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Income-related inequalities in cardiovascular disease from mid-life to old age in a Northern Swedish cohort: A decomposition analysis

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Abstract

While the social determinants of cardiovascular disease (CVD) are fairly well-known, the determinants of socioeconomic inequalities in CVD are scarcely studied and almost completely based on cross-sectional designs in which the changing circumstances across the life course are not taken into account. The present study seeks to incorporate a life course approach to the social determinants of socioeconomic inequalities in CVD. The specific aims were to 1) examine how income-related inequalities in CVD change over two decades of the mid-late life course, and 2) identify the key social determinants of the inequalities at each time period. The cohort (N = 44,039) comprised all individuals aged 40–60 years in 1990 who during 1990–2010 were enrolled in the county-wide preventive effort: “Västerbotten Intervention Program” (VIP). The cohort was followed over these two decades by Swedish population register data linked within the Umeå SIMSAM Lab micro data infrastructure. First-time hospitalization for CVD and mean earned income were used to calculate the concentration index (C) during four periods of 5–6 years. The C for each period was decomposed by sociodemographic factors, using Wagstaff-type decomposition analysis. Results suggest that inequalities in CVD increase gradually from mid-life to old age; from initially non-significant to particularly marked among the elderly. The decomposition showed that, from middle to old age, educational and employment inequalities underwent a transition from initially dominant to a moderate role in explaining the health inequalities, coupled with an increasing importance of age and a stable role of income. In conclusion, the study illustrates the need for incorporating a dynamic life course perspective into research, policy and practice concerned with equity in health.

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1. Introduction

Sweden and Europe have seen an alarming development with entrenched or even increased socioeconomic inequalities in cardiovascular disease (CVD) and other forms of health during the last couple of decades (Mackenbach, 2006; Socialstyrelsen and Statens Folkhälsoinstitut, 2013). To meet this challenge, research has begun to explore the determinants of not only health but of health inequalities at the population level. However, the majority of this small body of research is based on cross-sectional designs in which the changing circumstances across the life course are not considered. The present study therefore seeks to contribute to the literature by prospectively examining how both socioeconomic inequalities in health, as well as their social determinants, develop over the course of 20 years in a Northern Swedish cohort followed from middle-aged to old age.

To tackle the challenge of increased health inequities while continuing to improve population health, a key first step is to understand the determinants of health inequities (Dahlgren and Whitehead, 2006). To this end, public health research has in recent years begun to utilize measures such as the concentration index, which quantify the degree of socioeconomic related inequality in a health variable (O'Donnell and Wagstaff, 2008), and decomposition analysis, a technique which allows separating, quantifying and comparing the independent contribution of...
different determinants to the population-level distribution of health (O’Donnell and Wagstaff, 2008). Although, to the authors knowledge, no study has decomposed socioeconomic inequalities in manifest CVD, a few studies (Alaba and Chola, 2014; Combes et al., 2011; Fateh et al., 2014; Goli et al., 2014; Hajizadeh et al., 2014; Hudson et al., 2014; Ljungvall and Gerdtham, 2010; McGill, 2014) have examined inequalities in CVD risk factors by this technique. However, they are with a few exceptions (Ljungvall and Gerdtham, 2010) based on cross-sectional analysis or comparison over the time of repeated cross-sectional measures.

In addition to the methodological limitations of cross-sectional designs, such approaches are unable to take into consideration that health inequalities can change not only with changing societal trends, but also along the life course. In a wider sense, by using cross-sectional designs health inequalities are construed as a static phenomenon, or merely a reflection of secular changes in society. As such, despite life course and aging approaches are well-established when within social epidemiological research on CVD (Pollitt et al., 2005), they have practically been absent in the study of health inequalities. Particularly in the context of an aging population, understanding health inequalities from a life course perspective is essential information for the development of life course sensitive interventions against the increasing health inequalities (Islam et al., 2010).

1.1. The present study in a life course, secular and geographical intersection

The point of departure of the present study is that socioeconomic inequality in health is a dynamic phenomenon, which is situated and develops in a particular temporal-geographical setting. The study was conducted in a certain intersection comprising the complexities of the individual life course from middle-age to old age, the historical and secular context of Sweden through the 1990s and 2000s, and the specific geographical setting of the county of Västerbotten. All of these dimensions may be important to understand how health inequalities and their determinants develop over time, in general and in the present study.

First, with regard to the life course period under study, middle-age to old age is a period in life in which manifest CVD start to be widespread, and as such is a period in which following a population may be particularly relevant to understanding developments of socioeconomic inequalities in CVD (WHO Commission on Social Determinants of Health (2010)). Moreover, during this period in life people retire (in Sweden typically around age 65 years), and as such this period reflects marked changes in the financial and occupational situation (Islam et al., 2010).

Second, the secular trends in Sweden during the study period can be exemplified by increased income inequalities since the early-mid 1990s (OECD, 2011), and the country was also hit by the global economic crisis in the late 2000s. During the same period welfare systems have undergone changes, involving e.g. cut-backs in social assistance and employment benefits, and an increased focus on private health care providers (Raphael, 2014). These developments remodel the context for population health in Sweden and can therefore be expected to influence population patterns of health and health inequalities.

Third, the county of Västerbotten comprises both the more populous and economically active coastal areas with cities such as Umeå and Skellefteå, as well as the large and sparsely populated inland areas. The county has also been target for the implementation of the population-wide Västerbotten Intervention Program (VIP) since 1990 (Norberg et al., 2010b). The VIP was developed in the mid-1980s, in response to high myocardial infarction mortality rates in the county. The VIP model includes population-based and individual prevention strategies, directed at those 40, 50 and 60 years old. The presence of a population-wide intervention against CVD may shape the prerequisites for population patterns of health, and ideally may counteract the secular development toward greater health inequalities (Norberg et al., 2010b).

With this specific setting as the empirical point of departure, the present study seeks to contribute to the literature by examining the social determinants of socioeconomic inequalities in CVD by following a middle-aged Swedish cohort, aged 40–60 years at baseline, across two decades. The specific aims are to 1) examine how income-related inequalities in CVD change over two decades (four periods) of the mid-late life course, and 2) identify the key social determinants of the inequalities at each time period.

2. Methods

2.1. Population and data

The cohort (N = 44,039) comprised all individuals aged 40–60 years in 1990 who during 1990–2010 were enrolled in the county-wide preventive effort “Västerbotten Intervention Program” (VIP). Since 1990, all individuals aged 30 (only until 1995), 40, 50, and 60 years who live in the county are invited to participate in a health examination at their local health care centers. The response rate to this invitation has increased from 59% in 1995 to 69% in 2010 (Norberg et al., 2010b) and number of participants per year vary between n = 3000 and n = 7000 (Norberg et al., 2012).

The cohort was followed from 1990 to 2010 by Swedish population register data linked within the Umeå SIMSAM Lab micro data infrastructure. Demographic and socioeconomic data of the individuals originated from registers of Statistics Sweden (e.g. Income and Taxation Register, Integrated Database for Labor Market Research, and Register of the Total Population) while information about CVD was obtained from the National Patient Register of the National Board of Health and Welfare.

To operationalize the outcome (income-related inequalities in CVD), the entire study period 1990–2010 was divided into four periods: period 1 (1990–1994), period 2 (1995–1999), period 3 (2000–2004), and period 4 (2005–2010). These time periods were selected to give an overall picture over the two decades of follow-up over the aging process: ages 40–60 years at starting point to 44–64 years (period 1), ages 45–65 to 49–69 years (period 2), age 50–70 to 54–74 years (period 3) and ages 55–75 to 60–80 years at ending point (period 4). The time periods correspond to a successively increasing proportion of individual and population-oriented activities from the Västerbotten Intervention Program and matches the secular changes of increased socioeconomic inequalities in Sweden, here measured as income inequality: stable-low (period 1), increasing-moderate (Period 2), stable-moderate (Period 3), and increasing-high (Period 4) (OECD, 2011).

2.2. Variables

2.2.1. Health outcome

The outcome of interest was CVD events between the years 1990 and 2010. CVD events were defined as first time hospitalization with main diagnosis of circulatory disease (ICD-10 codes I00–I99, and ICD-9 codes 390–459). Registers from 1987 to 1989 were used to exclude patients with a prior hospitalization for CVD. Those who were hospitalized for first time with a main diagnosis of CVD were categorized as having an incident event (1) while those who were never hospitalized or hospitalized by other conditions were categorized as not having a CVD incident event (0). Cause-of-death register was not available in the Umeå SIMSAM Lab database, therefore deaths due to first event of CVD in non-hospitalized
persons were not included. For measuring health inequalities, incident cases accumulated across each of the four study periods were used.

2.2.2. Socioeconomic indicator

The variable used to capture the socioeconomic status and living standards was the total earned income. Total earned income include all taxable earnings of an individual over the course of any given year, including incomes from employment, income from business if the person is self-employed, pension due to retirement, long-term disability benefits received prior to minimum retirement age, and other taxable transfers such as parental leave benefits and unemployment benefits. It does not include income from capital, such as profit from renting or selling property, or stock profit.

To estimate health inequalities, continuous total earned income averaged across each of the four study periods were used. In addition, income at the beginning of each study period (i.e. at 1990, 1995, 2000, and 2005) was used as an explaining factor, divided into quintiles with lowest (1) to highest (5) in order to facilitate interpretation.

2.2.3. Social determinants of health inequalities

Social determinants of inequality in CVD morbidity included factors with known or plausible links to CVD and to individual financial conditions (e.g. Lang et al. (2012)); demographic variables (sex, age); socioeconomic and material conditions (income quintiles, education, immigrant status, economically active/inactive); family conditions (civil status, children in household) and geographical area (inland/coastland with or without hospital). All variables were categorical, coded as follows:

Sex was defined as male (0) and female (1).

Age was categorized into four groups: 40–44 years (1), 45–49 years (2), 50–54 years (3), and 55–60 years (4) in 1990. As the four age groups were followed throughout the aging process, the groups correspond to 5 years older in 1995, 10 years older in 2000, 15 years older in 2005 and 20 years older in 2010.

Education was categorized into seven groups of highest level of education achieved: Compulsory education less than 9 years (1), Compulsory education nine years (2), Secondary education up to 2 years (3), Secondary education 3 years (4), Post-secondary education less than 3 years (5), Post-secondary education 3 years or more (6) and postgraduate (7). Levels 6 and 7 were collapsed in the decomposition analyses due to small sample size of level 7.

Immigrant status was defined as immigrant (1) if the individual at some time after birth has migrated to Sweden, and non-immigrant (0) otherwise.

Concerning employment status, an individual was defined as economically active (1) if he/she has reported any economic activity of has been working over the course of any given year, or economically inactive (0) if the individual has not been working or have reported him/herself as economically inactive.

Civil status was categorized into four groups: unmarried (1), married/co-habiting (2), divorced/separated (3), and widowed (4).

Children in household was defined as couple/co-habiting/single without child (0) and couple/co-habiting/single with child 0–18 years living at home (1).

Geographical area was based on the Västerbotten municipality in which each participant was registered, and categorized into: coastal municipality with hospital (0), coastal municipality without hospital (1), inland municipality with hospital (2), inland municipality without hospital (3), and municipality outside Västerbotten (4).

All explaining variables were measured at the first year of each period, i.e. in 1990, 1995, 2000 and 2005.

2.3. Statistical analysis

2.3.1. Representativity

To explore to what extent the cohort reflected the population of Västerbotten, we compared the cohort at baseline (1990) with the total population of Västerbotten aged 40–60 years with respect to explanatory variables (hospitalization data not available for VIP non-participants). Compared to the total population, the cohort participants importantly had a comparable average annual income (158 kSEK vs 156 kSEK; 2% difference), and differed <5% with respect to sex, married civil status and employment status, but with a small (<10%) underrepresentation of having children in household, and a larger underrepresentation of low-educated (11% difference) and of immigrants (23% difference).

2.3.2. Estimation of health inequalities

Socioeconomic inequalities in cardiovascular disease were estimated by concentration indexes (C) and concentration curves (CC), using mean income as the socioeconomic indicator and first time hospitalization with CVD as the main diagnosis as the health outcome. The C, which is directly related to the CC, is defined as twice the area between the CC and the line of equality (the 45-degree line), and assumes values between −1 and +1. (See Appendix for more details on the statistical procedures). To examine the changes in the health inequalities across 20 years (aim 1), CC and C were calculated for the cohort in four time-periods: 1990–1994 (period 1), 1995–1999 (period 2), 2000–2004 (period 3) and 2005–2010 (period 4).

2.3.3. Decomposition of health inequalities

To estimate the contribution of socioeconomic factors to the observed health inequalities (aim 2), Wagstaff-type decomposition analysis of concentration indices was used. The decomposition of the C is based on regression analysis of the relationship between a health variable and a set of k determinants. C can be decomposed into the contributions of the k factors in which each contribution is the product of the sensitivity of health with respect to k factors and their degree of income-related inequality (O'Donnell and Wagstaff, 2008).

The C at each of the four study periods was decomposed by socioeconomic factors in separate decomposition analyses. The determinants described above (demographic factors, socioeconomic and material conditions, family conditions and geographical area), measured in the first year of each study period, were used as decomposing factors. (Further details on the statistical procedures can be found in Appendix). In the result sections, the contribution of each determinant to the observed health inequality is reported both as absolute contribution (i.e. expressed in the same unit as the concentration index), and as relative contribution (i.e. percentage of the total concentration index).

3. Results

3.1. Characteristics of the study population

Characteristics of the population included in the cohort over the four periods of analysis are shown in Table 1. The CVD events per each 5–6-year period increased gradually as the population aged; cumulative incidence per 5 years ranged from 4.1% in the first study period, through 5.3% and 6.3% the second and third period, to 7.7% in the last period. Fixed characteristics such as immigrant status and sex were unsurprisingly fairly constant across the study periods, as was geographical area and educational achievement. Demographic, social and family characteristics that tend to change across this period of the life course, developed as expected in the
study population. A decreasing proportion was economically active (from 91.9% in 1990 to 50.6% in 2005) or had children in household (from 45.1% to 3.7%), and an increasing proportion was divorced (from 10.3% to 14.5%) or widowed (from 2.4% to 7.9%). Mean income (in all quantiles) increased across the study periods, although at a slower pace in the lowest (from 81kSEK in 1990 to 104kSEK in 2005) than highest (from 281kSEK to 419kSEK) quintile, resulting in gradually increasing absolute gaps in income.

3.2. Development of health inequalities

Fig. 1 shows concentration curves for each period under analysis, reflecting the development of income-related inequalities in CVD across the four study periods. The concentration curve of period 1 approached the diagonal line of 45°, indicating that this was a period of very low inequality. Concentration curves of the other three periods lay above the main diagonal, indicating that people with lower income have a greater proportion of CVD incident events than those with higher income. Visually comparing the four period curves, an increase in inequality can be seen as the curve shifts further from the line of equity as time passes and the population ages.

The concentration indexes (Table 2 as “Inequality (total)”) confirm what was observed in the curves. The overall concentration index of period 1 had a negative value very close to zero (-0.013, SE = 0.013) indicating a subtle but non-significant inequality against people with lower income. The magnitudes of these inequalities were however significant and gradually increased across periods 2, 3 and 4 (-0.075 SE = 0.012; -0.097 SE = 0.011; and -0.105 SE = 0.009, respectively).

3.3. Development of determinants of health inequalities

3.3.1. Income inequality in the determinants

The results of the decomposition analysis for each of the periods under analysis are shown in Table 2 and summarized in Fig. 2. First,
as an initial analysis, we examined the income inequalities for each of the determinants. The column under the heading “C” presents the degree of income-related inequality (concentration index) in each of the variables included as determinants. The C indicated that the low-income population was concentrated among the older (age groups 3 and 4) and women in all study periods. Immigrants were also concentrated among the less affluent population. As expected, people with secondary education and higher were better-off than those with two years of secondary education or less, as were those economically active. With regard to family conditions, widowhood was more common amongst the people with lower income than amongst the wealthy in the last two periods, whereas having children in household was concentrated among the better-off across all four periods.

3.3.2. Contribution of the determinants to income-related inequality in CVD

Second, and directly corresponding to aim 2, we examined the contribution of each determinant to the income-related inequality in CVD morbidity. The columns under the heading “contribution to C” and “Adj %” present both absolute (in the same unit as the C) and relative (adjusted percentage contribution toward inequality) contributions of each determinant.

Concerning demographic determinants, results showed that age and sex jointly made positive absolute contributions (i.e., in the opposite direction to the overall health inequality) in the first three periods of analysis and became negative in the last period (52.7% contribution), indicating that this group of variables played greater explanatory role in contributing to the health inequality in the older stages. Although women were concentrated among the less-affluent population their contribution was in the opposite direction to the overall concentration index as they also showed lower probabilities to have a CVD event. On the contrary, age was a determinant contributing to the inequality against the lower income population and with an increasing contribution over the time, from 20.1% in period 1 to 52.7% in the last period. Particularly age groups 3 and 4 displayed negative contributions across all four periods, and the oldest age group made the strongest contributions throughout the periods (ranging from 17.2 to 36.3% contributions), which can be expected from the dual concentration of CVD events (Table 1) and lower income (Table 2) among the older age groups.

The group of socioeconomic and material conditions together displayed negative absolute contributions (i.e. contributing to the overall health inequality) in all periods of analysis indicating that these factors had a supportive contribution to the inequality affecting the lower income population. It is interesting to note that whereas this group of variables explained a considerable amount to the health inequality at all four periods, its importance decreased over time; highest contribution in the first period (68.7%), with lower in the second and third period (63.3% and 65.6%, respectively), and lowest in the last period (45.4%). Regarding the contribution of specific socioeconomic and material variables, different longitudinal patterns were seen depending on the indicator in question. Income inequalities explained a substantial

Table 2
Summary of results of decomposition analyses: concentration index across each 5–6-year period decomposed by factors measured at the first year of each study period.

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<td>0.009**</td>
<td>0.033</td>
<td>-0.128</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inland with hospital</td>
<td>0.013**</td>
<td>0.020</td>
<td>-0.002</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.003</td>
<td>0.002</td>
<td>-0.055</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>-0.010</td>
<td>8.8</td>
<td>-0.004</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inequality (total)</td>
<td>-0.013</td>
<td>-0.075</td>
<td>-0.097</td>
<td>-0.105</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.013</td>
<td>0.012</td>
<td>0.011</td>
<td>0.009</td>
</tr>
<tr>
<td>Residual</td>
<td>0.010</td>
<td>0.004</td>
<td>-0.007</td>
<td>-0.001</td>
</tr>
</tbody>
</table>

Coeff = Marginal effects from the probit model, * indicates p < 0.05 and ** indicates p < 0.01.
portion of the inequality in CVD morbidity to the advantage of the better-off people, which was of a comparable magnitude across all four periods (ranging between 36.2 and 47.0%). Inequalities in education also explained a portion of the inequalities in all periods, but to a more varying degree depending on the period: the contribution of the three lowest levels of education was largest in period 1 (21.7%), lower in period 2 and 3 (12.2% and 13.3%, respectively), and lowest in period 4 (3.6%). As such, the negative effect of the education inequalities to the overall health inequality became smaller as the population grew older and the time passed, contrasting to the more stable contribution of income inequalities across all study periods.

Immigrant status played an insubstantial role in explaining the inequalities at all periods. Being economically active only initially made a moderately strong contribution to the overall health inequality (10.4% in period 1), but which was gradually reduced over time (7.9% in period 2 and 5.3% in period 3) and shifted to an insubstantial contribution in the other direction - to the disadvantage of the better-off - in the last period.

Regarding the set of family conditions variables, they together made an insubstantial negative absolute contributions to the overall concentration index at all ages (ranging between 0.6% and 2.7%), indicating that this group of variables only played a small explanatory role for the observed health inequalities. Similarly small explanatory contribution was seen for geographical area, with the only noticeable contribution being to the insubstantial health inequality of the first period.

3.3.3. Overall assessment of the model

Third and last, as an overall assessment of explanatory strengths of the decomposition models, most of the inequality in CVD morbidity to the advantage of the better-off segment of the population was explained by the determinants observed in this study, as seen in the small residuals during the last three periods (residuals ranging from 0.001 to 0.007). The exception was for the first period in which the health inequality was small and the concentration index non-significant, and the inequality was thus explained by the residual component. The decomposition estimates from all four study periods are reported as a point of reference, but the estimates from period 1 should be interpreted carefully.

4. Discussion

To our knowledge, this is the first study decomposing the health inequalities in CVD morbidity in a longitudinal cohort. Our results indicate that inequalities in CVD morbidity display a gradual increase of inequalities from mid-life to old age; initially non-significant but particularly marked among the elderly. With regard to the importance of determinants for these health inequalities, our findings reveal patterns of both continuity and change from mid-life to old age. Continuity was seen for income inequality, which was a stable and substantial contributing factor across the all study periods, and for immigrant status, family conditions and geographical area, which were consistently of little importance. In contrast, the importance of educational inequalities underwent a transition from initially dominant to a finally insubstantial role across the study period. A similar pattern of decreasing importance was seen for employment status, albeit a lower level of importance. Conversely, an increasing importance of age emerged, from initially moderate to dominant in the last study period.

4.1. Increasing health inequalities

The finding of increasing health inequalities across the entire study period was mirrored by consistent and increasing contribution of older age in the decomposition analysis. Together, these results suggest a key importance of the life course and aging in explaining the increasing inequalities. The literature regarding health inequalities in older stages of life is somewhat inconsistent. On the one hand, some studies (Goli et al., 2014; Huisman et al., 2003; von dem Knesebeck et al., 2003) have pointed out that level of frailty in the older populations (70 + years) is distributed along the socioeconomic gradient. Consequently, those living longer also belong to high socioeconomic position, which would make the distribution of poor health in older populations more homogeneous and hence less unequal. On the other hand, other studies have pointed out that disparities instead are maintained in old age after retirement, since socioeconomic factors can have a
long-term cumulative influence that deepens the inequalities with increased age (Di Cesare et al., 2013; Islam et al., 2010; Steptoe and Marmot, 2004). Moreover, it may be difficult to change health behaviors relevant for CVD among the low-income elderly (Mcgill, 2014), which could contribute to increased socioeconomic inequalities in CVD at older age (Di Cesare et al., 2013). Such notions of increased health inequalities with aging correspond to the findings in our study, which in itself is an important finding since it illustrates that the socioeconomic gradient in CVD is very much present among older people in Sweden. This also expands observations of persistent inequalities in self-rated health suggested in Swedish aging populations during the 1980s and 1990s (Islam et al., 2010).

From a secular perspective, the results of a widening gap are also in correspondence with the increased income inequalities in the last two decades in Sweden (OECD, 2011), which together with the changes in policies weakening the welfare system (Raphael, 2014) might have deepened health inequalities disfavoring the less-affluent population. Indeed, it has been stated that policies that resulted in increased socio-economic inequalities are associated with greater subsident socio-economic differences in cardiovascular disease, as well as in other non-communicable diseases (Di Cesare et al., 2013).

From a regional perspective, this development has also been seen in other studies following the population of Västerbotten by repeated cross-sections during the same study period, showing persistent or widening social gaps in cardiovascular risk factors like obesity (Norberg et al., 2010a) glucose intolerance, diabetes (Lindahl et al., 2010), blood pressure and hypertension (Ng et al., 2012). As noted elsewhere (Engstrom et al., 2000), increased population-level social gaps in cardiovascular risk factors may contribute to the increasing inequalities in CVD seen in the present study. In order to counteract the structural societal and life-course dependent forces that together contribute to rising health inequalities in older age, an explicit equity lens approach may be helpful in the development and implementation of cardiovascular interventions (Beauchamp et al., 2010).

4.2. Life course transitions and continuities of determinants

Our findings regarding determinants of the health inequalities are easiest understood in terms of transitions and continuities occurring along the life course. First, a marked finding was the dual transition in explanatory importance of education and to a lesser degree employment on the one hand, which successively gave way to an increasing importance of age on the other. This transition can possibly be understood from a life course perspective, where a relative shift occurs from the formative influences of labor market conditions during middle-age to an increasing impact of aging and corresponding life conditions during late life, as a greater proportion of the population enters retirement (Islam et al., 2010). Indeed, whereas an educational gradient has been reported for CVD (or CVD risk factors) in the middle-aged population of Sweden (Lindahl et al., 2010; Ng et al., 2012; Norberg et al., 2010a; Socialstyrelsen and Statens Folkhälsoinstitut, 2013) and other countries (Di Cesare et al., 2013; Huismann et al., 2003; Mackenbach et al., 2008), a decreasing educational/occupational gradient has also been reported from middle age to old age (Khanolkar et al., 2011). This pattern may reflect the same underlying phenomenon as displayed in our study. These findings further emphasize the need for viewing health inequality and its determinants not as a static phenomenon, but as circumstances that change dynamically along the life course.

Second, the results highlight the income distribution as a continually important factor in explaining inequalities in CVD over time, and independently of the aging process and related changes in life, such as retirement. Previous cross-sectional decomposition analyses on cardiovascular risk factors (obesity, alcohol consumption) conducted in Sweden (Combes et al., 2011; Ljungvall and Gerdtham, 2010), and in other contexts (Alaba and Chola, 2014; Fateh et al., 2014; Goli et al., 2014; Hajizadaeh et al., 2014) have also found that income is the factor that explains the largest fraction of the inequalities. Our findings thus extend these cross-sectional findings by suggesting a continual importance of income inequalities across middle to old age, despite the increased income inequalities occurring in Sweden during the same time period (OECD, 2011).

Third, a rather consistent insubstantial importance was seen for immigrant status, family conditions, and geographical area, indicating that these circumstances do not contribute importantly to income inequalities in health beyond the importance of the other studied determinants. For example, whereas immigrants and minorities may have a greater risk of socioeconomic disadvantage, such influences are already considered by low income and education. Our results concerning family conditions are similar to the findings of other cross-sectional decomposition analyses, suggesting very small contributions to inequalities in CVD risk factors (Adina and Chola, 2014; Hajizadaeh et al., 2014; Hudson et al., 2014; Ljungvall and Gerdtham, 2010), and to inequalities in self-rated health in old age (Goli et al., 2014).

Fourth, concerning gender, women were non-contributors to the inequality, i.e. the inequality was concentrated among the men. This finding illustrates the relative disadvantage of women on the labor market, expressed in for example lesser earning, in combination with lower morbidity among women than among men in CVD (Norberg et al., 2012) and other non-communicable diseases (Di Cesare et al., 2013; Mackenbach, 2006). From the regional perspective of the VIP, women have also displayed greater reductions in CVD risk factors and increasing awareness of control and treatment compared to men (Lindahl et al., 2010; Ng et al., 2012; Norberg and Danielsson, 2012; Norberg et al., 2010a). As such, when it comes to income-related inequalities in CVD, gender plays a complex role owing to its divergent relation to structural disadvantage and simultaneous health-related advantage of women.

4.3. Methodological considerations

The main strengths of the present study are the longitudinal cohort design spanning over as much as 20 years, a large sample, and use of register data with excellent coverage and without recall bias.

Some potential limitations should be considered when interpreting our results. The cohort was constructed from all participants in VIP, and as such is a sample of the total population of Västerbotten aged 40, 50 or 60 years at any point during 1990–2010. Previous examinations of the VIP as a whole have found lower CVD hospitalizations and higher education among VIP participants than in the target population (Norberg et al., 2012), and we also found underrepresentation of immigrants. Most explanatory variables, income included, were however similarly distributed as in the target population, suggesting that the representativity is acceptable.

With regard to the measures, hospitalization events should be considered a rather crude measure of CVD. Income only comprised individually earned income and as such does not reflect other aspects of the total financial situation for example personal wealth or income for other household or family members which nevertheless may be important for certain individuals’ financial situation (e.g. housewives or other individuals outside the labor market or with
low personal income). Income is also a more fluctuating socioeconomic indicator than for example education. Following recommendations of others (Islam et al., 2010; Ljungvall and Gertham, 2010) we used mean income and accumulated CVD events across 5–6 years, to offset some of the issues of precision such as fluctuations of current income. It should also be noted that the appropriateness of income, as the ranking variable to measure socioeconomic inequalities, potentially could vary across the life course, and that health inequalities by other socioeconomic variables (e.g. education) may differ in relationship between the CVD events and the variables (x axis). For the interpretation of the Concentration Curve, the curves of each period were compared with the line of 45° (line of equality).

The combination of transition and continuity in the contributions of explanatory factors illustrates the need for incorporating a dynamic life course perspective into research, policy and practice concerned with equity in health. Policy and interventions may need to apply a joint equity lens and life-course approach, in which reduction of the CVD burden and of CVD inequalities are interrelated and reinforcing priorities, and where the choice of action is dependent on life course stage.

Appendix

For the Concentration Curves, the cumulative percentage of CVD first time hospitalizations (y axis) was plotted against the cumulative percentage of the population, ranked by mean income (x axis). For the interpretation of the Concentration Curve, the curves of each period were compared with the line of 45° (line of equality). Formally the concentration index is defined as (O’Donnell and Wagstaff, 2008):

\[
C = \frac{2}{n \mu} \sum_{i=1}^{n} h_i R_i - 1
\]

Where \( h_i \) is the variable of interest for the ith person; \( \mu \) is the mean or proportion of \( h \); \( n \) is the number of people; and \( R_i \) is the ith ranked individual according to their socioeconomic status, from the most disadvantaged to the least disadvantaged.

A negative value of the C when the concentration curve lies above the line of equality means that the health outcome (CVD) is concentrated among people with low income. Conversely, a concentration curve below the line of equality indicates that the health outcome is concentrated among people with high income. The C would be zero if there is no socioeconomic-related inequality; i.e. perfect equality.

An important consideration when calculating the concentration index for a binary health outcome is that the bounds of the C for a binary variable are not –1 and +1 but instead depend on the mean (\( \mu \)) of the variable. According to Wagstaff (2008), for large samples, the lower bound is \( \mu - 1 \) and the upper bound is \( 1 - \mu \) and the interval of the index shrinks as the mean rises. A feasible solution to this problem is to normalize the concentration index by dividing through by 1 minus the mean (O’Donnell and Wagstaff, 2008), which is the method employed in the present manuscript.

According to Wagstaff et al. (O’Donnell and Wagstaff, 2008), for any linear additive regression model of health (y), such as:

\[
y = \alpha + \sum_k \beta_k x_k + \epsilon
\]

the concentration index for y, C, can be written:

\[
C = \sum_k (\beta_k x_k / \mu) C_k + GC_x / \mu
\]

Where \( \mu \) is the mean of y (health outcome variable), \( \bar{x}_k \) is the mean of \( x_k \) (determinants), \( C_k \) is the concentration index for \( x_k \) (defined analogously to C), and \( GC_x \) is the generalized concentration index for the error term (\( \epsilon \)). C is equal to a weighted sum of the concentration indices of the \( k \) determinants, where the weight for \( x_k \) is the elasticity of y with respect to \( x_k \). The residual component – captured by the last term \( GC_x / \mu \) – reflects the socioeconomic-related inequality in health that is not explained by systematic variation in the determinants across socioeconomic groups. Normalizing the C by dividing it through 1 minus the mean yields:

\[
C_{\text{normalized}} = \frac{C}{1 - \mu} = \sum_k (\beta_k x_k / \mu) C_k + \frac{GC_x / \mu}{1 - \mu}
\]
In summary, the steps performed for the decomposition analysis for each of the four study periods were:

1) the probit regression model of the health variable was estimated, in order to obtain the marginal effects of the set of socioeconomic determinants ($\beta_i$);
2) the weighted averages of the health outcome ($\mu$) and each of the determinants ($\mu_k$) were calculated;
3) the concentration indexes of each of the determinants were calculated ($C_i$);
4) the elasticity of the health variable ($\gamma$) with respect to the determinants ($x_k$) were calculated; and
5) the unique contribution of each of the determinants was quantified.

In decomposition analysis, contributions of the determinants must be interpreted in relation to the overall $C$. When the overall health concentration index is negative, a negative absolute contribution of a certain determinant indicates a supportive effect of the socioeconomic-related inequality (i.e. the estimated inequality is partly attributable to the determinant analyzed). A positive absolute contribution points towards an inequality counteracting effect (the determinant analyzed counteracts the negative effect of the inequality against the poor). An opposite interpretation is required when the overall $C$ is positive.

The relative contribution is calculated by dividing the absolute contribution by the total explained portion of the concentration index. As expressed by Yiengprugsawan et al. (2007), the unadjusted percentages calculated on the overall explained portion of the $C$ tend to show an exaggerated figure of their importance, instead using adjusted percentages (calculated on the total explained portion that make contributions to the same direction of the concentration index) provide a better description of their contributions (Yiengprugsawan et al., 2007), and so we calculate adjusted percentages to present the results in this study.

References


