Workplace socioeconomic characteristics and coronary heart disease: a nationwide follow-up study

Per-Ola Forsberg, Henrik Ohlsson, Kristina Sundquist

ABSTRACT

Objectives Important gaps in previous research include a lack of studies on the association between socioeconomic characteristics of the workplace and coronary heart disease (CHD). We aimed to examine two contextual factors in association with individuals’ risk of CHD: the mean educational level of all employees at each individual’s workplace (educationwork) and the neighbourhood socioeconomic characteristics of each individual’s workplace (neighbourhood SESwork).

Design Nationwide follow-up/cohort study.

Setting Nationwide data from Sweden.

Participants All individuals born in Sweden from 1943 to 1957 were included (n=1 547 818). We excluded individuals with a CHD diagnosis prior to 2008 (n=67 619), individuals without workplace information (n=576 663), individuals lacking residential address (n=4139) and individuals who had unknown parents (n=7076). A total of 892 321 individuals were thus included in the study (426 440 men and 465 881 women).

Primary and secondary outcome measures The outcome variable was incident CHD during follow-up between 2008 and 2012. The association between educationwork and neighbourhood SESwork and the outcome was explored using multilevel and cross-classified logistic regression models to determine ORs and 95% CIs, with individuals nested within workplaces and neighbourhoods. All models were conducted in both men and women and were adjusted for age, income, marital status, educational attainment and neighbourhood SESresidence.

Results Low (vs high) educationwork was significantly associated with increased CHD incidence for both men (OR 1.29, 95% CI 1.23 to 1.34) and women (OR 1.38, 95% CI 1.32 to 1.47) and remained significant after adjusting for potential confounders. These findings were not replicable for the variable neighbourhood SESwork.

Conclusions Workplace socioeconomic characteristics, that is, the educational attainment of an individual’s colleagues, may influence CHD risk, which represents new knowledge relevant to occupational health management at workplaces.

INTRODUCTION

Coronary heart disease (CHD) is a major cause of mortality and morbidity worldwide that confers substantial costs to society. A large proportion of CHD incidence can be explained by individual-level factors, such as sociodemographic characteristics (age, sex, socioeconomic status (SES)), health behaviours (smoking, physical inactivity, poor diet), and metabolic risk factors (hypertension, diabetes, hypercholesterolaemia).

In addition to individual-level SES, findings from several studies have established that the socioeconomic characteristics of an individual’s neighbourhood of residence are associated with CHD, after taking individual-level SES into account. These previous findings indicate that contextual factors may have their own independent effect on the development of CHD mortality and morbidity. However, although several studies have already demonstrated an association between neighbourhood socioeconomic characteristics and CHD, important gaps in previous research include a lack of studies on the association between socioeconomic characteristics of the workplace and CHD. As people spend a large part of their awake time at work, such studies are needed in order to get a comprehensive picture of the contextual influences on people’s CHD risk.

Previous studies on the role of the workplace concerning cardiovascular diseases have mainly focused on psychosocial stress at work, job strain, effort–reward imbalance and long working hours. However, to the best of our knowledge, no previous nationwide study has examined the...
association between CHD and contextual socioeconomic variables at work, including the mean educational level of all employees at each individual’s workplace (education_work) and the neighbourhood socioeconomic characteristics of each individual’s workplace (neighbourhood SES_work).

The aim of the present study was therefore to examine the association between CHD incidence and the two contextual variables education_work and neighbourhood SES_work in men and women, adjusted for individual-level sociodemographic characteristics.

METHODS

The study was conducted as a nationwide follow-up/cohort study. The data used in the present study were retrieved from nationwide registers provided by the Swedish National Board of Health and Welfare (health-care data) and Statistics Sweden (population data). The main registers included the Hospital Discharge Register, which contains inpatient data from 1987 to 2015, and the Outpatient Register, which contains outpatient data from 2001 to 2015. All data were linked by the personal Swedish identification number, which was replaced by a serial number in order to maintain people’s integrity.

We included all individuals in Sweden born between 1943 and 1957 (n=1 547 818; see figure 1).

We then excluded individuals with a CHD diagnosis prior to 2008 (n=67 619), individuals without sufficient workplace information (n=576 663), as well as individuals lacking a residential address (n=4139) or who had unknown parents (n=7076). A total of 892 321 individuals were thus included in the study (426 440 men and 465 881 women; see table 1).

We assessed information from all individuals at baseline (31 December 2007). Each individual was classified into one neighbourhood of residence and one workplace. Neighbourhoods were defined from data derived from Statistics Sweden’s Small Areas for Market Statistics (SAMS). There are approximately 9200 SAMS throughout Sweden, with an average population of 1000. The SAMS were initially created for administrative purposes by the Swedish authorities, are characterised by homogeneous

![Flow chart of inclusion and exclusion criteria in the study. CHD, coronary heart disease.](http://bmjopen.bmj.com)
types of buildings and are limited by ‘natural’ boundaries, such as motorways, rivers or hills. Workplace was defined based on the coordinates of the workplace address within a 250×250 m grid.

**Outcome variable**
The outcome variable was CHD during the follow-up period of 2008–2012. The CHD diagnoses were defined using International Classification of Diseases (ICD) codes ICD-9: 410–414 or ICD-10: I20–25. The CHD outcome included both non-fatal and fatal events.

**Contextual variables**
For each workplace, the mean of the educational attainment of all employees was determined (education\textsubscript{work}). Education\textsubscript{work} was categorised into three groups: <12 years (low education), 12–14 years (middle education) and >14 years (high education) of education.

A summary index was calculated to characterise neighbourhood-level SES, which was based on four items: low education level, low income, unemployment and receipt of social welfare. The index was categorised into three groups: below 1 SD from the mean (high SES), above 1 SD from the mean (low SES) and within 1 SD of the mean (middle SES). Each individual in the study had two neighbourhood SES values: neighbourhood SES of their workplace (neighbourhood SES\textsubscript{work}) and neighbourhood SES of their residence (neighbourhood SES\textsubscript{residence}); the latter was included for adjustment purposes.

There were a total of 9092 SAMS and 95 991 workplaces in this study. The median number of employees per workplace was 58 (25th and 75th percentiles=18 and 184, respectively).

**Individual-level variables**
Individual-level information included age (continuous); annual household income (size-weighted, standardised); marital status (married/cohabiting vs widowed/divorced/single) and educational attainment (education\textsubscript{individual}, seven levels, used as a continuous variable). Men and women were analysed separately in the models.

**Statistical methods**
We used multilevel and cross-classified logistic regression models with individuals nested within two classifications: neighbourhoods and workplaces. This model enabled us to investigate the similarity of CHD within different classifications. If the classifications are relevant for the individual variation in CHD, one would expect a considerable part of the variance to be at the neighbourhood and/or workplace level; that is, there would be a clustering of CHD within neighbourhoods and/or workplaces.

First, for each of the two contextual variables (education\textsubscript{work}, neighbourhood SES\textsubscript{work}), we created a model (model 1) with only one of these contextual variables. In the next model (model 2), we controlled for individual-level factors. In the final model (model 3), we also controlled for the other workplace contextual factors as well as neighbourhood SES\textsubscript{residence}. We performed all analyses for men and women separately.

We calculated the variance components attributed to the two different classifications (neighbourhood of residence and workplace) as well as the sum of the two variance components. We also calculated the intraclass correlation (ICC) for the higher level (ICC\textsubscript{higher level}), that is, the ICC for both neighbourhood of residence and workplace. The ICC is interpreted as the proportion of the total variation in CHD incidence that is explained by differences between neighbourhoods and workplaces. In order to calculate the ICC, we used the latent variable method:

\[
\text{ICC}_{\text{higher level}} = \frac{\text{V}_{\text{residence}} + \text{V}_{\text{workplace}}}{\text{V}_{\text{residence}} + \text{V}_{\text{workplace}} + \pi^2/3}
\]

where \(\text{V}_{\text{residence}}\) is the variance attributed to the neighbourhood of residence and \(\text{V}_{\text{workplace}}\) is the variance attributed to the workplace. We also computed the share of higher-level variance that is attributed to each of the two different classifications. The analyses were performed using MLwiN V.3.02 and SAS V.9.4.
Patient and public involvement

Patients or the public were not directly involved in the design, conduct, reporting or dissemination plans of our research.

RESULTS

Distribution of study population and number of CHD cases

Of the 892,321 individuals in the study, there were a total of 14,766 male (3.5%) and 6,219 female (1.3%) CHD cases during the follow-up. Some differences between the subgroups in the proportions of those who developed CHD appeared (online supplemental table 1).

Distribution of study population and number of CHD cases for men and women separately

Online supplemental table 2 shows the distribution of the study population and the number of CHD cases for men and women separately and by the individual-level variables.

Distribution of study population and number of CHD cases by the contextual variables

Online supplemental table 3 shows the distribution of the study population for CHD cases and non-CHD by the categories education\textsubscript{work}, neighbourhood SES\textsubscript{work}, and neighbourhood SES\textsubscript{residence}.

Tables 2 and 3 show ORs with 95% CIs for incidence of CHD in men (table 2) and women (table 3) based on education at work.

Tables 2 and 3 show the results of the multilevel and cross-classified logistic regression models in men and women, respectively, with individuals nested within the two classifications workplace and neighbourhood of residence. Here, education\textsubscript{work} is used as the primary contextual variable.

In the first model (model 1), low compared with high education\textsubscript{work} was significantly associated with higher CHD incidence for both men (OR 1.29, 95% CI 1.23 to 1.34) and women (OR 1.38, 95% CI 1.29 to 1.47), as shown in tables 2 and 3. After adjusting for individual-level and contextual-level characteristics in the full model (model 3), low compared with high education\textsubscript{work} remained significantly associated with higher CHD incidence, but with slightly lower ORs, for both men (OR 1.11, 95% CI 1.05 to 1.17) and women (OR 1.13, 95% CI 1.05 to 1.22). There also appeared to be a gradient between education\textsubscript{work} and individual risk of CHD, after adjusting for individual-level variables in all models.

The ICC was 2.03% at the higher level (both workplace and neighbourhood of residence), 0.96% at workplace level and 1.08% at neighbourhood\textsubscript{residence} level in model 3 for men. The variance was 0.032 (SE 0.002) at workplace level and 0.036 (SE 0.010) at neighbourhood\textsubscript{residence} level in model 3 for men (data not presented in tables).

The ICC was 3.24% at the higher level, 1.73% at workplace level and 1.56% at neighbourhood\textsubscript{residence} level in model 3 for women. The variance was 0.058 (SE 0.010) at workplace level and 0.052 (SE 0.012) at neighbourhood\textsubscript{residence} level in model 3 for women.

Tables 4 and 5 show ORs with 95% CIs for incidence of CHD in men (table 4) and women (table 5) based on neighbourhood SES at work.

Tables 4 and 5 show the results of the multilevel and cross-classified logistic regression models in men and women.
women, respectively, with neighbourhood SES work used as the primary contextual variable. In the first model (model 1), low compared with high neighbourhood SES work was not significantly associated with higher CHD incidence for men (OR 1.07, 95% CI 0.99 to 1.16) but for women (OR 1.15, 95% CI 1.03 to 1.28), as shown in tables 4 and 5. After adjusting for the individual-level and contextual-level characteristics in the full model (model 3), low compared with high neighbourhood SES work was not significantly associated with higher CHD incidence in men (OR 1.02, 95% CI 0.94 to 1.12) or women (OR 1.03, 95% CI 0.91 to 1.16).

For the individual-level variables (both men and women), high age, low education and low income were

<table>
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<tr>
<th>Table 3</th>
<th>ORs with 95% CIs for incidence of coronary heart disease in women based on education at work: results of multilevel and cross-classified logistic regression models</th>
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<td></td>
<td>Model 1</td>
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<td>OR</td>
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<tr>
<td>Education at work (ref high)</td>
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<td>Middle</td>
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<tr>
<td>Low</td>
<td>1.38</td>
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<tr>
<td>Age</td>
<td>1.08</td>
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<tr>
<td>Marital status (ref married/cohabiting)</td>
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<td>Neighbourhood SES work (ref high SES)</td>
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<td>Low</td>
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<tr>
<td>Neighbourhood SES residence (ref high SES)</td>
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Model 1: univariate model; model 2: adjusted for individual characteristics; model 3: full model. Statistically significant results (p<0.05) are marked in bold. SES, socioeconomic status.

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<tr>
<th>Table 4</th>
<th>ORs with 95% CIs for incidence of coronary heart disease in men based on education at work: results of multilevel and cross-classified logistic regression models</th>
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<td>Model 1</td>
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<td>Neighbourhood SES work (ref high SES)</td>
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<td>Age</td>
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<td>Income</td>
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<td>Education at work (ref high)</td>
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<tr>
<td>Middle</td>
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<td>Low</td>
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<td>Neighbourhood SES residence (ref high SES)</td>
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Model 1: univariate model; model 2: adjusted for individual characteristics; model 3: full model. Statistically significant results (p<0.05) are marked in bold. SES, socioeconomic status.
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Table 5  ORs with 95% CIs for incidence of coronary heart disease in women based on neighbourhood characteristics at work: results of multilevel and cross-classified logistic regression models

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<th>Model 1</th>
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<th>Model 3</th>
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<td>Neighbourhood SES&lt;sub&gt;work&lt;/sub&gt; (ref high SES)</td>
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<td>Middle</td>
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<td>1.04 to 1.23</td>
<td>1.08</td>
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<td>Low</td>
<td>1.15</td>
<td>1.03 to 1.28</td>
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<td>0.98 to 1.25</td>
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<td>0.91 to 1.16</td>
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<td>Age</td>
<td>1.08</td>
<td>1.07 to 1.08</td>
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<td>Marital status (ref married/cohabiting)</td>
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<tr>
<td>Education, individual</td>
<td>1.11</td>
<td>1.09 to 1.13</td>
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<td>Education at work (ref high)</td>
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<td>1.04</td>
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<td>1.35</td>
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Model 1: univariate model; model 2: adjusted for individual characteristics; model 3: full model. Statistically significant results (p<0.05) are marked in bold.

DISCUSSION

The main finding of the present study was that CHD incidence is significantly associated with the mean educational attainment at work (education<sub>work</sub>) but not with neighbourhood SES at work (neighbourhood SES<sub>work</sub>). These findings were consistent for both men and women, after adjusting for potential confounders. The results of the present study represent new knowledge. Our study is the first to examine whether two different socioeconomic characteristics at work (education<sub>work</sub> and neighbourhood SES<sub>work</sub>) are associated with CHD incidence, and the results may be useful for tailored preventive efforts at workplaces.

To test the robustness of our data, we also examined the association between neighbourhood residential SES (neighbourhood SES<sub>residence</sub>) and, in agreement with previous research, the results confirmed that the neighbourhood SES<sub>residence</sub> is significantly associated with CHD risk in both men and women, after adjustment for individual-level sociodemographic characteristics. The risk of CHD in women seemed to be more strongly associated with neighbourhood SES<sub>residence</sub> than in men, which is also in agreement with previous research. Although contextual factors may influence the CHD risk to a lesser extent in men, it is important to keep in mind that women have a lower absolute CHD risk. During the follow-up of this study, 1.3% of women compared with 3.4% of men were diagnosed with CHD.

Previous research has suggested various mechanisms that may lay behind the associations between neighbourhood residential SES and individual CHD risk. Possible mechanisms include the potential influence of neighbourhood SES<sub>residence</sub> on health-related behaviours such as a healthy diet, physical activity and non-smoking. For example, a lack of access to smoke-free environments, healthy food and safe places to exercise may deny people the opportunity to develop and maintain heart-healthy behaviours. Moreover, access to healthcare resources for treating metabolic risk factors for CHD, such as hypertension and diabetes, may differ between neighbourhoods. Lack of social cohesion, and in particular violent crime, as well as social disorganisation and signs of lacking social control such as vandalism and littering, might also explain the well-established association between neighbourhood SES<sub>residence</sub> and individual risk of CHD.

However, the associations between CHD incidence and the contextual variables of educational attainment at work as well as neighbourhood SES at work have not been studied before. Our findings are therefore important as people spend a large proportion of their time at work and are therefore also exposed to contextual factors at work, which might affect their CHD risk in addition to other environmental exposures.
The novel finding of an association between the lower mean educational attainment of an individual’s colleagues and CHD risk is important. Possible explanations exist in previous studies showing that behaviours and attitudes can be contagious and spread in social networks, such as those in workplaces. For example, highly educated colleagues might have more knowledge of good health-related behaviours such as having a healthy diet, being physically active and refraining from smoking. Conversely, if one’s colleagues smoke, they might encourage others to join them for a smoke break. However, further studies are needed to uncover these mechanisms. Our study findings of 11% (men) and 13% (women) of increased risks from the variable education_work may be considered to be modest. However, these risks were adjusted for individual-level sociodemographic variables (including education), neighbourhood SES_work and neighbourhood SES_residence and, although the individual risk was moderately increased, it may lead to a large number of CHD cases at the population level.

In this study, we found no significant association between CHD incidence and neighbourhood SES_work in the full model. One possible explanation for this might be that, although people spend much time at work, most of the time at work may be spent indoors, rather than in the surrounding neighbourhood. People may therefore be more affected by their colleagues than by the surrounding neighbourhood at work.

Limitations and strengths

There are a few limitations to this study. Residual confounding may exist as socioeconomic measures only represent proxies for individual-level SES. Another limitation is that workplaces were defined based on the geographical location, that is, the address. This means that colleagues at the same address may be working in different buildings and have little or no interaction with each other. Individuals with missing information on their workplace were not included in our study (n=576 663). The majority of these individuals were, however, unemployed (n=445 907) and the scope of the present study was to examine the potential influence of workplace on CHD. The study was limited to Sweden but included the whole population in the specified age group. The findings are therefore most likely generalisable to countries with similar socioeconomic structures and which also provide universal healthcare to their populations. This is, to the best of our knowledge, the first study examining the association between workplace socioeconomic characteristics and CHD. Further studies are needed to confirm our findings in other settings.

This study also has several strengths. The large cohort included almost all working residents of Sweden. The Hospital Discharge Register has very high validity and the diagnoses have a positive predictive value of >95%. Furthermore, the use of cross-classified multilevel modelling helped separate contextual effects from individual-level effects. For this purpose, it is important not only to investigate average measures of associations but also the potential clustering in certain contexts. The clustering of CHD in our neighbourhoods was of similar magnitude as that in previous studies.

Conclusion

Workplace socioeconomic characteristics, in particular the educational attainment of an individual’s colleagues, may influence CHD risk. These findings may be important to consider for occupational health management in workplaces in order to improve the employees’ cardiac health.

Contributors All authors contributed to the conception and design of the work. KS contributed to the acquisition, P-OF and HO contributed to the analysis, and all authors contributed to the interpretation of data. P-OF drafted the work and KS and HO revised it critically for important intellectual content. P-OF acts as a guarantor for the overall content of the study. All authors made a final approval of the version to be published. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval This study complies with the Declaration of Helsinki and was approved by the Ethics Review Board at Lund University (2011/492 and later amendments).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. The data that support the findings of this study are available, upon request, from the Swedish authorities (the National Board of Health and Welfare; Statistics Sweden). Restrictions apply to the availability of these data, which were used with permission from the authorities.

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