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Neighborhood violent crime and unemployment increase the risk of coronary heart disease: A multilevel study in an urban setting ☆

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Abstract

Little is known about the association between neighborhood social disorganization and coronary heart disease (CHD). This study used the theoretical frameworks of the Chicago school and the Stirling County group in order to analyze the impact of neighborhood violent crime and neighborhood unemployment on CHD in an urban setting, the capital of Sweden. The entire population of Stockholm County aged 35–64 years on January 1, 1998 was included in the study. All individuals were followed for CHD until December 31, 1998. Small area neighborhood units were used to define neighborhoods. The neighborhood-level variables were calculated as rates of violent crime or unemployment in the small area neighborhood units, categorized in quintiles. Multilevel logistic regression was used to estimate odds ratios and neighborhood-level variance in three different models. When rates of neighborhood violent crime or neighborhood unemployment increased, the risk of CHD increased among both women and men. In neighborhoods with the highest rates of violent crime (quintile 5), the odds ratios were 1.75 (CI = 1.37–2.22) and 1.39 (CI = 1.19–1.63) for women and men, respectively. In neighborhoods with the highest unemployment rates, the corresponding odds ratios were 2.05 (CI = 1.62–2.59) and 1.50 (CI = 1.28–1.75). These average neighborhood effects on CHD (fixed effects) remained almost unaltered after inclusion of the individual-level variables. The neighborhood-level variance indicated significant differences in CHD between neighborhoods, and the neighborhood-level and individual-level variables partly explained the variance between neighborhoods (random effects). Public safety and social stability in socially disorganized neighborhoods need to be improved in order to promote cardiovascular health.

Keywords: Coronary heart disease; Chicago school; Neighborhood violent crime; Neighborhood unemployment; Multilevel models; Sweden

Introduction

Recent research has established an association between neighborhood social deprivation and coronary heart disease (CHD), one of the leading causes of death in industrialized countries (Diez Roux et al., 2001; Sundquist, Malmstrom, &

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Johansson, 1999; Sundquist, Winkleby, Ahlen, & Johansson, 2004). In addition, the association between neighborhood social deprivation and crime is consistent in previous research (Kawachi, Kennedy, & Wilkinson, 1999; Kennedy, Kawachi, Prothrow-Stith, Lochner, & Gupta, 1998). During most of the last century socially deprived neighborhoods in US cities have been associated with criminal violence and residential instability (Sampson, Raudenbush, & Earls, 1997). Possible pathways between neighborhood social deprivation and CHD could therefore be neighborhood social disorganization and disintegration. During the 1940s the urban settings in Chicago influenced Shaw and McKay (1942) to create their theories of neighborhood social disorganization with a special focus on neighborhood crime. They found that Chicago neighborhoods characterized by poverty, residential instability, and dilapidated housing had increased rates of crime, delinquency, and adverse health outcomes such as infant mortality and low birth weight (Sampson, 2003a). The Chicago school sociologists concluded that neighborhoods possess features that persist over time. More than half a century after Shaw and McKay created their neighborhood social theories Sampson et al. revealed that census tracts in Chicago with high homicide rates also had high rates of infant mortality, low birth weight, accidental injuries, and suicide (Sampson et al., 1997). In eastern Canada the Stirling County group developed their theories of social disintegration. Their work shares many of the concepts described in the Chicago school and includes crime, residential mobility, and unemployment (Leighton, Hardings, Maclin, Macmillan, & Leighton, 1963). To our knowledge, no previous study has analyzed the association between neighborhood social disorganization and disintegration, measured as violent crime and unemployment rates, and CHD.

Our study was partly based on the theoretical frameworks from the Chicago school and the Stirling County group in order to analyze the impact of neighborhood violent crime and neighborhood unemployment on CHD in an urban setting, i.e. a total of 700,000 men and women in the capital of Sweden. The definition of violent crime included all types of criminal violence against persons, such as homicide, aggravated assault, robbery, and rape. We calculated violent crime and unemployment rates in small area neighborhood units and applied multilevel analytic technique, which has proven to be the most appropriate way to analyze neighborhood effects on different health outcomes (Subramanian, Jones, & Duncan, 2003).

During the last decade, multilevel analyses have made it possible to separate the individual effect from the neighborhood effect on health. Thus, individuals (level 1) nested within neighborhoods (level 2) can be analyzed with respect to the average disease risk (fixed effects) and the variance around the average disease risk (random effects) at multiple levels (Snijders & Bosker, 1999). The first aim of this study was to analyze the association between neighborhood violent crime and neighborhood unemployment and CHD. The second aim was to analyze whether the hypothesized association between neighborhood violent crime and neighborhood unemployment and CHD remains after accounting for the following individual-level demographic and socioeconomic factors: age, income, employment status, and marital status. Furthermore, we analyzed whether the hypothesized neighborhood variation in CHD could be explained by the neighborhood-level and individual-level factors.

Methods

This cumulative incidence study included the entire population of Stockholm County aged 35–64 years on January 1, 1998. Individuals whose addresses were not able to be geocoded to a neighborhood area (2.6% of the sample) were excluded. Nine-hundred and twenty eight individuals were excluded from the study because they lived in neighborhood areas with less than 50 individuals. In the final sample 336,295 men and 334,057 women were followed to first hospitalization due to fatal or nonfatal CHD, death from all causes, or end of study on December 31, 1998. Individual data were obtained from a research database at the Karolinska Institute in Stockholm, containing highly complete demographic and socioeconomic information on the entire adult population in Sweden. The linkage of data from several national population registers constructed the research database. In order to identify CHD events, these data were linked to the National Hospital Discharge Register and the Cause of Death Register. The Swedish registration system provides a personal identification number for each

individual, which was used to follow each individual during the entire study period.

Neighborhoods were defined on the basis of small area market statistics provided by Statistics Sweden, the Swedish government-owned statistics bureau. Small area market statistics (SAMS) constitute small geographic areas with boundaries defined by homogeneous types of buildings and are therefore relatively homogeneous regarding socioeconomic structure. Stockholm County is divided into 1051 SAMS neighborhoods. The average population in each SAMS neighborhood is approximately 2000 people for Stockholm County. The home addresses of the individuals had been previously geocoded, allowing us to identify the SAMS neighborhood in which the individuals lived. The Swedish government-owned land-surveying bureau provided the geocoding for all individuals.

Outcome variable

Coronary heart disease (CHD): First hospitalization for fatal or nonfatal CHD event, classified according to the International Classification of Diseases, ICD 9 (410–414) and ICD 10 (I20–I25).

Neighborhood-level variables

Neighborhood violent crime: Unidentified violent crime data for the year 1998 were provided by the police authorities in Stockholm County for each SAMS neighborhood. The definition of violent crime included all types of criminal violence against persons, such as homicide, aggravated assault, robbery, and rape. The number of violent crimes was divided by the number of inhabitants in each SAMS neighborhood. The distribution was then divided into quintiles. Quintile 1 represented neighborhoods with the lowest proportion of violent crime and quintile 5 represented neighborhoods with the highest proportion of violent crime.

Neighborhood unemployment: The neighborhood unemployment variable was categorized into quintiles, based on the proportions of unemployed individuals for each SAMS neighborhood. This variable was based on data obtained from national registers. Employment status for the entire Swedish population is measured each year during 1 week in November. Individuals who are paid for at least 1 h during the measurement week and whose employer reported this payment to the tax authorities are counted as employed. Self-employed people are also counted as employed. The reason for using categories instead of using the neighborhood variables continuously is that neighborhood effects are thought to be nonlinear (Granovetter, 1978).

Individual-level variables

Age: Was categorized as follows: 35–39, 40–44, 45–49, 50–54, 55–59, and 60–64 years.

Gender: Women and men were analyzed separately.

Income: Was based on the annual family income divided by the number of people in the family, i.e. individual family income per capita. This variable was provided by Statistics Sweden (the Swedish Government-owned statistics bureau). The income parameter also took into consideration the ages of people in the family and used a weighted system whereby small children were given lower weights than adolescents and adults. The calculation procedure was performed as follows: The sum of all family members' incomes was multiplied by the individual's consumption weight divided by the family members' total consumption weight. Income was categorized into four groups according to income level.

Employment status: Was dichotomized as (1) employed and (2) unemployed.

Marital status: Was categorized as (1) married and (2) single.

Statistical analysis

The logistic model used to estimate the proportion of CHD was given by

$$\pi_{ij} = \exp(f_{ij} + u_j)/(1 + \exp(f_{ij} + u_j)),$$

where π_{ij} denotes the logistic function, f_{ij} the fixed effect of the model and u_j the neighborhood random effect from a normal distribution with zero mean. The distribution error of the incidence was assumed to be binomial. We performed three separate models for women and men with individuals at the first level and neighborhoods at the second level. Model 1 represented the empty or unconditional model, model 2 included the neighborhood-level variables violent crime or unemployment and model 3 included the neighborhood-level variable and the individual-level variables age, income, employment status, and marital status.

Fixed effects

As a good approximation of hazard ratios, we used multilevel logistic regression (Larsen, Petersen, Budtz-Jorgensen, & Endahl, 2000; Snijders & Bosker, 1999) to estimate odds ratios (OR) with 95% confidence interval. Because of the large number of individuals it was not possible to use a multilevel Cox proportional hazards model in the computing process. However, logistic regression is a good approximation of Cox's proportional hazards model when the sample size is large, the outcome incidence rate is low, the follow-up time is not too long, and the risk ratios are of moderate size (Callas, Pastides, & Hosmer, 1998).

Random effects

In order to calculate the between-neighborhood variance we tested for random intercepts. Random intercepts can be seen as the variance in average odds of CHD between the neighborhoods.

The proportion of the neighborhood-level variance explained by the different variables was calculated as follows:

$$V_{EXPLAINED} = \frac{V_0 - V_1}{V_0} \times 100,$$

where V_0 is the neighborhood-level variance in the empty model, and V_1 is the neighborhood-level variance in the different models.

The significance of the neighborhood-level variance was tested by Wald's test.

We tested for cross-level interactions between the neighborhood-level variables and each of the individual explanatory variables. No significant cross-level interactions were found and therefore no cross-level interaction terms were included in the models.

Parameters were estimated by the 2nd-order PQL procedure that provides improved estimates under the binominal distributional assumption. Extrabinomial variation was explored systematically in all models and we found no evidence of under- or overdispersion. MLwiN was used to perform the analyses (Rasbash et al., 2000).

Ethics

This study was approved by the Ethics Committee of the Karolinska Institute in Stockholm.

Results

Table 1 shows the female study population, in quintiles, by the neighborhood-level and

Table 1
Description of the female study population (in percentages) by neighborhood and individual-level characteristics and cumulative incidence of coronary heart disease (CHD)

Neighborhood-level characteristics	Unemployment					Violent crime				
	Quintile 1 (lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (highest)	Quintile 1 (lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (highest)
Rate (%)	<1.9	1.9–3.1	3.2–4.7	4.8–6.4	>6.4	<0.81	0.81–1.39	1.40–2.21	2.22–3.46	>3.46
Mean age	48.1	48.2	48.2	47.8	47.4	48.2	48.2	47.9	47.9	47.6
Individual-level characteristics (%)										
Income										
Group 1 (highest)	46.4	33.5	22.0	13.4	7.1	38.4	31.6	22.2	17.4	13.1
Group 2	28.4	30.3	24.1	20.8	18.7	27.9	25.9	25.3	23.0	20.5
Group 3	16.4	21.9	28.3	31.7	34.0	20.2	23.4	27.2	29.3	32.0
Group 4 (lowest)	8.8	14.2	25.7	34.1	40.2	13.6	19.1	25.4	30.3	34.4
Employment status										
Employed	98.3	97.5	96.5	95.5	92.9	97.5	97.0	96.5	95.6	94.3
Unemployed	1.7	2.5	3.5	4.5	7.1	2.5	3.0	3.5	4.4	5.7
Marital status										
Married	75.2	67.0	49.1	39.3	40.9	68.5	59.2	51.8	46.8	45.5
Single	24.8	33.0	50.9	60.7	59.1	31.5	40.8	48.2	53.2	54.5
CHD cumulative incidence (%)	0.17	0.20	0.23	0.26	0.36	0.18	0.20	0.24	0.27	0.33

All women aged 35–64 in Stockholm County, January 1, 1998, $N = 334{,}057$.

Table 2
Description of the male study population (in percentages) by neighborhood- and individual-level characteristics and cumulative incidence of coronary heart disease (CHD)

Neighborhood-level characteristics	Unemployment					Violent crime				
	Quintile 1 (lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (highest)	Quintile 1 (lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (highest)
Rate (%)	<1.9	1.9–3.1	3.2–4.7	4.8–6.4	>6.4	<0.81	0.81–1.39	1.40–2.21	2.22–3.46	>3.46
Individual-level characteristics (%)										
Mean age	48.5	48.4	47.9	47.3	46.8	48.4	48.1	47.7	47.6	47.1
Income										
Group 1 (highest)	47.9	34.9	23.7	14.1	6.8	39.4	33.3	23.1	18.1	13.3
Group 2	29.3	31.8	26.1	22.0	18.2	28.9	27.2	26.6	23.8	20.8
Group 3	14.6	19.8	25.1	28.4	30.2	18.4	20.8	24.6	26.4	28.1
Group 4 (lowest)	8.3	13.5	25.0	35.6	44.7	13.4	18.8	25.7	31.7	37.8
Employment status										
Employed	98.5	97.5	95.7	93.6	88.5	97.5	97.0	96.5	95.6	94.3
Unemployed	1.5	2.5	4.3	6.4	11.5	2.5	3.0	3.5	4.4	5.7
Marital status										
Married	74.3	66.7	49.5	39.2	43.0	67.3	58.9	51.3	47.5	47.4
Single	25.7	33.3	50.5	60.8	57.0	32.7	41.1	48.7	52.5	52.6
CHD cumulative incidence (%)	0.51	0.50	0.56	0.67	0.77	0.49	0.56	0.57	0.69	0.70

All men aged 35–64 in Stockholm County, January 1, 1998, $N = 336{,}295$.

individual-level variables and the cumulative incidence of CHD. Quintile 1 represents neighborhoods with the lowest proportion of violent crime/unemployment and quintile 5 represents neighborhoods with the highest proportion of violent crime/unemployment. The highest percentages of women with low income, unemployed women, and single women were found in neighborhoods with the highest proportion of violent crime/unemployment. The highest cumulative incidence of CHD among women was found in quintile 5.

Table 2 shows the male study population, in quintiles, by the neighborhood-level and individual-level variables and the cumulative incidence of CHD. The distribution of the individual-level variables among men was similar to the distribution for the women. The highest cumulative incidence of CHD among men was found in quintile 5, i.e. in neighborhoods with the highest proportion of violent crime/unemployment.

Table 3 shows odds ratios with 95% confidence interval for CHD (fixed effects) and the neighborhood-level variance (random effects) in three different models for the neighborhood-level variable violent crime. Model 1 represents the empty model, model 2 includes the neighborhood-level variable violent crime and model 3 includes the neighborhood-level variable and the individual-level variables age, income, employment status, and marital status. The results are presented separately for women and men. Table 4 shows the fixed and random effects for the neighborhood-level variable unemployment. The models are presented in the same way as in Table 3.

Fixed effects

When neighborhood violent crime increased, the risk of CHD increased significantly for both women and men. In quintile 5, the odds ratios were 1.75 (CI = 1.37–2.22) and 1.39 (CI = 1.19–1.63) for women and men, respectively. Results were almost unaltered after inclusion of the individual-level variables in model 3. For neighborhood unemployment a similar pattern was observed; when rates of neighborhood unemployment rose, the risk of CHD increased. In quintile 5, the odds ratios were 2.05 (CI = 1.62–2.59) and 1.50 (CI = 1.28–1.75) for women and men, respectively. Low individual income and being single were associated with an increased CHD risk for both women and men.

Random effects

Neighborhood violent crime

For both women and men, the between-neighborhood variance (i.e. the random intercept) was over 1.96 times the standard error in the empty model

Table 3
Neighborhood violent crime in quintiles

Variable	Level	Model 1 Empty model		Model 2 With neighborhood-level variables		Model 3 With neighborhood- and individual-level variables[b]	
		Women	Men	Women	Men	Women	Men
Fixed effects							
Neighborhood-level variables							
Quintile of neighborhood violent crime	Quintile 1 (lowest)			1	1	1	1
	Quintile 2			1.08 (0.83–1.40)	1.15 (0.98–1.36)	1.06 (0.82–1.37)	1.16 (0.99–1.36)
	Quintile 3			1.30 (1.01–1.67)	1.16 (0.99–1.37)	1.23 (0.96–1.59)	1.17 (0.99–1.37)
	Quintile 4			1.47 (1.15–1.89)	1.39 (1.19–1.63)	1.37 (1.07–1.75)	1.39 (1.19–1.62)
	Quintile 5 (highest)			1.75 (1.37–2.22)	1.39 (1.19–1.63)	1.65 (1.30–2.10)	1.41 (1.20–1.65)
Individual-level variables							
Income	Group 1 (lowest)					2.55 (1.96–3.31)	2.04 (1.75–2.39)
	Group 2					1.84 (1.45–2.35)	1.68 (1.46–1.94)
	Group 3					1.75 (1.38–2.21)	1.40 (1.22–1.60)
	Group 4 (highest)					1	1
Employment	Employed					1	1
	Unemployed					0.81 (0.54–1.21)	1.04 (0.86–1.27)
Marital status	Married					1	1
	Not married					1.35 (1.13–1.60)	1.29 (1.15–1.44)
Random effects							
Between-neighborhood variance (SE[a])		0.202 (0.058)	0.102 (0.025)	0.141 (0.053)	0.081 (0.024)	0.100 (0.050)	0.053 (0.022)
Explained variance (%)				30	21	50	48

Odds ratios (OR) with 95% confidence intervals for coronary heart disease (fixed effects) and neighborhood variance (random effects) in three different models. 334,057 women and 336,295 men residing in 1051 neighborhoods in Stockholm County, January 1, 1998 followed until December 31, 1998.

[a]Standard error.

[b]Age not shown.

Table 4
Neighborhood unemployment in quintiles

Variable	Level	Model 1 Empty model		Model 2 With neighborhood-level variables		Model 3 With neighborhood- and individual-level variables[b]	
		Women	Men	Women	Men	Women	Men
Fixed effects							
Neighborhood-level variables							
Quintile of neighborhood unemployment	Quintile 1 (lowest)			1	1	1	1
	Quintile 2			1.11 (0.86–1.44)	0.97 (0.82–1.14)	1.05 (0.81–1.36)	0.94 (0.80–1.10)
	Quintile 3			1.28 (0.99–1.64)	1.10 (0.93–1.29)	1.17 (0.91–1.50)	1.08 (0.92–1.27)
	Quintile 4			1.46 (1.14–1.87)	1.30 (1.12–1.53)	1.34 (1.04–1.72)	1.31 (1.12–1.54)
	Quintile 5 (highest)			2.05 (1.62–2.59)	1.50 (1.28–1.75)	1.87 (1.46–2.39)	1.51 (1.29–1.77)
Individual-level variables							
Income	Group 1 (lowest)					2.36 (1.81–3.07)	1.91 (1.62–2.24)
	Group 2					1.75 (1.37–2.24)	1.60 (1.39–1.85)
	Group 3					1.70 (1.34–2.15)	1.36 (1.19–1.57)
	Group 4 (highest)					1	1
Employment	Employed					1	1
	Unemployed					0.79 (0.53–1.18)	1.02 (0.84–1.24)
Marital status	Married					1	1
	Not married					1.36 (1.15–1.62)	1.30 (1.16–1.46)
Random effects							
Between-neighborhood variance (SE[a])		0.202 (0.058)	0.102 (0.025)	0.107 (0.050)	0.073 (0.023)	0.078 (0.047)	0.044 (0.021)
Explained variance (%)				47	28	61	57

Odds ratios (OR) with 95% confidence intervals for coronary heart disease (fixed effects) and neighborhood variance (random effects) in three different models. 334,057 women and 336,295 men residing in 1051 neighborhoods in Stockholm County, January 1, 1998 followed until December 31, 1998.

[a]Standard error.

[b]Age not shown.

(model 1), indicating that there were significant differences in CHD between neighborhoods. After inclusion of the neighborhood-level variable (model 2) and the individual-level variables (model 3) the between-neighborhood variance remained significant for both women and men. The explained variance increased for both women and men after stepwise inclusion of the neighborhood-level and individual-level variables and reached 50% and 48%, respectively, in model 3. This implies that the neighborhood-level and individual-level variables partly explained the variance between neighborhoods.

Neighborhood unemployment

For women, the between-neighborhood variance (i.e. the random intercept) was over 1.96 times the standard error in the empty model (model 1), indicating that there were significant differences in CHD between neighborhoods. After inclusion of the neighborhood-level variables (model 2) the between-neighborhood variance remained significant for women but disappeared after inclusion of the individual-level variables (model 3). For men, the between- neighborhood variance was significant in all three models. The explained variance increased for both women and men after stepwise inclusion of the neighborhood-level and individual-level variables and reached 61% and 57%, respectively, in model 3.

Discussion

When neighborhood violent crime and neighborhood unemployment increased, the risk of CHD increased among both women and men. These average neighborhood effects on CHD (fixed effects) remained almost unaltered after inclusion of the individual-level variables. The neighborhood-level variance indicated significant differences in CHD between neighborhoods, which were partly explained by the neighborhood-level and individual-level variables (random effects).

To our knowledge, no previous study has used violent crime rates in small area neighborhood units to analyze the association between neighborhood social disorganization and CHD. In addition, our study was performed in an urban setting, i.e. the capital of Sweden, and was based on the urban theories of the Chicago school and the Stirling County group.

Recent studies from the US and Sweden have found an association between neighborhood social deprivation and CHD, after adjustment for individual-level factors (Diez Roux et al., 2001; Sundquist et al., 1999; Sundquist, Winkleby, et al., 2004). Kawachi et al. (1999) and Kennedy et al., (1998) used state-level ecological data on crimes and demonstrated a consistent association between social deprivation and crime, indicating that crime and social deprivation share the same social source. This is important because crime has been suggested to lie in the direct pathway between the neighborhood social environment and health (Kawachi et al., 1999; Kennedy et al., 1998; Sampson et al., 1997). Sampson et al. (1997) reported that the mediator between concentrated disadvantage, residential instability, and violent crimes was collective efficacy, defined as social cohesion among neighbors and their willingness to intervene on behalf of the common good. Crime is associated with social control and a susceptible indicator of social relations in a neighborhood (Kawachi et al., 1999; Kennedy et al., 1998; Sampson et al., 1997). Social disorganization has been defined as "inability of a community structure to realize the common values of its residents and maintain effective social controls" (Sampson & Groves, 1989). Moreover, there is an association between crime and signs of lacking social control, such as vandalism and litter in disadvantaged physical environments (Skogan, 1990). In urban neighborhoods social disorganization is accompanied by poverty, high unemployment rates, and high mobility, i.e. people with sufficient economic resources move out of the neighborhood. A high rate of mobility is the first sign of neighborhood social disorganization, followed by changes in the age structure and then in the household structure (Lindén, 1987; Sundquist, Rosén, Lindén, & Scherstén, 1994). Occupants with financial and social problems and unemployed persons move into the neighborhood. This development leads to less social control, which in turn might increase crime. A sharp breakdown of social structures is related to alienation and anti-social behavior particularly among young male adults (Field, 2003). High rates of juvenile delinquency existed in the same neighborhoods for several decades, although the ethnic and racial composition changed during the same time (Sampson, 2003b; Shaw & McKay, 1942). Neighborhoods with high crime rates acquire a bad reputation and become unattractive on the housing market. In contrast,

neighborhoods with a good reputation may provide a social environment where young people acquire status and self-esteem, which encourages their integration into a broader society and reduces the risk of violent crime (Kawachi, Kennedy, Lochner, & Prothrow-Stith, 1997).

Miller claimed that crime occur in a distinctive lower-class subculture, i.e. the lower classes have different norms and values that encourage lower-class men to commit criminal acts (Miller, 1958). Bordua criticized this notion and stated that Miller seems to believe that the influence of lower-class subculture is so deep that other institutions, for example schools, have no impact on young delinquents. Bordua's interests included theory and research on delinquency causation and violent crime. He argued that violent crime is caused by firearms ownership rather than by the influence of lower-class subculture (Bordua, 1986). The Chicago school's ideas of how the environment affects social behavior have been criticized as being too deterministic. For example, Matza did not agree that subcultures of delinquency maintain. In contrast, he argued that delinquents appreciate the norms and values of the society and that most delinquents eventually grow out of delinquency once they obtain adult status (Matza, 1964). Pfohl criticized the Chicago school sociologists as being disproportionally male, white, and unable to look beyond their own cultural expectations. He described social organizations as power relations, which are organized in a hierarchical/ patriarchal structure (Pfohl, 1994).

Boardman (2004) showed that physical health differentials were due to stress disparities across neighborhoods. Thus, the biological pathway between neighborhood violent crime, neighborhood unemployment and CHD may be mediated by an abnormal neuroendocrine secretory pattern (Rosmond et al., 2003) due to stress (cortisol, testosterone and IGF-1) and accumulation of fat in visceral adipose tissues (the metabolic syndrome) (Bjorntorp, 2001) and/or via markers of endothelial inflammation (Dogra, Herrmann, Irish, Thomas, & Watts, 2002) such as high-level sensitive C-reactive protein, interleukin-6, tumor necrosis factor alpha, and fibrinogen.

It is also plausible that unhealthy behaviors and CHD risk factors could act as mediators in the neighborhood effect on CHD. Previous research has shown that the neighborhood socioeconomic environment is associated with an increased prevalence of CHD risk factors (Smith, Hart, Watt, Hole, & Hawthorne, 1998; Diez Roux et al., 1997), including high diastolic blood pressure, elevated cholesterol levels, poor dietary habits, smoking, physical inactivity, and obesity (Sundquist et al., 1999; Hart, Ecob, & Smith, 1997; Cubbin, Hadden, & Winkleby, 2001; Ellaway, Anderson, & Macintyre, 1997; Yen & Kaplan, 1998; Diez Roux et al., 1999).

However, our results should be interpreted with caution since association does not prove causality.

Limitations and strengths

There are several limitations to this study. First, data on individual-level behavior, such as smoking, were not available to us. However, in one of our previous studies the association between neighborhood characteristics and CHD did not change when smoking was added (Sundquist, Winkleby, et al., 2004). Those findings were in agreement with the findings of a study from the US, in which the addition of smoking to regression models that already contained individual socioeconomic characteristics had little effect on the relationship between neighborhood characteristics and the incidence of CHD (Diez Roux et al., 2001). Second, we had no data on the individuals' perception of their neighborhoods, such as fear of being assaulted. Third, residual confounding probably exists because individual socioeconomic status cannot be measured precisely and completely (Braveman, Cubbin, Marchi, Egerter, & Chavez, 2001; Kaufman, Cooper, & McGee, 1997). Fourth, we had no data on neighborhood residential mobility, which is one important sign of neighborhood social disorganization and disintegration, together with crime and unemployment.

This study has also several strengths. Firstly, the individual-level and neighborhood-level variables has a nearly 100% completion rate in the national population registers. Secondly, the Swedish government-owned land-surveying bureau provided the geocoding for all individuals in this study. When the accuracy of commercial geocoding was investigated in the US, accuracy rates ranged from 44% to 84% (Krieger, Waterman, Lemieux, Zierler, & Hogan, 2001). Thirdly, the urban sample of 700,000 women and men included all individuals aged 35–64 in Stockholm, the capital of Sweden. Fourthly, to our knowledge, no previous study has used crime rates at small area neighborhood units, i.e. the SAMS neighborhoods. The boundaries of SAMS neighborhoods are drawn to include similar types of housing and are likely to correspond well to

neighborhoods in social terms. Fifthly, the validity of the diagnosis for myocardial infarction was high in an evaluation for 1987 and 1995 by the National Board of Health and Welfare (The National Board of Health and Welfare, 2000). Sixthly, there was no loss to follow-up as the Swedish registration system provides a personal identification number for each individual, which was used to follow each individual during the entire study period. Finally, the consistent contributions of past research suggest that neighborhood social environments are not simply proxies for individual socioeconomic status and that research should be focused on both individuals and neighborhoods (Diez Roux et al., 2001; Haan, Kaplan, & Camacho, 1987; Kaplan, 1996; Macintyre, Maciver, & Sooman, 1993; Malmstrom, Sundquist, & Johansson, 1999; Robert, 1999; Yen & Kaplan, 1999). The use of multilevel models in public health research, including both individual-level and neighborhood-level factors, has been shown to be of vital importance (Diez-Roux, 1998; Malmstrom et al., 1999; O'Campo et al., 1995; Sundquist, Malmstrom, & Johansson, 2004; Sundquist, Winkleby, et al., 2004). Subsequently, the use of a new paradigm characterized by "relations within and between localized structures organized in a hierarchy of levels" is recommended (Susser & Susser, 1996). In this study, we therefore used multilevel models to analyze the association between neighborhood violent crime and neighborhood unemployment and CHD.

Implications

Neighborhood violent crime and unemployment increases the risk of CHD. Public safety and social stability in socially disorganized neighborhoods need to be improved in order to promote cardiovascular health. Concentrated neighborhood disadvantage could partly be avoided through tenants' buyouts (Kawachi et al., 1999), which might reduce social disorganization and disintegration. In addition, improved neighborhood safety could encourage people who live in the neighborhood to be more physically active, which in turn would reduce the risk of CHD (Critchley & Capewell, 2003).

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