categories as an ordinal covariate in regression equations. †Because of differences in the distribution of income in white and black people, the two lower categories are combined in white subjects and the two highest categories are combined in black subjects.

socioeconomic characteristics. As the distributions of CES-D scores were slightly positively skewed, the analyses were repeated after a log transformation. Because nearly 80% of participants were in block groups with only one subject and only 2% were in block groups with five subjects or more, no special methods were necessary to account for the clustering.

We used the continuous form of the CES-D score as a measure of depressive symptoms, rather than the cut off point of 16 used to screen for major depressive disorder, because of the better sensitivity of continuous data.²⁵ However, we reran final adjusted models for neighbourhood

socioeconomic score and ethnic composition using a CES-D score dichotomised at 16 and found qualitatively similar results (data not shown).

RESULTS

The study population was 56% female, with similar numbers of white and black women but rather more white compared with black men (table 1). Mean ages for the four groups ranged from 34.3 (black men) to 35.6 (white women). Black men and women earned substantially less than their white counterparts, ($p < 0.001$ for both genders) and had received

Table 5 Age adjusted mean differences in CES-D scores by individual level socioeconomic indicators and neighbourhood characteristics before and after adjustment for each other. Black people

	Black men			Black women		
	Model with age, neighbourhood score+ education	Model with age, neighbourhood score + income	Model with age, neighbourhood score + income + education	Model with age, neighbourhood score+ education	Model with age, neighbourhood score + income	Model with age, neighbourhood score + income + education
Race specific quartiles of neighbourhood score						
Q1: Lowest	1.89 (0.85)	1.12 (0.89)	0.92 (0.88)	1.37 (0.87)	0.50 (0.89)	0.28 (0.89)
Q2	1.59 (0.84)	0.87 (0.87)	0.72 (0.86)	0.29 (0.86)	-0.40 (0.87)	-0.57 (0.87)
Q3	0.98 (0.84)	0.55 (0.84)	0.55 (0.84)	-0.34 (0.85)	-0.64 (0.86)	-0.81 (0.86)
Q4: Highest	Reference	Reference	Reference	reference	reference	reference
p trend across quartiles*	0.02	0.2	0.3	0.08	0.5	0.6
Individual level income†						
<16000						
16000-34999		5.38 (0.93)	4.18 (1.00)	5.62 (0.88)	4.35 (0.93)	
35000-49999		2.56 (0.82)	1.90 (0.85)	3.18 (0.86)	2.67 (0.87)	
50000-74999		1.14 (0.93)	0.92 (0.93)	2.15 (0.94)	1.92 (0.93)	
75000+		Reference	Reference	reference	Reference	
p trend across categories*		0.0001	0.0001	0.0001	0.0001	0.0001
Individual level education						
High school diploma or less	3.79 (1.17)		2.25 (1.22)	5.19 (1.17)		3.63 (1.20)
1-3 years college	1.45 (1.20)		0.81 (1.20)	2.06 (1.16)		1.20 (1.17)
4 years college	-0.41 (1.32)		-0.76 (1.31)	1.11 (1.26)		0.74 (1.26)
Some graduate school	Reference		Reference	reference		Reference
p trend across categories*	0.0001		0.002	0.0001		0.0001

*p Values for trend obtained by including categories as an ordinal covariate in regression equations. †Because of differences in the distribution of income in white people and black people, the two lower categories are combined in white subjects and the two highest categories are combined in black subjects.

less education ($p < 0.001$ for both). Mean block group scores were similar for men and women of each ethnic group but were higher for white people compared with black people ($p < 0.0001$ for both) signifying that white people tended to live in significantly better off neighbourhoods. White men and women lived in predominantly white neighbourhoods (medians 93% and 92% respectively, with interquartile ranges 80%–97%), while for the black population the percentage of black people in the neighbourhood was much more variable (median of 42% for men and 48% for women, with interquartile ranges 11%–86%). CES-D scores were significantly higher in black people than in white people among both men and women (both $p < 0.0001$). CES-D scores were higher in women than in men for black people ($p = 0.0002$), but this was less clear for their white counterparts ($p = 0.05$). As previously reported,²⁸ both income and education are correlated with neighbourhood score for black and white people. In these analyses, Spearman correlation coefficients between the income and education categories and the neighbourhood score ranged from 0.22 to 0.45, low enough to estimate their independent effects.

While there were significant trends in mean CES-D scores across categories of individual income, education, and neighbourhood score (table 2), differences in score between the top and bottom categories were usually greater for the income and education categories than for the neighbourhood score categories. To further investigate whether associations of neighbourhood score with depressive symptoms were similar across categories of individual level income and education we estimated mean differences in CES-D per unit increase in neighbourhood score by categories of individual level income and education (table 3). We stratified using approximate median splits for each individual level variable. Although the interactions were marginally significant for black men and white women, there was no clear evidence for an interaction on an additive scale between the effect of neighbourhood on CES-D score and either individual income or education.

In tables 4 and 5, each column gives adjusted mean differences in CES-D scores corresponding to a separate model including age and the neighbourhood and personal socioeconomic variables for which estimates are shown. Results were similar after log transformation of CESD score (data not shown). The effect of neighbourhood seems either

weak, when adjustment for education is made, or non-existent, once adjustment for individual income is made. However, the effects of education (except for white men) and individual income persist after adjustment for each other and for neighbourhood score. The largest differences in mean CES-D score between the top and bottom categories are observed for income. Similar results to those for neighbourhood score were obtained when its components were investigated separately and adjusted for the corresponding individual level indicator (data not shown).

In both ethnic groups, after adjustment for age, CES-D scores decrease with decreasing percentage black in the block group and increase with decreasing percentage white (table 6). These differences are reduced after adjustment for individual level income and education and disappear after additional adjustment for neighbourhood score, with the exception of white women and possibly white men, among whom the inverse association with percentage white people persists after adjustment. For black men, the direction of the association seems to be reversed after adjustment, but this inverse association was not statistically significant. When adjusting only for age and neighbourhood score (results not shown), differences persist for percentage white for white men and women, and percentage black for white and black men. For white people, the analysis was repeated using two categories because of the small ranges involved (results not shown). For percentage black, the highest quartile was compared with the three lower ones; for percentage white, the lowest quartile was compared with the rest. Again, only the inverse relation with percentage white for women persists after adjustment (an increase in CES-D score of 1.27 (95% CI 0.19 to 2.34) for the lowest quartile of percentage white compared with the rest.) When we reran our final adjusted models using a CES-D score dichotomised at 16, we found qualitatively similar results (data not shown).

DISCUSSION

Among all four race sex groups, but most noticeably for black men and women, CES-D score was inversely related to individual income, education (all assessed in 1995–96), and neighbourhood score (assessed using address in 1995–96 and census data in 1990). In addition, CES-D score was negatively associated with percentage white block group composition and positively with percentage black composition. However,

Table 6 Adjusted mean differences in CES-D scores by block group racial composition before and after adjustment for individual level income, education, and neighbourhood score

	White men		White women		Black men		Black women	
	Adjusted for age	Age + income, education, and neighbourhood score	Adjusted for age	Age + income, education, and neighbourhood score	Adjusted for age	Age + income, education, and neighbourhood score	Adjusted for age	Age + income, education, and neighbourhood score
Race specific quartiles of percentage black								
Q1: Lowest	-1.22 (0.64)	-0.61 (0.65)	-1.04 (0.71)	-0.24 (0.70)	-1.62 (0.87)	0.52 (1.09)	-1.50 (0.85)	-0.09 (1.08)
Q2	-1.41 (0.68)	-0.61 (0.69)	-1.43 (0.67)	-0.64 (0.68)	-0.87 (0.88)	0.40 (0.99)	-0.05 (0.85)	0.82 (0.98)
Q3	-0.02 (0.65)	0.64 (0.66)	-0.30 (0.70)	0.06 (0.70)	-0.73 (0.88)	0.15 (0.91)	-0.51 (0.84)	0.59 (0.91)
Q4: Highest	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
p trend across quartiles*	0.01	0.12	0.05	0.5	0.07	0.6	0.1	0.9
Race specific quartiles of percentage white								
Q1: Lowest	1.80 (0.66)	1.27 (0.66)	2.29 (0.69)	1.66 (0.68)	1.69 (0.87)	-0.25 (1.11)	1.93 (0.85)	1.14 (1.06)
Q2	0.76 (0.65)	0.81 (0.65)	0.86 (0.69)	0.68 (0.68)	0.96 (0.86)	-0.19 (0.94)	0.33 (0.86)	0.45 (0.90)
Q3	0.41 (0.63)	0.47 (0.63)	0.72 (0.71)	0.49 (0.70)	0.82 (0.84)	0.19 (0.84)	1.28 (0.87)	1.08 (0.86)
Q4: Highest	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
p trend across quartiles†	0.006	0.05	0.001	0.02	0.06	0.8	0.07	0.4

*Median values for quartiles of percentage black are 0.2, 1.4, 3.6, and 18.2 for white people and 4.2, 23.4, 70.0, and 97.7 in black people. †Median values for quartiles of percentage white are 65.9, 88.6, 94.9, and 98.1 for white people and 1.8, 21.3, 58.4, and 83.0 in black people.

Key points

- Area ethnic composition has been found to be related to mental health, such that, for persons of a given ethnicity, rates of mental disorder decrease as the percentage of persons of the same ethnicity living in the community increases.
- The results of studies on neighbourhood socioeconomic status and mental health have been more conflicting.
- Neither neighbourhood socioeconomic characteristics nor ethnic density were consistently related to depressive symptom score once individual income and education were taken into account.

associations of neighbourhood score with depressive symptoms were weak and inconsistent after adjustment for individual level socioeconomic indicators. Associations of racial composition with CES-D largely disappeared after controlling for individual and neighbourhood socioeconomic variables. There was no evidence of interaction between neighbourhood and personal socioeconomic indicators.

Our findings with respect to neighbourhood socioeconomic context are consistent with two other recent studies. Reijneveld and Schene¹⁰ found a significant association of neighbourhood socioeconomic status with mental disorder, as measured by increased general health questionnaire score, when controlling for education or occupation, but this disappeared after adjustment for individual level income. Yen and Kaplan⁹ found that residence in a poverty area was related to higher incidence of depressive symptoms but this effect disappeared after controlling for individual level confounders including income and education. These findings regarding depressive symptoms stand in contrast with the relations found between area socioeconomic status and both coronary heart disease and its risk factors.^{30–38}

Our results do not confirm a possible causal link between neighbourhood ethnic density and depressive symptoms in American white or black young adults. Percentage black was positively related with CES-D scores and percentage white was inversely related to CES-D scores in both white and black participants, but these associations disappeared after adjustment. These patterns suggest that the observed associations are attributable to confounding by neighbourhood and individual level socioeconomic indicators. However, if as Halpern¹³ suggests, the effects of ethnic density on mental illness only become apparent when group density falls below a critical mass (perhaps 40%), the distribution of ethnic density seen in our data may not have allowed us to detect true ethnic density effects in white people, who showed high residential segregation. In black people, median ethnic density for the lowest and highest quartiles of percentage black in neighbourhoods were 4% and 98%, suggesting that the range was appropriate to detect a contextual effect.

An important limitation of our study (and of others focusing on neighbourhood deprivation) is that aggregate

Policy implications

- Both national and local interventions to reduce the prevalence of depressive symptoms should focus on people with low personal education and income.
- Further study of the effects neighbourhood level factors on depression is needed.

census block socioeconomic characteristics may be a poor proxy for the specific features of residential environments that are relevant to mental health. Physical and social characteristics, both objective and perceived, have been hypothesised to be relevant to the mental health of residents,^{39–41} but census block characteristics may not adequately capture these. The size of the geographical area potentially relevant to mental health outcomes remains unresolved. Future work with specific hypotheses regarding the processes involved may need to investigate areas of varying sizes.

Our analyses were limited to persons still participating in the CARDIA study at year 10. Potential retention bias cannot be directly tested with available data. Although year 10 follow up rates were slightly lower for black participants and for persons of low education, differences were small. While year 10 participants are likely to be healthier, this would only bias our estimates if retained persons are selected on the basis of both health status and neighbourhood characteristics. With respect to external validity, the CARDIA sample generalises only roughly to a broader population of 28–40 year olds because of the aim to recruit approximately equal numbers by age, sex, and race and the restriction to four urban areas. While it would have been interesting to test for interactions between neighbourhood and individual characteristics and original recruitment site, such interactions were not tested because many participants had moved by year 10.

Our study linked individual data collected in 1995–1996 to census data collected in 1990. Unfortunately census data for 1995 were not available. We believe the 1990 data are a reasonable approximation to the census tracts in which participants resided in 1995–1996. Because study participants were not clustered in neighbourhoods (there was usually only one participant per census tract) we were not able to apply multilevel modelling techniques to estimate the percentage of variance in CES-D that is between and within neighbourhoods. However, the limitations of using this type of variance decomposition exercise to draw inferences regarding causal neighbourhood effects have been repeatedly noted.^{42–44} In addition, as discussed by Snijders and Bosker,⁴⁵ the power to detect the fixed effects of group level variables (which was our main interest in this paper) is actually maximised by sampling many groups with few people. Lastly, the correlations between neighbourhood score and individual income and education is only in the range of 0.2–0.4. Therefore we do not believe the sample design of our study is likely to have seriously hindered our ability to detect neighbourhood effects, although their precision would have been increased by a larger number of people per block through the reduced effect of confounding between area and individual characteristics. On the other hand, the misspecification of neighbourhoods and the absence of direct measures of the neighbourhood level variables of interest is undoubtedly an important limitation, and could explain our negative results.

In addition, further study of the effect of neighbourhood level factors would benefit from data on address changes to account for length of residence in a given neighbourhood. These types of analyses require residential mobility data for CARDIA, which are not available at this time. More longitudinal designs on the effect of changes to neighbourhoods are also desirable, such as the work of Dalgard and Tams,⁴⁶ which showed a relation between improvements in the environment of one area and in the mental health of its residents.

As previously reported,²⁸ the range of neighbourhood characteristics (in both socioeconomic status and ethnic composition) differed substantially between white and black

participants, making direct comparisons difficult and resulting in the need to use race specific categories. Thus any race differences in the associations need to be interpreted bearing in mind that what is being compared is the effect of area level deprivation and racial composition on depressive symptoms relative to members of the same ethnic group.

In summary, in this bi-ethnic sample of urban US adults, we found small and often inconsistent cross sectional associations of neighbourhood socioeconomic characteristics with depressive symptoms once personal socioeconomic factors were taken into account. Personal income, however, was strongly and inversely associated with CES-D score in all race and gender groups, most strongly in black people, and there was no evidence that neighbourhood context modified these associations. Neighbourhood ethnic density was not consistently related to depressive symptom score once socioeconomic factors were taken into account. Further elucidation of the relation between residential environments and depressive symptoms will require longitudinal analyses of the development of depressive symptoms that focus on the investigation of specific neighbourhood attributes.

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Authors' affiliations

C Henderson, Health Services Research Department, Institute of Psychiatry, London, UK

A V Diez Roux, University of Michigan Center for Social Epidemiology and Population Health, USA

D R Jacobs Jr, Division of Epidemiology, School of Public Health, University of Minnesota, USA and Department of Nutrition, University of Oslo, Oslo, Norway

C I Kiefe, Division of Preventive Medicine, University of Alabama at Birmingham, and Birmingham Veterans Affairs Medical Center, USA

D West, University of Arkansas Medical Sciences, USA

D R Williams, University of Michigan Institute for Social Research, USA

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