Individual health, neighborhood characteristics, and allocation of primary health care resources

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To Jan, Alexander, Sofia, and Elisabet

Abstract

Aims To examine whether neighborhood education and neighborhood income predict incidence rates of coronary heart disease (CHD), beyond individual characteristics (*study 1*). To examine whether neighborhood deprivation, measured with Care Need Index (CNI), predicts CHD incidence rates, beyond individual characteristics (*study 2*). To examine whether low scores in a social participation index predict CHD incidence rates, after adjustment for individual characteristics (*study 3*). To examine the relationship between CNI and poor self-reported health at neighborhood level, to examine whether the transformed CNI can be used for a total allocation of primary health care resources and to compare the transformed CNI with the official Stockholm model (*study 4*).

Methods In *study 1* 25,319 individuals between 1986 and 1993 from the Swedish Annual Level of Living Survey (SALLS) were followed until December 31, 1997, for CHD incidence events. Neighborhood level characteristics were defined by the use of neighborhood education and neighborhood income. Individual level characteristics were defined as age, sex, and education or income. Multilevel Cox proportional hazard models were used to analyze the data. In *study 2* the whole Swedish population, aged 40–64, was followed from December 31, 1995, to December 31, 1999, for CHD incidence events. Multilevel logistic regression was used in the analysis with individual level characteristics (age, income) at the first level and neighborhood deprivation, measured by CNI, at the second level. In *study 3* 6,861 individuals from SALLS, interviewed in 1990/91 were followed until December 31, 2000, for CHD incidence events. Individual characteristics were age, sex, education, housing tenure, smoking habits, and a social participation index. Cox regression was used in the statistical analysis. In *study 4* the population in Stockholm County was divided into deciles by CNI, according to the level of neighborhood deprivation. CNI ratios were calculated for each decile by dividing the CNI means in each decile 2–10 by the CNI mean in decile 1. A sample from SALLS was used to estimate Odds Ratios (OR) for poor self-reported health in the deciles. The ORs were then compared with the CNI ratios. Hierarchical logistic regression was used in the statistical analysis.

Results In *study 1* each neighborhood measure predicted CHD incidence rates after adjustment for individual characteristics (hazard ratios 1.32 and 1.25). CHD events would hypothetically be reduced by 25–26 percent for women and 10–15 percent for men if everyone had the same CHD risk as those living in the most affluent neighborhoods. In *study 2* the risk of developing CHD was 87 percent higher for women and 42 percent higher for men in the most deprived

neighborhoods than in the most affluent neighborhoods, after accounting for individual characteristics. In both *study 1* and *study 2* the variance at neighborhood level was small but significant, indicating that there was a neighborhood effect on CHD beyond the individual effect. In *study 3* there was a gradient between the social participation index and CHD. After adjustment for individual characteristics, the risk of CHD for persons with low social participation remained high (hazard ratio = 1.69). In *study 4* the CNI was transformed into a positive scale. CNI ratios corresponded to the ORs of poor self-reported health in the deciles. The transformed CNI showed a high degree of agreement with the official model.
Conclusions CHD prevention needs to combine both individual- and neighborhood-level approaches, in order to reduce socioeconomic disparities in CHD. Although the neighborhood effect was small, it is of importance since the outcome, CHD, is highly prevalent among the entire population. The CNI model, which is an exclusively need-based tool, constitutes an attractive approach for the total allocation of primary health care resources.

Keywords
Coronary heart disease, Self-reported health, Social participation, Social capital, Care Need Index, CNI, Primary health care resources, Cox regression, Follow-up study, Incidence rates, Multilevel, Population-attributable fraction, Neighborhood deprivation, Socioeconomic status.

Contents

List of publications

1 *Neighborhood socioeconomic environment and incidence of coronary heart disease: A prospective follow-up study of 25,319 women and men in Sweden:* Kristina Sundquist, Marilyn Winkleby, Helena Ahlén, Sven-Erik Johansson (Submitted)

2 *Neighbourhood deprivation and incidence of coronary heart disease: A multilevel study of 2.6 million women and men in Sweden:* Kristina Sundquist, Marianne Malmström, Sven-Erik Johansson (Accepted for publication in Journal of Epidemiology and Community Health) [2]

3 *Social Participation and Coronary Heart Disease: A Follow-up Study of 6,900 Women and Men in Sweden:* Kristina Sundquist, Martin Lindström, Marianne Malmström, Sven-Erik Johansson, Jan Sundquist (Social Science and Medicine, In press)[1]

4 *Care Need Index, a Useful Tool for the Distribution of Primary Health Care Resources:* Kristina Sundquist, Marianne Malmström, Sven-Erik Johansson, Jan Sundquist (Journal of Epidemiology and Community Health 2003 May;57(5):347–52)[2]

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Abbreviations

CHD	Coronary Heart Disease
CI	Confidence Interval
CNI	Care Need Index
CVD	Cardiovascular Disease
GP	General Practitioner
HR	Hazard Ratio
ICC	Intra Class Correlation
ICD	International Classification of Diseases
IR	Incidence Rates
n	Sample size
N	Population size
OR	Odds Ratio
PAF	Population-Attributable Fraction
SALLS	Swedish Annual Level of Living Survey
SAMS	Small Area Market Statistics
SD	Standard Deviation
SE	Standard Error
SES	Socioeconomic Status
ULF	"Undersökning av Levnadsförhållanden" (Swedish)
UPA score	Underprivileged Area score
WHO	World Health Organization

Introduction

The overall purpose of this study is to analyze neighborhood socioeconomic characteristics, individual social participation and their independent effect on coronary heart disease (CHD). Moreover, the aim is to develop the Care Need Index (CNI) into a useful tool for the total allocation of primary health care resources in accordance with the need in the population. It is well known that low individual socioeconomic status (SES) is strongly associated with different health outcomes, for example CHD[1–5]. Furthermore, during the last few decades there has been a decline in the incidence rates of CHD in Western countries[6]. However, this improvement in health has not reached all groups in society equally[7]. For individuals with low SES the risk of CHD still remains higher than for individuals with high SES.

A growing body of research has demonstrated that individual behavior and health are influenced by the characteristics of the neighborhoods in which people live. Neighborhood social characteristics seem to influence cardiovascular risk factors[8,9] and CHD[10,11]. Despite substantial evidence for SES disparities in CHD, our understanding of the mechanisms involved is limited. However, it is likely that the causes of SES disparities in CHD risk are most likely multifactorial, involving both individual and neighborhood characteristics. Potentially important mechanisms for the neighborhood effect on human biology may have several explanations, such as material (the social structure), behavioral (CHD risk factors), and psychosocial (social networks and social participation) explanations, which may each increase the vulnerability to developing CHD. For example, insufficient social capital may be an important pathway of increased CHD risks because of its association with poor health-related behaviors[12]. Residence in an affluent neighborhood may facilitate access to healthy food, smoke-free environments, physical leisure activities, cultural activities, safe recreation areas, sufficient social capital, and political empowerment, all of which can contribute to better health.

The allocation of health care resources, and particularly primary health care resources, has been a difficult task for politicians in many Western countries. In order to find useful tools for primary health care allocation different approaches have been tried out. In the UK the Underprivileged Area (UPA) score was developed to allocate additional resources to the five percent most deprived neighborhoods. In Sweden CNI was constructed as a modified UPA score in order to allocate resources to primary health care in deprived neighborhoods.

In the present thesis, the independent effects of low neighborhood education and low neighborhood income, neighborhood deprivation (by CNI), and low scores in the social participation index will be examined, after adjustment for individual characteristics. The CNI will also be further developed in order to use it for a total, need-based allocation of primary health care resources. CNI will then be compared with the official model in Stockholm County.

Socioeconomic status

The concept of SES is nowadays a well-known factor in many fields of research and is used to exhibit the position that individuals or groups hold in society. A variety of other terms have been used to express SES, such as socioeconomic position, social class, social status, social position, social stratification and social inequalities based on different historic traditions. It was first recognized during the last half of the 19th century, when Karl Marx and Max Weber introduced their theories of social stratification. Karl Marx minted the concept of social classes, based on how people gain their living[13]. As a consequence of his theory, the relationship between classes was a matter of who owned the means of production versus the working class. Subsequently, the existence of economic inequalities in society could be objectified. Max Weber accepted the class concept from Marx, but added those skills, education, and other qualifications which were of importance for the jobs people could get. Weber introduced the concept of "status," i.e. the prestige, social honor, and lifestyle that groups of people are accorded by others. Social status acts independently of social class. However, in the USA, the Functionalists introduced a new approach to social stratification[14]. They argued that complex societies require stratification into sectors, and this argument has been used in order to justify differences in health status between sectors in the society.

Different ways to measure SES have been developed, according to these social theories. These SES measures have been used as important predictors of different health outcomes.

Individual measures of socioeconomic status

SES has been measured somewhat differently depending on different research traditions. The most common way to describe SES is in terms of education, occupation, income and/or wealth. These measures reflect the individual's knowledge, skills, and assets. The different measures of SES are indicators of individual resources and predictors of individual "life chances." It can be presumed that no measure is conceptually better than any other[15]. However, although correlated, these SES indicators probably measure different aspects of SES. In the present thesis, SES has been operationalized as educational status or income (study 1), income (study 2), and educational status and housing tenure (study 3).

The WHO definition of health

The WHO (World Health Organization) has defined health as "a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity." Disease, illness, and sickness are different aspects of health.

Disease refers to the objective part of health from a professional point of view, classifying diseases partly on the basis of how they are caused. Illness refers to the subjective feeling of being healthy or not. The presence of illness is not necessarily a function of the existence of disease and vice versa. Sickness is defined as the social dimension or as the social consequence of ill health.

Self-reported health

The outcome self-reported health (study 4) has been used in many previous studies[16,17] and is based on how a person perceives his or her general health. Self-reported health includes illness and is therefore a more subjective health measure than, for example, disease. However, studies from different parts of the world have shown a high association between self-reported health and mortality[18–21]. Self-reported health can also be used as an indicator of health care need, being a useful predictor of the use of health care[22,23]. The reliability of self-reported health has been shown to be high in test-retests[23,24]. Therefore, self-reported health, a predictor of both mortality and the use of health care, might be an applicable base for the allocation of primary health care resources.

Socioeconomic status and health

The relationship between low SES and health has been recognized for centuries ever since Paracelsus in 1567 discovered an increased disease risk among miners. In Sweden, the relationship between low SES and mortality is well documented[25–28]. The Stockholm Female Coronary Risks study showed that women with unskilled or semiskilled occupations had a fourfold higher CHD risk than executives/professionals[1]. Finnish longitudinal data exhibited even higher CHD incidence rates among people with low SES[2]. In the English Whitehall study civil servants with the lowest employment grade had a 1.6 times higher risk of CHD than participants with the highest employment grade[4]. In California the same pattern was observed among middle-aged employed men with low educational status. They had roughly twofold higher CHD mortality risks than those with high SES[5].

A significant decline in CHD mortality has been shown in Sweden during the last 15 years[6]. The WHO MONICA Project also showed a decline in coronary risk, probably because of a decline in cardiovascular disease (CVD) risk factors[29]. Furthermore, a considerable decline in mortality rates has been observed in the USA since 1960, but not for people with low SES. They still have higher mortality rates than those with higher incomes or better education. This gap in mortality increased between 1960 and 1986[7].

Neighborhood measures of socioeconomic status

Single socioeconomic indicators, such as education, occupation, income and/or wealth, can be used, if aggregated, to measure the neighborhood SES. In aggregated form, the indicators lose their individual connection. The neighborhood SES can also be measured with composite indices of social deprivation such as the Carstairs score and the Townsend score. These composite indices of social deprivation consist of a combination of different socioeconomic, sociodemographic and material indicators. For example, the *Carstairs score* is an unweighted combination of four variables: unemployment, no car, overcrowded housing, and low social class. The *Townsend score* consists of the unweighted variables unemployment, no car, no home ownership, and overcrowding. The *Underprivileged Area (UPA) score* is somewhat differently constructed from the social deprivation indices. It also takes into consideration the general practitioner's (GP's) ranking of the impact on their workload of the following indicators: elderly people living alone, children under five, unemployed people, single parents, overcrowding, manual workers, highly mobile people, and foreign-born people from the New Commonwealth or Pakistan. The UPA score is used to allocate an extra deprivation payment to the five percent most deprived neighborhoods, but has not been useful for a total allocation of primary health care resources because of the presence of negative values. All three scores originate from the UK. The different variables were chosen because of their association with poor health and because they were easily accessible. However, in countries like the USA where individual data are more difficult to obtain, the Gini coefficient and Robin Hood index are used to identify neighborhood social deprivation[30]. The higher the score of both these indices, the less egalitarian is the distribution of income. Poor neighborhoods in Alameda County were described by the percentages of unemployed, aid to families with dependent children, aid to the disabled and to the blind, police workload, active tuberculosis cases, dilapidated housing units, renter-occupied units, and units with shared or no bathroom[31].

Care Need Index

With the UPA score as a model, the Care Need Index (CNI) was developed in Sweden using the Swedish GPs' ranking of the impact of eight socio-demographic items on their workload[32].

We chose CNI as a measure of neighborhood deprivation, because it is accessible for all SAMS neighborhoods in Sweden. Moreover, CNI is highly correlated to the Townsend score, a deprivation score from the UK (r = 0.79)[32]. The original CNI was based on data from the Swedish Population and Housing Census from 1990: elderly living alone, children under age 5, unemployed people, unskilled workers, single parents, high mobility, overcrowding, and foreign-born people from Southern and Eastern Europe, Asia, Africa, and South America. CNI scores calculated for all SAMS neighborhoods in Sweden, a total of 8,509, gave the range from –76 to 54. The scale was constructed so that the higher the CNI score, the more deprived the neighborhood. According to CNI, the most deprived neighborhoods were associated with four times higher psychiatric hospital admission rates and 10 times higher alcohol clinic admission rates than in the most affluent neighborhoods.[33] All-cause mortality and CHD mortality were three times higher in the most deprived neighborhoods than in the most affluent neighborhoods[34]. Moreover, CVD risk factors (smoking, no physical activity, obesity) were more frequent in the neighborhoods with the highest CNI scores[35]. In the fall of 2000, CNI was revised because Swedish register data lack information about the items overcrowding and unskilled workers after 1990. Instead the item low educational status was added. At the same time CNI was updated with a new survey where all GPs in Sweden ranked the importance for their workload of the items in the revised CNI (see Table 1). However, there are some limitations with CNI, since CNI is useful only to calculate extra deprivation payments for the most deprived neighborhoods. The construction of the scale, with its negative values, makes CNI unsuitable for a total allocation of primary health care resources. In the present thesis, we intend to develop CNI into a more practical tool for the total allocation of primary health care resources to all types of neighborhoods, both affluent and deprived (study 2).

Table 1 A comparison between the original and the revised CNI.

	Original CNI (1996)	**Revised CNI (2000)**
Variables	Elderly living alone	Elderly living alone
	Children under age 5	Children under age 5
	Unemployed people	Unemployed people
	Single parents	Single parents
	High mobility	High mobility
	Foreign-born people	Foreign-born people
	Unskilled workers	*Low educational status*
	Overcrowding	----
Range	–76 – +54	–53 – +79
Mean	0	0
SD	15	16.7

The official Stockholm model for allocation of resources to health care

The official model is currently used in Stockholm for allocation of resources to primary health care, hospital care, private doctors, and drug treatments. For the allocation of resources to primary health care, an area-based, ecological regression model is used with morbidity as an outcome. Morbidity is defined as long-term sick leave >30 days. The following explanatory variables are used at an area-based level: proportions of foreign-born people (all countries except Sweden included) and proportions of men with low/average income. For every area a weight is calculated based on the morbidity in the area, with the average morbidity in the county used as reference. The population in each area is also weighted according to age, with small children and retirees given higher weights than the reference, i.e. the working population. In study 4 CNI is compared with the official model for the total allocation of primary health care.

Health care need

CNI, UPA score and the official Stockholm model include need-based items in their modeling of the allocation of health care resources. All these tools have defined "need" according to the higher need for health care among certain groups in society. Need must be differentiated from demand because need can exist without demand, and demand can exist without need. Use of health care is the result of need and/or demand. Moreover, in a Swedish study of met and unmet needs for medical and social services in the adult population, it was found that there are medical and social needs in the population that are not met. A met need is the same as utilization of service, for example, if a person with a disease is under treatment. An unmet need is more problematic to define. It can, for example, include a person with an actual need who has not consulted medical and social services or a person who has consulted medical and social services without any results[36]. Both perceived and evaluated need are included in The Behavioral Model of Health Services Use, initially developed in the USA in the 1960s, in order to predict use of health services. The Behavioral model also assessed the social structure by including traditional measures such as education, occupation, and ethnicity in the model[37]. To sum up, these models are in accordance with the higher need for health care among certain groups in society.

Health care utilization and equality

Sweden is well-known for its equal access to health care services irrespective of individual income. During the 1960s, higher health care utilization was observed among high-income groups[38]. In order to achieve more equal access to health care, user fees were reduced and during the 1970s and 1980s no socioeconomic differences were found in the proportion that had visited a doctor[39,40]. However, in 1993/94, inequalities in access to health care, favoring professionals, appeared in Sweden for the first time since the 1960s. This inequality did not appear in Britain[41] and in Sweden it might be explained by market-related reforms with a rapid expansion of private physicians and increased user fees during the 1990s. In contrast, another study using the same Swedish database could not find any socioeconomic changes in the utilization of health care services between 1988/89 and 1996/97. During the whole period, professionals used health care services to a higher extent than manual workers, after adjustment for self-rated health[42]. These results indicate that the demand for health care is separated from the actual need, with professionals having a higher demand than manual workers. This implies that health care resources should be allocated by the use of need-based tools, such as CNI, providing a basis for a more equal supply of primary health care, irrespective of individual resources.

Neighborhood SES and health

An increasing number of studies suggest that the neighborhood environments may have an important independent influence on individual health[31,43–46].

In a study from 1999, the most deprived neighborhood environments had an increased risk of poor cardiovascular health profiles, after adjustment for age, sex, and educational status. The most affluent neighborhood environments had the healthiest cardiovascular health profiles after adjustment for the individual level variables[35]. In contrast, a study using data from the British Longitudinal Study showed no neighborhood effect on premature mortality[47]. Other studies argued for an individual rather than a neighborhood effect on health[48,49]. Some authors have criticized the measurement of the neighborhood effect as being "an unspecified black box of somewhat mystical influences on health which remain after investigators have controlled for a range of individual and place characteristics"[50]. However, the consistent contribution of past research in this area suggests that neighborhood features are not simply proxies for individual SES and that research should be focused on both individuals and neighborhoods[44,46].

The use of models that include both individual-level and neighborhood-level factors has been shown to be of vital importance in public health research[16,51,52]. The use of a new paradigm in epidemiological research characterized by "relations within and between localized structures organized in a hierarchy of levels" is recommended[53]. With the use of the new methodological approach in epidemiology, multilevel analysis, it was possible to analyze both individual- and neighborhood-level risk factors and health outcomes. One of the first multi-level studies in Sweden demonstrated that people living in deprived neighborhoods had a higher prevalence of obesity, smoking, and physical inactivity than people living in more affluent neighborhoods[35]. By analyzing the influence of the neighborhood environment on individual health status, a gradient was found which showed that the risk of poor health increased with increasing deprivation, after adjustment for age, sex, educational attainment, and lifestyle factors[16]. In another study from Sweden, based on a national sample of 22,910 persons interviewed in 1988–92, high levels of deprivation had a corresponding increased risk of long-term illness and total mortality when age, sex, and individual SES were taken into consideration[54].

These results call for further studies to elucidate the pathways behind the neighborhood effect on health, which is important for future health intervention policies. In this thesis we have therefore used multilevel technique when analyzing the neighborhood effect on health (studies 1, 2, and 4).

Social capital and social participation

The concept of social capital can be applied to neighborhoods, communities, cities, and countries. Social capital has been defined as those features of social organization that facilitate cooperation for mutual benefit, i.e. interpersonal trust between citizens, group membership that facilitates collective action, density of civic associations, and norms of reciprocity[55–57]. More than one century ago, Durkheim stated: "The group thinks, feels and acts entirely differently from the way its members would if they were isolated."[58] Durkheim's original work provided a foundation for recent researchers to shape the concept of social capital. Past studies have shown a relationship between social capital and different health outcomes, for example self-rated health[17]. Social capital has mostly been operationalized at the individual level as social participation, i.e. formal and informal networks and activities, friends to rely on, control of one's own life, and trust[59,60]. Putnam has recently clearly emphasized that social participation in formal as well as informal social networks and activities is the most essential part of the social capital concept, or "what it is"[61]. Furthermore, social trust is a closely related consequence of social capital, or "what it does". Empowerment is an aspect of social capital, applicable to individuals (personal control) and organizations (political power and legal rights)[62]. Empowerment is a strategy by which people, organizations, and communities gain control over their own affairs[63]. The highest risks of poor health were found among groups with the least power in society[64,65]. In addition, women are often discriminated against politically, economically, and socially, constituting a base for structural gender discrimination. This discrimination may adversely affect their efforts regarding CHD health promotion and treatment[66]. In study 3 we examine whether the individual's social, cultural, and religious participation, political empowerment and perception of the social capital in the neighborhood predict incidence rates of CHD, after adjustment for demographic and socioeconomic characteristics and smoking.

Neighborhood contextual and compositional explanations for poor health

It is important to differentiate between compositional and contextual neighborhood differences in health[44,67]. A neighborhood's compositional effects on health mean the aggregate of all individual characteristics in a neighborhood, i.e., similar types of persons will have similar disease experiences no matter where they live. In addition, by a neighborhood's contextual effects on health is meant the aggregate effect of the social, cultural, and environmental characteristics of the neighborhood, i.e. similar types of individuals have a different disease status in different types of neighborhoods. Three types of explanations behind neighborhood differences in health have been suggested[68]. In addition to compositional and contextual effects the collective explanations, i.e. socio-cultural and historical features of neighborhoods, are also important to consider. The collective explanation relates to "social miasma" in which individuals conform to the behavior of the dominant group living in the neighborhood. That adds an anthropological perspective to the socioeconomic and epidemiological perspective when analyzing the neighborhood effect on health. Recently, the collective properties of the neighborhood have been included in the contextual explanation behind neighborhood differences in health[50].

Four reasons for the neglect of research on the neighborhood effect on health have been suggested[50]. Firstly, the strong criticism of inferring individual level associations from observations made on aggregated data on the neighborhood level, the "ecological fallacy." Secondly, the strong methodological development in statistics and computing science that made it possible for researchers to analyze large data sets on individuals. Thirdly, from the 1950s onward, political individualism and individualism in science dominated research. For example, the importance of the individual lifestyle, particularly the "big four"—smoking, exercise, alcohol, and diet—were the main focus instead of environmental and neighborhood conditions on health. Moreover, individualism was reinforced in the 1980s by the neo-liberalism in the USA (Reaganism) and in the UK (Thatcherism), "there is no such thing as society, there are only individuals."[50] Fourthly, there has been a lack of adequate operationalization and measurement of the neighborhood effect on individual health. Sally Macintyre[44] states that "contextual explanations for spatial variations in outcomes … would be that there are features of the social or physical environments which influence the health of those exposed to it."[69] She suggests a theoretical framework with five types of features of neighborhoods that might explain differences in health: (1) physical features of the environment shared by all residents in a locality (including quality of air, water, climate, etc.); (2) availability of healthy environments at home, work, and play; (3) services provided, publicly or privately, to support people in their daily lives; (4) socio-cultural features of a neighborhood; and (5) the reputation of an area. All these features are probably closely involved in the causal pathways behind the neighborhood effect on individual health.

Multi-level models

Individual biological and behavioral characteristics cannot give a complete explanation of the difference in morbidity between individuals. A long tradition of research suggests that the neighborhood characteristics may, in and of themselves, exert an important influence on disease risk. However, lack of appropriate models makes it difficult to separate the role of the neighborhood characteristics from the individual characteristics in the pathogenesis of diseases. The reason for this could be that many epidemiologists have not used multilevel models, although they have been applied in sociology and educational psychology to analyze, for example, classes (second-level) and pupils (first-level). By applying appropriate multilevel models, it is possible to separate the neighborhood effect from the individual effect on health, which is important for future intervention strategies. Moreover, it is also possible to calculate and express how much of the total variance is at the neighborhood level. In this thesis we have used multilevel models in studies 1, 2, and 4.

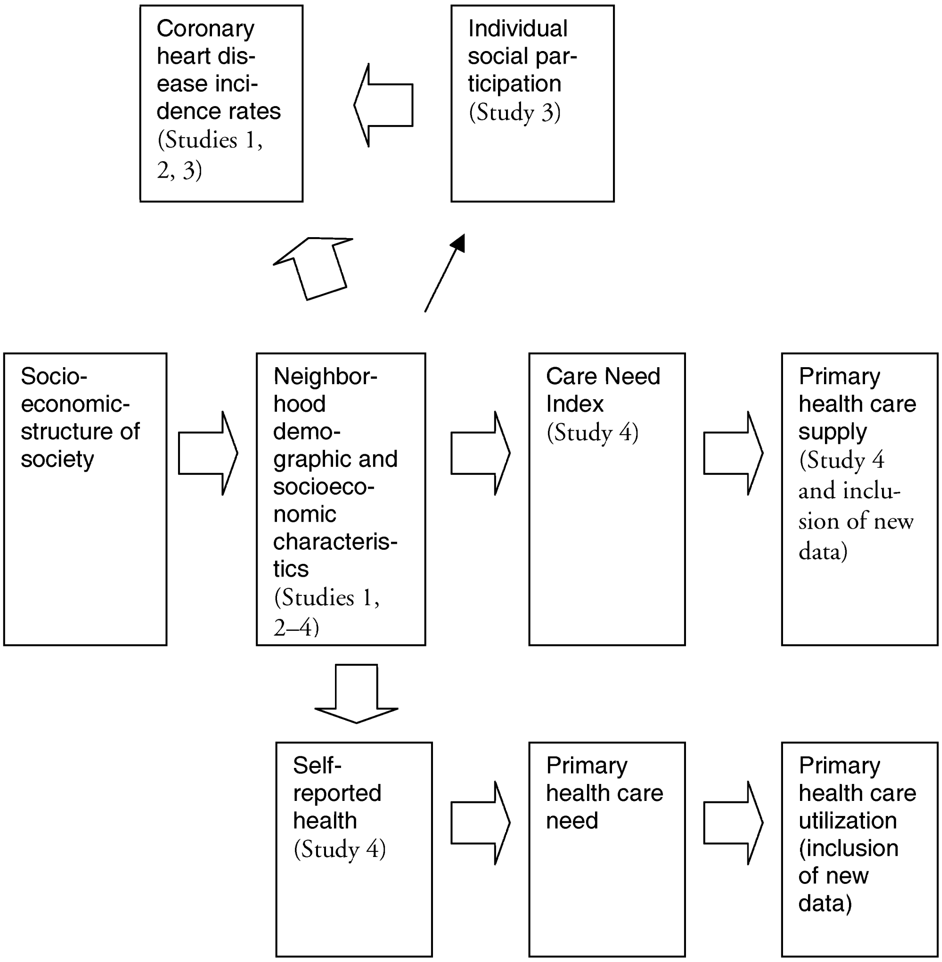
Theoretical model

The main focus of this thesis is on analyzing the individual and neighborhood effect on CHD, and constructing a need-based tool to allocate primary health care resources. Neighborhoods are defined by their demographic and socioeconomic characteristics. However, neighborhood socioeconomic characteristics are highly influenced by the socioeconomic structure of the society, such as state-level income inequalities. Income inequalities have been shown to be of great importance for health in rich Western countries. For example, Sweden and Norway had the highest life expectancy and the most equally distributed incomes among nine rich Western countries, while West Germany and the USA had the lowest life expectancy and the least equally distributed incomes[70]. However, more recent research on wealthy nations shows that the association between income inequalities, the psychosocial environment and different health outcomes is inconsistent[71]. This inconsistency implies that different health outcomes in the population are of a complex nature and might also include unequally distributed access to health care such as in the USA, where the effects of income inequalities on health are more pronounced[72]. Sweden is a society well known for its equally distributed health care. Nevertheless, recruitment of health care workers to primary health care in deprived neighborhoods has been difficult to accomplish and therefore the primary health care supply has, in practice, not been equal between deprived and affluent neighborhoods. In Sweden, people living in deprived neighborhoods visited primary health care and the emergency department more frequently than people living in affluent neighborhoods[73,74]. These results indicate a greater need for health care in deprived neighborhoods, showing the importance of using need-based tools in the allocation of primary health care resources. In London, people living in deprived neighborhoods had an increased risk of poor self-reported health and higher primary health care consultation rates than people living in the affluent neighborhoods[75]. High rates of poor self-reported health in a neighborhood may therefore be interpreted as a large need for primary health care. Although self-reported health is a good proxy for health care need and could be used as an instrument to allocate resources to health care, the use of self-reported health is complicated because it requires large, regular, and area-based surveys of the population. Therefore a need-based tool, such as CNI, is more appropriate to use because it is based on demographic and socioeconomic variables that are easy available from population registers. Some other aspects in the link between need for care and health care utilization have also been described in previous research: First, the willingness to utilize health care may vary between individuals who have the same need. Second, the demand for health care depends on the ability and willingness to pay for the health care utilization[76]. Finally, all forms of health care utilization are dependent on health care supply (see Figure 1).

Social participation in formal as well as informal social networks and activities is the most essential part of the social capital concept, or “what it is”, according to Putnam. Our social participation index measures the individual’s social, cultural and religious participation, political empowerment and perception of the social capital in the neighborhood.

The aims of this thesis are to examine whether neighborhood education and neighborhood income predict incidence rates of CHD, beyond individual characteristics (study 1); to examine whether neighborhood deprivation, measured with CNI, predicts CHD incidence rates, beyond individual characteristics (study 2); to examine whether low scores in the social participation index predict CHD incidence rates, after adjustment for individual characteristics (study 3); to examine the relationship between CNI and poor self-reported health at neighborhood level, to examine whether the transformed CNI can be used for a total allocation of primary health care resources, and to compare the allocation by the transformed CNI with the allocation by the official Stockholm model (study 4). Moreover, in addition to the four studies in this thesis, the allocation of resources to primary health care by CNI and the allocation by age-specific weights, based on primary health care costs per age group, will be compared (see end of *Methods*).

Figure 1 A theoretical model of individual health, neighborhood characteristics, social participation and allocation of primary health care resources.



Aims and hypotheses

General aims

To examine whether there is an association between low neighborhood education, low neighborhood income, high levels of neighborhood deprivation, low scores in the social participation index and CHD, beyond individual characteristics. Furthermore, to examine whether CNI can be transformed into a need-based tool for the total allocation of primary health care resources.

Specific aims

1 To evaluate the extent to which neighborhood education and neighborhood income predict incidence rates of CHD (study 1).

2 To examine the relationship between the two neighborhood measures and incidence rates of CHD after accounting for individual-level characteristics (study 1).

3 To calculate the population-attributable fraction in order to estimate the reduction in rates of CHD if all people lived in neighborhoods with the highest neighborhood education and highest neighborhood income (study 1).

4 To analyze whether there is an association between neighborhood deprivation, as measured by CNI, and incidence rates of CHD (study 2).

5 To analyze whether this association remains after accounting for individual income (study 2).

6 To analyze whether there is a neighborhood effect on CHD beyond the individual effect (study 1 and 2).

7 To examine whether there is an association between social, cultural, and religious participation and political empowerment and the individual's perception of the neighborhood, as measured in the social participation index, and incidence rates of CHD (morbidity and mortality) (study 3).

8 To examine whether this association remains after adjustment for age, sex, educational status, housing tenure and smoking habits (study 3).

9 To transform the CNI into a positive scale in order to use it as a tool for the total allocation of resources to primary health care, not only to the most deprived neighborhoods (study 4).

10 To examine the relationship between CNI and poor self-reported health, ranging from deprived to affluent neighborhoods (study 4).

11 To exemplify how primary health care resources in Stockholm County (1.7 million inhabitants) can be allocated by the transformed CNI, compared with the official model (study 4).

Hypotheses

We hypothesize: that low neighborhood education and low neighborhood income predict incidence rates of CHD, after accounting for individual-level characteristics; that there is an association between neighborhood deprivation, as measured by the CNI, and incidence rates of CHD, after accounting for individual-level characteristics; that there is a neighborhood effect on CHD beyond the individual effect; that low scores in the social participation index are associated with increased incidence rates of CHD even after adjustment for individual demographic and socioeconomic characteristics and smoking; that there is a relationship between CNI and poor self-reported health. Given this relationship, CNI is hypothesized to be a need-based tool for the total allocation of primary health care resources.

Materials

The Swedish Annual Level of Living Survey (SALLS)

The main purpose of the Swedish Annual Level of Living Survey (SALLS, in Swedish "Undersökning av LevnadsFörhållanden, ULF") is to collect information about the Swedish population's living conditions. The data are collected by face-to-face interviews lasting approximately one hour, conducted by trained interviewers. SALLS has been conducted by Statistics Sweden since 1974 and from the beginning it contained detailed questions about health, education, economic resources, housing, employment, and working environment. Shortly after the start of SALLS, many questions about leisure, transportation, social relations, political resources, and sense of security were added. Over the years, there have been four main themes in SALLS: social relations, work, health, and physical environment. Every annual survey includes a number of indicators for these four themes. Certain questions are repeated every year, in order to provide consistency for some of the most important background variables, e.g. self-reported health, socioeconomic conditions, family type, etc. Other questions, which are not repeated annually, provide information that makes it possible to follow the development in some selected fields. The annual sample, drawn from the *Total Population Register* (in Swedish *RTB*), is a simple random sample of individuals who are permanent residents in Sweden aged 16–84. Some years there has been an over-sampling of elderly people. The annual sample size has varied between 6,100 and 9,000. One main reason for the wide use of SALLS in epidemiological studies is the large amount of variables, approximately 700 in total. Other advantages of SALLS are the availability of data, the sample size, the periodicity (annual since 1975), the construct (a national sample), and the low non-response rate (about 20 percent). The influence of non-response has been studied by analyzing the mortality in the 1988/89 samples in a proportional hazard model adjusted for sex, age, marital status, and region. Of the non-respondents about 70 percent consisted of refusals, 20 percent was not found and 10 percent was ill. Those who refused among the non-respondents had the same mortality as the respondents, but those who were not found and those who were ill had significantly higher mortality. The reliability of the variables has been analyzed by re-interviews (test-retest method) giving kappa coefficients between 0.7 and 0.9.[77] A sample of variables has been evaluated in several re-interview studies, showing good stability over time.[78]

SALLS is used in studies 1, 3, and 4.

The In-Care Register

The In-Care Register is based on WHO recommendations and contains all hospital admissions with dates of admission and discharge, according to the International Classification of Diseases (ICD). ICD 9 was used 1987–1996 and ICD 10 from 1997 onwards.

This register is used in studies 1, 2, and 3.

The Cause of Death Register

The Cause of Death Register contains annual information about all deaths with death causes. The register is based on ICD, according to WHO recommendations. The under-coverage is very low: 0.36 percent in 1996. The coding error is estimated from a sample (2.5 percent) of deaths and was found to be 3 percent.[79] The register is produced by Statistics Sweden and since 1994 it has been published by the National Board of Health and Welfare. Since the autopsy frequency has decreased successively from 50 percent (1970) to 19 percent (1996),[80] the register is mostly based on the physician's statement.

The register is used in studies 1 and 3.

MigMed

MigMed is a longitudinal research database at Karolinska Institutet, Family Medicine, Stockholm, where each individual can be followed from 1990 to 1999. MigMed is linked to several other databases: *Louise:* A register including the entire population aged 20 and above, in total about 6 million persons. Louise contains annual specifications of income from different sources (e.g., employment, self-employment, unemployment, parental leave), education, employment, place of work, and place of living with geographical coordinates. *The Immigration Register* has data on immigration, immigration year, and country of birth. *The Total Population Register* consists of all individuals who have a residence permit, i.e. people who stay more than 6 months in Sweden. It includes annual data on marriages, divorces, mobility from one neighborhood to another, emigration from and return to Sweden. *The In-Care Register* and *The Cause of Death Register* are also linked to MigMed.

MigMed is used in studies 1, 2, and 4.

Small Area Market Statistics (SAMS)

SAMS or Small Area Market Statistics, owned by Statistics Sweden, consists of the smallest area units in a system covering the whole geographic area of Sweden. SAMS were originally created for commercial purposes, for example delivery of advertising brochures. The boundaries are drawn to include similar types of buildings and are therefore comparatively homogenous regarding socioeconomic structure. In the municipality of Stockholm the average population per SAMS is about 2,000 inhabitants and in the rest of Sweden about 1,000. The total number of SAMS in the whole of Sweden is about 9,700. Neighborhood social position, expressed as CNI, is calculated for all SAMS neighborhoods in Sweden. Individual health outcomes can also be located at SAMS level, because of the linkages between the registers in MigMed.

SAMS was used in studies 1, 2, and 4.

Methods

Table 2 An overview of the four studies.

	Study 1	Study 2	Study 3	Study 4
Data source	SALLS MigMed SAMS In Care *and* Cause of Death Register	MigMed SAMS In Care Register	SALLS In Care *and* Cause of Death Register	SALLS MigMed SAMS
Outcome	CHD	CHD	CHD	Self-reported health
Number of cases	1,189	52,360	445	6,614
Study design	Follow-up	Follow-up	Follow-up	Cross-sectional
Measure of risk	Hazard Ratio	Odds Ratio	Hazard Ratio	Odds Ratio
Statistical model	Multilevel Cox proportional hazard models	Multilevel logistic regression	Cox regression	Hierarchical logistic regression
Interview period	1986–93	–	1990–91	1992–97
Follow-up	1986/93– Dec. 31,1997	Dec. 31,1995– Dec. 31,1999	1990/91– Dec. 31, 2000	–
Age	35–74	40–64	35–74	25–74
Sample size	25,319	–	6,861	27,346
Population size	3,524,077	2,637,628	3,885,372	5,244,000
Response rate % (SALLS)	78.2	–	77.6	79.0

The items in CNI

CNI was used in studies 2 and 4. The CNI included proportions of seven demographic and socioeconomic items from Swedish public registers for each SAMS neighborhood (see Table 3). Unemployment was defined as being out of work without receiving any early retirement pension or study allowance; high mobility was defined as residents who had moved house during the past year; low educational status was defined as <10 years. Foreign-born people included all countries with the exception of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Japan, Liechtenstein, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Switzerland, UK, and USA.

Calculation of CNI

In the fall of 2000, all 3,922 Swedish GPs received a questionnaire that 2,541 answered (response rate 64.8 percent). In this questionnaire the GPs ranked the impact of the seven items on their workload on a ranking scale from 0 to 9. The ranking made it possible to calculate weights for all the seven items and CNI scores at neighborhood level.

Table 3 The general practitioners' ranking of the variables in CNI (2000).

Variable	CNI $weight_i$
Elderly (>65) living alone	6.2
Foreign-born people	5.7
Unemployed people	5.1
Single parents	4.2
High mobility	4.2
Low educational status	4.0
Children (<5)	3.2

The CNI was based on weights obtained from the impact of seven items on the general practitioners' workload (see Table 3).

The steps in the calculation of the CNI

1 The seven items were expressed as proportions of total residents in each of the Swedish SAMS neighborhoods.

2 All Swedish GPs (response rate 64.8 percent, 2000) ranked the impact on their workload of the seven items on a scale from 0–9, with a higher value implying a higher workload, see table 3.

3 The population was then normalized by applying an angular transformation (arc sin √), meaning that each item was transformed to a symmetrical distribution to minimize the disproportionate effect of outliers (extreme values). The means (m_i) and standard deviations (s_i) of the transformed proportions

were calculated for Sweden as a whole.

For each SAMS CNI was calculated as follows: For each SAMS the proportions (p_i) of the seven items were standardized by calculating Z-scores (mean = 0 and variance = 1).[81]

For each item the deviation from Sweden was calculated. The standardized value for each item is calculated as follows:

$$Z_i = [(p_i - m_i)/s_i]$$

4 The standardized value for each item (Z_i) was multiplied by each weight ($weight_i$) calculated from the GPs' ranking. Thus the contribution of each item (V_i) in CNI was calculated as follows:

$$V_i = weight_i \times Z_i$$

For each SAMS the sum of V_i for all the items in CNI was calculated in order to obtain the CNI score for every SAMS in Sweden:

$$CNI = \Sigma V_i$$

5 The mean CNI score is 0, which corresponds to the average CNI score for Sweden as a whole. The higher the CNI score, the more deprived is the neighborhood. The CNI scores varies from –53 (most affluent) to +79 (most deprived).

Study 1

We used data from SALLS consisting of 25,319 women and men, aged 35–74, surveyed between 1986 and 1993. The sample represented on average 3,524,077 women and men, 35–74 years of age at the year of the interview. The response rate was 78.2 percent. In order to identify CHD events, these data were linked to the In-Care Register and the Cause of Death Register. Participants were followed from date of interview to first hospitalization due to CHD, death from all causes, or censoring until December 31, 1997 (mean follow-up time of 7.0 years).

Neighborhoods were defined on the basis of SAMS. Of our sample, on average eight individuals resided in each SAMS. SAMS with fewer than 50 people (a total of 1,583 SAMS, 58 sampled individuals) were excluded because of unstable statistical estimates. This yielded a final sample of 6,145 SAMS. The home addresses of the participants in the survey had been previously geocoded, allowing us to identify the SAMS neighborhood in which the participants lived. To estimate the length of exposure to a certain neighborhood, we used a longitudinal subsample consisting of 40 percent of the participants, who were asked how long they had lived at their home address. We found that 75 percent of the subsample had lived at their home address at least eight years preceding the survey.

Outcome variable

Coronary heart disease (CHD): Time to first hospitalization for fatal or non-fatal CHD event, classified according to ICD 9 (410–414) and ICD 10 (I20–I25). Out-of-hospital deaths due to CHD (1.5 percent of all CHD events) were not included because of the low autopsy rates in Sweden leading to possible unreliable causes of death on the death certificates. In order to begin the study with a sample as healthy as possible, participants hospitalized for a CHD event during the interview year, or two years preceding the interview year were excluded. We were not able to exclude participants with a CHD event earlier than 1986 because the In-Care Register only records information beginning in 1986. The validity of myocardial infarction diagnosis has been evaluated for 1987 and 1995 and was considered to be high[82].

Individual-level variables

Sex.

Age: was used as a continuous variable, centered at the mean age of all respondents to aid in the interpretation of the regression coefficients[83].

Level of education was classified into three categories, <10 years (no high school), 10–12 years (some high school or completion of high school), and >12 years (more than high school).

Income level: defined as annual family income divided by number of people in the family. The family income measure also took into consideration the ages of people in the family and used a weighted system whereby small children were given lower weights than adolescents and adults.

Smoking habits comprised two levels: daily smokers and all others. This variable was added only in the full model and results from this analysis are not shown.

Neighborhood-level variables

Data used to calculate the two measures of neighborhood socioeconomic environment (neighborhood education and neighborhood income) were ronment (neighborhood education and neighborhood income) were obtained from MigMed, containing annually collected individual data for the entire Swedish adult population. Our two neighborhood measures were calculated from the age group 25–64 and are defined below. We chose the lower age cutpoint of 25 because in Sweden many people do not complete their formal education before this age, nor do they have a financial position independent of their parents. However, people under 25 and over 64 are included in the family income measures when they lived in homes with one or more persons aged 25–64. Data from January 1992 (the midpoint of the entire study) were used in the calculation of the neighborhood measures. These national data were then linked to the SAMS neighborhoods.

Neighborhood education: Proportion of people with less than 10 years of education, calculated for each neighborhood. The distribution was then divided into quintiles. Quintile 1 represents neighborhoods with the lowest proportions of people with low education (range 0–21 percent) and quintile 5 represents neighborhoods with the highest proportions of people with low education (range 42–78 percent).

Neighborhood income: Proportion of families with incomes in the lowest national income quartile, calculated for each neighborhood. The distribution was then divided into quintiles. Quintile 1 represents neighborhoods with the lowest proportions of people with low income (range 0–16 percent) and quintile 5 represents neighborhoods with the highest proportions of people with low income (range 34–100 percent).

The correlation between neighborhood income and neighborhood education was 0.65, calculated as correlation at SAMS level between proportions of people with low educational status and proportions of people with low income (Pearson's correlation coefficient).

The population-attributable fraction ($PAF = \Sigma (AF_i \times P_i)$) was calculated as percentage PAF and absolute PAF, where AF_i is the attributable fraction for neighborhood quintile i and P_i represents the proportion of all cases that falls in quintile i[84].

Study 2

Study population and data sources

We performed a 4-year follow-up study of the entire Swedish population aged 40–64 years, in total 2.6 million individuals. The individuals were followed from December 31, 1995, until first admission to hospital due to CHD, death, or to censoring on December 31, 1999. All individual data were obtained from MigMed. By means of a unique personal identification number we linked these data to the Cause of Death Register and the In-Care Register at the Center for Epidemiology (National Board of Health and Welfare). All individuals were geocoded to their SAMS neighborhoods. Of the total 9,667 SAMS existing in Sweden we excluded 1,120 with less than fifty inhabitants because of unstable statistical estimates. This yielded a final sample of 8,547 SAMS. A total of 64,528 of the individuals (2.8 percent) were excluded from the study because of missing SAMS codes. All 2.6 million individuals were divided into ten groups (deciles) according to the level of neighborhood deprivation, measured by CNI, in the SAMS neighborhood where they lived. By this method each decile contained approximately 1/10 of the individuals. CNI was calculated for each decile.

Outcome variable

Coronary heart disease (CHD) was defined as first non-fatal admission to hospital according to ICD 9 (410–414) and ICD 10 (I20–I25). Individuals with CHD hospitalization during 1994 and 1995 were excluded.

Individual level variables

Age was used as a continuous variable, and centered at the mean age of all individuals[83].

Individual income was divided into quintiles according to income level.

Since our sample included the whole population in the actual age group, individual data were limited to certain variables such as age, gender, and SES. We chose to use only income as a measure of SES since the correlation between different SES measures is high.

Neighborhood level variable

Care Need Index (CNI) was measured on December 31, 1995, for all SAMS in the final sample. For calculation of CNI, see above, beginning of *Methods*.

Study 3

This follow-up study was based on data from SALLS. The sample of 6,861 women and men, aged 35–74, was collected in 1990 and 1991 and followed to the first admission to hospital due to CHD, death from all causes, or to censoring on December 31, 2000. The years 1990 and 1991 included a number of questions about the individual's social, cultural, and religious participation, political empowerment, and perception of the social capital in the neighborhood. The non-response rate was 22.4 percent.

Outcome variable

Coronary heart disease (CHD): morbidity and mortality according to ICD 9 (410–414) and ICD 10 (I20-I25). Morbidity was defined as the first admission to hospital due to CHD. Individuals hospitalized with a CHD event between 1986, when the In-Care Register started, and day of interview were excluded.

Explanatory variables

Sex.

Age. The respondents were categorized into the following groups: 35–44, 45–54, 55–64, and 65–74 years of age.

Socioeconomic status (SES) was operationalized as educational status and housing tenure.

Educational status was classified into three categories, <10 years (no high school), 10–12 years (some high school or completion of high school), and >12 years (more than high school).

Housing tenure was divided into two groups: (1) ownership and (2) renting.

Smoking habits comprised two levels: daily smokers and all others.

Social participation. Eighteen variables were selected from SALLS in order to create the social participation index. Variables 1–3 represent the individual's perception of the social capital in the neighborhood, variables 4–15 represent the social, cultural and religious participation, and variable 16–18 the political empowerment of the respondent.

A factor analysis (principal component analysis)[85] of the 18 variables was conducted and resulted in five factors with eigenvalues larger than one. Of these five factors only the first had a large eigenvalue (3.19), while the other four eigenvalues were lower than 1.5. Therefore the social participation index was calculated only from the first factor by dividing the sample into quartiles. The first quartile comprised individuals with low social participation. The second and third quartiles represented individuals with middle social participation and the fourth quartile high social participation. The standardized scoring coefficients, obtained from the first factor in the factor analysis, are shown in parentheses. The higher the value of the coefficient, the greater was the importance of the variable in the social participation index. All the 18 variables contributed positively (scoring coefficients >0) to the social participation index.

The 18 variables were based on 18 questions in SALLS, for example if the individual was member of a choir, or had taken part in a study circle. The response alternatives were constructed as follows:

[1] "Yes, at least once during the last 12 months" or "No"

[2] "Yes" or "No"

1/ Neighbors talk often in the area[2] (0.058)
2/ Attended mutual activity in the neighborhood[1] (0.094)
3/ Socialize with neighbors at least once every three months[2] (0.066)
4/ Went to restaurant for pleasure[1] (0.163)
5/ Went to disco or dance restaurant[1] (0.102)
6/ Went to cinema[1] (0.181)
7/ Went to theater[1] (0.183)
8/ Went to concert[1] (0.188)
9/ Went to art exhibition[1] (0.195)
10/ Went to other exhibition or museum[1] (0.183)
11/ Went to library[1] (0.162)
12/ Attended divine service[1] (0.089)
13/ Member of a choir[2] (0.049)
14/ Active in a sports association[2] (0.069)
15/ Taken part in a study circle or an evening course[1] (0.123)
16/ Membership in a political party[2] (0.040)
17/ Attended meeting of a local group (environmental for instance)[1] (0.072)
18/ Knowledge of how to appeal against authorities[2] (0.153)

Study 4

This cross-sectional study was based on a national sample of the whole Swedish population, comprising 27,346 interviews of women and men, aged 25–74, from SALLS 1992–97. All individuals in the sample were geocoded to the SAMS neighborhood where they lived and then divided into deciles by the social position, expressed as CNI, of their SAMS neighborhood. MigMed was used to calculate the CNI, at SAMS level, for the total population of Stockholm County, 1.7 million people, divided into deciles. The non-response rate in SALLS was 21 percent.

Outcome variable

Poor self-reported health was based on the question: "How would you describe your general health?" There were three response alternatives: good, bad, or anywhere between good and bad. Those who answered that their health status was bad or anywhere between good and bad were considered as having a poor self-reported health status.

Explanatory variables

Individual level

Sex.

Age: used as a continuous variable

Neighborhood level

CNI: calculated at SAMS level for Sweden as a whole and then linked to our sample. The CNI scores could not be matched with SAMS for 1,294 respondents, representing about 4.7 percent of the whole sample. SAMS with less than 50 inhabitants were excluded because of the instability of the estimated proportions. For calculation of CNI, see above, beginning of *Methods*.

The transformation of CNI

The CNI scale for Sweden was transformed into a positive scale (mean=100; SD=15) in order to avoid negative values according to the formula:

$$Y_j = (s_y/s_x) \times (X_j - M_x) + M_y,$$

where:

Y_j is the individual j value in the transformed distribution,
s_y is the standard deviation in the transformed distribution (16.7),
M_y is the mean value in the transformed distribution (100),
X_j is the individual j value in the original distribution,
s_x is the standard deviation in the original distribution (15),
M_x is the mean value in the original distribution (0).

The transformed CNI scores for the whole of Sweden vary from 50 (most affluent) to 164 (most deprived).

Allocation of resources by CNI: the Stockholm County example

The CNI was used to measure the social position of the area. In MigMed, each individual has an area social position measured by the CNI according to his or her area of living. The whole population of Stockholm County was divided into deciles according to each individual's area social position, with CNI scores ranging from 61 in the most affluent decile to 140 in the most deprived decile. Each decile comprised approximately 170,000 individuals. In the next step, the means of the transformed CNI for Stockholm County were calculated for each decile. These means were used as CNI weights. These CNI weights for each decile of the population of Stockholm County were used in the calculation of new CNI weights for six administrative areas in Stockholm County.

Stockholm County is divided into six independent administrative areas: North-East (NE), North-West (NW), Northern Stockholm (NS), Southern Stockholm (SS), South-West (SW) and South-East (SE).

For the respective administrative area the following calculation was made:

1 The CNI weights were multiplied by the size of the population (N) of each of the CNI deciles so that ten values (CNI weights × N) were obtained.
2 These ten values were summarized in one sum [$\Sigma_{\text{deciles } 1-10}$ (CNI weights × N)].
3 The CNI weights for each decile were summarized in one sum [$\Sigma_{\text{deciles } 1-10}$ (CNI weights)].
4 These two sums were divided, so that the sum [$\Sigma_{\text{deciles } 1-10}$ (CNI weights × N)] was divided by the sum [$\Sigma_{\text{deciles } 1-10}$ (CNI weights)]. The value thus obtained is called the final CNI weight and was calculated in the same way for each administrative area.
5 The sum of the six final CNI weights was calculated [$\Sigma_{\text{areas } 1-6}$ (final CNI weights)].
6 The allocation of resources to each administrative area in percentage is obtained by dividing the final CNI weight for each administrative area by the sum of the final CNI weights ($\Sigma_{\text{areas } 1-6}$ (final CNI weights) for all administrative areas (multiplied by 100). The proposed CNI model was compared with the official model used in Stockholm County.

Ethics

The ethics committee at Huddinge University Hospital, Karolinska Institutet, Stockholm, has approved this study (Registration number 12/00 with an additional registration April 4, 2002).

Care Need Index, age-specific weights and allocation of resources to primary health care

Outside the four studies, this example is based on preliminary data from an evaluation of primary health care in Sweden conducted by the National Board of Health and Welfare. It is a comparison of allocation of resources to primary health care by CNI and allocation by age-specific weights. The age-specific weights are based on primary health care costs per age group and 1,000 inhabitants in Örebro County. Nine primary health care centers in different parts of Sweden are used in the example: Arvika, Gagnef, Holmsund, Håbo, Möllan, Ryd, Segeltorp, Stenungsund, and Vaxholm. The fictive budget for these nine primary health care centers is in total 100 million SEK to allocate. Table 4 shows population number, CNI mean and transformed CNI mean for the nine primary health care centers. The formulas for calculation of CNI are shown in the method section above. The transformed CNI scores varied between 87.4 and 100.4, which is close to the CNI mean in Sweden. Lower CNI scores imply more affluent catchment areas for the primary health care centers. The most affluent areas are Holmsund and Segeltorp.

Table 4 Population number, CNI mean, and transformed CNI mean for the nine primary health care centers.

Primary health care center	Population number	CNI Mean	Transformed CNI Mean
Arvika	26 449	1.35	98.1
Gagnef	10 290	–0.45	96.5
Holmsund	7 949	–11.20	87.4
Håbo	16 966	–3.88	93.6
Möllan	4 733	–6.19	91.6
Ryd	8 998	4.16	100.4
Segeltorp	9 654	–9.63	88.7
Stenungsund	19 733	–4.01	93.5
Vaxholm	8 496	–5.58	92.2
Total	113 268	–2.96 [1)]	94,4 [2)]

[1)] Mean, Sweden has the mean = 0
[2)] Mean, Sweden has the mean = 100

Age is an important factor associated with primary health care utilization. Children <5 and elderly >65 have the highest utilization of primary health care. Table 5 shows age-specific weights calculated as relative weights based on costs for primary health care per age group and 1,000 inhabitants in Örebro County.

Table 5 Relative age-specific weights based on primary health care costs per age group and 1000 inhabitants in Örebro County.

Age-group	Relative age-specific weights
0–5	2.5
6–29	1
30–34	1.2
35–39	1.2
40–44	1.2
45–49	1.2
50–54	1.3
55–59	1.5
60–64	1.6
65–69	2.0
70–74	2.1
75–79	2.5
80–	2.5

CNI takes age into consideration only to a small extent. Therefore we compared a transformed CNI model (model 2) with a model based on age-specific weights (model 3) for distribution of the fictive 100 million SEK to the nine primary health care centers. Model 1 shows the allocation related to each primary health care center's proportion of the total population (Table 6). The allocation of resources by the transformed CNI model is very similar to the model for allocation according to age-specific weights. The transformed CNI model agrees with the model based on age-specific weights except for the Ryd primary health care center, which differs in this example by almost two percentage units. This may partly be explained by the fact that Ryd has a large student population. Students have not reached their final socioeconomic position and will therefore be considered as having a low educational status. The two-percent difference seems small but corresponds to 2 million SEK, i.e. the approximate cost for two GPs. CNI is based on need of primary health care while the age-specific weights are an economic measure of the utilization of primary health care.

A limitation of model 3 is the lack of data from each primary health center. Instead the age-specific costs for primary health care from Örebro County were used. A limitation in this example is the absence of primary health care centers in more deprived neighborhoods. Therefore CNI will have less influence on the resource allocation while age distribution will have more influence on the allocation of primary health care resources.

Table 6 Allocation (percentage) of 100 million SEK to the primary health care centers according to three different models.

Primary health care centers	Population N = 113,268	Allocation by transformed CNI; final weights	Allocation by age-specific weights
	Model 1	Model 2	Model 3
Arvika	23.35	24.12	24.91
Gagnef	9.08	9.25	9.47
Holmsund	7.02	6.49	6.63
Håbo	14.98	14.75	14.45
Möllan	4.18	4.06	4.16
Ryd	7.94	8.56	6.67
Segeltorp	8.52	8.12	8.49
Stenungsund	17.42	17.38	17.60
Vaxholm	7.50	7.28	7.61
Total	100	100	100

Statistical analysis

Study 1

A multilevel Cox proportional hazards model was used to calculate the hazard ratios of CHD because it reflects the hierarchical structure of our data[86].

Separate models were used to identify the independent effect of neighborhood education and income (level 2) on incidence of CHD after adjustment for individual-level factors (level 1).

The model was:

$$h_{ij}(t) = \exp\left[\gamma_{00}(t) + \sum_k \gamma_{0k} N_{kj} + \sum_p \gamma_p I_{pij} + U_{0j} + R_{ij}\right] h_0(t)$$

where I_{ij} represents the set of individual demographical and explanatory variables, N_{kj} represents each set of level 2 variables, U_{0j} represents the intercept random effect, $\gamma_{00}(t)$ represents the intercept of time t and R_{ij} represents the individual residual. $h_{ij}(t)$ represents the hazard function of time t and $h_0(t)$ represents the baseline hazard function. The time t was defined as number of months from the individual's entry in the study until CHD or censoring. The index $_j$ represents areas whereas the index $_i$ represents individuals.

We first analyzed the age- and sex-adjusted associations (i.e., hazard ratios) between the two measures of neighborhood socioeconomic environment and CHD. We then added measures of individual-level socioeconomic characteristics (i.e. income and education). This strategy was used for each of the two sets of neighborhood variables. The models were also tested for cross-level interactions between level 1 and level 2. No significant interactions were found ($p>0.05$).

All of the multilevel analyses were performed with MlwiN[87] using the macro for Survival and Event duration models[88].

Preliminary estimates of the effects were made by a first-order marginal quasi-likelihood estimation procedure. To obtain more accurate estimates, the final models were then re-estimated using a predictive quasi-likelihood procedure in combination with a second order Taylor expansion series. The results are presented as hazard ratios (HR) with 95 percent CI.

The incidence rates (IR) for CHD, based on all persons aged 35–74 interviewed between 1986 and 1993, were calculated separately from the multilevel model and separately for the two measures of neighborhood socioeconomic environment, standardized for age and sex, and presented as the number of cases per 10,000 person-years.

Study 2

Age-standardized incidence rates were calculated. We performed a multilevel logistic regression modeling[89,90] with individuals at the first level and neighborhoods at the second level, to estimate odds ratios (OR) with 95 percent confidence intervals (CI). Because of the large sample size it was not possible to use a multilevel Cox proportional hazards model in the computing process. Therefore, we instead used a multilevel logistic regression without including time as a variable in the model. Under certain circumstances (large sample size, low outcome incidence rate, risk ratios of moderate size, and not too long follow-up), logistic regression is a good approximation of Cox's proportional hazard model[91]. We compared the two approaches by analyzing a sub-sample of 25,000 individuals with both a multilevel logistic regression and a multilevel Cox proportional hazards model, and the results were almost identical. Thus the results were presented as ORs and are a good approximation of hazard ratios.

We performed three models with separate analyses for women and men. The full model included age, the neighborhood variable, and individual income.

The logistic model used is given by:

$$y_{ij}=\exp(f_{ij}+u_j/(1+\exp(f_{ij}+u_j))+e_{ij})$$

where f_{ij} denotes the fixed part of the model and u_j the random part. The e_{ij} denotes the residual part.

We calculated the second level (i.e. neighborhood) intercept variance.

We computed the intra-class correlation (ICC), i.e. the intra-neighborhood correlation, in order to estimate to what extent the individual propensity for CHD for individuals within the same SAMS was similar to that of individuals in other SAMS neighborhoods. The ICC expresses the proportion of the total variance that is at the neighborhood level. The ICC in multilevel logistic regression can be estimated by different procedures[92].

We applied the latent variable method[89] as exemplified by:

$$ICC = \frac{V_n}{V_n + \pi^2/3}$$

where V_n is the between variance between neighborhoods and $\pi^2/3$ is the variance between individuals.

The proportion of the second level variance explained by the different variables was calculated as:

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

where V_0 is the age-adjusted variance in the initial model and V_1 is the second level variance in the different models.

We tested whether there were any random effects by the two highest and the two lowest income levels. No such effects were found. This implies that the relationship between the first-level variables (individual income) and CHD was the same in all kinds of SAMS, independently of differences in individual income. Possible cross-level interactions were tested, but none were found. We also examined whether there was any heterogeneity between the SAMS neighborhoods in each CNI decile by calculating the variance for every decile. For example, for women, the highest variances were found in deciles 2, 6, 8, 9, and 10.

Parameters were estimated by 2nd-order PQL. Extra-binomial variation was explored systematically in all models and we found no evidence of under- or overdispersion. The MLwiN, Version 1.10.0007 software package[93] was used to perform the analyses.

Study 3

The SAS software package was used in the statistical analyses[94].

A factor analysis (principal component analysis) was performed in order to create the social participation index from the 18 variables in SALLS.

The estimated total population size in different subgroups, based on the explanatory variables, were calculated from weights obtained in a post-stratification by the variables sex, age, marital status, and geographical region (in total, about eighty strata). By summing the individual weights in the different variables the population size was estimated. Population data were obtained from the Total Population Register for the year of the data collection. Furthermore, the weights were obtained by dividing the population size in each stratum by the corresponding sample size.

Age-adjusted incidence rates (per 10,000 persons per year) of CHD were calculated between 1990 and 2000[95]. A Cox regression model[96] was used to estimate the hazard ratio (HR) of CHD in the different variables. The results are shown as HR with 95 percent confidence intervals (CI). Risk time was calculated from the interview until the first admission to hospital for CHD, or death. All others were censored on December 31, 2000. By including an interaction between each independent variable and time, the proportional hazards assumption was tested. All variables met the assumption. There were no interactions between the social participation index and the other variables in the model.

Study 4

The prevalence of poor self-reported health status was standardized by sex and age (indirect standardization)[95]. Hierarchical logistic regression was used in the analysis of data and the models were fitted using the SAS macro GLIMMIX[97,98]. A restricted maximum likelihood procedure was used in the method of estimation. The inclusion of a macro error term mixed the model with the CNI as a random effect. The interactions between fixed effect factors and the CNI were treated as random effects. No such interactions were found. The results were exhibited as OR with a 95 percent CI. The fit of the model was inferred from an extra-dispersion parameter, which met this demand.

Main Results

Study 1

There was an apparent gradient between each of the measures neighborhood education and neighborhood income, and age- and sex-standardized incidence rates of CHD. As neighborhood education and neighborhood income decreased, incidence rates of CHD increased by about 40 percent (data not shown).

Table 7 shows the full models, adjusted for age, sex and individual-level education or income. For neighborhood education, the risk remained significantly higher in quintile 5 with a hazard ratio (HR) = 1.32 (CI: 1.07–1.62), showing that women and men living in neighborhoods with the lowest neighborhood education had a 32 percent higher risk of developing CHD than women and men in neighborhoods with the highest neighborhood education. For neighborhood income, the risk of CHD remained significantly higher in quintile 5 (HR = 1.25, CI = 1.02–1.54), than in quintile 1. The variance at neighborhood level was over twice the standard error for both neighborhood measures, indicating that there were significant differences in CHD between neighborhoods even after adjustment for individual age, sex, income or education, and neighborhood socioeconomic environments. However, in absolute terms the variance was relatively small, indicating that the neighborhood effect was small, although significant.

In an additional analysis (data not shown) smoking habits were included in the full model. This new variable showed a strong association with CHD but did not change the regression coefficients or the variance in the full model.

CHD events, expressed as percent PAF, would hypothetically be reduced by 25–26 percent for women and by 10–15 percent for men for each neighborhood measure if all people had the same incidence rates as those living in the neighborhoods with the highest neighborhood education and/or the highest neighborhood income (highest quintile specific to each gender). In absolute terms, men living in the neighborhoods with the lowest neighborhood education would benefit the most. Their incidence rates would be reduced by 1,752 events per year for the whole population (data not shown).

Table 7 Hazard ratios (HR) for CHD with 95% confidence intervals (CI) by the two neighborhood measures, women and men, aged 35–74, Sweden. Models, adjusted for age, sex, and individual-level income or education, multilevel Cox regression.

Variable	**Level**	**Neighborhood education[1]**	**Neighborhood income[2]**
		HR (CI)	HR (CI)
Age (continuous)		1.08 (1.07–1.09)	1.08 (1.07–1.09)
Sex	Men	2.13 (1.89–2.40)	2.19 (1.94–2.47)
	Women	1 (ref)	1 (ref)
Individual-level family income	Group 1 (lowest income)	–	1.34 (1.08–1.65)
	Group 2	–	1.34 (1.09–1.64)
	Group 3	–	1.18 (0.95–1.45)
	Group 4	–	1.16 (0.94–1.44)
	Group 5 (highest income)	–	1 (ref)
Individual-level education	<10 years	1.27 (1.05–1.55)	–
	10–12 years	1.44 (1.19–1.75)	–
	>12 years	1 (ref)	–
Neighborhood measure (in quintiles)	Q1	1 (Ref)	1 (Ref)
	Q2	1.11 (0.89–1.38)	1.08 (0.87–1.34)
	Q3	1.14 (0.92–1.41)	1.15 (0.93–1.41)
	Q4	1.17 (0.94–1.44)	1.14 (0.92–1.40)
	Q5	1.32 (1.07–1.62)	1.25 (1.02–1.54)
Between neighbor-hood variance (SE)[3]		0.17 (0.07)	0.22 (0.07)

[1] Adjusted for age, sex, and individual-level education.
[2] Adjusted for age, sex, and individual-level family income.
[3] Standard Error

Study 2

For both women and men, age-adjusted CHD incidence rates increased with increasing neighborhood deprivation (data not shown).

Table 8 shows the age-adjusted and full model for women. When individual income decreased and the level of neighborhood deprivation increased, the risk of CHD increased. For example, in CNI decile 5 the risk of developing CHD was 29 percent higher than in decile 1 with an Odds Ratio (OR) = 1.29 (CI = 1.18–1.41). In decile 10, representing the most deprived neighborhoods, the CHD risk for women was 102 percent higher (OR = 2.02, CI = 1.86–2.20) than in decile 1, the most affluent neighborhoods. This pattern remained in the full model after adjustment for age and individual income. In decile 5 the CHD risk was 23 percent higher (OR = 1.23, CI = 1.13–1.35) and in decile 10 the CHD risk was 87 percent higher (OR = 1.87, CI = 1.72–2.03).

Table 9 shows the age-adjusted and full model for men. In the age-adjusted model the risk of developing CHD was 19 percent higher (OR = 1.19, CI = 1.13–1.25) in CNI decile 5 than in decile 1. In decile 10 the CHD risk for men was 65 percent higher (OR = 1.65, CI = 1.57–1.73) than in decile 1. In the full model this pattern remained. In decile 5 the risk of developing CHD was 10 percent higher (OR = 1.10, CI = 1.04–1.16) than in decile 1 and in decile 10 the CHD risk was 42 percent higher (OR = 1.42, CI = 1.35–1.49) than in decile 1.

The variance at neighborhood level was over twice the standard error, indicating that there was a significant neighborhood effect on CHD risk.

The Intra Class Correlation (ICC) in the full model was 0.021 for women and 0.009 for men, indicating that 2.1 percent and 0.9 percent of the total variance could be explained at the neighborhood level for women and men, respectively.

Individual income for women explained 16 percent of the age-adjusted neighborhood variance, and this percentage was 45 percent for the neighborhood deprivation variable (CNI). The corresponding percentages for men were 35 and 44 percent.

The full model including individual income and CNI explained 30 and 42 percent of the neighborhood variance for women and men, respectively.

Table 8 Multilevel logistic regression showing odds ratios (and 95% confidence intervals) of CHD by age, individual income, and deciles of CNI for the 1,312,344 women aged 40 to 64 years and residing in 8,547 neighborhoods. December 31, 1995, followed until December 31, 1999.

Variable	Age-adjusted	Full model
Individual characteristics		
Income[1]		
1st Quintile (highest income)	1 (Ref)	1 (Ref)
2nd Quintile	1.24 (1.16–1.32)	1.22 (1.14–1.30)
3rd Quintile	1.47 (1.38–1.56)	1.46 (1.37–1.55)
4th Quintile	1.74 (1.64–1.85)	1.68 (1.58–1.78)
5th Quintile (lowest income)	1.75 (1.65–1.85)	1.70 (1.60–1.79)
Neighborhood variance (SE)[3]	0.084(0.009)	See below
Intra-class correlation (ICC)	0.025	See below
Explained variance[2] (%)	16%	See below
Neighborhood characteristics		
CNI in deciles		
1 (most affluent)	1 (Ref)	1 (Ref)
2	1.00 (0.92–1.11)	1.07 (0.98–1.17)
3	1.18 (1.08–1.29)	1.13 (1.04–1.24)
4	1.33 (1.22–1.46)	1.28 (1.17–1.39)
5	1.29 (1.18–1.41)	1.23 (1.13–1.35)
6	1.38 (1.26–1.51)	1.33 (1.21–1.45)
7	1.39 (1.27–1.52)	1.33 (1.22–1.45)
8	1.45 (1.33–1.59)	1.39 (1.27–1.52)
9	1.60 (1.47–1.75)	1.52 (1.40–1.66)
10 (most deprived)	2.02 (1.86–2.20)	1.87 (1.72–2.03)
Neighborhood variance (SE)[3]	0.055 (0.008)	0.07 (0.008)
Intra-class correlation (ICC)	0.016	0.021
Explained variance[2] (%)	45%	30%

[1] Annual individual median income in SEK: 1st Quintile (176,700), 2nd Quintile (138,500), 3rd Quintile (116,700), 4th Quintile (98,000), and 5th Quintile (67,000).
[2] Using age-adjusted variance as reference (=0.10).
[3] Standard Error.

Table 9 Multilevel logistic regression showing odds ratios (and 95% confidence intervals) of CHD by age, individual income and deciles of CNI for the 1,325,284 men aged 40 to 64 years and residing in 8,547 neighborhoods. December 31, 1995, followed until December 31, 1999.

Variable	Age-adjusted	Full model
Individual characteristics	(Age and income included)	(Age, income and CNI included)
Median income[1]		
1st Quintile (highest income)	1 (reference)	1 (reference)
2nd Quintile	1.24 (1.19–1.28)	1.21 (1.17–1.26)
3rd Quintile	1.40 (1.35–1.45)	1.36 (1.31–1.40)
4th Quintile	1.57 (1.51–1.62)	1.50 (1.45–1.55)
5th Quintile (lowest income)	1.71 (1.65–1.77)	1.62 (1.56–1.68)
Neighborhood variance (SE)[3]	0.034 (0.004)	See below
Intra-class correlation (ICC)	0.010	See below
Explained variance[2] (%)	35%	See below
Neighborhood characteristics	(Age and CNI included)	
CNI in deciles		
1 (most affluent)	1 (reference)	1 (reference)
2	1.04 (0.99–1.10)	1.01 (0.96–1.07)
3	1.08 (1.03–1.14)	1.02 (0.97–1.08)
4	1.18 (1.12–1.25)	1.10 (1.04–1.16)
5	1.19 (1.13–1.25)	1.10 (1.04–1.16)
6	1.25 (1.18–1.31)	1.15 (1.09–1.21)
7	1.28 (1.21–1.34)	1.16 (1.10–1.23)
8	1.34 (1.28–1.42)	1.19 (1.13–1.25)
9	1.40 (1.33–1.48)	1.26 (1.20–1.33)
10 (most deprived)	1.65 (1.57–1.73)	1.42 (1.35–1.49)
Neighborhood variance (SE)[3]	0.029 (0.003)	0.03 (0.003)
Intra-class correlation (ICC)	0.009	0.009
Explained variance[2] (%)	44%	42%

[1] Annual individual income in SEK: 1st Quintile (235,200), 2nd Quintile (172,900), 3rd Quintile (146,100), 4th Quintile (121,500), and 5th Quintile (83,600).
[2] Using age-adjusted variance as reference (=0.052).
[3] Standard Error.

Study 3

Advanced age was strongly associated with low scores in the social participation index. In the youngest group (35–44 years), only 14.3 percent had low social participation compared to 43.3 percent in the oldest group (65–74). Low attained educational level was also strongly associated with low social participation. Some 44.4 percent of the persons with a low attained level of education but only 6.4 percent of those with a high attained level of education were found in the lowest tertile of the social participation index, i.e. low social participation (data not shown).

The crude incidence rate per 10,000 persons per year for CHD (data not shown) showed that respondents with a low attained level of education and low social participation (tertile 1) exhibited 6.9 times higher incidence rates of CHD than persons with a high attained level of education and high social participation (tertile 3). People renting their homes and with low social participation had about five times higher incidence rates of CHD than those who owned their homes and had high social participation.

The sex- and age-adjusted hazard ratios (HR) for CHD showed a gradient between the social participation index and CHD, so that those with low social participation (tertile 1) had the highest risk of CHD, with a HR of 2.15 (CI = 1.57–2.94), followed by HR = 1.67 (CI = 1.23–2.27) for those with middle social participation (tertile 2). Low SES, i.e. low attained level of education and renting, was associated with an increased HR for CHD (Table 10).

In the full model (see Table 10), the HR for CHD remained significantly higher for persons with low social participation (HR = 1.69; CI = 1.21–2.37) and middle social participation (HR = 1.45; CI = 1.06–1.98), after adjustment for age, sex, education, housing tenure, and smoking habits.

Table 10 The association between the social participation index and CHD, after stepwise inclusion of the explanatory variables in the Cox regression model, presented as hazard ratio (HR) with 95% confidence interval (CI). Ages 35–74, 1990/91, followed through 2000, Sweden. Models 1–4, also adjusted for age. n = 6,861.

		Model 1	**Model 2**	**Model 3**	**Model 4**
Variable	Level	HR (CI)	HR (CI)	HR (CI)	HR (CI)
Sex	Men	2.57 (2.10–3.14)	2.60 (2.13–3.19)	2.66 (2.17–3.25)	2.62 (2.14–3.21)
	Women	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Social	Low	2.15 (1.57–2.94)	1.84 (1.32–2.57)	1.74 (1.24–2.43)	1.69 (1.21–2.37)
participation	Middle	1.67 (1.23–2.27)	1.50 (1.09–2.05)	1.47 (1.07–2.01)	1.45 (1.06–1.98)
index	High	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Education	Low		1.59 (1.14–2.23)	1.61 (1.15–2.26)	1.59 (1.14–2.24)
	Middle		1.53 (1.09–2.13)	1.54 (1.11–2.15)	1.53 (1.10–2.13)
	High		1 (Reference)	1 (Reference)	1 (Reference)
Housing	Renting			1.41 (1.15–1.71)	1.37 (1.12–1.67)
tenure	Owning			1 (Reference)	1 (Reference)
Smoking	Yes				1.23 (1.00–1.52)
	No				1 (Reference)

Study 4

Comparison between CNI deciles in Stockholm County and self-reported health (Table 11)

The risk of poor self-reported health in every decile was expressed as odds ratios (OR) with 95 percent CI in a hierarchical logistic model adjusted for sex and age, based on a random sample (n = 27,346) of the total population of Sweden. There was a significant strong association between the transformed CNI and poor self-reported health. There was also a clear gradient, an approximately 150 percent increased risk of poor self-reported health status for people living in the most deprived neighborhoods (OR = 2.50; CI = 2.12–2.95), compared with those living in the most affluent neighborhoods (OR = 1). The CNI ratios (mean CNI for CNI decile 2–10 divided by mean CNI for decile 1) increased with increasing CNI deciles (increasing deprivation) based on the population of Sweden and the population of Stockholm County. As they were very similar, it is concluded that the strong association between the transformed CNI and poor self-reported health obtained in a random sample of the Swedish population also exists in Stockholm County.

Table 11 The risk (odds ratio [OR]) of poor self-reported health in different CNI deciles in a model adjusted for sex and age (25–74 years), analyzed by a hierarchical logistic model, based on the Swedish Annual Level of Living Survey 1992–97 (all Sweden); n=27,346. Weights and ratios (CNI weight divided by 78) for the transformed CNI scale for Sweden and Stockholm County by CNI decile and with about 170,000 persons in each decile (Stockholm County).

CNI deciles for Sweden	OR (95% CI)	Mean CNI weight Sweden (transformed)	CNI ratio Sweden	Mean CNI weight Stockholm County (transformed)	CNI ratio Stockholm County
1 (50.1 – ≤ 83.0)	1 (Reference)	78	1	78	1
2 (83.0 – ≤ 88.2)	1.17 (0.98–1.38)	86	1.11	84	1.08
3 (88.2 – ≤ 91.7)	1.30 (1.10–1.54)	90	1.16	89	1.14
4 (91.7 – ≤ 94.9)	1.48 (1.25–1.75)	93	1.20	93	1.19
5 (94.9 – ≤ 98.0)	1.39 (1.18–1.65)	96	1.24	97	1.24
6 (98.0 – ≤ 101.5)	1.55 (1.31–1.84)	100	1.28	100	1.29
7 (101.5 – ≤ 105.2)	1.54 (1.30–1.82)	103	1.33	104	1.33
8 (105.2 – ≤ 110.6)	1.77 (1.50–2.09)	108	1.38	110	1.41
9 (110.6 – ≤ 120.3)	1.74 (1.47–2.06)	115	1.48	117	1.50
10 (>120.3)	2.50 (2.12–2.95)	132	1.70	130	1.66

Application of CNI as an allocation resource index in Stockholm County (Table 12)

The transformed CNI model was compared with the official model currently used for the allocation of economic resources to the primary health care services in Stockholm County. CNI means for the six administrative areas in Stockholm were calculated. None of the most deprived neighborhoods (decile 10) were found in the affluent north-eastern (NE) part of Stockholm. The largest differences in allocation of resources when the CNI model was used were seen in the southern Stockholm (SS) and south-western (SW) areas. The SS area, which was as deprived as the SW area according to CNI, received 1.7 percent less resources with the CNI model than with the official model and the SW area received 1.2 percent more resources when the CNI model was used. The difference seems slight, but since the total annual budget for primary health care in Stockholm is 3.3 billion SEK, these *additional* resources would result in more than 50 new GPs for the deprived SW area. However, the SS area loses the same amount of economic resources. There were not such large changes in the allocation of resources in the northern Stockholm (NS) and south-eastern (SE) areas, –0.8 percent units and +0.7 percentage units, respectively. In the NE and north-western (NW) areas in the northern part of Stockholm, there were only minor changes when the CNI model was used.

Table 12 A comparison of indices for the allocation of economic resources to primary health care (percentage), CNI and percentage of the variables included in the CNI and low income in the six different administrative areas of Stockholm County.

Variable	Administrative area						
	NE	NW	NS	SS	SW	SE	Total %
Distribution by CNI model	12.7	16.6	21.2	15.1	21.4	12.9	100.0
Distribution by official model	12.4	16.4	22.0	16.8	20.2	12.2	100.0
CNI mean (transformed)	90	97	97	102	101	95	
Immigrants from Finland Southern and Eastern Europe, Asia, Africa and South America	7.8	18.0	22.7	12.3	28.0	11.3	100.0
Low educational status (<10 years)	11.2	17.5	18.3	13.1	25.6	14.3	100.0
Elderly persons living alone	12.1	14.1	26.3	20.8	18.1	8.7	100.0
Single parents	11.7	17.3	18.9	16.0	21.8	14.4	100.0
Unemployed people	9.3	16.0	21.6	15.9	24.7	12.5	100.0
High mobility	11.8	17.8	22.1	15.2	20.8	12.3	100.0
Children under 5	13.9	17.2	19.4	12.9	21.9	14.7	100.0
Low income (the lowest quartile)	15.8	14.2	22.3	18.2	19.4	10.0	100.0

Discussion

The main findings of this thesis are that each of the two neighborhood measures (low neighborhood education and low neighborhood income) and neighborhood deprivation (as measured by CNI) predicts incidence rates of CHD after adjustment for individual-level characteristics. For both neighborhood measures and neighborhood deprivation, there are small but significant neighborhood effects on CHD beyond the individual effect. Low scores in the social participation index, measuring the individual's social, cultural, and religious participation, political empowerment, and perception of the social capital in the neighborhood, predict incidence rates of CHD, even after adjustment for individual characteristics. By increasing neighborhood deprivation (by CNI) there is an increased risk of poor self-reported health status, an indicator of health care need. In addition, it was possible to transform CNI into a need-based tool, useful for a total allocation of primary health care resources in both affluent and deprived neighborhoods.

It is well known that individual socioeconomic characteristics, such as education and occupation, are associated with CHD risk factors and CHD[99–103]. A newer body of research has explored the associations between area socioeconomic characteristics and CHD. The area units that have been used in previous work embrace neighborhoods, counties, regions, and states. The area socioeconomic characteristics that have been studied in conjunction with CHD outcomes include income levels[104,105], education and occupational levels[106,107], and segregation and discrimination[10]. An increasing number of studies suggest that neighborhood environments may have important independent effects on individual health, beyond individual-level characteristics[31,43,44,46,108]. One study from the USA showed that spatial concentration of poverty in urban areas was significantly associated with increased risk of all-cause mortality. This result remained significant after adjustment for individual-level household income and race/ethnicity [109]. A longitudinal study from the USA used a summary score for the neighborhood socioeconomic environment that included neighborhood indicators of income and education. After adjustment for individual-level socioeconomic characteristics, the study showed that neighborhood socioeconomic characteristics predicted CHD incidence rates, a finding in agreement with our study[46]. In another study, this time using multilevel logistic regression models, the same authors showed that the neighborhood environment was associated with both an increased prevalence of CHD and increased levels of risk factors for CHD[110]. In order to study the effect of neighborhood level characteristics on CHD outcomes, independent of individual-level characteristics, some previous studies have used multilevel models. Our results, from another context, agreed with these studies[10,110], demonstrating an independent effect of neighborhood education, neighborhood income, and neighborhood deprivation, as measured with CNI, on incidence rates of CHD. Other studies, using multilevel methods, also yielded results consistent with our findings, demonstrating a neighborhood effect on CHD risk factors such as high diastolic blood pressure, high cholesterol levels, smoking, physical inactivity, and obesity[35,111]. In contrast, other studies disagreed with our study and suggested that the differences in CHD risk between neighborhoods are merely a result of differences between individuals. A British study, based on longitudinal census and survey data, showed no neighborhood effect on mortality[47]. Furthermore, a few other studies did not detect any neighborhood effects on mortality, only an individual effect[48,112].

The mechanisms linking neighborhood socioeconomic characteristics and different health outcomes are still unclear. It is plausible that the unhealthy behaviors (e.g., smoking, poor dietary practices, physical inactivity) that showed strong relationships with CHD in previous studies are in the causal pathway between neighborhoods and CHD, thus acting as mediating variables. Neighborhoods can certainly influence health behaviors. For example, low-income neighborhoods (operationalized as our neighborhood income measure) probably lack access to smoke-free environments, healthy food, and safe places to exercise, which deny people the opportunity to develop and maintain heart healthy behaviors. Moreover, low neighborhood education (operationalized as our neighborhood education measure) may hinder people from accessing resources and/or interacting with people who have greater knowledge about CHD, such as benefits of not smoking and obtaining treatment for hypertension and diabetes. Low neighborhood education, as well as low neighborhood income and neighborhood deprivation, may isolate people from resources and positive knowledge that are associated with health behaviors and CHD. However, including smoking in the full model in study 1 did not change the regression coefficients or the variance, although there was a strong association between smoking and CHD. It is likely that body mass index, diet, and physical activity also have a limited effect on the regression coefficients. This is in agreement with a multilevel study from the USA, where mortality risks remained high and unaltered in deprived neighborhoods even after the addition of body mass index to the full model, which already included individual smoking[113]. Feelings of hopelessness and alienation due to relative neighborhood deprivation may also mediate the neighborhood effect on CHD. Another multilevel study from the USA demonstrated the importance of income inequality for mortality[72]. In contrast to the USA, Canada has a lower degree of income inequality and in Nova Scotia, Canada, neighborhood socioeconomic characteristics were not significantly associated with mortality[114]. When wealthy nations were compared, the association between neighborhood characteristics and different health outcomes was inconsistent[71]. For example, France, Italy, and Spain, countries with higher income inequalities, had higher life expectancy than Denmark and Finland, countries with lower income inequalities. This implies that neighborhood characteristics as determinants of health are of a complex nature and might also include equally distributed access to health care, education, and social services. This equality is absent in the USA, where the effects of income inequalities on health are more pronounced. Several plausible pathways might generate neighborhood differences in health, including physical and psychosocial features of the environment, housing, services provided, isolation from health-promoting milieus and discrimination. It is also possible that relative poverty is of greater importance than absolute poverty in wealthy nations. Historical and cultural features of a country are also important to consider, especially if comparisons between countries are desirable. The Swedish society is well-known for its equity. However, we found a significant neighborhood effect on CHD risk, beyond the individual effect.

Social capital is a neighborhood measure separable from individual social participation. However, the close connection between social capital and social participation suggests that it may be possible to compare previous studies of social capital and health with our findings of a significant relationship between low scores in the social participation index and CHD. Our finding was consistent with an ecological study in the USA, where lower levels of social capital, defined as social trust, were associated with increased rates of CHD mortality[115]. Other studies have found an association between low social capital and other health outcomes. For example, people in the USA living in states with low social capital, had a higher risk of poor self-reported health[17].

A few pathways linking social participation and social capital to CHD are possible. First, a high level of social capital may improve cardiovascular health by promoting more rapid transmission of health information, adaptation of healthy behavior norms and social control over deviant health-related behavior, such as, for example, smoking[116,117]. Second, high levels of social capital may influence the health of the individuals by providing affective support and serving as the source of self-esteem and mutual respect[17,118]. In addition, low levels of social capital may cause psychosocial stress due to insufficient social networks and a lack of empowerment. All these pathways may link social participation and social capital to CHD. Putnam has recently clearly emphasized that social trust, which could easily be thought of as a proxy for social capital, is a closely related consequence of social capital or "what it does". According to Putnam, social participation is the most essential part of the social capital concept or "what it is"[61]. Materialistic, political, or relational deficits may also be the link between social capital and poor health[119,120]. A materialistic explanation is that poor social capital is one of the mediators between income inequality and poor health[120]. Income inequalities seem to result in low social cohesion at the community level, particularly among relatively poor people[115]. These materialistic, political and relational deficits may all be relevant to the pathways suggested above.

The social capital within a communitarian tradition was recently criticized because of its close connection to political ideology and neglect of class conflict[121]. Moreover, social capital showed weaker associations with population health indicators than did economic inequality and working-class power, according to a study from the USA using population health indicators from 16 wealthy countries[122]. Therefore, when studying the impact of social capital and social participation on health, it is essential to include measures of socioeconomic inequality. In our study there was an association between low scores in the social participation index and increased CHD incidence rates, even after adjustment for both educational status and housing tenure.

The transformed CNI ratios and the risks of poor self-reported health, an indicator of health care need, showed a clear gradient, increasing with increasing neighborhood deprivation in Stockholm County. In London, people living in deprived neighborhoods had an increased risk of poor self-reported health[75], in accordance with our study. In contrast, in a non-metropolitan British area there was no association between the UPA score, the Townsend score and poor self-reported health[123]. In another British study, the authors showed that socioeconomic and demographic factors such as unemployment, living in rented accommodation, and being from the Indian subcontinent, were associated with more frequent consultations with general practitioners, even after adjustment for individual social position[124]. The primary health care consultation rates were also higher in the deprived neighborhoods in London than in the affluent neighborhoods[75]. High rates of poor-self-reported health in deprived areas may therefore be interpreted as a high need for primary health care. There is also an association between CNI and other health outcomes. For example, people living in the deprived neighborhoods in Sweden, as measured by the CNI, had higher rates of psychiatric hospital admissions, alcohol clinic admissions, cardiovascular risk factors (smoking, no physical activity, obesity), all-cause mortality and coronary heart disease mortality[33–35]. The pressure on primary health care centers located in such areas is therefore considerable[74,75] and surveys in both the UK and Sweden revealed that many GPs regarded socioeconomic factors such as a high proportion of unemployment, elderly people living alone, and single mothers as having a direct effect on their workload[32,125].

After the transformation to a positive scale, CNI might be used as a direct empirical model for a total allocation of primary health care resources. CNI constitutes a need-based alternative to the official model, which is used in Stockholm County for allocation of primary health care resources. Although it is not possible to conclude which model is the best for allocating resources to the most deprived neighborhoods, the CNI model includes seven items, measuring social need. The official model used in Stockholm County is a combined model based on need and morbidity. The traditional way health authorities in the UK calculate the budget for primary health care is a budget based on historical expenditure, including an allowance for deprivation. In a study from Scotland, it was suggested that progressivity in the delivery of health care could be regarded as a frontier problem analogous to efficiency[126]. In Sweden, as in several other Western countries, recruitment of GPs to the most deprived neighborhoods has been difficult. A more progressive distribution of resources to the primary health care centers in the most deprived neighborhoods would facilitate the recruitment of general practitioners so that, hopefully, people's health in these areas would also improve. It should be pointed out that, in the present study, the most deprived neighborhoods (the tenth decile) showed a much higher risk of poor self-reported health (OR = 2.5) than the corresponding CNI ratio (1.7). This may indicate that, after the total distribution of resources has been made, additional resources may be provided for the most deprived neighborhoods.

Strengths and limitations

The present studies have several strengths. First, one advantage is the use of large, well-defined random samples of the whole Swedish population. Second, the sampling procedure is simpler in Sweden than in many other countries because of the Swedish population register. A ten-digit personal identification number, assigned to each person in Sweden for his or her lifetime, is recorded in all registers and was used for record linkages between SALLS, the In-Care register, and the Cause of Death register. Third, the use of these linkages made it possible to calculate incidence rates of CHD, a much stronger outcome for determining causal relationships than prevalence rates. Fourth, the data in SALLS were collected in face-to-face interviews by well-trained interviewers. The reliability of the items included in SALLS was analyzed by means of re-interviewing (test-retest method), giving kappa coefficients between 0.7 and 0.9[77]. Other advantages of SALLS are the large sample size, the periodicity (yearly since 1975) and the low non-response rate. Fifth, the use of a multilevel technique in studies 2, 3, and 4 provides information at both the individual and the neighborhood level, making it possible to separate the individual effect from the neighborhood effect. Sixth, the items in CNI are renewed annually, making it easy to update the index. CNI included proportions of seven socioeconomic and demographic items for each SAMS neighborhood. Earlier studies of CNI have shown a strong association between CNI and other health outcomes[33–35]. Seventh, the items in the social participation index included 18 variables from SALLS, measuring the individual's social, cultural, and religious participation, political empowerment, and perception of the social capital in the neighborhood. Eighth, the validity of the diagnosis for myocardial infarction (one of the main CHD diagnoses and the most severe) was high in an evaluation for 1987 and 1995 by the Swedish Board of Health and Social Welfare[82]. Ninth, neighborhood data from the national database were highly complete; education and income were almost 100 percent complete. Completeness of addresses for geocoding to determine neighborhood location was also high (90 percent). Tenth, the SAMS neighborhoods were relatively small (approximately 1,500 people) and seem coherent when it comes to both ownership and the type of buildings that make up the area. SAMS were defined according to commercial distribution, which may reflect patterns of social interactions more precisely than other classifications, such as census tracts that are larger and defined on the basis of geographic boundaries.

These studies also have certain limitations. First, response bias may have occurred if the non-respondents differed from the respondents with respect to CHD incidence rates. Of the non-respondents approximately 70 percent consisted of refusals, 20 percent were not found and 10 percent were sick. The all-cause mortality in the total sample, including both non-responders and responders, were analyzed in a proportional hazard model adjusted for sex, age, marital status, and region. Those who refused had the same mortality risk as the respondents, but the other two groups had significantly higher mortality risk. The hazard ratios will probably be less influenced by non-response than absolute measures such as e.g. incidence rates. It is likely that the non-respondents were of low SES, living in deprived neighborhoods. Their non-response is likely to have resulted in underestimated hazard ratios. There is also a potential self-report bias in SALLS, which might constitute a limitation. Second, we did not know the length of time participants were exposed to their neighborhoods. However, based on a longitudinal subsample, we found that a high percentage of the sample (75 percent) had lived at their home address at least eight years preceding the survey. Third, on individual-level health behaviors related to CHD (e.g. smoking, diet, and physical activity) we only had information about smoking habits (studies 1 and 3). Fourth, residual confounding most likely exists in the education and income measures[127,128]. For example, length of education does not measure the quality of schooling or literacy. Fifth, the In-Care Register only records information beginning in 1986. Therefore exclusion of individuals with a CHD event two years preceding the interview year was not possible for those interviewed in 1986 and 1987, which probably constitutes a selection bias (study 1). In study 4, a possible limitation might be the significance and interpretation of self-reported health. However, this indicator of health has been shown to be a good predictor of, for example, mortality and the need for primary health care (see methods). Study 4 also has a few more limitations as it is based on cross-sectional data that do not allow inferences to be drawn about causal pathways. Owing to non-response, the prevalence of poor self-reported health in the population may be underestimated to some extent, although probably not the relative measures. Approximately 5 percent of all respondents could not be matched with CNI scores, possibly because of incorrect addresses or new residential areas without CNI scores. The risk of this introducing a bias is probably small because the risk would be at the same level in the whole Swedish population. The transformed CNI is currently focused on Stockholm

County, a big region with 1.7 million inhabitants, which might pose problems of generalizability. However, our findings agree with other studies from the UK[75,124], and therefore we believe that they have wider applications. In other industrialized countries, CNI could be adapted as a practical need-based tool for a total allocation of primary health care resources. The analysis of the association between the transformed CNI and poor self-reported health is based on a random sample of the Swedish population, but the allocation of resources is restricted to Stockholm County and constitutes a limitation. Finally, the CNI ratios in Sweden and Stockholm County were almost identical. Therefore, the conclusions concerning the association between the transformed CNI and poor self-reported health obtained for the whole population of Sweden can be generalized to Stockholm County.

Conclusions and recommendations

Our findings suggest that CHD prevention should combine both individual and neighborhood level approaches. Although the neighborhood effect was small, it is of importance since the outcome, CHD, is highly prevalent among the entire population. Currently health care resources are directed primarily at the individual level with a focus on providing individuals with knowledge and resources to help them achieve and maintain health. For example, physicians and other health professionals stress the importance of their patients developing heart-healthy behaviors and provide CHD health education and resources about smoking, dietary factors, and physical activity[129–133]. These individual-level approaches have had disappointing results both in Sweden[134] and in the US[135]. Perhaps it is time to consider more comprehensive approaches to heart health, where increasing resources are devoted to improvements in the social environment, such as accessible and affordable recreation facilities, smoke-free environments, healthy foods, and formal and informal social networks. Such approaches should include city planning that promotes the development of integrated neighborhoods where people from different incomes and educational levels have an opportunity to interact with each other and to access resources to enable better health outcomes for all people, regardless of neighborhood socioeconomic characteristics. Lack of social and economic investments in deprived neighborhoods creates large populations with poor health. Such a development would generate not only individual suffering but also high pressure on primary health care, and galloping costs in the whole health care system. In addition, distribution of health care resources should use need-based tools, such as CNI. The transformed CNI can be used to allocate both total primary health care resources and additional economic resources to primary health care centers in deprived neighborhoods. This exclusively need-based tool constitutes an attractive approach for the total allocation of primary health care resources.

Summary in Swedish

Svensk sammanfattning

Bakgrund

Det är väl känt att såväl individens socioekonomiska status (inkomst, utbildning, yrke) som bostadsområdets sociala status har betydelse för uppkomsten av kranskärlssjukdom. I denna avhandling studeras sambandet mellan bostadsområdets utbildningsnivå och inkomstnivå och kranskärlssjukdom efter justering (statistisk hänsyn) för ålder, kön, samt individens utbildning eller inkomst (delarbete 1). Sambandet mellan bostadsområdets socioekonomiska status, mätt med Care Need Index (CNI), och kranskärlssjukdom studeras separat för kvinnor och män efter justering för ålder och individuell inkomst (delarbete 2). Socialt deltagande mäter individernas deltagande i samhällslivet och i delarbete 3 studeras sambandet mellan socialt deltagande och kranskärlssjukdom efter justering för ålder, kön, rökning och social position. CNI är ett viktat behovsindex som kan användas för att mäta ett bostadsområdes sociala status. CNI baseras på svenska distriktsläkares skattning av hur arbetsbelastningen påverkas av följande faktorer: ensamstående äldre, barn under fem år, ensamstående föräldrar, lågutbildade, arbetslösa, utlandsfödda och hög omflyttning i området. I Stockholms läns landsting används f n ett index för fördelning av primärvårdsresurser som både baseras på socioekonomiska faktorer och ohälsotal på bostadsområdesnivå. Då det riskerar att växa fram stora befolkningsgrupper i de socialt mest utsatta bostadsområdena med en hög sjuklighet, behöver praktiska verktyg för resursfördelning i primärvården utvecklas. Ursprungligen utvecklades CNI med syftet att fördela resurser till de mest utsatta områdena, men har behövt vidareutvecklas för att bli användbart för en total fördelning av primärvårdsresurser (delarbete 4). Med ytterligare kunskap om sambanden mellan individ, social miljö, bostadsområdets egenskaper och kranskärlssjukdom, kan nya metoder utvecklas för att utjämna de sociala skillnaderna i ohälsa med tonvikt på individens omgivning.

Frågeställningar

Delarbete 1 [Sundquist et al. Neighborhood socioeconomic environment and incidence of coronary heart disease: A prospective follow-up study of 25,319 women and men in Sweden (Submitted)]

Kan bostadsområdets socioekonomiska egenskaper (andel lågutbildade respektive låginkomsttagare) predicera incidenstalen (morbiditet och mortalitet) i kranskärlssjukdom efter justering för individens sociala position? Hur mycket skulle incidenstalen sjunka (absolut och i procent) om alla bodde i de mest välbärgade områdena?

Delarbete 2 [Sundquist et al. Neighborhood deprivation and incidence of coronary heart disease: A multilevel study of 2.6 million women and men in Sweden (Accepterad i Journal of Epidemiology and Community Health)]

Finns det ett samband mellan bostadsområdets sociala status och kranskärlssjukdom efter justering för individuell inkomst? Är denna bostadsområdeseffekt på kranskärlssjukdom en effekt utöver den individuella effekten?

Delarbete 3 [Sundquist et al. Social Participation and Coronary Heart Disease: A Follow-up Study of 6,900 Women and Men in Sweden (Soc Sci and Med, In press)]

Har individens sociala deltagande något inflytande på morbiditet och mortalitet i kranskärlssjukdom? Kvarstår detta eventuella samband efter justering för ålder, kön, rökning, utbildning och bostadens upplåtelseform?

Delarbete 4 [Sundquist et al. Care Need Index, a Useful Tool for the Distribution of Primary Health Care Resources (J Epidemiol Community Health 2003 May;57(5):347–52)]

Kan CNI transformeras till ett verktyg för en total resursfördelning i primärvården? Finns det något samband mellan behovet av primärvård definierat som en förhöjd risk för självrapporterad ohälsa och det nya transformerade CNI? Skiljer sig resursfördelningen enligt det transformerade CNI från resursfördelningen enligt den modell som f n används i Stockholms läns landsting?

Material och metoder

Delarbete 1: Ca 25 000 män och kvinnor (ålder 35–74 år) ur ULF 1986–1993 följdes t o m 31 December 1997 med avseende på morbiditet och mortalitet i kranskärlssjukdom. Individerna länkades till sitt bostadsområde (SAMS, small area market statistics). Bostadsområdets utbildningsnivå definierades såsom andel personer med mindre än 10 års utbildning i området och inkomstnivå såsom andel personer i den lägsta nationella inkomstkvartilen i området. Områdena indelades i kvintiler efter utbildnings- respektive inkomstnivå. Justering för individens ålder, kön och utbildning eller inkomst utfördes. Statistisk analys: Multilevel Cox proportional hazard models.

Delarbete 2: Alla män och kvinnor i Sverige i åldern 40–64 år följdes 31/12 1995–31/12 1999 med avseende på insjuknande i kranskärlssjukdom. Män och kvinnor analyserades separat, justerat för ålder och individuell inkomst. Varje individ kopplades till sitt bostadsområde (SAMS). Bostadsområdets sociala status bestämdes med hjälp av CNI. Statistisk analys: Multilevel logistisk regression.

Delarbete 3: Ca 6900 individer ur ULF (Undersökningar av Levnadsförhållanden, SCB) 1990–91 följdes t o m 31 december 2000 med avseende på kranskärlssjukdom. Åren 1990–91 valdes då många frågor om socialt deltagande ingick. Ett s.k. social participation index konstruerades utifrån 18 variabler i ULF. Faktoranalys av dessa 18 variabler utfördes. Utfallsvariabel: Morbiditet och mortalitet i kranskärlssjukdom enligt ICD 9 (410–414) samt ICD 10 (I20-I25). Dödsorsaksregistret och Slutenvårdsregistret matchades på ULF. Oberoende variabler: ålder, kön, utbildning, bostadens upplåtelseform, rökning och social participation index. Statistisk analys: Proportional hazard model.

Delarbete 4: För att kunna vikta CNI, besvarade ca 2500 distriktsläkare (svarsfrekvens 65 %) hösten 2000 ett frågeformulär där de skattade olika sociala och demografiska faktorers inflytande på arbetsbelastningen. CNI-medelvärden för hela Stockholms befolkning uppdelad i decentiler räknades fram på bostadsområdesnivå med hjälp av databasen MigMed, som innehåller uppgifter om bl a ålder, kön, inkomst samt bostadsområde (SAMS) för hela Sveriges befolkning. ULF användes för att skatta förekomsten av självrapporterad ohälsa. Statistisk analys: Logistisk hierarkisk regression.

Resultat

Delarbete 1

Individer som bodde i områden med den lägsta utbildningsnivån respektive inkomstnivån hade förhöjd risk att utveckla kranskärlssjukdom (relativa risker beräknade som hazard ratios: 1.32, respektive 1.25) efter justering för individuell inkomst eller utbildning. När rökning lades till i modellen förändrades de relativa riskerna endast marginellt. Antalet fall i kranskärlssjukdom skulle hypotetiskt sjunka med 25–26 % för kvinnor och 10–15 % för män om alla bodde i bostadsområdena med den högsta utbildnings- eller inkomstnivån.

Delarbete 2

I bostadsområdena med den lägsta sociala statusen var risken att utveckla kranskärlssjukdom 87 % högre för kvinnor och 42 % högre för män, jämfört med områdena med högst social status, efter justering för inkomst. Variansen var låg men signifikant, vilket visar att det finns vissa skillnader som kan förklaras av bostadsområdeseffekter utöver individeffekter på insjuknandet i kranskärlssjukdom.

Delarbete 3

Risken för kranskärlssjukdom för individer med lägst socialt deltagande jämfört med individer med högst socialt deltagande var ökad, ca 70 % (hazard ratio = 1.69, 95 % konfidensintervall (KI) = 1,21–2,37), efter justering för ålder, kön, utbildning, bostadens upplåtelseform och rökning.

Delarbete 4

CNI med medelvärde 0 (spridning –53 till +79, standardavvikelse 15) transformerades så att medelvärdet blev 100 (spridning 50–164, standardavvikelse 16). Det transformerade CNI var användbart till en total fördelning av resurser till primärvården. Risken för självrapporterad ohälsa var 150 % högre (Odds Ratio = 2,50; KI = 2,12–2,95) för personer som levde i de mest utsatta bostadsområdena jämfört med personer som levde i de mest välbärgade bostadsområdena. CNI-kvoterna (som bildas genom att dividera decentilerna 2–10 med decentil 1) varierade mellan 1 (decentil 1, d v s de mest välbärgade områdena) och 1.66 (decentil 10, d v s de mest utsatta områdena). CNI-kvoterna i decentiler för Stockholms läns landsting visade en god överensstämmelse med oddskvoterna i decentiler för självrapporterad ohälsa i ett urval av Sveriges befolkning. Detta kan ses som en indikation på att CNI kan användas för en total resursfördelning i primärvården.

Slutsatser

Hälsobefrämjande åtgärder avseende kranskärlssjukdom behöver kombineras både på individ- och bostadsområdesnivå. Detta är av betydelse för individens hälsa, för folkhälsan och för en optimal användning av sjukvårdens resurser. CNI, som baseras på vårdbehov, kan användas som ett verktyg för en total resursfördelning till såväl de socialt mest utsatta som de mest välbärgade bostadsområdena i primärvården.

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