Health Inequalities

Area social characteristics and carotid atherosclerosis

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Objectives: To explore the effect of social characteristics of residential areas on carotid atherosclerosis prevalence.

Methods and results: The associations among area social characteristics and B-mode ultrasound determined carotid plaque-score (a semi-quantitative scale measuring the degree of atherosclerosis in the carotid bifurcation area) were cross-sectionally investigated in a general population sample of 4033 men and women. Area socioeconomic circumstances were described through a social deprivation index calculated from migration rate, percentage residents with foreign citizenship among those with foreign background, dependency on social welfare support, and employment rate. Living in socially deprived areas was associated with an increased carotid plaque-score in both men (P for trend = 0.004) and women (P for trend = 0.007). These associations were only slightly reduced after adjustment for individual level indicators with a decrease of the absolute mean difference in carotid plaque-score between worse-off and better-off areas of 9% for men and 13% for women whereas adjustment for risk factors turned the trend non-significant in women, however, not in men.

Conclusions: Those living in socially deprived areas in general had more extensive carotid atherosclerosis. However, in these areas there were a substantial number of individuals with low degrees of carotid atherosclerosis and vice versa. Thus, with regard to conceptual ideas of causal inference, the social characteristics of an area seem to be associated with the prevalence of carotid atherosclerosis. However, with regard to benefits of prevention, focusing on geographical areas would probably give a restricted benefit, where only some high-risk individuals would be reached.

Keywords: atherosclerosis, carotid arteries, cardiovascular diseases, social context, socioeconomic factors

The existence of associations between individual level data on social position and health is well documented and relatively undisputed. During recent years also studies relating area social characteristics to variations in coronary heart disease morbidity and mortality have appeared.1-9 Contextual measures of social characteristics are thought to provide information that is not captured by the individual level measures and may thus lead to a greater understanding of social determinants of health. Area environment may theoretically affect cardiovascular risk through pathways involving e.g., health-related behaviours, stress, and social support,1,5,10-12 based on differences in, for example, social norms and physical environment.7,12

Studies on the mechanisms behind the association between area social context and cardiovascular disease (CVD) have mainly focused on clinical events such as myocardial infarction or stroke. Previous studies from the city of Malmö have shown that social characteristics of residential areas are related to incidence of myocardial infarction,13 stroke,14 and to the prognosis among patients with CVD.15 During recent years the use of a preclinical outcome for research into the causes of social differences in health has grown in interest since explanations of these differences, such as social differences in access to medical care or health-related downward mobility, are less important sources of bias.16 In the field of cardiovascular disease, such an approach also makes it possible to differentiate mechanisms related to atherogenesis from mechanisms related to plaque rupture or thrombus formation in the later stages of the natural history of cardiovascular disease.17,18 B-mode ultrasound is non-invasive and has been shown to be a reliable and valid measure of carotid atherosclerosis, which has been found to be related to general atherosclerosis.9,20

The purpose of the present study was to explore the association between social characteristics of residential areas and carotid atherosclerosis. To the best of our knowledge, only one previous study has been made connecting the preclinical stages of the atherosclerotic disease process with the social context.21

Materials and methods

The subjects in this study constituted a part of the large, population-based Malmö Diet and Cancer Study (MDCS).22 All men and women living in the city of Malmö (235,000 inhabitants in 1991) in the south of Sweden, born during 1926–1945, were invited to a baseline examination between 1991 and 1996. The total participation rate in MDCS was 40.8%. The non-participants have been described elsewhere.23 In short, the sociodemographic distribution showed no marked deviations from the general population of Malmö in the same age bracket concerning educational level, type of employment, marital status, and percentage living alone.23 A random fifty percent of those born between 1926 and 1945, who entered the MDCS from October 1991 and February 1994, were invited to take part in a study on the epidemiology of carotid artery disease and 6103 individuals (98%) accepted the invitation to participate in the carotid artery disease study.24 In February 1992 a new more detailed version of the baseline questionnaire was used. In the present study, only those

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Subjects attending the MDCS between February 1992 and February 1994 (n = 10 798), with a completed questionnaire (n = 10 196), who accepted the invitation to participate in the carotid artery disease study (n = 4884) were included in the study population. Fasting blood samples were taken under standardized conditions. A total of 353 potential subjects were excluded due to incomplete laboratory test results and 107 individuals were excluded due to the presence of known CVD. Subjects were considered to have a history of CVD if they had been treated for myocardial infarction and/or stroke according to national and regional myocardial infarction and stroke registers. Using this definition, men had a prevalence of CVD of 4.2% (n = 79) and women 1.1% (n = 28). Individuals exceeding 65 years of age (n = 353) were excluded together with individuals with missing data on area residence (n = 38). The remaining 4033 subjects (2382 women and 1651 men), ages 46 to 65, all of whom lived in the vicinity of Malmö, Sweden, constituted our study population.

**Measures of social characteristics at the area level**

Information on area characteristic was obtained from official statistics from the Malmö City Council and data from Statistics, Sweden. For administrative purposes, the city is divided into 18 geographical areas. These areas have been used to study the distribution and determinants of health in the city. In our study, the areas used (n = 17) comprised on average approximately 14 000 individuals. The harbour area has not been included due to the small number of residents. Area socioeconomic circumstances were described through a comprehensive social deprivation index. This index has been described in detail elsewhere. Briefly, it was computed from four standardized variables (rate of migration, the percentage of residents with low educational level, and correlates well with other well-known measures of social contextual circumstances.

**Measures of social characteristics at the individual level**

Educational level was assessed through the baseline questionnaire and classified into three categories. ‘Primary education’ included those who had less than 9 years of education, ‘some secondary education’ included those who had 9 and up to 11 years of education, ‘completed secondary education’ included those who had completed secondary school (12 years) and those who had education at college or university level. Data on education were not available for five individuals. Employment status was categorized as (i) employed or self-employed, (ii) students, housewives and unemployed and (iii) long-term ill and early retirement pensioners. Data on employment status were not available for six individuals. Ethnicity was categorized as born in Sweden and born abroad. Data on ethnicity were not available for two individuals. Occupational status was categorized into one of six categories: high level non-manual employees, medium level non-manual employees, low level non-manual employees, skilled manual workers, unskilled manual workers, and self-employed based on current or latest occupation. Data on occupation were not available for 38 individuals.

**Atherosclerotic risk factors**

Risk factors were estimated on the basis of laboratory tests, baseline examinations, and through the questionnaire administered at the baseline visit. Information regarding smoking habits, physical activity, medical history, and use of medication was based on the self-administered questionnaire. Details of assessment procedures regarding smoking habits (‘never’, ‘former’, and ‘current smoker’), measurements of blood pressure (mm Hg), body mass index (BMI), low density lipoprotein cholesterol, and high density lipoprotein cholesterol have been reported. Physical activity at leisure time was assessed as a total activity score based on the participants’ answers in the questionnaire, and dichotomized into low and modest/vigorous physical exercise at the lowest quartile. The different activities were scored according to duration and effort. Subjects were classified as having diabetes mellitus if they reported the diagnosis in the questionnaire, had a fasting whole venous blood glucose >6.1 mmol/l or if they were taking medication for diabetes mellitus. Use of blood pressure lowering medication was self-assessed by questionnaire.

**Carotid atherosclerosis**

Participants underwent B-mode ultrasonography (Acuson 128 CT system) of the right carotid artery. IMT of the common carotid artery (CCA) and presence of plaques were measured according to a standardized protocol by trained, certified sonographers as previously described. IMT was determined in the far wall according to the leading edge principle, using a specially designed computer assisted analysing system. The bifurcation area of the right common carotid artery was scanned within a pre-defined window comprising 3 cm of the distal common carotid artery, the bulb, and 1 cm of the internal and external carotid artery, respectively, for the occurrence of plaques. The degree of carotid atherosclerosis was further measured by a carotid plaque-score, which is a semi-quantitative scale measuring the degree of atherosclerosis in the bifurcation area. The carotid plaque-score had 5 units, where 0 = no plaques (defined as focal IMT >1.2 mm) or wall thickenings; 1 = one small plaque (<10 mm²) or wall thickening (IMT >1.2 mm); 2 = two or more small plaques (<10 mm²); 3 = one plaque >10 mm²; 4 = one plaque >10 mm² plus one or more small plaques (<10 mm²); 5 = two or more plaques >10 mm², one circumferent plaque, or one plaque causing more than 50% stenosis. Each image was analysed without knowledge of the subject’s identification code to minimize the possibility of observer bias. Methods of quality control have been published previously. Out of those who underwent examination by ultrasound, there were no data on mean carotid IMT for 28 individuals and no data on carotid plaque-score for 743 individuals.

**Statistical methods**

The strategy was to fit multilevel regression analyses regarding areas as second level units. Multilevel modelling takes into account the possibility of a clustering of individual health status within areas, that is, the possibility that individuals living in a specific area are alike each other due to the sharing of a number of influences. The intraclass correlation (ICC) denotes the degree of similarity among the outcomes of members of the same area and is the proportion of the total variance in the outcome variable that occurs at the area level. In case the variance at the second level was small, that is, the individual measures could be regarded as independent, a single level regression analysis was performed instead (SPSS computer software v. 11.0). The data were cross-sectional. All analyses were adjusted for age and stratified by sex. Area characteristics was explored as a continuous variable and categorized into tertiles. First, age-adjusted associations between area social deprivation index and carotid plaque-score were investigated stratified by sex. Second, to distinguish the contextual effect.
from the individual level effect, data on individual level social characteristic were then included. Third, additional adjustment for cardiovascular risk factors (smoking, physical activity, diabetes mellitus, systolic blood pressure levels, treatment for hypertension, LDL cholesterol, HDL cholesterol, and BMI) were made.

Results

The age-adjusted mean of carotid plaque-score varied between the areas from 1.20 to 1.81 for women (P = 0.01) and from 1.26 to 2.14 for men (P = 0.003). However, there was a big spread of carotid plaque-score between the individuals in the same area. The results from the multilevel models with a random intercept including age also showed an ICC that was less than 1% with respect to carotid plaque-score. This means that there was no evident clustering of carotid plaque-score at the area level. Therefore, only the results from the single level model are reported.

Social deprivation index

The four variables included in the social deprivation index were highly intercorrelated, with r > 0.77, P < 0.001 for all. This index was highly correlated with per capita proportion of manual workers (r = −0.66, P < 0.001), but less correlated with per capita proportion of people with low educational level (r = −0.22, P < 0.001).

Study population

The associations in the study population between individual level social characteristics and the area social deprivation index are shown in table 1. Areas with a low score on the social deprivation index, that is, worse-off areas, showed higher prevalences of disability pensioners, individuals with low educational level, individuals born outside Sweden, manual workers and housewives, students and unemployed taken together, compared to areas with a high score on the social deprivation index, that is, better-off areas.

Distribution of the carotid plaque-score in relation to the social deprivation index

Figure 1 shows the distribution (%) of carotid plaque-score (0–5) in each of the three tertiles of socioeconomic deprivation index of residential areas. As shown in the figure, higher scores on the carotid plaque scale are more prevalent areas with lower social deprivation index, that is, in the worst-off areas, however, there are not only individuals with high scores in these areas. Similarly, lower scores on the carotid plaque scale are more prevalent in areas with higher social deprivation

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<table>
<thead>
<tr>
<th>Individual level characteristics</th>
<th>Tertiles of social deprivation index*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First tertile n(%) (Most deprived)</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
</tr>
<tr>
<td>12 years or more</td>
<td>378 (27.8)</td>
</tr>
<tr>
<td>9–11 years</td>
<td>309 (22.7)</td>
</tr>
<tr>
<td>8 years or less</td>
<td>674 (49.5)</td>
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<tr>
<td>All</td>
<td>1361 (100)</td>
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<tr>
<td>Occupational status</td>
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<tr>
<td>High level non-manual</td>
<td>89 (6.6)</td>
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<tr>
<td>Medium level non-manual</td>
<td>218 (16.1)</td>
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<tr>
<td>Low level non-manual</td>
<td>306 (22.6)</td>
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<tr>
<td>Skilled manual</td>
<td>166 (12.3)</td>
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<tr>
<td>Unskilled manual</td>
<td>452 (33.5)</td>
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<tr>
<td>Self-employed</td>
<td>120 (8.9)</td>
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<tr>
<td>All</td>
<td>1351 (100)</td>
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<tr>
<td>Employment status</td>
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<tr>
<td>Housewives, students and unemployed</td>
<td>127 (9.3)</td>
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<tr>
<td>Employed or self-employed</td>
<td>880 (64.7)</td>
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<td>Long-term ill or disability pensioners</td>
<td>353 (26.0)</td>
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<tr>
<td>All</td>
<td>1360 (100)</td>
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<td>Ethnicity</td>
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<tr>
<td>Not born in Sweden</td>
<td>209 (15.3)</td>
</tr>
</tbody>
</table>

*The social deprivation index was computed through data on the rate of migration, the percentage of residents with foreign citizenship among those with foreign background, the percentage of people receiving social welfare support (negative signs), and rate of employment (positive sign). The index ranged from −7.18 to 5.01 with a higher score reflecting a higher socioeconomic status for the area. The index was divided into tertiles at −1.52 and 2.43.
reflecting a higher socioeconomic status for the area (negative sign) and rate of employment (positive sign). The index ranged from *The social deprivation index was computed through data on the rate of migration, the percentage of residents with a higher socioeconomic status for the area. The index was divided into tertiles at continuous variables.

mass index, low density lipoprotein cholesterol and high density lipoprotein cholesterol. Smoking, physical activity presence and women with missing data on educational level, 38 individuals with missing data on occupational status, 6 individuals with missing on.

‡Significantly different from the reference category.

†Reference category

Table II

<table>
<thead>
<tr>
<th>Area characteristics</th>
<th>Age</th>
<th>+Individual level social characteristics§</th>
<th>+Risk factors#</th>
<th>+All</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Deprivation Index*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Tertile†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Tertile</td>
<td>−0.23†</td>
<td>−0.21</td>
<td>−0.22</td>
<td>−0.21</td>
</tr>
<tr>
<td>Third Tertile</td>
<td>−0.32†</td>
<td>−0.29†</td>
<td>−0.25†</td>
<td>−0.25†</td>
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<tr>
<td>P for trend</td>
<td>0.004</td>
<td>0.009</td>
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<td>0.034</td>
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<tr>
<td><strong>Women</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Social Deprivation Index*</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>First Tertile†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Tertile</td>
<td>−0.13</td>
<td>−0.10</td>
<td>−0.05</td>
<td>−0.04</td>
</tr>
<tr>
<td>Third Tertile</td>
<td>−0.23‡</td>
<td>−0.20‡</td>
<td>−0.14‡</td>
<td>−0.12‡</td>
</tr>
<tr>
<td>P for trend</td>
<td>0.007</td>
<td>0.022</td>
<td>0.11</td>
<td>0.18</td>
</tr>
</tbody>
</table>

*The social deprivation index was computed through data on the rate of migration, the percentage of residents with foreign background, the percentage of people receiving social welfare support (negative sign) and rate of employment (positive sign). The index ranged from −7.18 to 5.01, with a higher score reflecting a higher socioeconomic status for the area. The index was divided into tertiles at −1.52 and 2.43.

†Reference category

§Significantly different from the reference category.

#Adjusted for age, educational level, employment status, ethnicity, and occupational status. There were 5 individuals missing data on educational level, 38 individuals with missing data on occupational status, 6 individuals with missing on employment status, and 2 individuals with missing data on ethnicity.

#Adjusted for age, smoking, physical activity, systolic blood pressure, treatment for hypertension, prevalent diabetes, body mass index, low density lipoprotein cholesterol and high density lipoprotein cholesterol. Smoking, physical activity presence of diabetes, treatment for hypertension were included as categorical variables. All remaining variables were adjusted for as continuous variables.
with an increasing carotid plaque-score with decreasing social deprivation index, ($P$ for trend = 0.016) for men and ($P$ for trend = 0.002) for women.

**Discussion**

Contextual measures have been linked to later stages of the atherosclerotic disease process such as coronary morbidity and mortality. 

1. **Our findings indicate that also the preclinical stages of the atherosclerotic disease process are influenced by the area context. In our study the age-adjusted differences in carotid plaque-score between areas in the lowest and highest tertile of socioeconomic deprivation index were 0.23 units among women and 0.32 units among men. To get an idea of the importance of differences in carotid plaque-score of this magnitude, it should be mentioned that in an earlier study using the MDCS-data we showed an increase in the risk of future cardiac events of 63% per SD (1.67 units) in carotid plaque-score in the age and sex-adjusted model.

However, even though area social characteristics seem to play a role in the understanding of social determinants of health, the results showed only a weak clustering of persons based on areas in relation to the extent of carotid atherosclerosis. Earlier studies have shown that it is possible to find larger area differences using measures of association focusing on fixed mean parameters such as, for example, regression coefficients alongside with smaller measures of health variation (i.e., ICC). These measures give complementary information.

While traditional measures of associations between area social characteristics and individual health are relevant in the understanding of what links social structure to various health outcomes, measures of health variation have value in the understanding of the similarity of individuals living in the same area with respect to health status. Such information might prove important in the development of preventive strategies. In our study, those living in socially deprived areas in general had more extensive carotid atherosclerosis. However, in these areas there were also a substantial number of individuals with low degrees of carotid atherosclerosis and vice versa and in low-risk areas there were individuals with a high degree of carotid atherosclerosis. Thus, with regard to conceptual ideas of causal inference, the social characteristics of the area seem to be associated with the prevalence of carotid atherosclerosis. However, with regard to benefits of prevention, focusing on high-risk areas would probably give a restricted benefit, where only some high-risk individuals would be reached.

The only previous population-based study on the effects of area social characteristics on subclinical cardiovascular disease was performed among an elderly population as part of the Cardiovascular Health Study. 

This study showed inverse relations between various measures of area socioeconomic characteristics and the prevalence of subclinical CVD. Neighbourhood scores tended to be inversely associated with subclinical disease even after adjustment for personal socioeconomic indicators (i.e., personal income, educational level, and occupational status), but the associations were not statistically significant. We do not think that the amount of residual confounding is a bigger problem in our study than in the Cardiovascular Health study since we have detailed assessments of individual level occupational status (were the mean time in the latest occupation was 19.2 years), educational level, employment status, and if being foreign born or not.

There is a wide variety of exposure measures on social contextual effects on risk factor levels as well as cardiovascular disease. While some indices measure aspects of material deprivation, that is, entailing a lack of goods, services, resources, and amenities, other measures try to capture aspects social deprivation, that is, entailing a non-involvement in relationships, customs, and functions. However, it has been argued that these dimensions are highly correlated and that it might be difficult to determine which of the contextual aspects is the most important. The purpose with the index used in our study was to achieve an instrument to rank the areas according to different concepts of social deprivation in Sweden of today. The concepts chosen were only to a small extent dependant on age. The measure used includes aspects of social exclusion (as operationalized through proportion of residents with foreign citizenship among those with foreign background, and rate of employment), social frustration (as operationalized through migration rate), and poverty (as operationalized through proportion of people receiving social welfare support). This index has been shown to be associated with cardiovascular risk factor levels as well as cardiovascular events.

The mechanisms linking specific characteristics of neighbourhoods to health of the persons who live there are not clearly understood. These might include material conditions such as access to healthier food, recreational facilities, housing conditions, and community health clinics, as well as psychosocial factors such as exposure to various psychosocial stressors, access to social support and crime rates. Psychosocial factors may in turn influence both health behaviours and physiology. Social differentiation might then be generated and sustained through social interaction within the areas affecting consumption habits, attitudes, coping strategies, and cognitive and social skills. Thus, the mechanism involved in the association between area social characteristics and atherosclerosis might theoretically involve behavioural factors as well as psychological and physiological factors. In our study, the associations between area characteristics and carotid atherosclerosis were generally markedly reduced after adjustment for physiological and behavioural risk factors.

The residential areas used in this study are administrative constructs. Since the size of these areas were rather big, they might not correspond to what people might perceive as 'their' area or as 'us' in the sociological sense of these terms. This might also lead to difficulties in assessing a potential clustering of individuals based on geographical area. However, earlier studies, using smaller geographical areas in Malmö, have shown a very small clustering effect with regard to hospitalization for ischemic heart disease. Focusing on the context of ideas of causal inference, earlier studies have shown differences between these 17 areas with regard to incidence and mortality from myocardial infarction, stroke, blood pressure levels, and levels of cardiovascular risk factors.

Certain methodological issues need to be addressed. First, to reduce the risk of residual confounding from unmeasured aspects of individual socioeconomic status, the indicators used were chosen to best correspond to the variables used at the area level. The results also show a high correlation between the indicators at the area and individual levels, respectively. However, there may still be other confounders that were not measured in our study. Since we investigated preclinical atherosclerosis, dependent misclassification because of downward socioeconomic mobility due to cardiovascular symptoms does not seem to be a likely source of bias.

Misclassification of exposure is a potential cause of bias. First, our study was cross-sectional, which means that there might be potential problems in the definition of relevant area exposure when using an outcome measure with a disease process starting already in childhood. It is well known that individuals move between different areas during the course of their lives. It could therefore be expected that the present area exposure would have only a limited effect on the outcome measure compared to using area measures earlier in time. Second, the areas would probably be more homogenous if using smaller areas. Furthermore, the variables that were chosen as social indicators might perhaps be too crude to...
characterize the social dimension of an area. The variables used in the analyses were so-called derived variables that were constructed by aggregating data on the characteristics of the people living in the areas. These aggregate characteristics were then assumed to affect all individuals living in the area. More precise measures including psychosocial stressors as well as area measures of factors related to cardiovascular risk factors, might perhaps be more adequate measures of area social characteristics. However, such misclassification would most likely be non-differential, which would lead to a reduction of the true associations. A high migration rate might lead to a dilution of a potential association between area characteristics and carotid atherosclerosis, which is a process that develops over a long period of time. In this population, migration rate between or out of areas varied between 5 and 22% with a median of 13%. However, excluding areas with the highest mobility rates showed similar results as in the whole population.

Misclassification of end point is another potential cause of bias. Carotid plaque-score is a semi-quantitative measure of the degree of atherosclerosis and has been shown to be related to risk factor levels\(^{33-34}\) as well as incidence of cardiovascular events.\(^{31,38}\) Although, the bifurcation area is the segment where carotid plaques are most commonly observed,\(^{15}\) carotid plaques located at other places in, for example, the distal part of the internal carotid artery or outside the pre-defined ‘window’ of the carotid artery were not encompassed in this study. However, it has recently been demonstrated that carotid plaques increase the risk of stroke and cerebral infarction plaque, irrespective of their location.\(^{40}\) In addition, assessment of carotid plaque-score was performed blinded to clinical information, the reproducibility was good,\(^{24}\) and if misclassification had occurred, it is likely to be non-differential, which would lead to a reduction of the true associations.

Our study is based on a community-based sample of the general population, which makes it less sensitive to selection bias than samples based on workplace or populations in clinical settings. An earlier study has shown that the sociodemographic distribution in MDCS showed no marked deviations from the general population of Malmö in the same age bracket concerning educational level, type of employment, marital status, and percentage living alone.\(^{23}\) Furthermore, the participation rates were higher in areas with high socioeconomic level.\(^{14}\) Thus, a disproportionate loss of exposed cases may arise if subjects with higher probability of case-status (e.g., due to the fact that they are smokers) are even less inclined to participate in areas considered as exposed to poor social contexts. However, as long as the non-attendance rate among risk-factor-exposed individuals from wealthy areas is not much higher than amongst exposed individuals from deprived areas, this does not explain our results. Furthermore, there is no apparent reason to believe that preclinical atherosclerotic manifestations would influence the subjects’ participation differentially with respect to area social characteristics, since it is an end point which could be expected to be asymptomatic in a vast majority of cases (particularly since all individuals with known CVD were excluded from the analyses).

In conclusion, the results of our study show that area social characteristics may influence the atherosclerotic disease process independently of individual level social characteristics. After adjustment for risk factors, the association between area social characteristics and atherosclerosis was generally reduced, indicating that these factors are somehow shaped and influenced by the area you live in. However, even though area social characteristics seem to play a role in the understanding of social determinants of health, the results showed only a weak clustering of persons based on areas in relation to the extent of carotid atherosclerosis, that is, there are lots of individuals with higher degrees of carotid atherosclerosis also in medium and better-off areas and vice versa. Thus, with regard to conceptual ideas of causal inference, the social characteristics of an area seem to be associated with the prevalence of carotid atherosclerosis. However, with regard to benefits of prevention, focusing on geographical areas would probably give a restricted benefit, where only some high-risk individuals would be reached.

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**Key points**

- Area social characteristics seem to influence the degree of atherosclerosis independently of individual level social characteristics.
- However, even though area social characteristics seem to play a role in the understanding of social determinants of health, the results from the multilevel models showed only a weak clustering of persons based on areas in relation to the extent of carotid atherosclerosis.
- Thus, focusing interventions at geographical areas instead of individuals would probably give a restricted benefit, where only some high-risk individuals would be reached.

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**References**


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