A matter of context
Social inequalities in incidence of myocardial infarction

Maria Kölegård Stjärne

doctoral thesis
Health Equity Studies No 6
in Public Health Sciences
A matter of context

Social inequalities in incidence of myocardial infarction

by

Maria Kölegård Stjärne

Health Equity Studies No 6
Centre for Health Equity Studies (CHESS)
Stockholm University/Karolinska Institutet 2005
Abstract

Coronary heart disease is the leading cause of death and makes the separate largest contribution to social inequalities in the burden of disease in Sweden. The purpose of this dissertation is to study the potential influences of local social environment on incidence of myocardial infarction (MI), thereby contributing to understanding of the social aetiology of MI. Specific aims are to define social dimensions of the neighbourhood context, and to analyze their possible contextual effects on the incidence of MI. Further, to explore mechanisms underlying such effects, with an emphasis on the interplay between social context and individual socioeconomic position, and to evaluate the contribution of established biomedical risk factors and health behaviours. Finally, to evaluate whether economic residential segregation contributes to social inequalities in incidence of MI.

The analyses in the studies are based on the Stockholm Heart Epidemiology Program (SHEEP), a population-based case-control study of first events of myocardial infarction, which comprised all Swedish citizens aged 45-70 in Stockholm County, 1992-1994.

The studies indicate that structural material and economic conditions in neighbourhoods are relevant to individual MI risk. We find graded effects of concentration of affluence, level of economic resources, and material deprivation. The effects of social fragmentation and contextual dimensions, as defined by factor analyses, were weaker and less graded. Socioeconomic homogeneity only had an effect in combination with resource level within neighbourhoods. Our results show that women living in economically disadvantaged contexts have an incidence of MI twice as high as those living in economically advantaged contexts; for men the incidence is 50% higher. These figures have been adjusted for family socioeconomic position, disposable income, own education, position on the labour market and cohabitation, all of which influence both where a person lives and the risk of coronary heart disease.

Further, we explored mechanisms that might underlie the relations. First, we considered whether individuals in different social strata are differentially vulnerable to their neighbourhood context. The results suggest that women with a low disposable income are more vulnerable to the effect of a low-income context. Further, we find an indication of increased vulnerability to contextual effects among lower strata of both non-manual employees and manual workers. Second, we evaluated the contribution of established biomedical risk factors and health behaviours as mediators. We find that smoking and insulin resistance make notable contributions to the excess risk of MI in economically disadvantaged areas, after making prior adjustment for individual social characteristics.

Finally, our results indicate that structural economic conditions in neighbour-
hoods do matter with regard to adult social class inequalities. The effect is not restricted to lower social strata, but since individuals in lower social strata more often live in disadvantaged contexts, and also seem to be more vulnerable to the effects of these contexts, we conclude that economic segregation creates neighbourhood contexts that contribute to social class inequality in incidence of MI.

**Keywords:** myocardial infarction, social context, area deprivation, neighbourhood, multi-level.
Svensk sammanfattning

Ischemisk hjärt sjukdom är den främsta dödsorsaken och utgör det enskilt största bidraget till sociala ojämlikheter i den totala sjukdoms bördan i Sverige.

Avhandlingens övergripande syfte är att studera potentiell påverkan från den lokala sociala miljön på risken att insjukna i hjärtinfarkt, och därigenom bidra till ökad förståelse av hjärtinfarkts sociala etiologi. Specifika syften är att definiera sociala dimensioner av grannskapskontexten, och att analysera möjliga kontextuella effekter på förstagångsinsjuknande i hjärtinfarkt. Vidare, att utforska underliggande mekanismer för sådana effekter, med tonvikt på samspelet mellan social kontext och individuellt social position, och att utvärdera hur etablerade biomedicinska riskfaktorer och hälsorelaterade beteenden bidrar som medierande faktorer. Slutligen, att utvärdera huruvida ekonomisk boendesegregation bidrar till sociala ojämlikheter i hjärtinfarktsinsjuknande.

Analyserna i studien baseras på Stockholms hjärtinfarktsprogram (SHEEP), en populationsbaserad epidemiologisk studie med fall-kontroll design av förstagångs insjuknande i hjärtinfarkt, innefattande samtliga svenska medborgare i åldrarna 45-70 i Stockholms län, under åren 1992-1994.

Sammantaget talar dessa studier för att det finns en kontextuell effekt. Det vill säga, socioekonomiskt resurssvaga kontexter ökar risken för hjärtinfarkt för dem som bor där även efter att hänsyn tagits till olika individuella förhållanden.

Av de aspekter av den sociala kontexten som vi har haft möjlighet att studera så har andelen höginkomsttagare, den ekonomiska resursnivån och materiell deprivation inom grannskapet tydligast effekt på risken att insjukna i hjärtinfarkt. Effekterna av social fragmentering och kontextuella dimensioner som definierats av en faktoranalys var mindre tydliga, och socioekonomisk homogenitet hade endast effekt i kombination med områdens socioekonomiska resursnivå.

Kvinnor som lever i socioekonomiskt resurssvaga kontexter har en fördubblad hjärtinfarktsrisk jämfört med de som lever i välbeställda kontexter; för män är risken att insjukna 50% högre i resurssvaga kontexter. Dessa siffror har justerats för familjens socioekonomiska position, disponibla inkomst, individuell utbildningsnivå, position på arbetsmarknaden och om man är sammanboende, vilka samtliga påverkar både var en person bor och hjärtinfarktsrisken.

Det tycks som om den kontextuella effekten drabbar alla, men inte med samma kraft. Resultaten tyder på att kvinnor med låg disponibel inkomst är mer sårbara för effekten av en socioekonomiskt resurssvag kontext, samt att det finns en ökad sårbarhet för kontextuella effekter i lägre sociala strata i både tjänstemanna- och arbetargrupper.

Vidare finner vi indikationer på att den kontextuella effekten delvis medieras via
kända riskfaktorer. Rökning och insulinresistens bidrar till överrisken för hjärtinfarkt i socioekonomiskt resurssvaga områden, även efter att hänsyn tagits till olika individuella sociala karakteristika.

Slutligen finner vi att den kontextuella effekten bidrar till skillnaderna mellan socioekonomiska grupper i hjärtinfarktsinsjuknaden och drar slutsatsen att ekonomisk segregation skapar grannskapskontexter som bidrar till den sociala ojämlikheten i hjärtinfarktssjuklighet.
List of publications

This thesis is based on the following publications, which will be referred to in the text by their Roman numerals. Published papers were reproduced with permission from the BMJ Publishing Group and Oxford University Press.

I. Kölegård Stjärne M, Diderichsen F, Reuterwall C, Hallqvist J. Socioeconomic context in area of living and risk of myocardial infarction - Results from Stockholm Heart Epidemiology Program (SHEEP). *Journal of Epidemiology and Community Health* 2002;56:29-35

II. Stjärne MK, Ponce de Leon A, Hallqvist J. Contextual effects of social fragmentation and material deprivation on risk of myocardial infarction - Results from the Stockholm Heart Epidemiology Program (SHEEP). *International Journal of Epidemiology* 2004;33:732-41


Innehåll

Abstract
Svensk sammanfattning
List of publications

1 Introduction .................................................................................................................13
  1.1 Background ........................................................................................................... 14
  1.2 Social context and myocardial infarction .............................................................. 14
    1.2.1 Myocardial infarction ..................................................................................... 14
    1.2.2 The local social context ................................................................................ 15
    1.2.3 Health effects ............................................................................................... 16

2 Aims ..........................................................................................................................20
  2.1 Specific objectives ............................................................................................... 20

3 Material and methods ............................................................................................21
  3.1 Studybase ............................................................................................................. 21
  3.2 Case definition ..................................................................................................... 21
    3.2.1 Identification ............................................................................................... 21
    3.2.2 Classification .............................................................................................. 21
  3.3 Sampling of controls ......................................................................................... 22
  3.4 Collection of individual information .................................................................. 22
  3.5 Contextual units .................................................................................................. 22
    3.5.1 Theoretical definition .................................................................................. 22
    3.5.2 Identification of ecological units ................................................................. 23
  3.6 Definition, classification and measurement of contextual exposures .............. 24
    3.6.1 Local social context ..................................................................................... 25
    3.6.2 Social fragmentation .................................................................................... 27
    3.6.3 Material deprivation ..................................................................................... 28
    3.6.4 Level of economic resources ....................................................................... 29
    3.6.5 Degree of socioeconomic homogeneity or heterogeneity ......................... 30
    3.6.6 Concentration of affluence ......................................................................... 32
  3.7 Induction time ...................................................................................................... 33
3.8 Individual exposures, confounders and possible intermediate variables .............................................. 34
3.8.1 Social class ................................................................. 34
3.8.2 Income .................................................................. 34
3.8.3 Confounders ............................................................... 34
3.8.4 Possible intermediate variables .................................... 35

4 Statistical methods ........................................................................... 36
4.1 Effect measures ........................................................................ 36
4.1.1 Logistic regression ......................................................... 36
4.1.2 Hierarchical logistic regression ........................................... 36
4.2 Correlations ........................................................................... 36
4.2.1 Partial correlation ............................................................ 36
4.3 Measures of biologic interaction ................................................... 37

5 Results and interpretations ................................................................. 38
5.1 Study I: Socioeconomic context in area of living and risk of myocardial infarction ........................................... 38
5.2 Study II: Contextual effects of social fragmentation and material deprivation on risk of myocardial infarction .......... 38
5.3 Study III: Neighbourhood Socioeconomic Context, Individual Income and Myocardial Infarction: analyses of within- and between-level interactions ......................................................... 39
5.4 Study IV: Impact of economic segregation on social class inequalities in incidence of myocardial infarction – exploration of cross-level interactions ......................................................... 40

6. General discussion .......................................................................... 41
6.1 Contextual effects ...................................................................... 42
6.2 Mechanisms – mediating/confounding factors ................................. 44
6.3 Precision ................................................................................. 45
6.4 Selection .................................................................................. 45
6.5 Misclassification ......................................................................... 46

7 Conclusions .................................................................................... 47
Acknowledgements ............................................................................. 48
References .......................................................................................... 50
Original papers I-IV .............................................................................. 59
1 Introduction

Do places make a difference to people’s health and well-being? Can the physical and social characteristics of a neighbourhood shape the health of its residents? These are elusive questions, and there is no doubt about their importance historically when public health primarily was achieved by cleaning up dirty cities. But what about today? Do living areas matter when the majority of people have the most basic needs fulfilled, and the physical and social surroundings no longer can be regarded as an immediate health threat?

We know that living conditions in Swedish urban areas differ substantially. Both in a historical perspective (Olsson 1992) and in contemporary urban development, it is the affluent rather than the poor who, in many respects, are the driving force behind the process of spatial polarization, since they have more options and, to a greater extent, can choose where to live. As a result, high-income earners are more segregated than poor people, both in Sweden (Andersson 2000) and elsewhere (Massey 1996). In the wake of the Swedish recession of the early 1990s, unemployment rates skyrocketed, which may have contributed to deepening ethnic residential segregation and an increase in the geographical concentration of poverty (Andersson 2000).

Social inequality in coronary heart disease is well documented. As Kaplan and Kiel (1993) concluded in their review: “During 40 years of study there has been a consistent inverse relation between cardiovascular disease, primarily coronary heart disease, and many of the indicators of SES”. Coronary heart disease makes a contribution of 19 percent for men and 14 percent for women to the total burden of disease in Sweden. A third of the total burden is attributable to socioeconomic inequalities in health, to which coronary heart disease makes the greatest contribution (Ljung et al. 2005). Even though incidence and mortality rates are decreasing, the social differences persist (FHR 2005).

Geographical differences in myocardial infarction (MI) are considerable, even in Sweden. In Stockholm, the incidence varies between municipalities by a factor of 2.3 for women and 2.0 for men (Hammar et al. 1998) However, as Duncan argues, “it must not be concluded in a circular argument that because health outcomes vary geographically, that places must make a difference. Rather we need both an understanding of the mechanisms by which places can affect people, and rigorous empirical evidence that this is indeed the case” (Duncan et al. 1993).

My intention with this work is to contribute pieces of empirical evidence that will promote such understanding.
1.1 Background
During the 1990s the future development and focus of epidemiology were extensively debated. The individually focused risk-factor approach was criticized for not fulfilling the mission of epidemiology, which includes the discovery of “agent, host, and environmental factors which affect health in order to provide the scientific basis for the prevention of disease and injury and the promotion of health” (Terris 1992). Epidemiologists were calling for paradigm shifts, new theoretical frameworks, and alternative conceptual models. A general request for acknowledgment of the combined roles of society, economy and biology at multiple levels of organization was formulated (Krieger 1994, Susser & Susser 1996, Schwartz et al. 1999). The significance of research into the social environment was pointed to, both for preventive actions and for a better understanding of disease aetiology. The social environment has been referred to as encompassing the groups to which we belong, the neighbourhoods in which we live, the organization of our workplaces, and the policies we create to order our lives (Syme 1992, Yen & Syme 1999). Accordingly, epidemiologists reconsidered the prospect that places make a difference to people’s health and well-being (Macintyre et al. 1993, Kaplan 1996, Diez Roux 1998), and neighbourhood research came to be part of the public-health agenda (Kawachi & Berkman 2003).

1.2 Social context and myocardial infarction
1.2.1 Myocardial infarction
Cardiovascular disease (CVD) is the leading cause of death, both in Sweden (FHR 2005) and worldwide (WHO 2004). Coronary heart disease kills more than 7 million people each year, and causes 43 percent of global deaths from CVD, which makes it the most prominent type of cardiovascular disease. The contribution to disability-adjusted life years (DALY) is considerable. Among men, coronary heart disease is responsible for 7 percent of the global DALYs, and thereby the second largest disease, while it accounts for 5 percent among women as the third greatest disease (WHO 2004).

Death rates from coronary heart disease are decreasing in Sweden, and also in many other Western countries, following a century of increasing death rates (Nieto 1999). In Sweden, the decrease was 23 percent from 1987 to 2002, which accounted for a substantial increase in life expectancy. Among men, the 3-year observed gain in life expectancy was almost solely attributable to the decrease in cardiovascular death rates (FHR 2005).

The onset of cardiovascular symptoms is usually seen in late middle age. As for myocardial infarction, women have lower incidence and tend to show clinical manifestations about ten years later than men (Hammar et al. 1998). However, the
underlying processes develop over the life-span, and there are indications of in-uterus processes (Lawlor et al. 2004, Perry & Lumey 2004); atherogenesis may start even in childhood (Kuh & Davey Smith 1997). Further factors with short-term effects, and also triggering factors (Möller 2003) have been recognized. This means that a variety of factors may be of importance at various phases of the disease process. However, uncertainties regarding the aetiology of MI still remain.

There are geographical and regional variations in CHD (Alfredsson 1983, Hammar 1992, Hammar et al. 1998, 2001) that, even in Sweden, have contributed to an increased interest in possible determinants and underlying mechanisms. Environmental factors, such as air pollution, noise exposure and quality of drinking water, have been evaluated (Rosenlund 2005). Further, as a reaction to regional variation in case-fatality rates, quality differences in the health-care system have been discussed (Köster et al. 2003), and differences (albeit disputable) between hospitals have been indicated (Merlo et al. 2005, Ahlbom et al. 2005). Ecological correlations between mortality rates and area-level deprivation (Malmström et al. 1999) have suggested social explanations, and the findings have been further explored in multi-level studies of incidence based on both individual and area information (Stjärne et al. 2002, 2004, Sundquist et al. 2004). Further, higher rates of out-of-hospital deaths have been found in deprived areas (Tydén et al. 2001). Out-of-hospital deaths, by contrast with the quality of in-hospital care, may be seen not only as a sign of propensity to seek emergency treatment, or time for transportation to an emergency unit, but also as an indicator of co-morbidity and severity of atherosclerosis.

1.2.2 The local social context

The most common way of looking at geographical differences related to area-level deprivation is to consider them as compositional, and thereby reducible to differences between the types of people living in any one neighbourhood. An implication of this is that poor people have the same mortality rate wherever they live, whereas – given a contextual explanation – mortality rates among poor people will vary according to which kind of area they live in. Also, on a contextual explanation, the health of people in the mid-income range and high-income earners depends to some extent on their social context. In 1993, it was noted by Macintyre et al. that area-level data were commonly used as surrogates for missing individual-level data, which led them to point to the need to study features of the local social and physical environments that might promote or inhibit health; they suggested that improvements in public health might be achieved by a greater focus on places.

Their study was followed by an examination of the impact on mortality of area-level deprivation in England and Wales, adjusted by individual deprivation, which
concluded that “the evidence does not confirm any social miasma whereby the shorter life expectancy of disadvantaged people is further reduced if they live in close proximity to other disadvantaged people” (Sloggett & Joshi 1994, p. 1473). This paper worked as a trigger for a wave of studies attempting to isolate contextual effects from compositional ones with regard to different health outcomes (Pickett & Pearl 2001, Kawachi & Berkman 2003).

The idea of studying effects at multiple levels of organizations is by no means new (Yen & Syme 1999). In 1969, Valkonen wrote a sociological paper on individual and structural effects in ecological research, where he defines and discusses many of the obstacles that (despite method development) still represent the main issues of socio-epidemiological research into neighbourhoods and health. Contextual analysis is referred to as the approach used to studying the effects of properties of groups or collectives on individual outcomes. Special emphasis is placed on the investigation of structural effects, where the analytical variables are formed from the properties of members of the collectives, such as average educational level or proportion of workers in an area. These are separated from the global effects of value systems, norms or climates, which have no individual-level equivalents. On the issue of whether geographical and regional variations in outcomes are reducible to individual-level explanations he argues that:

“If the ecological variation of y can be explained by the ecological variation of x, a new question may arise: How then can the ecological variation of x be explained? The explanation can be found in new variables that have ecological variance. However in some phase of the causal chain there apparently must be a global-type variable characterizing the areas as wholes and explaining the differences in the composition of the populations of the areas” (Valkonen 1969, p. 55).

1.2.3 Health effects
A vast majority of multilevel studies that explore the health effects of varying neighbourhood characteristics have investigated their impact on all-cause mortality (reviewed in Pickett & Pearl 2001, Kawachi & Berkman 2003). An early influential investigation within the confines of the Alameda County Study was performed by Haan et al. They reported an increased age-, sex-, and race-adjusted mortality risk of 1.71 among residents living in poverty areas, which essentially remained following adjustment for individual socioeconomic position and health behaviours. They concluded that “these results support the hypotheses that properties of the social environment may be important contributors to the association between low socioeconomic status and excess mortality and this contribution is independent of individual behaviours.” (Haan et al. 1987, p. 989). Since then, multilevel studies have
linked neighbourhood deprivation and different measures of poverty to a wide range of health-related outcomes and health behaviours, such as risk of smoking (Diez Roux et al. 1997, 2003, Duncan et al. 1999), higher body mass index (Ellaway et al. 1997), lower quality diet (Diez Roux et al. 1999, Lee & Cubin 2002), and ill-health, including depressive symptoms (Yen & Kaplan 1999) and poor self-rated health (Robert 1998). Further, infectious disease, infant mortality and low birth weight, and asthma are linked to neighbourhood conditions in a “state of the art” volume edited by Kawachi & Berkman (2003).

In addition to the four studies presented in this dissertation, we have found ten multi-level studies that investigate neighbourhood context in relation to CVD. All are original studies of the effect of neighbourhood social context on individual cardiovascular disease mortality and coronary heart disease morbidity, adjusted for individual socioeconomic position (SEP). The results of the ten studies are presented in the right-hand column of Table 1. For sake of comparability, the reported results are all contextual effects, adjusted by individual social characteristics (but to different extents). In four studies, neighbourhood was defined as a census tract or similar, and in six studies as a census block-group. Eight of the studies use summary measures to define the neighbourhood context, whereas the other two use single indicators. Outcomes vary, as do the age groups considered; further, some results are adjusted by sex whereas others are stratified. All of this restricts comparability. In general, all but one of the studies find a significant effect of neighbourhood context on individual cardiovascular disease mortality and coronary heart disease morbidity when individual social characteristics are adjusted for. However, the effects seem to be weaker among older age-groups.

Taken together, the general conclusion seems to be that where you live matters for your health, although probably not as much as who you are (Pickett & Pearl 2001). Nevertheless, elucidating the causal relation between context and health requires more attention to be paid to issues related to residual confounding, the role of individual-level variables, reciprocal effects, and study designs (Blakely & Woodward 2000, Diez Roux 2001, 2004, Macintyre et al. 2002, Oakes 2004, Subramanian 2004). Revealing the causal role played by context is indeed a multidisciplinary task.
<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Geographic areas</th>
<th>Contextual Measure</th>
<th>Outcome</th>
<th>Contextual effects adjusted by individual SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borrell et al. 2004 Atherosclerosis Risk in Communities Study</td>
<td>Residents in four communities in the United States, 45-64 yrs</td>
<td>Census-block groups, average population 1,000</td>
<td>A summary score of: • Median household income • Median value of housing units • Households with interest, dividend or rental income • Adult residents who completed high school • Employed residents with high grade occupations</td>
<td>Cardiovascular disease mortality</td>
<td>Highest vs. lowest tertile adj. by age, sex, income, education, occupation White 1.4 (1.0-2.2) African Americans 1.1 (0.8-1.6)</td>
</tr>
<tr>
<td>Davey Smith et al. 1998 Reinfrew and Paisley Study</td>
<td>Residents in the towns of Reinfrew and Paisley, 45-64 yrs</td>
<td>Postcode sectors, average population 4,660</td>
<td>Carstairs deprivation score: • Male unemployment • Household overcrowding • Car ownership • Households in semi and unskilled manual occupations</td>
<td>Cardiovascular disease mortality</td>
<td>Carstairs scores category 6-7 relative to 1-3, adj. by age, social class Women 1.33 (1.05-1.69) Men 1.26 (1.04-1.52)</td>
</tr>
<tr>
<td>Diez Roux et al. 1997 Atherosclerosis Risk in Communities Study</td>
<td>Residents in four communities in the United States, 45-64 yrs</td>
<td>Census-block groups, average population 1,000</td>
<td>Four different indicators: • Adults with incomplete high school • Median household income • Median value of houses • Proportions of people in occupational categories II-VI</td>
<td>Prevalence of coronary heart disease (ECG abnormalities or earlier diagnosed MI, coronary heart surgery, balloon angioplasty)</td>
<td>Categories based on decile values category 10 vs. category 1, adj. by age and individual income or education (area level analogue) Women from 1.66 to 2.82 (all 95% CI above 1) Men from 0.82 to 1.26 (all 95% CI including 1) No effects were found in predominantly black communities</td>
</tr>
<tr>
<td>Diez Roux et al. 2001 Atherosclerosis Risk in Communities Study</td>
<td>Residents in four communities in the United States, 45-64 yrs</td>
<td>Census-block groups, average population 1,000</td>
<td>A summary score of: • Median household income • Median value of housing units • Households with interest, dividend or rental income • Adult residents who completed high school • Employed residents with high-grade occupations</td>
<td>Incidence of coronary heart disease</td>
<td>Highest vs. lowest tertile, adj. by age, income, education, occupation; White women 1.9 (1.1-3.1) men 1.7 (1.2-2.4) African Americans women 1.5 (0.9-2.5) men 1.3 (0.7-2.2)</td>
</tr>
<tr>
<td>Diez Roux et al. 2004 The cardiovascular health study</td>
<td>Residents in four communities in the United States, 65 yrs and older</td>
<td>Census-block groups average population 1,000</td>
<td>A summary score of: • Median household income • Median value of housing units • Households with interest, dividend or rental income • Adult residents who completed high school • Employed residents with high-grade occupations</td>
<td>Cardiovascular disease mortality</td>
<td>Highest vs. lowest tertile adj. by age, sex, income, education, occupation White 1.5 (1.2-1.9) African Americans 1.2 (0.7-2.2)</td>
</tr>
<tr>
<td>Study</td>
<td>Population Details</td>
<td>Measures</td>
<td>Prevalence Measures</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Lawlor et al. 2005 British Women's Heart and Health Study</td>
<td>Women in 23 British towns, 60-79 yrs</td>
<td>Electoral ward average population 5,700</td>
<td>Prevalence of coronary heart disease/angina pectoris</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LeClerc et al. 1998 National Health Interview Survey 1986-1990</td>
<td>Non institutionalized civilian female population in the United States 60 yrs and older</td>
<td>Census tracts average population 4,000</td>
<td>Proportion of female-headed families</td>
<td>Heart disease mortality (ICD9 390-456) &gt;24% relative to ≤9.9% adj. by age, race, income education marital status, employment status, BMI pre-existing condition</td>
<td></td>
</tr>
<tr>
<td>Nordstrom et al. 2004 The cardiovascular health study</td>
<td>Residents in four communities in the United States, 65 yrs and older</td>
<td>Census-block groups average population 1,000</td>
<td>A summary score of:</td>
<td>Prevalence of subclinical cardiovascular disease (asymptomatic atherosclerosis, ECG or echocardiogram abnormalities, angina pectoris, intermittent claudication) Highest vs. lowest tertile adj. by age, sex, race, income, education, occupation 65 yrs and older 1.25 (0.97-1.60)</td>
<td></td>
</tr>
<tr>
<td>Sundquist et al. 2004</td>
<td>Swedish population 20 yrs and older</td>
<td>Small Area Market Statistics average population 1,000</td>
<td>Care Need Index;</td>
<td>Incidence of non-fatal coronary heart disease (ICD9 410-414) Categories based on decile values category 10 vs. category 1 adj. by age and individual income</td>
<td></td>
</tr>
<tr>
<td>Wiltzaman and Smith 1998 National Health and Nutrition Examination Study 1971-1974</td>
<td>Residents in the United States 25-74 yrs and older</td>
<td>Census tracts average population 4,000</td>
<td>Federal criteria for poverty area;</td>
<td>Cardiovascular disease mortality Poverty areas adjusted by age, sex, race, marital status, income, education, BMI, smoking, alcohol, exercise, baseline health status, hypertension, cholesterol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low income families;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low education;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unemployed;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Substandard housing;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unskilled male labourers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Children in homes with single parents</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Multi-level studies of the neighbourhood context in relation to cardiovascular disease mortality and coronary heart disease morbidity.
2 Aims
The overall aim of this dissertation is to study the potential influences of local social environment on incidence of myocardial infarction (MI), and thereby contribute to understanding its social aetiology.

2.1 Specific objectives
- To define and measure relevant social dimensions of the neighbourhood context (I-IV).
- To investigate whether there is any contextual effect at all of the local social environment on incidence of MI (I-IV).
- To analyse whether different aspects of the local social environment have similar contextual effects on the incidence of MI (I-IV).
- To study the mechanisms underlying any such effects, with an emphasis on the interplay between the social context and individual socioeconomic position (III-IV).
- To evaluate established biomedical risk factors and health behaviours as mediating mechanisms (III).
- To study whether and how differentiation in neighbourhood contexts contribute to social inequalities in incidence of MI (IV).

The specific empirical questions are addressed in the Results section (5.1-5.4).
3 Material and methods
All four studies in this dissertation are based on material from the Stockholm Heart Epidemiological Program (SHEEP). The original database was supplemented with a broad range of contextual information collected from data sources, including Swedish censuses, several routine registers (such as the income-tax, motor-vehicle, land registries, etc.), and a registry-based total population cohort. The procedure is described in detail in Section 3.6.

3.1 Studybase
SHEEP is a population-based case-control study of the causes of myocardial infarction, reported on in detail earlier by Hallqvist (1998), Reuterwall et al. (1999), Möller (2003) and Bennet (2003). The study base consists of all Swedish citizens aged 45-70, resident in Stockholm County with no prior clinically diagnosed MI in anamnesis. Men were included from 1992 to 1993 (two years) and women from 1992 to 1994 (three years). During the period January to October 1992, the upper age limit was 65 years, but from November 1992 onwards it was set at 70 years. The incidence of MI in Stockholm 1993-1995 was 13 for women and 42 for men per 10,000 person-years in the age group 45-69.

3.2 Case definition
3.2.1 Identification
Cases were recruited from three sources: all coronary and intensive care units at the internal medicine departments of the ten emergency hospitals in Stockholm County (97 percent of all non-fatal cases), the computerized Hospital Discharge Register for the County, and death certificates from the National Register of Causes of Death maintained by Statistics Sweden (SCB). Cases were included at time of disease onset.

3.2.2 Classification
Cases were diagnosed according to standardized criteria accepted by the Swedish Association of Cardiologists in 1991 (heart intensive care - 1990). An acute myocardial infarction was considered to be present if there were typical symptoms in combination with changes in enzyme levels (CK, CK-MB or LD) or the appearance of a new pathologic Q-wave on ECG, or – for fatal cases – on the basis of autopsy findings (66 percent of the female fatal cases, and 72 percent of the male). To ensure that only individuals with first-time MI events were included in the study, each case were checked for earlier MIs, from 1975 and onwards, in the Hospital Discharge Register. Potential subjects were also asked questions about earlier events, and medical records were consulted when required. In total, the study comprised 538 non-fatal female
cases and 1,105 male cases. The fatal cases were 223 female and 380 male, defined as death within 28 days of onset.

3.3 Sampling of controls
One control per case was randomly selected from the corresponding study base, strata-matched to cases by age, sex and hospital-catchment area (ten areas). A computerized register of the Stockholm population was used to sample five control candidates per case within two days of the case event. In this way, another candidate who belonged to the study base at the time of case incidence could replace a non-responding control. Controls for non-responding cases were included, and occasionally both the initial and substitute control were included due to a late reply on part of the former. Accordingly, there were finally more controls than cases. All controls were initially checked for previous MI using the same procedure as for cases; they were all alive when recruited, regardless of the vital status of the corresponding case. In total, 1,118 female and 2,088 male controls were encompassed by the analyses.

3.4 Collection of individual information
All participants received a postal questionnaire covering a large set of potential risk factors. A telephone interview minimized partial non-participation (missing data within a returned questionnaire). Information on fatal cases was obtained six to twelve months later from close kin. Response rates to the questionnaire were 72 percent for females and 81 percent for males, while the corresponding figures for controls were 70 percent and 75 percent respectively. Subjects responded to about the same extent in different age groups, and were equally inclined to participate regardless of catchment area. For non-fatal cases and their controls, a health examination was carried out approximately three months after disease onset. Participants were requested to attend a medical centre after over-night fasting for blood sampling, blood-pressure measurements and anthropometrical tests.

The database was continuously updated with information from new laboratory tests, and in 2003 extensive linkage of register-based information concerning income, wealth and family structure was carried out. Further, the address history from the questionnaire was used in 2002 to allocate geographic information system (GIS) codes to each participant.

3.5 Contextual units
3.5.1 Theoretical definition
The contextual constructs studied in this dissertation are all defined at neighbourhood level. We consider the neighbourhood to be the natural social arena or unit
within which inhabitants regularly interact with each other and with institutions. There is no “single definition” of neighbourhood. In Sampson’s (1999) view, the traditional definition from the early Chicago School is worth preserving; a neighbourhood then refers to an ecological subsection of a larger community, a collection of both people and institutions occupying a spatially defined area that is conditioned by a set of ecological, cultural and political forces (Park 1916). Sampson regards two aspects as of key importance; neighbourhoods are ecological units, and they are nested within successively larger communities. He further acknowledge that the size of a neighbourhood differs according to the phenomenon of interest, and states that, operationally, it is possible to conceive of a hierarchy of imbricate ecological units that vary in size and function.

However, in epidemiological studies the choice of most appropriate statistical unit is often driven by data availability. To some extent, this was the case for the studies in this dissertation, although data access and the possibility of obtaining different levels of aggregation must generally be considered as good in Sweden.

Various operationalizations have been evaluated in relation to health outcomes. In work by Krieger et al. (2002 AJE, AJPH), census tracts and census-block groups are treated as the most suitable geographical units for the monitoring of social inequalities in health in the US, but use of zip codes is improper for this purpose. The same conclusion was drawn by Reijneveld et al. (2000) in a study from Amsterdam (where results were also adjusted according to individual socioeconomic position). Census tracts/block groups are fairly homogenous with regard to population characteristics, economic status and living conditions, whereas zip-code/postcode sectors are administrative units established by the postal service for the most efficient delivery of mail. However, even after the criterion of having socially meaningful geographical boundaries is met, the question of appropriate level of aggregation persists, and is dependent on the specific research question. Scale effects are often found. The general pattern is that the effects of measures pertaining to the level of economic poverty/wealth increase at lower levels of aggregation, whereas effects of measures of income inequality weaken when moving from higher to lower levels and may even change direction (Soobader & LeClere 1999, Blakely et al. 2002, Hou & Myles 2005).

3.5.2 Identification of ecological units
In this dissertation, two different statistical units for the quantitative measurement of neighbourhood context have been used – parishes in Study I, and census areas in studies II-IV. The SHEEP database comprises individual address history, including information on parish and municipality affiliation. In Study I, the local social context was operationalized at parish level, which approximately corresponds to a census tract. In 1990
Stockholm County comprised 143 parishes, 89 metropolitan and 54 rural (as defined by the number of block buildings in the area). Populations ranged in size from 816 to 56,478 in the 89 metropolitan parishes, and the median population was 14,422.

Before the second study was conducted, GIS codes were assigned to all SHEEP participants, thereby enabling us to define the census area in which each person lived. Thus, in studies II-IV the local social context could be operationalized by census area (which approximately corresponds to a census-block group). The census areas (FoB-områden) originate from the first census (1960), and are defined according to homogeneity criteria regarding types of buildings and land use – with the aim of discriminating between urban and rural areas, housing and working areas, and small-houses and apartment-block areas. Boundaries were revised with each census (every fifth year), until the final census was carried out in 1990. From that year the classification has been called the base-area classification (basområdesindelningen), which is continually updated by the Office of Regional Planning and Urban Transportation.

In 1990, Stockholm County comprised 1,133 base areas, of which 982 were urban. Urban areas are defined as ones with no less than 200 inhabitants, or no more than 200 metres between buildings. Since processes of economic and residential segregation differ between rural and urban areas, our contextual analyses are based on urban areas, with the further exclusion of sparsely inhabited and industrial sites.

3.6 Definition, classification and measurement of contextual exposures

This dissertation mainly focuses on the effects of differentiation in the structural distribution of resources within urban areas and, as a consequence, the level of socioeconomic resources in neighbourhoods. Uncertain of whether social differentiation was ecologically structured, and – even if it was – whether this would have contextual effects with regard to MI, we adopted an explorative approach. This entailed mapping out different aspects of the social context within the urban region (Study I). Led by our earlier findings and by the work of others, we built upon an established conceptual distinction between material and social forms of deprivation (Townsend et al. 1988, Macintyre et al. 2002) (Study II). To allow for questions regarding the entire range of resources at area level, i.e. not only the clustering of disadvantage but the structural distribution of resources (Lynch et al. 2000), we focused on level of economic resources and investigated interaction with socioeconomic homo/heterogeneity in neighbourhoods (Paper III). Finally (in Paper IV), we adopted theories of the distribution of advantage (Massey 1996, Browning & Cagney 2003) and evaluated the association between concentration of affluence and MI.

There follows below a description of the contextual concepts employed, presented in chronological order.
3.6.1 Local social context

*Theoretical and Empirical Definition*

For the first study we used an explorative approach, based on factorial ecology and theories of social-area analyses, in order to describe the social context in residential areas. This analytical approach has its roots in the Chicago School of Sociology, where several sociologists described the patterns and consequences of city growth and development. In the 1950s Shevky and Bell (1955) developed three constructs to reflect social differentiation and stratification in urban industrial society, namely social rank, urbanization and family status, and segregation. As a reaction to their theory of social-area analysis, quantitative methods – in particular, factor analyses (Yen & Syme 1999) – were developed for the description of neighbourhoods. Indeed, typologies based on this schema came to be known as “social area analyses,” the main idea being that social stratification manifests itself by geographical area (Berry & Kasarda 1977, Sampson 1999). Studies of American cities based on factor-ecology approaches have largely confirmed that social differentiation occurs along the dimensions of *socioeconomic status*, *family stability* (e.g. household composition, divorce, and proportion of elderly) and *ethnic status*.

*Measurement*

We conducted factor analyses on 21 social, economic and demographic indicators that might theoretically be of importance for the assessment of a social context. Factor analysis is based on the assumption that some underlying dimensions, which are smaller in number than the number of observed variables, are responsible for any covariation found between observed variables. An exploratory factor analysis based on maximum likelihood estimates was performed. In order to avoid making any prior assumption about the correlation between factors we used an oblique rotation with a solution based on the oblimin criterion with Kaiser normalization. Three factors were extracted, which jointly explained 75 percent of the common variance.
Table 2. Pattern matrix from the factor analysis with loadings for each socioeconomic indicator (loadings ≥ 0.5 marked in bold).

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low education, 45–64 years</td>
<td>0.99</td>
<td>0.04</td>
<td>-0.07</td>
</tr>
<tr>
<td>High-income men, 20–64 years</td>
<td>-0.95</td>
<td>-0.46</td>
<td>0.07</td>
</tr>
<tr>
<td>White collar</td>
<td>-0.94</td>
<td>0.11</td>
<td>-0.10</td>
</tr>
<tr>
<td>Blue collar</td>
<td>0.91</td>
<td>-0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>Low education, 25–44 years</td>
<td>0.85</td>
<td>-0.35</td>
<td>0.03</td>
</tr>
<tr>
<td>Unemployed, 18–24 years</td>
<td>0.59</td>
<td>-0.10</td>
<td>0.13</td>
</tr>
<tr>
<td>Living alone, 45–64 years</td>
<td>-0.06</td>
<td>0.97</td>
<td>-0.14</td>
</tr>
<tr>
<td>Living alone, 65 years+</td>
<td>-0.11</td>
<td>0.89</td>
<td>-0.12</td>
</tr>
<tr>
<td>Moved to</td>
<td>-0.05</td>
<td>0.74</td>
<td>-0.10</td>
</tr>
<tr>
<td>Owner occupied</td>
<td>0.10</td>
<td>-0.72</td>
<td>-0.28</td>
</tr>
<tr>
<td>Low-income men, 20–64 years</td>
<td>0.17</td>
<td>0.69</td>
<td>0.24</td>
</tr>
<tr>
<td>Moved from</td>
<td>-0.10</td>
<td>0.68</td>
<td>0.19</td>
</tr>
<tr>
<td>Not gainfully employed, 45–64 years</td>
<td>0.19</td>
<td>0.66</td>
<td>0.38</td>
</tr>
<tr>
<td>Unemployed, 25–64 years</td>
<td>0.24</td>
<td>0.65</td>
<td>0.36</td>
</tr>
<tr>
<td>Immigrants, non-European</td>
<td>-0.06</td>
<td>-0.03</td>
<td>0.86</td>
</tr>
<tr>
<td>Social welfare</td>
<td>0.24</td>
<td>0.17</td>
<td>0.75</td>
</tr>
<tr>
<td>Not gainfully employed, 25–44 years</td>
<td>-0.17</td>
<td>0.34</td>
<td>0.74</td>
</tr>
<tr>
<td>Social housing</td>
<td>0.21</td>
<td>0.03</td>
<td>0.68</td>
</tr>
<tr>
<td>Lone parent</td>
<td>0.16</td>
<td>0.05</td>
<td>0.63</td>
</tr>
<tr>
<td>#Nationalities</td>
<td>-0.33</td>
<td>0.17</td>
<td>0.57</td>
</tr>
<tr>
<td>Immigrants, European</td>
<td>0.18</td>
<td>-0.20</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Our interpretation of the derived factors encompasses the following:

- The first factor defines Swedish working-class areas with low mobility, where young adults have difficulties in entering the labour market.
- The second factor defines areas with high migration and exclusion from family and the labour market, primarily among the middle-aged and elderly.
- The third factor defines ethnically heterogeneous areas with high proportions of social housing, welfare recipients and single parents.

Accordingly, our findings show interesting similarities with the dimensions – socioeconomic status, family stability and ethnic status – suggested by earlier American studies.
Exposure categories
To evaluate the effects of contextual dimensions on MI three factor scales were created. We used a regression method that creates scales in such a manner that the correlation between the underlying common factor and the scale is maximized (Kim & Mueller 1989). Parishes were divided into five categories according to their quintile values; the effect of any contextual feature was evaluated without any prior assumption being made regarding the form of the relationship in question.

3.6.2 Social fragmentation
Theoretical and empirical definition
In the second study we sought to evaluate the effects of social forms of deprivation distinct from their material counterparts (and vice-versa). Townsend et al. (1988) describes social forms of deprivation as involving non-participation in roles, relationships, customs and functions, and a lack of the rights and responsibilities implied by membership of a society. Social fragmentation can be seen as a component of social deprivation. We use a measure developed by Congdon (1996), which has been primarily employed in studies of suicide. It is ultimately based on Durkheim’s theories of social integration, but also corresponds to the family-stability factor defined for the social-area analyses described in 3.6.1. According to Congdon the index seeks to measure social integration and social support resting on non-institutional ties (with partners or families) and institutional and community ties. Social integration (regarded as positive) is characterized by stable family lifestyle, low population turnover, and possibly some religious and/or ethnic community structures; by contrast, social fragmentation (regarded as negative) is characterized by social isolation, weak kin and community ties, and a non-family household bias (Congdon 2004).

Measurement
The Congdon index is a composite one, encompassing: private households in rented accommodation, residents aged under 65 and living alone, residents aged over 15 and not married, and residents who moved in or out during the previous year. To summarize the indicators in a single index, each area value is z-transformed by subtracting the overall mean and dividing by the standard deviation. The z value reflects the area’s deviation from the mean on any one indicator.

Exposure categories
The neighbourhoods were divided into four categories according to their quartile values on the social-fragmentation index. Thereby, the contextual effect of a relatively high level of social fragmentation could be evaluated in relation to MI incidence.
3.6.3 Material deprivation

*Theoretical and empirical definition*

Townsend and colleagues (1988, p. 36) define material deprivation as follows: “Material deprivation entails a lack of goods, services, resources and amenities, i.e. an absence of the physical environment that is customary in the society in question.” The authors further state that “indicators of deprivation are sometimes direct and sometimes indirect, sometimes representing conditions or states and sometimes representing the victims of those condition or states. From a sociological perspective it is important to distinguish between the measurement of deprivation in different areas and the kind of people experiencing that deprivation.” This point is of even greater importance when moving from ecological studies of the unequal distribution of health to multilevel studies of health determinants at individual and structural levels. Treating immigrants, children or the elderly as a part of the deprivation phenomenon implies that a high concentration of these groups causes disease.

The measure of area deprivation constructed by Townsend et al. in 1988 consists of four different indicators: unemployment, car ownership, housing tenure, and overcrowding. Unemployment was used as an indicator of a general lack of material resources and the insecurity to which this gives rise. Car ownership and housing tenure were included as proxies for income data, car ownership reflecting current economic situation, and owner occupancy reflecting wealth and income in the longer term (although housing tenure might in fact reflect more aspects of wealth and stability than income). Overcrowding represents living circumstances and housing condition.

*Measurement*

Like the Congdon index, Townsend’s index of relative material deprivation is a summary measure. Two indicators (overcrowding and unemployment) were log-transformed due to their skewed distributions, then all indicators were z-transformed and summed with equal weights. Values were imputed for areas with a missing value on only one item (n=29). A regression model was fitted with available data, and predictions of the missing values were made on the basis of the regression equation.

*Exposure categories*

To evaluate the effects of area deprivation on MI, neighbourhoods were divided into four categories according to their quartile values. Thereby, we do not measure the effects of a specific level of material resources, but rather the effect of a level of material deprivation in neighbourhoods relative to other levels, i.e. the effect of living in contexts that are most deprived in relation to those living in contexts with least deprivation within the same society.
3.6.4 Level of economic resources

*Theoretical and empirical definition*

The neighbourhood economic context embraces a broad range of aspects with a possible health impact. Our aim in Study III was to elaborate on the influence of resource level in combination with homo/heterogeneity aspects. The neo-materialist hypothesis entails that, even after basic material conditions are satisfied, additional improvements might conceivably produce gains in health, and that health is sensitive to fine gradations of material conditions within wealthy countries, both at individual and structural levels (Lynch et al. 2000). We regard this as an argument for focusing on resource levels across the entire range, not only in deprived contexts. Level of economic resources is an indicator of a variety of underlying conditions. Macintyre and colleagues published an influential paper in 1993, in which they conceptualized socio-environmental influences on health. They presented five organizing categories, of which three have later (Macintyre et al. 2002) been considered as belonging to material and infrastructural resources, i.e. the physical setting shared by all residents, the availability of healthy environments, and services provided to support people in their daily life. The level of economic resources is considered as a property of the neighbourhood socioeconomic environment; however, if substantial contrasts are present, it may also be a sign of residential economic segregation within an urban region.

To assess the level of economic resources in neighbourhoods we calculated median income in each one. The median gives the amount of disposable income held by the person with the mid-position in the area distribution based on rank order, which makes it insensitive to extreme values or outliers.

*Measurement*

Equivalent disposable household income was used as a measure of income. Our calculations were based on a register-based total population cohort, including all individuals aged 18 years or over in 1990. This concept of income includes earnings and income from self-employment from both spouses, and the cash benefits that the family receives, and it also accounts for taxes paid. In order to compare income between individuals from households of differing size and structure, we adjusted income in line with an equivalence scale. The scale used was based on the norms for social assistance in Sweden at this time.

*Exposure categories*

The neighbourhood median income variable was left untransformed, and modelled both as a continuous and as a categorical variable. Categories were based on quartile values of the neighbourhood distribution – although aggregated into three categories
when the cross-classification with neighbourhood income dispersion was made, and then into two categories when cross-classified with personal income.

3.6.5 Degree of socioeconomic homogeneity or heterogeneity

Theoretical and Empirical Definition

We assessed income dispersion within neighbourhoods, considering it as a measure of socioeconomic heterogeneity or homogeneity. A relatively high income dispersion within a neighbourhood indicates that a certain degree of socioeconomic heterogeneity is present, mirroring a mix of residents with divergent social and economic characteristics. Absence of income dispersion, on the other hand, indicates a high degree of socioeconomic homogeneity within a neighbourhood. In combination with substantial contrasts in income levels between neighbourhoods, this would be an expression of spatial social polarization. The residential composition of a neighbourhood is partly a result of housing and zoning strategies, but is also driven by segregation processes in a wider sense. Our hypothesis is based on the long-standing claim in social planning that it is an advantage to society if people from different walks of life share the same neighbourhood (SOU 1990, Olsson 1992). The suggestion that economic heterogeneity in urban communities has beneficial effects can be found in sociological research as well. Based on studies of American urban ghettos, Wilson (1987) argues that the social transformation of inner-city areas has resulted in an increased concentration of the most disadvantaged segment of the urban black population, and that removal of middle/upper-income black families destroy an important social buffer to the effects of prolonged joblessness and industrial transformation. He further argues that a certain proportion of middle/upper-income people are necessary in urban communities to sustain basic institutions. It should be emphasized that this line of reasoning applies to subunits within an urban area, and is not to be confused with the income-inequality hypothesis (Wilkinson 1992), which is couched at a higher level of aggregation. As earlier pointed out, a low degree of income dispersion within a neighbourhood is not incompatible with high-income dispersion within the referent urban region or nation (Fritzell 2005).

A procedure for operationalizing the concept of homogeneity/heterogeneity is not self-evident, and we considered four different approaches: a) distance between percentile 20 and percentile 80, b) ratio of percentile 80/percentile 20, c) coefficient of variation, and d) the Gini coefficient. The Gini coefficient was chosen in the extended analyses on ground that it has previously been used in studies of the same kind (Soobader & LeClere 1999, Blakely et al. 2002, Hou & Myles 2005). Moreover, it is scale-invariant, measuring dispersion independent of income level; it is also insensitive to extreme values in both tails, since it is based on rank order, and is thereby robust in calculations with small numbers. The coefficient ranges from 0 to
1, where 0 represents total homogeneity, and 1 maximum heterogeneity. If the Gini coefficient is 0, every share of the cumulative population possesses an equal share of total disposable income in the unit of analysis.

**Measurement**
The coefficient for each area is given by:

$$Gini = 1 - \sum_{i=0}^{k-1} (Y_{i+1} + Y_i) \ (X_{i+1} - X_i)$$

where $Y =$ cumulative proportion of disposable income, $X =$ cumulative proportion of the population, $k =$ number of individuals. The Lorenz curves in Figure 1 graphically illustrate the neighbourhood range of income homogeneity and income heterogeneity (Gini coefficient 0.09 - 0.76). The graph shows the cumulative area population on the x-axis and the cumulative area income in the y-axis. The diagonal line shows a totally equal income distribution, where every individual earns an equal share of the summed income within the neighbourhood. The line closest to the diagonal indicates the area with most income homogeneity in Stockholm, and the third line indicates the area with most income heterogeneity. The coefficient reflects the area between the diagonal and the curve.

![Lorenz curves](image.png)

**Figure 1.** Lorenz curves illustrating the range of neighbourhood income homogeneity and income heterogeneity in Stockholm 1990.
Exposure categories

Categories of exposure were based on quartile values of the neighbourhood distribution. When cross-classified with neighbourhood income level, an aggregation to three categories was performed: 25 percent with most income homogeneity, 50 percent intermediate areas, and 25 percent with most income heterogeneity.

3.6.6 Concentration of affluence

Theoretical and Empirical Definition

Although area-level studies mostly have tried to measure the other end of the economic distribution, typically measuring poverty rates, we would argue that it is both theoretically and empirically of great interest also to focus upon the better-off. First, the affluent, rather than the poor, are in many respects the driving force behind any process of spatial polarization, since they have more options and choice in deciding where to live. In line with this, research results have shown that high-income earners are more segregated than poor people, both in the U.S. (Massey 1996) and Sweden (Andersson 2000). In the U.S., at least, growing economic segregation is also, as pointed out by Danziger (1996) among others, driven by a rising concentration of affluence. In ongoing research on the health effects of concentration of affluence, it has been proposed that the actual distribution of advantage is a crucial dimension of the economic structure (Robert 1998, Waitzman & Smith 1998, Browning & Cagney 2003, Wen et al. 2003).

It has been suggested that the underlying mechanisms are that affluent residents draw more and higher quality health services to their neighbourhoods, and reinforce the viability of local organizations and services that indirectly benefit health (Browning & Cagney 2003).

Measurement

We use the proportion of high-income earners in each neighbourhood to measure concentration of affluence. The income measure used is equal to the income measure described in 3.6.4. The exact operationalization of high-income earners, is of course, arbitrary but it still coincides fairly well with results derived from other procedures. Our dividing line is 150 percent of median income, i.e. three times the poverty level, assuming a standard poverty threshold of 50 percent, whereas Massey (1996), for example, used a measure equivalent to four times the poverty threshold in an American context. The cut-off point we used for equivalent disposable household income was SEK 127,000, which left us with 154,400 individuals, i.e. 12 percent of the income earners in Stockholm County in 1990.
**Exposure categories**

Concentration of affluence was modelled as both a continuous and as a categorical variable. We found no threshold effects in the crude analyses, and the variable was most effective in adjusting the social class difference in MI when used in its continuous form. In the analyses of class-related differential susceptibility, the variable was divided into three categories based on the area-density function: areas below one standard deviation (SD) from the mean, areas within one SD, and areas above one SD.

**3.7 Induction time**

The scientific literature has little to offer concerning what might be the appropriate time interval between contextual exposure and the onset of myocardial infarction. But, as pointed out by Blakely and Woodward (2000), a zero time lag between exposure and outcome is usually implausible in social epidemiology, which makes it necessary to think about the stability over time of the ecological exposure. In Study I we use info-

![Boxplot of length of residence in years at previous addresses and the latest before inclusion among cases and controls.](image)

**Figure 2.** Boxplot of length of residence in years at previous addresses and the latest before inclusion among cases and controls.

...tion on home parish one year before inclusion, whereas in studies II-IV information on latest address before inclusion is used to ascribe relevant neighbourhood context. From this we know that the contextual exposure was present before disease onset, but neither length of residence nor residential mobility was considered. However, we know that residential stability among SHEEP participants is high; 72 percent of the cases and 76 percent of the controls in the study had lived at the same address for 10 years or more, and the average number of addresses over the thirty-year period before disease onset was...
2.5. Rosenlund and Berglund at the dept. of Environmental Health recently analysed the full address history for SHEEP participants. The boxplot gives the length of residence at the latest address before inclusion, and at all previous addresses, among cases and controls. It shows a median length of residence on the latest address before inclusion of 18 years among cases and 19 years among controls.

3.8 Individual exposures, confounders and possible intermediate variables

Individual exposure information and potential individual-level mediators and confounders were assessed through the questionnaire, registry information or the health examination, and defined in accordance with previous reports based on SHEEP material.

3.8.1 Social class
We used the Swedish system of socioeconomic classification (Andersson et al. 1981), which is largely derived from different employment relations, to operationalize social class. Six categories are distinguished: high-grade, intermediate, and routine non-manual employees; skilled and unskilled manual workers; and the self-employed. The classification is based on the underlying aim of differentiating positions within the labour market (Erikson & Goldthorpe 1992).

In studies III and IV adult social-class position is further determined by the so-called dominance method, which regards information on occupation from both spouses, and uses the one considered as having the greatest impact on consumption pattern, type of dwelling and the upbringing of children within a family (Erikson 1984). For study subjects, we use information on latest occupation before inclusion in the questionnaire study, and for their spouses information on latest occupation from the 1990, 1985 and 1980 censuses.

3.8.2 Income
Income is measured as equivalent disposable household income at year of inclusion on the basis of registry data (see the concept of income described in 3.6.4). The income variable is categorized by quartile values, based on the distribution among SHEEP controls.

3.8.3 Confounders
Education was defined as each participant’s highest educational level and mostly categorized as compulsory school or vocational training, upper-secondary (Swedish high) school, and university.
Labour-market position at inclusion was determined as employed and self-employed, on old-age pension, unemployed and housewife, and long-term ill and on early-retirement pension.
Family status was defined as either married or cohabiting or not.
Country of birth was defined as born in Sweden and born abroad.
Social class in childhood is based on information on father’s occupation, or if missing, on mother’s occupation, with subjects being allocated to six classes.

3.8.4 Possible intermediate variables

Health behaviours
Smoking status is defined as either never smoker, ex-smoker or current smoker, and is based on information from the questionnaire. Ex-smokers are those who stopped smoking more than two years previously.
Overweight is defined as body mass index (BMI) >27 kg/m², primarily calculated from weight and height measured at the health examination but, if unavailable, from self-report information in the questionnaire.
Low physical activity during leisure time is derived from the questionnaire, and considered to be present if a person exercises very little or only takes occasional walks.

Biomedical risk factors
A person is considered as having diabetes if there is a questionnaire response specifying insulin, drug or diet-treated diabetes.
Hypertension is defined as a systolic pressure above 170 mmHg, and/or a diastolic pressure above 95 mmHg, and/or on the basis of information from the questionnaire stating the receipt of medical treatment for hypertension.
Elevated total cholesterol is defined as >6.5 mmol/l, or with reference to information on lipid-lowering medication at time of health examination.
Elevated triglycerides are defined as fasting levels above 2.3 mmol/l.
Insulin resistance is defined as fasting levels above 11 mmol/l for women, and 12 mmol/l for men.
4 Statistical methods

4.1 Effect measures

The case-control data were analyzed using both unconditional logistic regression (Rothman & Greenland 1998) in studies I and IV, and random intercept logistic regression (Leyland & Goldstein 2001) in studies II-IV. Parameter estimates were assessed using 95% confidence intervals (CI).

4.1.1 Logistic regression

In Paper I, odds ratios (OR) were calculated as estimators of incidence rate ratios (IRR) to measure the effect of contextual exposures on incidence of MI. The final analyses were performed using unconditional logistic regression. The fact that cases and controls were stratum-matched enabled the use of information from all available controls in SHEEP. Prior results from hierarchical regression models showed that the clustering of MI in parishes was low (a variance partitioning coefficient (VPC) of 0.007 for men and 0.053 for women). Thus, the assumption of independence is approximately met, and we further verified that there was no underestimation of the standard errors by comparing the results of the single-level models with those of the hierarchical models.

In Paper IV we estimated IRRs to measure the effect of social class on MI incidence by means of unconditional logistic regression models. However, in the following analyses, hierarchical regression models were used to assess the combined effects of social class and structural economic conditions in neighbourhoods.

4.1.2 Hierarchical logistic regression

In papers II, III and IV, due to the nested structure of the data, we estimated IRRs to measure the effect of contextual exposures on incidence of MI by means of random intercept logistic regression models (the VPCs for MI in neighbourhoods are 0.065 for men and 0.146 for women). We use a hierarchy that defines individuals as first-level units, nested within small residential areas as second-level units. Logit link functions are used, and we report effect estimates from the fixed part of the model. All final models are fitted using a penalized quasilikelihood procedure with a second-order Taylor expansion series, as suggested by Goldstein and Rasbash (1996). The presence of over-dispersion was evaluated, and all final models met a binomial-distribution assumption.

4.2 Correlations

4.2.1 Partial correlation

In Study II partial correlation analyses were performed to enable comparison of our
results with results from other ecological studies. In this case, we wanted to know how large the correlation between MI and the Townsend index was, corrected by the correlation between MI and the Congdon index and vice-versa.

Our strategy was to use a two-level hierarchical model to regress MI on each of the indices, and a single-level model to regress the indices on each other. Then, we found the correlation between the residuals from the model that regressed MI on Congdon and the residuals from the model regressing Townsend on Congdon. This gives the correlation between MI and Townsend free of Congdon. The procedure was repeated, correcting for Townsend.

4.3 Measures of biologic interaction
In studies III and IV we evaluated both within-ecological level interactions and cross-level interactions. Rothman’s model for the analysis of biological interaction or synergism was used for this purpose. The model assesses whether or not there are more cases occurring only in the presence of joint exposures or, in other words, if there is a departure from additivity of effects (Rothman & Greenland 1998). We used two measures to quantify interaction: the synergy (S) index with 95% CI (Rothman 1976) in Study III, and the relative excess risk due to interaction (RERI) (Rothman & Greenland 1998) in Study IV.

The synergy index is given by:

\[ S = \frac{IRR_{11} - 1}{(IRR_{10} - 1) + (IRR_{01} - 1)} \]

where IRR denotes the incidence rate ratios with IRR_{00} (jointly unexposed) as denominator; IRR_{10} and IRR_{01} are the rate ratios for those with one exposure, and IRR_{11} for those with both exposures. The index denotes synergy if its value exceeds 1.0, and antagonism if it is less than 1.0.

The relative excess risk due to interaction is given by:

\[ RERI = IRR_{11} - IRR_{10} - IRR_{01} + 1 \]

The same notation is used as for the S index. If the sum is greater than zero, the effect of joint exposure exceeds additivity. Zero indicates that the effect of joint exposures is the sum of the independent effects of the two exposures. Further, in the same study we assessed the proportion of MI cases among the double exposed that was due to interaction, as suggested by Rothman (2002).

Attributable Fraction (AF) due to interaction = RERI / IRR\textsubscript{11}
5 Results and interpretations

5.1 Study I: Socioeconomic context in area of living and risk of myocardial infarction

Objective: to analyse the contextual effect of social deprivation on risk of myocardial infarction among males and females separately, considering possible confounding from the corresponding individual social factors (the compositional effect). Further, to develop an index identifying and measuring specific socioeconomic contexts of parishes in the Stockholm metropolitan area.

In the first study we adopt an explorative approach to the definition of different aspects of the social context in parishes. We identify twenty one indicators, mostly derived but also integral, which – on theoretical grounds – might be of importance for the assessment of a social context. By means of factor analysis we single out three contextual dimensions, namely class structure, social exclusion and poverty. This indicates that social differentiation in contemporary Stockholm occurs along dimensions earlier recognized and described in sociological studies of urban development in the U.S. However, the contextual effect of the differentiation measured at parish level is quite modest. The relative risk of MI among men is slightly increased in disadvantaged parishes on all three dimensions, whereas among women we find a lower relative risk in parishes that are advantaged on the class-structure dimension. Additionally, we find that some parishes, due to their size, comprise several small areas that differ contextually, which in turn makes parishes less suitable for this analytic purpose.

5.2 Study II: Contextual effects of social fragmentation and material deprivation on risk of myocardial infarction

Questions: Does material deprivation, as measured by the Townsend index, increase the risk of MI? Are there persisting contextual effects, after adjustment, for indicators of individual social position that operate in segregation processes? Does social fragmentation, as measured by the Congdon index, increase the risk of myocardial infarction, and – if so – does the excess risk persist after adjustment for individual factors? Is it possible to disentangle the effect of material deprivation, according to Townsend, and the effect of social fragmentation, according to Congdon, on MI? Which is the most important, and to what extent are they mutual confounders?

In the second study we have the possibility of refining the geographical classification, allowing the operationalization of neighbourhoods as smaller, more homogenous residential areas. The aim is to evaluate the effect of two constructs, one belonging
to material and infrastructural resources, the other to collective social functioning which are presented as central to the current public-health debate. These are assessed as material deprivation and social fragmentation – by means of two internationally established indexes, Townsend and Congdon. We find increased incidence of MI in both materially deprived and socially fragmented contexts, but slightly stronger and more clearly graded in the case of material deprivation. However, we are not able to distinguish independent effects from either one of the two constructs due to the high correlation between them, indicating that both material deprivation and social fragmentation may contribute to an excess relative risk of MI.

5.3 Study III: Neighbourhood Socioeconomic Context, Individual Income and Myocardial Infarction: analyses of within- and between-level interactions

Questions: Is residence in a low-income neighbourhood associated with an increased incidence of MI? Is residence in a neighbourhood with a high degree of income homogeneity likewise associated with an increased incidence of MI, after adjustment for individual social characteristics reflecting the social selection of people into different contexts; and, further, after mutual adjustment? We also examine whether there is synergy between neighbourhood income level and income homo/heterogeneity, and finally we investigate other potential mechanisms: Does the individual economic situation make people more vulnerable to the effect of a low-income context? To what extent are established biomedical risk factors and health behaviours involved as mediators of the contextual effect?

In the third study we focus on material and infrastructural resources but extend the analyses. The aim is to capture a spatial social polarization by combining level of resources, measured by median income level, with degree of socioeconomic homogeneity, measured by Gini coefficient. The results show a consistent and graded increase in MI incidence along a decrease in level of resources, but income homogeneity alone does not seem to impact on relative risk of MI. When combined, a high degree of homogeneity seems slightly to sharpen the effect of low-income level in neighbourhoods, but only among men. We bring the issue a step further by analysing the interaction between individual income and income level in the neighbourhood, and find that women in low-income families are more vulnerable to a setting with a low level of economic recourses. We also evaluate the mediating contribution of established risk factors, and find that smoking and insulin resistance may act as mediators in the context–disease relation.
5.4 Study IV: Impact of economic segregation on social class inequalities in incidence of myocardial infarction – exploration of cross-level interactions

Objective: to evaluate how much of the differences in risk of MI between social classes that can be attributed to effects of the distribution of affluence as a measure of economic segregation, to assess the combined effects of social class and structural economic conditions in neighbourhoods, and to explore if susceptibility to neighbourhood context differs across social classes.

The fourth study is based on a slightly different approach, since we evaluate how much of the social-class inequality in MI incidence can be ascribed to economic segregation via spatial concentration of affluence, which we measure by the proportion of high-income earners in a neighbourhood. We find that the excess relative risk of MI among routine non-manuals is reduced by approximately 40 percent and among manual workers by approximately 30 percent when a contextual adjustment is made. The contextual contribution remains about the same, in relative terms, when controlling for individual childhood class, education and income. The process of economic segregation creates local social contexts that increase MI incidence in all social strata. Further, there is an indication of increased vulnerability to contextual effects in the lower strata of both non-manual employees and manual workers suggesting a mechanism via which the contextual contribution is not only the product of higher prevalence of a negative contextual exposure.
6. General discussion

All four studies contribute to further elaboration of the first objective of the dissertation, namely to define relevant social dimensions of the neighbourhood context. The primary focus of the dissertation is on aspects of structural material and economic conditions in neighbourhoods. Even though we lack opportunities directly to measure material and infrastructural resources, our results indicate that a polarized economic structure creates local social contexts that influence health. Further, the distribution of advantage is a crucial aspect. Studies I-IV address the pertinent question of whether or not there are any contextual effects at all. Based on these analyses, in which we carefully considered confounding from the selection of people with different individual characteristics (the compositional effect), would argue that there are such effects. Women living in economically disadvantaged contexts have an incidence of myocardial infarction (MI) twice as high as those living in economically advantaged contexts; for men the incidence is 50% higher. These figures have been adjusted for family socioeconomic position, disposable income, own education, position on the labour market and cohabitation, all of which influence both where a person lives and the risk of coronary heart disease.

We further analyze whether different aspects of the local social environment have similar contextual effects on the incidence of MI, and find clear effects of concentration of affluence, level of economic resources, and material deprivation. The effects of social fragmentation and the three dimensions defined by the factor analyses were all less convincing due to the shape of the relationships. Socioeconomic homogeneity only had an effect in combination with resource level. As a potential mechanism in the context–MI relation, studies III and IV explore the interplay between the social context and individual socioeconomic position, and evaluate whether individuals in different social strata are differentially vulnerable to their neighbourhood context. In Study III we find that women with a low disposable income are more vulnerable to the effect of a low-income context. In Study IV, there was an indication of increased vulnerability to contextual effects among lower strata of both non-manual employees and manual workers. Further, Study III evaluates established biomedical risk factors and health behaviours as mediating mechanisms. We find that smoking and insulin resistance make notable contributions to excess risk in economically disadvantaged areas, after making prior adjustment for individual social characteristics (which also account for health behaviours and biomedical risk factors that are unevenly distributed across social strata). In Study IV the role of economic segregation is evaluated via analyses of whether and how differentiation in neighbourhood contexts contributes to social-class inequalities in incidence of MI. The study shows that structural economic conditions in neighbourhoods do matter with regard to adult social-class inequali-
ties. The effect of economic segregation is not restricted to lower social strata, but since individuals in lower social strata more often live in disadvantaged contexts, and also seem to be more vulnerable to the effects of these contexts, we conclude that economic segregation creates neighbourhood contexts that contribute to social-class inequality in incidence of MI.

6.1 Contextual effects

The main question addressed in this dissertation is whether specific aspects of the local social environment have an impact on MI incidence. Answering this question can be regarded as a first step towards attaining the “ultimate goal” of understanding the causal role played by context. The aim was to evaluate effects of specific features of the social environment, built on theoretical constructs of macro phenomena of possible relevance to the social aetiology of MI. We did not look for non-specific “neighbourhood effects” or geographic differences in a more general sense. As a consequence, our analytical strategy was to treat the coefficients of each “contextual exposure” as the effect parameters of interest, thereby enabling us to estimate the average effect of the contextual exposure in the population. We intentionally strove to maintain a parsimonious second-level modelling strategy, since there are many issues regarding operationalization and measurement of the theoretical constructs that still need to be resolved (Diez Roux 2001, Macintyre et al. 2002).

A conservative approach to the interpretation and reporting of variance parameters was adopted (i.e.$\chi^2_m$), mainly because our intention was not to explain variation in MI incidence between individuals or between geographical units (neighbourhoods), but also because there were a number of caveats. First, statistical power is differently affected by the number of areas and the number of individuals within areas in the case of estimating variance components and in that of detecting the effects of a neighbourhood-level variable (Snijders & Bosker 1999). The test of association between a neighbourhood-level variable and outcome will often have more power than a test for neighbourhood variance (Diez Roux 2004). Second, the size of the detected second-level variance is dependent on the estimation method used, e.g. maximum likelihood or penalized quasi-likelihood (Goldstein & Rasbash 1996); in the present studies, it varies substantially according to method. Third, the estimate of variance between areas is conditional on the individual-level variables included in the model. Insignificant second-level variation in an empty model may change to significant variation when relevant individual-level confounders are included. When the opposite occurs, i.e. when significant variation turns into insignificant, the individual-level variables may be confounded by an omitted contextual variable, whose effect cannot be detected unless included in the model (Diez Roux 2004). Finally, there is no obvious
interpretation of the size of a variance parameter. However, during a lecture given in 2004, Leyland made an interesting suggestion; by considering the mean of the residuals +/- 1.96 SD, an OR associated with being located at the 97.5th centile rather than the 2.5th centile can be calculated. The mean of the second-level residuals in Study I was 0.041 (0.049) The figure looks small, but how small is it really? Calculating an OR as suggested by Leyland gives 2.2, a difference of 120% between the two parishes.

Following this line of argument, we have been restrictive in our use of measures like the Intraclass Correlation Coefficient (ICC) and the Variance Partition Coefficient (VPC). These measures describes the percentage of variation attributable to the higher-level source of variation (Goldstein et al. 2002), but does not reflect any causal parameters and should therefore not be seen as measures of effect. Nevertheless, ICC is increasingly being used as a “neighbourhood effect” measure.

Greenland (Rothman & Greenland 1998) makes the following comment on the subject: “A major quantitative objective of most epidemiological studies is to estimate the effect of one or more exposures on disease occurrence in a well defined population at risk. A measure of effect is not just any measure of association such as correlation coefficient (or \( R^2 \)), rather it reflects a particular causal parameter.” And further: “Correlation coefficient and \( R^2 \) can give even more distorted impressions when multiple regressors are present (binary outcomes). For this reason we strongly recommend against their use as measures of association or effect when modeling incidence or prevalence”

Causal inference in observational epidemiology is based on the counterfactual assumption that individuals are exchangeable within strata of measured confounders. The average causal effect of an exposure would be determined if we went back in time, changed an individual’s exposure status and nothing else, and determined the effect of this change on disease occurrence. An approximation of this is to compare disease occurrence among the exposed with occurrence among the unexposed. However, it might be too strong an assumption to make that individuals living in well-off neighbourhoods are exchangeable with those in less well-off neighbourhoods, in all senses except living-conditions, within strata of education, occupation, income, labour-market position and family status. If they are different (in a way not caused by the neighbourhood context), then the effect measure will suffer from residual confounding (Oakes 2004). Indeed, this is a common problem within social epidemiology, and also epidemiology in general, when making causal inferences (Kaufman & Cooper 1999). In response, it has been pointed out that analytical models are never perfect and that, even with a not fully satisfied exchangeability assumption, they may provide useful information about the structuring of health in our societies (Krieger & Davey Smith 2000, Kaufman & Cooper 1999, Blakely & Woodward 2000).
Oakes (2004) raises specific criticism against causal inference of neighbourhood studies. He argues that any effect of the neighbourhood socioeconomic context should be totally ascribed to residual confounding at individual level, due to social stratification and selection of individuals to different neighbourhoods: “there is (approximately) complete confounding between the background attributes of persons in a given neighbourhood and complete (approximately) separation between the background attributes of people in other neighbourhoods” (Oakes 2004 p. 1938). If rightly interpreted, this means that there will always be a perfect match between individual socioeconomic position and a social environment shaped by residential segregation, thereby making it impossible to separate them. I would argue that social stratification is a main driving force behind both the different structural positions possessed by individuals within a society and the residential segregation that leads to spatial polarization of structural resources. Whether they are separable or not is an empirical question, but the overlap found in the current studies is far from complete. To obtain further insight into the social aetiology of MI it is of great interest to assess the contribution made by both sources. But as Diez Roux (2004) states “associations … on neighbourhood health effects are what they are: measures of conditional associations under certain assumptions” (p.1959).

6.2 Mechanisms – mediating/confounding factors
The SHEEP study has extensive information on individual level confounders, which facilitates the reduction of “omitted individual level variable bias”, and enables analyses of mechanisms. Due to constant interplay between individuals and their context, a clear distinction between what is confounded by individual social position and health behaviours and what is mediated through these factors is not possible to make (Diez Roux 2001, 2004, Macintyre et al. 2002, Oakes 2004, Subramanian 2004). To some extent, social surroundings shape people’s preferences and opportunities, and to some degree people will form their own social environment. We acknowledge the need to account for such reciprocal effects; however, applications of proposed methods that better account for these complex causal webs are still limited. The assumption throughout our analyses is that an individual’s social position influences the type of neighbourhood a person chooses, or has the ability, to live in. Accordingly, social position is treated as a confounder. Our general approach was to adjust for individual and family socioeconomic characteristics in order to make individuals from different contexts comparable in these senses. The combinations of social characteristics in our final models broadly capture aspects of social stratification and indicate the opportunity to acquire housing in desirable areas. However, we systematically reports results before and after adjustment was made.

The roles of individual health behaviours and biological risk factors in the context—
MI relation is so far unclear. Neighbourhood socioeconomic characteristics have been linked to the prevalence of cardiovascular risk factors (Diez Roux et al. 1997, Hart et al. 1997, Duncan et al. 1999). The common interpretation is that the contextual effect on cardiovascular disease is partly due to the different health behaviours that lead to the disease; that is, there is a greater prevalence of detrimental health behaviours in deprived areas. However, it is also hypothesized that health behaviours and pathophysiological processes are shaped by the context in which they occur. An example of this is the finding, with regard to the trend in coronary-artery risk in young adults, that living in an adverse socioeconomic context is related to the development of insulin resistance and metabolic syndrome (Diez Roux et al. 2002). There are also studies linking residential environment (in terms of accessibility, cost and aesthetic quality) to health behaviours, such as physically active/inactive lifestyles and dietary patterns (recently reviewed by Diez Roux 2003), although the evidence so far is limited. The general approach adopted in all four of the current studies was to treat individual health behaviours and biomedical factors as mediators, although we do not know the time points of initiation (i.e. before or after individuals moved in to the areas).

6.3 Precision
Assessments of the contextual exposures are based on information from the total population, which results in high precision on the contextual measures.

The number of SHEEP participants is quite small in some areas. However, an advantage of the multilevel model is that observations do not need to be balanced across neighbourhoods. Predictions from neighbourhoods with a small number of observations will have low weight with regard to the overall relationship, while predictions from neighbourhoods with many observations will be more reliable. Further, we estimate effects from groups of neighbourhoods with a specific context, not from separate neighbourhoods. Interaction analyses easily run into the problem of statistical power. The cell counts in extreme strata easily become very low. In light of this, we interpret results from the interaction measures as suggestive of patterns rather than exact numbers.

6.4 Selection
The SHEEP study is population-based with a high participation rate, and subjects were equally inclined to participate regardless of hospital-catchment area. This makes the studies in this dissertation less sensitive to selection bias due to a differential response rate associated with area-level deprivation, which can be a considerable problem in contextual studies (Leiland et al. 2004). Further, both the validity of MI diagnosis and the reliability of case identification were high (Hammar et al. 1991,
Linnersonjö et al. 2000). The use of incident first event of MI is especially relevant when evaluating the aetiological implications of contextual exposures. In particular, it reduces the risk of bias from health-related selection into low-income contexts. Also, as case-fatality rates have been found to be related to neighbourhood deprivation (Macintyre et al. 2001), the inclusion of both fatal and non-fatal cases reduces influences from factors such as availability of acute care or distance to hospital.

6.5 Misclassification

Misclassification of exposure is almost always present in large epidemiological studies. In the current investigations, a certain amount of non-differential misclassification is likely to have taken place, perhaps especially in Study I. If misclassification of exposure does not depend on disease status, it will tend to bias the association towards the null. Differential misclassification (i.e. dependent on disease status) is usually a potential problem in case-control studies, but is unlikely to have seriously affected the results of our studies.

In Study I, the local social context was operationalized at parish level. The populations of Stockholm parishes range from 816 to 56,478, with a median of 14,422, and are therefore large enough to comprise several small areas that differ contextually. If parishes are heterogeneous with regard to the neighbourhood characteristics under study, this will result in non-differential misclassification, biasing the relative risk towards unity.

For studies II to IV it was possible to operationalize the local social context at census-area level (median population 1,000, approximately corresponding to census-block groups). The use of administrative boundaries when estimating contextual exposures has been criticized. Nevertheless, we think that small residential areas capture the spatial differentiation of socioeconomic recourses reasonably well. The boundaries are natural in so far as possible, and homogeneous with regard to building structure and land use. Areas with similar contexts are grouped and analyzed as categories, and our conclusions are drawn not from a particular area but from groups of areas with a specific type of context. This implies that adjoining areas with similar contexts whose inhabitants do not necessarily perceive there to be a border between them are analyzed as belonging to the same group. However, what seems an appropriate scale for measuring level of socioeconomic resources may be less appropriate for measuring collective social functioning. This issue has to be taken up in relation to each type of context studied.

The neighbourhood contexts investigated in this dissertation are approximated by characteristics of the groups of individuals who live in them. The formation, however, is not random but driven by social processes, and may also reflect global characteristics of the neighbourhood without individual-level equivalence. The contexts summarize a number of specific circumstances to which residents will be more or less
exposed. Thus, conceptualization is comparable to that applying to individual social position, which can be seen as a summary term encompassing a variety of social, psychological and material exposures with potential health influences (Diez Roux 2001, Macintyre et al. 2002). Further, our contextual measures are not aggregated within the study population, but are based on information from the total population, and therefore not biased by psychological adjustments. It has been shown that residents’ self-reports of their neighbourhood environment frequently display less variation than do objective assessments (Macintyre & Ellaway 2003).

A limiting factor in the studies is lack of information on residential mobility and previous contextual exposures. We used latest address information at time of inclusion in all studies to define neighbourhood of residence, which meant that we did not consider any time lag or accumulation of contextual exposures. Lack of knowledge of residential duration for both cases and controls might imply non-differential misclassification of contextual exposures, which would bias the relative risk ratios towards unity. However, on the basis of the new analyses reported in Section 3.7, the residential stability of our age cohort must be regarded as high.

7 Conclusions

- The studies support the hypothesis that local social context influences incidence of myocardial infarction (MI). Individuals living in economically disadvantaged contexts have an increased risk of MI, after adjustment has been made for individual social characteristics.
- Concentration of affluence, level of economic recourses and material deprivation seem to be the aspects of local social context most relevant to MI incidence among the ones examined.
- Adverse socioeconomic conditions in a neighbourhood affect most of the subgroups analyzed, but there is an indication of increased vulnerability among lower social strata.
- The contextual effect is partly mediated by health-related behaviours and biomedical risk factors.
- Economic residential segregation create neighbourhood contexts that contribute to social class inequality in incidence of MI
Acknowledgements

My roller-coaster ride as a doctoral student has been tremendous fun, sometimes frightening and always challenging. Along the ride, I bumped into many persons who supported me, and in different ways contributed to the dissertation you have just skimmed through. I am grateful to many friends and colleagues, first and foremost my two supervisors, for giving me the opportunity to work on the SHEEP project. In particular, I would like to thank:

Johan Hallqvist, my main supervisor, for excellent guidance throughout the process. I am especially grateful for all the enlightening scientific discussions and for your incredible skill in bringing structure to my sometimes chaotic texts and vast amount of analysis.

Finn Diderichsen, my co-supervisor, for opening the scientific door and introducing me to the world of social epidemiology, and for all the wonderful support at the first phase of the work.

Johan Fritzell, my new found mentor and guide in the mysteries of sociology. For always reading the new manuscripts that I dropped upon you, and your rapid and constructive comments. One can never get too much (chocolate) support!

Antonio Ponce de Leon, my dear Brazilian friend, co-author and statistical advisor, for patiently answering my questions whatever the day or the time.

Monica Åberg Yngve, my MPH and PhD student companion, for sharing all the tricks of the trade for avoiding a dissertation disaster.

My colleagues at CHESS. You all contribute to a truly supportive scientific environment mixed with a very unscientific, friendly and warm atmosphere. I cannot imagine a better context in which to have finalized the work.

All of you who contributed to the studies and were there for me when needed, especially Michael Lundberg and Peeter Fredlund for helping me with SAS programming and giving statistical advice over the years, regardless of where your workplace was located; Tomas Andersson, Nicklas Berglund and Mats Rosenlund for valuable help with the weighting program and GIS coding; and, Marit Dahlén Gisselmann and Roger Köllegård for practical and tangible assistance at the final phase when my energy level was low.

Jon Kimber for patiently revising my English and managing to read what I mean and not what I write.

The socio-epidemiological research groups, both the good old one for good old times at the Department of Social Medicine where everything started, and the new SEG for stimulating discussion and friendship.

All fellow students and the Board of the Doctoral Program in Epidemiology at Karolinska Institutet, for making biostatistics and epidemiology enjoyable.
All my fabulous heart-warming friends who are always there for me, no matter what.

And finally,

My dear, dear family, mamma, pappa, Agneta och Camilla för det kärleksfulla stöd och den norrländska trygghet ni ger mig.

Caroline, min älskade tjej, katt för sin hatt som fixar allt själv om mamma pluggar.

Nisse, this wouldn't have happened without you, you make me believe that I can!

Maria Kölegård Stjärne, April 2005

These studies were supported by the Swedish Council for Social Research and Swedish Council for Working Life and Social Research.
References


Bennet A. Insulin resistance, genetic variation and cytokines; associations to myocardial infarction risk. Stockholm: Karolinska Institutet; 2003.


Lynch J, Due P, Mutanter C, Davey Smith G. Social Capital – is it a good investment strategy for public health. *J Epidemiol Community Health* 2000;54:404-408


Rosenlund M. Environmental Factors in Cardiovascular Disease. Stockholm, Karolinska Institutet; 2005.
Shevky E, Bell W. *Social Area Analysis: Theory, Illustrative Application and Computational Procedures*. Westport, CT: Greenwood;1955


WHO. The atlas of heart disease and stroke. Edited by Mackay J, Mensah G. 2004


Wilson WJ. The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy. Chicago: University of Chicago Press; 1987
