Scandinavian Journal of Public Health, 2018; 46: 204–213

ORIGINAL ARTICLE

Special Issue: In the era of pluralism: vaccination uptake, migrant health and child health trajectories

Ethnic disparities in educational and occupational gradients of estimated cardiovascular disease risk: The Healthy Life in an Urban Setting study

WILCO PERINI[1,2], CHARLES AGYEMANG[1], MARIEKE B. SNIJDER[1,3], RON J.G. PETERS[2] & ANTON E. KUNST[1]

[1]Department of Public Health, Academic Medical Center of the University of Amsterdam, The Netherlands, [2]Department of Cardiology, Academic Medical Center of the University of Amsterdam, The Netherlands, and [3]Department of Clinical Epidemiology, Biostatistics and Bioinformatics, Academic Medical Center of the University of Amsterdam, The Netherlands

Abstract

Background: European societies are becoming increasingly ethnically diverse. This may have important implications for socio-economic inequalities in health due to the often disadvantaged position of ethnic minority groups in both socio-economic status (SES) and disease, especially cardiovascular disease (CVD). *Objective:* The aim of this study was to determine whether the socio-economic gradient of estimated CVD risk differs between ethnic groups. *Methods:* Using the Healthy Life in an Urban Setting study, we obtained data on SES and CVD risk factors among participants from six ethnic backgrounds residing in Amsterdam. SES was measured using educational level and occupational level. CVD risk was estimated based on the occurrence of CVD risk factors using the Dutch version of the systematic coronary risk evaluation algorithm. Ethnic disparities in socio-economic gradients for estimated CVD risk were determined using the relative index of inequality (RII). *Results:* Among Dutch-origin men, the RII for estimated CVD risk according to educational level was 6.15% (95% confidence interval [CI] 4.35–7.96%), indicating that those at the bottom of the educational hierarchy had a 6.15% higher estimated CVD risk relative than those at the top. Among Dutch-origin women, the RII was 4.49% (CI 2.45–6.52%). The RII was lower among ethnic minority groups, ranging from 0.83% to 3.13% among men and −0.29% to 5.12% among women, indicating weaker associations among these groups. Results were similar based on occupational level. ***Conclusions:*** **Ethnic background needs to be considered in associations between SES and disease. The predictive value of SES varies between ethnic groups and may be quite poor for some groups.**

Key Words: *Cardiovascular disease, cardiovascular risk factors, socio-economic inequalities, educational inequalities, occupational inequalities, ethnic inequalities, prevention*

Introduction

Socio-economic inequalities in health and disease pervade European societies, particularly cardiovascular disease (CVD) [1,2]. Socio-economic inequalities exist in CVD mortality, morbidity and case fatality, although the association varies with specific CVD subtypes (e.g. a stronger socio-economic gradient with ischaemic cerebrovascular accidents relative to haemorrhagic cerebrovascular accidents) [3,4]. In addition, socio-economic inequalities exist in biomedical precursors of CVD, such as coronary artery calcification or dyslipidaemia [5,6]. Finally, socio-economic inequalities exist in the underlying risk factors such as smoking, diet and physical activity [7,8].

In recent decades, European societies have become increasingly diverse not only in socio-economic terms, but also in terms of ethnic background, due to

Correspondence: Wilco Perini, Department of Public Health, Academic Medical Center of the University of Amsterdam, Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands. E-mail: W.perini@amc.nl

(Date received 26 January 2017; reviewed 23 May 2017; accepted 12 June 2017)

© Author(s) 2017
Reprints and permissions: sagepub.co.uk/journalsPermissions.nav
DOI: 10.1177/1403494817718906
journals.sagepub.com/home/sjp
SAGE

immigration waves from non-Western countries, which started in the 1960s. The first generation of migrants is now starting to reach an age where diseases such as CVD are a main cause of mortality and disability.

The increasing ethnic diversity may have important implications for socio-economic inequalities in CVD because many ethnic minority groups have a socio-economically disadvantaged position relative to host populations. Furthermore, the socio-economic gradient of CVD may differ strongly between ethnic groups [9–11]. This was first described in the 1970s by Marmot et al. who reported socio-economic disparities in CVD among the host population in England and Wales, but found no socio-economic disparities in CVD among Indian minorities [12]. Subsequent studies, however, have reported differing results with regard to socio-economic gradients in CVD among ethnic minority populations, showing both strong and weak or absent socio-economic gradients among these populations [9–11,13].

More precise knowledge on the relation between socio-economic status (SES) and CVD within ethnic minority groups can help identify those who would most benefit from preventive interventions for CVD. In Europe, the European Society of Cardiology has recommended that preventive intervention for CVD is warranted only among those with sufficient estimated CVD risk. This CVD risk is estimated based on the occurrence of traditional CVD risk factors (e.g. smoking status and dyslipidaemia) [14,15]. Estimated CVD risk may vary according to SES and ethnic background [16,17]. Therefore, considering both SES and ethnicity may help identify those with sufficient estimated CVD risk to warrant preventive interventions. However, no studies have been carried out in Europe to determine the association of SES and ethnicity with estimated CVD risk. In addition, the studies that have assessed socio-economic gradients for certain individual CVD risk factors have shown inconsistent results [18,19].

To illustrate the importance of the increasing ethnic diversity to socio-economic inequalities in health, we assessed whether educational and occupational level gradients in CVD risk differ between ethnic groups. To do so, we analysed socio-economic gradients in estimated CVD risk and the individual CVD risk factors used for estimation, and determined whether and how these gradients differed between the ethnic groups.

Methods

Data were obtained via a questionnaire and a physical examination during the Healthy Life in an Urban Setting (HELIUS) study. HELIUS is a large-scale, multi-ethnic cohort study on health and health-care utilisation among different ethnic groups living in Amsterdam, The Netherlands. The aims and design of the HELIUS study have been described previously by Stronks et al. [20]. In brief, HELIUS included Dutch, Surinamese, Ghanaian, Turkish and Moroccan origin participants between 18 and 70 years of age living in Amsterdam who were randomly sampled, stratified by ethnicity, via the municipality register. The study protocols were approved by the Academic Medical Center Ethical Review Board, and all participants provided written informed consent.

Ethnicity

Each participant's ethnicity was defined according to the country of birth of the participant as well as that of his/her parents. Specifically, a participant was considered as of non-Dutch ethnic origin if he/she fulfilled either of the following criteria: (1) he or she was born abroad and has at least one parent born abroad (first generation), or (2) he or she was born in the Netherlands but both his/her parents were born abroad (second generation). Of the Surinamese immigrants in the Netherlands, approximately 80% are either of African or South-Asian origin. Surinamese subgroups were classified according to self-reported ethnic origin. Participants were considered to be of Dutch origin if the person and both parents were born in the Netherlands.

SES indicators

SES was estimated by self-reported educational level and occupational level. Educational level was based on the highest qualification attained, either in the Netherlands or in the country of origin, and it was categorised into four groups: (1) no or elementary schooling, (2) lower vocational or lower secondary schooling, (3) intermediate vocational or intermediate or higher secondary schooling and (4) higher vocational schooling or university. Occupational level was classified according to Dutch Standard Occupational Classification system for 2010. This document provides an extensive systematic list of all professions in the Dutch system. Based on this document, occupational level was classified into (1) elementary, (2) lower, (3) intermediate and (4) higher or academic, based on job title and job description, including a question on fulfilling an executive function.

Cardiovascular risk measures

Cardiovascular risk was estimated using the CVD risk algorithm currently used in Dutch primary care

[15]. This algorithm is derived from the systematic coronary risk evaluation (SCORE) algorithm for low-risk countries and estimates the 10-year risk of fatal plus non-fatal CVD based on age, sex, blood pressure, cholesterol/high density lipoprotein (cholesterol/HDL) ratio, smoking status and diabetes [15,21]. It is suitable for participants without prior CVD who are at least 40 years of age or, in case of a diabetes diagnosis, 25 years of age. [15].

Cardiovascular risk factors used for this study include achieving the physical activity norm (i.e. ≥30 minutes of moderate physical activity per day for five or more days a week), smoking status, diabetes status, blood pressure and cholesterol/HDL ratio. Habitual physical activity (hours/week) was measured with questions about the time spent on several activities during a normal week in the past few months using the Short Questionnaire to Assess Health-Enhancing Physical Activity (SQUASH) [22]. Smoking status was assessed via questionnaire. Blood pressure was measured twice using a validated automated digital blood pressure device (WatchBP Home; Microlife AG) on the left arm in a seated position after the person had been seated for at least five minutes. Fasting blood samples were drawn, and fasting glucose, total and HDL cholesterol were determined. Participants were considered to have diabetes if they reported a diabetes diagnosis, used glucose-lowering medication or in case of a fasting glucose ≥7.0 mmol/L.

Study population

Baseline data collected by both questionnaire and physical examination were available for 22,165 participants. We excluded participants with a Javanese Surinamese (n=233), other-unknown Surinamese (n=267) or unknown/other ethnic background (n=48). Furthermore, we excluded participants based on missing data regarding cardiovascular risk (i.e. smoking status, dyslipidaemia, and/or blood pressure; n=311) or educational level (n=180). In addition, we excluded participants who were not eligible for CVD risk estimation based on age <40 years or <25 years among those with diabetes (n=7434) or based on prior CVD (n=2363). This resulted in a study population of 11,329 participants.

Statistical analysis

Because of non-linear associations between age and estimated CVD risk/CVD risk factors, all analyses were stratified for sex and adjusted for age using seven- or five-year intervals (18–24, 25–29, 30–34, etc.). To study the association between SES and estimated CVD risk, we calculated the relative index of inequality (RII) for each ethnic group. The RII is a regression-based estimate of the association of SES with estimated cardiovascular risk, which takes the relative size of SES groups into account [23]. It is obtained by regressing the cumulative rank of each SES group [23]. The cumulative rank is equal to the proportion of individuals who have a higher SES, which is equal to the proportion of participants in higher SES groups plus one half of the proportion of participants within the own SES group [23]. The RII for estimated cardiovascular risk was estimated using ordinary least squares regression. In addition, we determined the RII for each individual CVD risk factor using binary logistic regression for categorical variables (i.e. achieving the physical activity norm, smoking status and diabetes) and ordinary least squares regression for continuous variables (i.e. systolic blood pressure and cholesterol/HDL ratio).

Because ethnic disparities regarding socio-economic inequalities in disease may differ between SES indicators, we repeated these analyses using occupational level instead of educational level as an indicator of SES. For these analyses, we excluded Moroccan females and Turkish females due to the high number of missing values regarding occupational level (n=516 and n=333, respectively).

Results

In our study population, Dutch and African Surinamese participants were older compared to the other ethnic minority groups (Table I). The proportion with highest education was highest among the Dutch. Most South-Asian Surinamese, African Surinamese and Ghanaian men had second lowest or second highest education, whereas most Turkish men and Moroccan men had lowest or second lowest education. Male–female differences in educational levels were small for South-Asian Surinamese and African Surinamese participants but substantial for the other ethnic minority groups. Estimated CVD risk was highest among the Dutch, South-Asian Surinamese and African Surinamese in both men and women, although Moroccan women showed a high estimated CVD risk relative to Ghanaian and Turkish women. The occurrence of individual CVD risk factors differed between ethnic groups, especially for diabetes prevalence.

Within each SES category, Dutch, South-Asian Surinamese and African Surinamese men showed the highest unadjusted estimated CVD risk (Figure 1). Socio-economic gradients based on educational rank were similar between ethnic groups, although for Turkish and Ghanaian men, the association

Table I. Characteristics of the study population.

	Dutch	South-Asian Surinamese	African Surinamese	Ghanaian	Turkish	Moroccan
Men						
N	1210	656	1001	603	708	679
Age, years	54.5 (8.5)	51.8 (7.9)	54.0 (7.5)	51.3 (6.7)	49.3 (6.5)	51.3 (7.9)
Educational level, %						
Lowest	3.8	14.6	7.0	18.9	33.5	39.5
Second lowest	17.4	39.3	44.7	47.4	32.6	25.2
Second highest	21.3	23.5	29.0	26.2	21.9	25.0
Highest	57.4	22.6	19.4	7.5	12.0	10.3
Estimated CVD risk, mean (%)	10.0 (10.1)	10.8 (9.9)	10.6 (10.0)	7.5 (6.6)	8.0 (8.3)	8.7 (9.8)
Systolic BP, mean mmHg	132.0 (16.7)	133.8 (16.8)	136.6 (17.8)	141.5 (17.7)	129.1 (15.0)	129.9 (15.3)
Cholesterol/HDL ratio, mean	4.2 (1.3)	4.6 (1.4)	3.8 (1.2)	3.6 (1.1)	4.8 (1.4)	4.4 (1.5)
Achieving physical activity norm,[c] % yes	73.2	60.2	70.1	62.2	53.5	61.9
Smoking status, % yes	21.7	38.0	42.7	7.1	38.1	22.5
Diabetes, % yes	6.6	28.4	14.9	18.4	17.8	19.7
Reported occupational level, % yes	96.9	92.8	93.9	90.9	89.0	91.3
Occupational level, %						
Lowest	1.4	10.2	8.4	59.7	17.9	25.0
Second lowest	15.0	36.9	45.2	27.9	51.9	45.6
Second highest	25.1	29.9	24.9	7.7	20.0	20.8
Highest	58.4	22.9	21.5	4.7	10.1	8.6
Women						
N	1438	930	1546	809	787	962
Age, years	54.2 (8.2)	52.6 (7.9)	53.2 (7.3)	49.1 (6.9)	49.0 (6.8)	50.4 (7.4)
Educational level, %						
Lowest	3.9	19.0	5.3	44.0	56.7	61.3
Second lowest	19.7	41.2	37.2	36.5	17.8	14.9
Second highest	20.7	22.5	33.2	17.7	18.2	18.0
Highest	55.7	17.3	24.3	1.9	7.4	5.8
Estimated CVD risk, mean (%)	5.4 (11.3)	7.8 (13.2)	6.5 (12.1)	3.1 (6.7)	4.0 (8.7)	5.0 (9.1)
Systolic BP, mean mmHg	123.6 (17.0)	132.0 (19.9)	133.6 (18.0)	138.3 (18.8)	125.9 (16.9)	125.3 (16.7)
Cholesterol/HDL ratio, mean	3.3 (1.1)	3.7 (1.1)	3.3 (1.1)	3.1 (0.9)	3.9 (1.1)	3.6 (1.0)
Achieving physical activity norm, % yes	78.0	55.1	59.5	47.6	35.8	43.9
Smoking status, % yes	20.9	16.3	21.7	3.0	23.6	1.9
Diabetes, % yes	3.1	21.1	14.2	12.9	15.4	20.3
Reported occupational level, % yes	96.5	88.0	93.2	86.4	×	×
Occupational level, %						
Lowest	2.4	16.9	5.7	78.5	×	×
Second lowest	15.8	33.4	28.5	14.7	×	×
Second highest	26.1	32.4	41.4	5.3	×	×
Highest	55.7	17.3	24.5	1.4	×	×

Data are presented as mean (*SD*) or percentages.
CVD: cardiovascular disease; BP: blood pressure; HDL: high-density lipoprotein.

seemed somewhat weaker. Among women, South-Asian Surinamese, African Surinamese and the Dutch showed a higher estimated CVD risk relative to Ghanaian, Turkish and Moroccan women at high educational rank (i.e. low education) but not at low educational rank (i.e. high education) due to a stronger socio-economic gradient among the Dutch, South-Asian Surinamese and African Surinamese relative to the other ethnic groups. Furthermore, in contrast to the other ethnic groups, Ghanaian women showed no or a slightly negative socio-economic gradient.

Among Dutch men, the age-adjusted RII of educational differences in estimated CVD risk was 6.15% (95% confidence interval [CI] 4.35–7.96%; Table II), indicating that in general, those at the bottom of the educational hierarchy had a 6.15% higher 10-year risk of CVD related morbidity or mortality compared to those at the top. The RII was smaller but also significant among South-Asian Surinamese men (RII 3.13, 95% CI 0.79–.48%). Among other minority groups, the RII was positive as well but did not attain statistical significance (RII 0.83–2.01%). The RII for Dutch men was significantly higher than

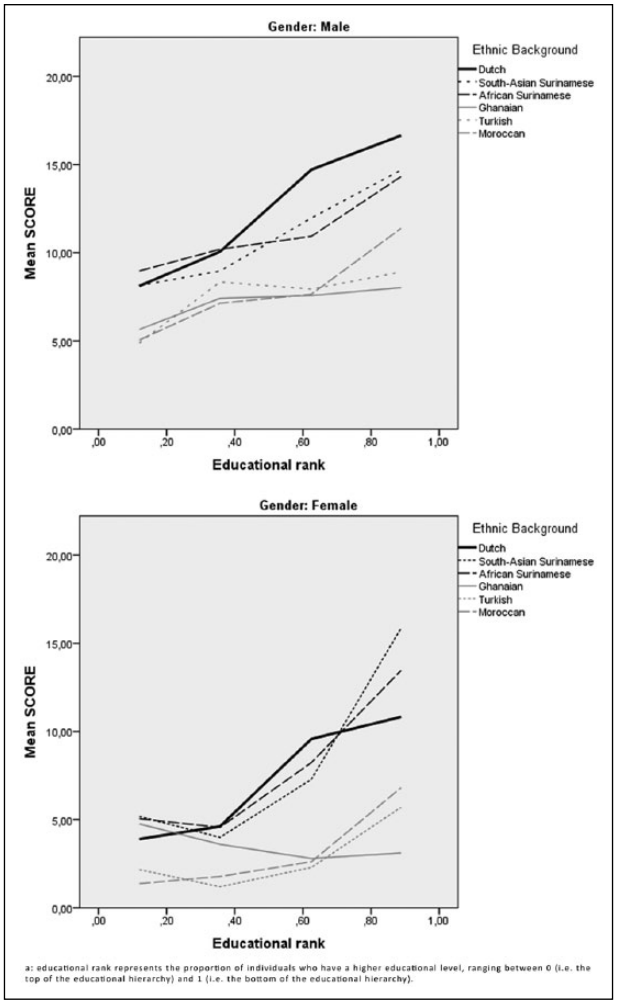

Figure 1. Estimated cardiovascular disease risk (SCORE) by educational rank, stratified for ethnic background (men top, women bottom).

for all ethnic minority men. Among Dutch women, the RII for estimated CVD risk was 4.49% (95% CI 2.45–.52%). Among ethnic minority South-Asian Surinamese women, African-Surinamese women and Turkish women, the RII was significant, ranging from 3.02% to 5.12%, and did not differ significantly from Dutch women. Among Ghanaian women and Moroccan women, the RII was not significant (RII −0.29%, 95% CI −2.26% to 1.68%; RII 1.45%, 95% CI −0.47% to 3.36%, respectively) and was significantly lower relative to the Dutch women.

The RII for all individual CVD risk factors were significant and positive among the Dutch men, except for achieving the norm for physical activity, which was negative though not significant. The RII of smoking was similar to the Dutch among most ethnic minority men, except among Ghanaian men who showed a lower RII relative to the Dutch. The RII for other individual CVD risk factors was often not

Table II. Association between cumulative educational rank and estimated CVD risk (SCORE) or individual CVD risk factors based on the relative index of inequality (RII) as determined via least-squares regression (beta) or binary logistic regression (odds ratio) with 95% confidence intervals, adjusted for age.

	Dutch	South-Asian Surinamese	African Surinamese	Ghanaian	Turkish	Moroccan
Men						
SCORE (%, beta)	**6.15 (4.35, 7.96)**	**3.13* (0.79, 5.48)**	2.01* (−0.14, 4.16)	1.28* (−0.72, 3.28)	0.83* (−1.23, 2.89)	1.06* (−1.34, 3.25)
Cholesterol/HDL ratio (mmol/L, beta)	**0.63 (0.31, 0.96)**	−0.02* (−0.44, 0.40)	−0.07* (−0.40, 0.27)	−0.14* (−0.54, 0.26)	0.28 (−0.13, 0.69)	0.17 (−0.27, 0.61)
Systolic BP (mmHg, beta)	**9.57 (5.47, 13.66)**	1.99* (−3.01, 7.00)	**2.73* (2.15, 7.60)**	6.04 (−0.36, 12.43)	1.60* (−2.59, 5.80)	0.41* (−3.87, 4.69)
Physical activity (odds ratio)	0.65 (0.36, 1.17)	1.12 (0.60, 2.12)	0.85 (0.46, 1.57)	0.85 (0.40, 1.80)	0.83 (0.47, 1.48)	0.74 (0.40, 1.39)
Smoking (odds ratio)	**3.41 (1.89, 6.18)**	**8.77 (4.41, 17.45)**	**3.58 (2.01, 6.48)**	1.79 (0.42, 7.65)	**2.64 (1.44, 4.85)**	2.05 (0.90, 4.25)
Diabetes (odds ratio)	**5.88 (2.38, 14.54)**	**3.19 (1.57, 6.49)**	1.24* (0.56, 2.75)	1.03* (0.40, 2.66)	1.66* (0.77, 3.59)	**2.72 (1.22, 6.05)**
Women						
SCORE (%, beta)	**4.49 (2.45, 6.52)**	**3.76 (1.23, 6.29)**	**5.12 (2.97, 7.28)**	−0.29* (−2.26, 1.68)	**3.02 (1.24, 4.80)**	1.45* (−0.47, 3.36)
Cholesterol/HDL ratio (mmol/L, beta)	**0.81 (0.56, 1.05)**	0.21* (−0.08, 0.50)	0.24* (−0.02, 0.50)	0.09* (−0.21, 0.39)	**0.60 (0.29, 0.91)**	0.15* (−0.12, 0.42)
Systolic BP (mmHg, beta)	**9.17 (5.54, 12.79)**	4.38 (−0.65, 9.30)	**3.91* (0.02, 7.80)**	5.28 (−0.81, 11.38)	**11.33 (7.01, 15.65)**	**9.47 (5.36, 13.58)**
Physical activity (odds ratio)	**0.32 (0.19, 0.56)**	1.00* (0.48, 1.74)	0.66* (0.41, 1.05)	**0.40 (0.20, 0.78)**	0.61 (0.34, 1.08)	**0.40 (0.23, 0.68)**
Smoking (odds ratio)	**9.90 (5.69, 17.24)**	2.00* (0.95, 4.23)	**5.37 (3.04, 9.48)**	4.10 (0.50, 33.55)	**0.41* (0.22, 0.76)**	**0.03* (0.01, 0.18)**
Diabetes (odds ratio)	**9.95 (3.10, 32.00)**	**4.09 (2.04, 8.19)**	2.45* (1.27, 4.71)	0.70* (0.27, 1.83)	**11.36 (3.93, 32.84)**	**3.43 (1.54, 7.63)**

Bold indicates statistically significant ($p<0.05$) beta or odds ratio.
*Significantly different from the Dutch.

significant and/or lower than the Dutch. Among Dutch women, the RII was significant and positive for all CVD risk factors except for the RII for achieving the norm of physical activity, which was significant but negative. Among Turkish and Moroccan, the RII for CVD risk factors was often significant and similar to the Dutch. However, the RII for smoking status was significant and <1.0 among Turkish and Moroccan women, whereas it was significant and >1.0 among Dutch women. In contrast, among South-Asian Surinamese, African-Surinamese and Ghanaian women, the RII for individual CVD risk factors was often not significant and was lower than that of the Dutch.

Similar to the distribution of education, the Dutch showed a relatively high prevalence of high occupational level relative to the ethnic minority groups (Table I). In addition, patterns of socio-economic differences in estimated CVD risk were similar based on education and occupation (Figures 1 and 2).

Socio-economic gradients in estimated CVD risk were similar for educational level and occupational level, and ethnic variations in these gradients were about similar too (Tables II and III). However, educational level was related to systolic blood pressure among Ghanaian men (RII 6.04 mmHg, 95% CI −0.36 to 12.43) while occupational level was not (RII −0.57 mmHg, 95% CI −7.60 to 6.46). In addition, occupational level was related to systolic blood pressure among Turkish men (RII 6.16 mmHg, 95% CI 0.85–11.47), whereas educational level was not (RII 1.60 mmHg, 95% CI −2.59 to 5.80). Finally, occupational level was strongly related to diabetes among Ghanaian women (RII 9.51, 95% CI 1.32–68.78) whereas educational level was not (RII 0.70, 95% CI 0.27–1.83).

Ethnic disparities regarding the socio-economic gradient of education and occupation for estimated CVD risk were mostly similar, except among Ghanaian men. For example, the RII of education for systolic blood pressure in Ghanaian men was not significantly different from Dutch men (Table II), while the RII of occupation for systolic blood pressure was significantly lower among Ghanaian men compared to Dutch men (Tables II and III).

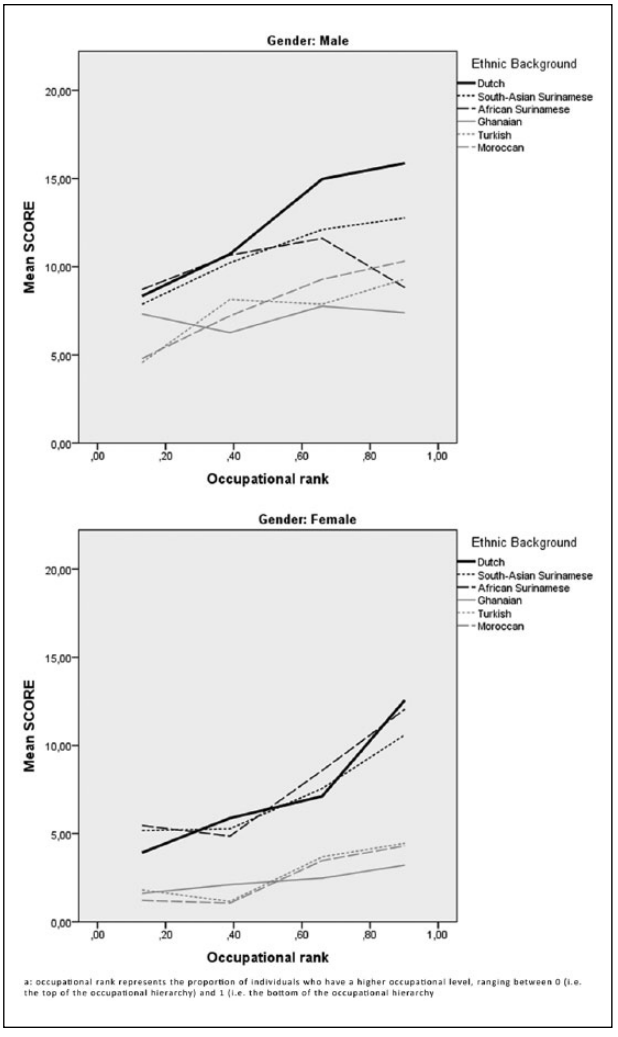

Figure 2. Estimated cardiovascular disease risk (SCORE) by Occupational rank, stratified for ethnic background (men top, women bottom).

Discussion

Key findings

Lower socio-economic status as determined by educational level and occupational level was associated with higher estimated CVD risk in most but not all ethnic groups. This association was stronger among the Dutch compared to ethnic minority groups, especially among men, in great part due to a stronger socio-economic gradient for systolic blood pressure and diabetes among the Dutch relative to the minority groups. South-Asian Surinamese and African Surinamese showed a relatively strong socio-economic gradient in estimated CVD risk compared to the other ethnic minority groups, especially among men, mainly due to a relatively strong socio-economic gradient in smoking.

Evaluation of limitations

A key strength of this study is the large, multi-ethnic database which included all CVD risk factors necessary to estimate CVD risk according to SCORE and sufficiently large sample sizes consisting of several ethnic minority groups which allowed for multi-ethnic comparisons, stratified for sex.

Table III. Association between cumulative occupational rank and estimated CVD risk (SCORE) or individual CVD risk factors based on the relative index of inequality (RII) as determined via least-squares regression (beta) or binary logistic regression (odds ratio) with 95% confidence intervals, adjusted for age.

	Dutch	South-Asian Surinamese	African Surinamese	Ghanaian	Turkish	Moroccan
Men						
SCORE (%, beta)	**6.04 (4.03, 8.05)**	**2.84* (0.30, 5.37)**	1.68* (−0.38, 3.73)	0.74* (−1.45, 2.92)	1.07* (−1.56, 3.69)	0.40* (−2.29, 3.08)
Cholesterol/HDL ratio (mmol/L, beta)	**0.75 (0.39, 1.11)**	0.12* (−0.33, 0.57)	−0.06* (−0.38, 0.26)	−0.25* (−0.68, 1.18)	0.19* (−0.33, 0.72)	0.18* (−0.36, 0.71)
Systolic BP (mmHg, beta)	**12.20 (7.71, 16.69)**	3.34* (−2.00, 8.67)	4.34* (−0.35, 9.04)	−0.57* (−7.60, 6.46)	**6.16 (0.85, 11.47)**	−1.15* (−6.26, 3.97)
Physical activity (odds ratio)	**1.12 (0.57, 2.17)**	1.54 (0.78, 3.04)	1.73 (0.97, 3.11)	1.25 (0.55, 2.82)	0.86 (0.42, 1.78)	0.85 (0.40, 1.80)
Smoking (odds ratio)	**2.00 (1.03, 3.88)**	**6.52* (3.19, 13.34)**	**4.32 (2.46, 7.58)**	1.65 (0.30, 8.92)	1.15 (0.55, 2.41)	2.32 (0.97, 5.52)
Diabetes (odds ratio)	**5.28 (1.95, 14.33)**	**2.82 (1.31, 6.08)**	1.68 (0.77, 3.67)	1.39 (0.47, 4.10)	**3.56 (1.28, 9.94)**	1.63 (0.63, 4.20)
Women						
SCORE (%, beta)	**4.18 (2.10, 6.25)**	1.66 (−0.80, 4.12)	**4.98 (2.76, 7.20)**	2.51 (−0.28, 5.30)	–	–
Cholesterol/HDL ratio (mmol/L, beta)	**0.81 (0.55, 1.08)**	0.27* (−0.23, 0.57)	0.12* (−0.15, 0.38)	0.33 (−0.07, 0.74)	–	–
Systolic BP (mmHg, beta)	**6.69 (2.83, 10.56)**	**6.46 (1.36, 11.56)**	**6.97 (2.97, 10.98)**	**10.12 (1.50, 18.74)**	–	–
Physical activity (odds ratio)	**0.60 (0.33, 1.09)**	1.26 (0.71, 2.22)	0.78 (0.48, 1.27)	0.50 (0.19, 1.28)	–	–
Smoking (odds ratio)	**5.88 (3.31, 10.45)**	1.99* (0.94, 4.19)	3.97 (2.23, 7.09)	0.58 (0.04, 7.67)	–	–
Diabetes (odds ratio)	**7.94 (2.29, 27.61)**	**4.47 (2.14, 9.35)**	**3.71 (1.90, 7.25)**	**9.51 (1.32, 68.78)**	–	–

Bold indicates statistically significant ($p<0.05$) beta or odds ratio.
*Significantly different from the Dutch.

However, there are also limitations to this study. First, due to the cross-sectional design, causal inferences regarding the relationship between SES and CVD cannot be made. However, given the age-related nature of CVD, it is unlikely that the occurrence of CVD risk factors (mostly in adult life) would have influenced educational achievement (mostly until early adulthood). Nonetheless, the occurrence of CVD risk factors might have influenced occupational mobility during adult life.

Second, as in all large epidemiological studies, objective measures of physical activity and smoking behaviour were not available, and therefore we had to rely on self-reported health behaviour. Recent studies reported a discrepancy between true behaviour and self-reported behaviour, the latter being reported in a more socially accepted direction (i.e. higher physical activity, lower smoking rates), with greater discrepancies at lower SES [24,25]. Consequently, the socio-economic gradient of physical activity and smoking status based on the self-reported data presented in this study may underestimate the true socio-economic gradient.

Third, measuring ethnic disparities in the socio-economic gradient of CVD is challenging, in part because different SES indicators may lead to different results [11]. Therefore, we compared the socio-economic gradients as determined by education to the socio-economic gradients as determined by occupation. The findings were mostly consistent regardless of how socio-economic status was defined. It would be of value to determine whether these results differ with other SES markers such as household income to get a more complete view of the association between SES and CVD.

Fourth, it is unknown whether the SCORE algorithm accurately estimates the 10-year CVD risk among all ethnic groups [14]. If this is not the case, ethnic disparities in the socio-economic gradient of estimated CVD risk as presented in this study may not accurately represent ethnic disparities in true CVD risk. However, because prevention is based on estimated CVD risk instead of true CVD risk, the results of this study are still of value for identifying subpopulations who show the highest estimated CVD risk and thus among whom preventive intervention for CVD is most warranted based on ethnic background and SES.

Fifth, this study was conducted among ethnic minority groups residing in The Netherlands, and results may differ for these ethnic minority populations within other countries. Nevertheless, our results might be applied to other countries with due caution, especially in European countries with

similar ethnic minority populations (i.e. Asian, Turkish or Moroccan).

Discussion of key findings

Although socio-economic gradients may vary for individual CVD risk factors, our study found that lower SES was associated with higher estimated CVD risk, especially among the Dutch, South-Asian Surinamese and African Surinamese. Therefore, among these ethnic groups, low SES may warrant lower thresholds for CVD risk estimation. However, among some ethnic minority groups (i.e. Ghanaians and to a lesser extent among Turkish and Moroccans), there was no or only a slight socio-economic gradient in estimated CVD risk. Among these ethnic minority groups, SES may not be as useful as an indicator in deciding when CVD risk estimation is warranted.

The observation that some ethnic minority groups show stronger socio-economic gradients than other ethnic minority groups may indicate that the latter ethnic minority groups are not yet as advanced in term of the social diffusion theory, which states that CVD risk was initially higher among high SES groups because they are the first to be able to afford the unhealthy lifestyle associated with the disease. According to the theory, over time, the disease will spread among low SES groups within high-income nations due to the increase of living standards and among less socio-economically advanced nations as a result from taking over the lifestyle of high-income nations [1]. This theory may apply to ethnic minority populations within high-income nations as they benefit from the increase in living standards, but may take some time to adopt Western lifestyle. If so, this would imply that association between SES and the estimated cardiovascular risk within ethnic minority populations might be strengthened in the future.

There was a relatively strong socio-economic gradient in estimated CVD risk among South-Asian Surinamese and African Surinamese participants compared to the other ethnic minority groups. Among men, this was related to a relatively strong socio-economic gradient for smoking among both Surinamese groups. This might be because Surinamese are in later phases of the tobacco epidemic compared to the other ethnic groups. However, an earlier Dutch study among participants aged 35–60 years reported similar socio-economic gradients for smoking between Surinamese, Turkish and Moroccan men [18].

Interestingly, Turkish and Moroccan women showed a positive socio-economic gradient for smoking status, whereas other women showed a negative gradient. An earlier study conducted in Amsterdam between 2001 and 2003 reported a positive association between education and smoking rates among Moroccan and Turkish women, indicating that the situation may have been stable among these women [18]. Similar patterns have been described in Turkey and Morocco [26,27]. Such stable patterns may be related to a persistent factor such as the perception of smoking as a symbol of modernity, emancipation and independence among Moroccan and Turkish women with high education [26,28].

In the past, CVD risk estimation models have already been developed which incorporate either SES or ethnic background [16,17]. Our results show that the association between SES and estimated CVD risk may differ between ethnic groups, and therefore a new model might be necessary which incorporates both ethnic background and SES in order to identify high CVD risk individuals accurately. However, such a model might perhaps be too complex or time-consuming for adequate use in primary care.

The observation that socio-economic disparities in CVD risk vary by ethnic group implies that ethnic disparities in CVD risk may differ by SES. In our study, ethnic disparities in estimated CVD risk were smaller among high SES group, which suggest that high SES may weaken the impact of ethnic background on CVD risk. This is in accordance with several previous studies regarding ethnic disparities in CVD by socio-economic status [19,29]. For example, a previous study from the Netherlands regarding metabolic syndrome among Dutch, African-Surinamese and South-Asian Surinamese showed larger ethnic disparities at low educational levels [19]. Similarly, a study conducted in the United States reported larger ethnic disparities in CVD at lower educational level [29]. However, another study from the United States did not show a clear difference between educational levels in the extent of ethnic disparities in smoking status, diabetes, hypertension or body mass index [30].

Conclusions

Lower SES as determined by educational level or occupational level was associated with higher estimated CVD risk in most but not all ethnic groups. The strength of the association varied across ethnic groups with generally weaker associations among the ethnic minority groups, particularly among Ghanaian, Turkish and Moroccan groups, compared to the majority population. Thus, the predictive value of SES for estimated CVD risk may differ between ethnic groups and may even be negligible among certain ethnic minority groups.

This study illustrates that the increasing ethnic diversity may have important implications for the study of socio-economic inequalities in disease. As socio-economic gradients for estimated CVD risk differ between ethnic groups, and especially between ethnic majority and minority populations, ethnic background needs to be considered in any association between SES and disease in current multi-ethnic societies.

Acknowledgements

The HELIUS study is conducted by the Academic Medical Center Amsterdam and the Public Health Service of Amsterdam. Both organisations provided core support for HELIUS. The HELIUS study is also funded by the Dutch Heart Foundation, the Netherlands Organization for Health Research and Development (ZonMw) and the European Union (FP-7). We gratefully acknowledge the AMC Biobank for their support in biobank management and high-quality storage of collected samples. We are most grateful to the participants of the HELIUS study and the management team, research nurses, interviewers, research assistants and other staff who have taken part in gathering the data for this study.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

References

[1] Mackenbach JP, Cavelaars AE, Kunst AE, et al. Socioeconomic inequalities in cardiovascular disease mortality; an international study. *Eur Heart J* 2000;21:1141–1151.

[2] Sommer I, Griebler U, Mahlknecht P, et al. Socioeconomic inequalities in non-communicable diseases and their risk factors: an overview of systematic reviews. *BMC Public Health* 2015;15:914.

[3] Lindmark A, Glader EL, Asplund K, et al. Socioeconomic disparities in stroke case fatality – observations from Riks-Stroke, the Swedish stroke register. *Int J Stroke* 2014;9:429–436.

[4] Li C, Hedblad B, Rosvall M, et al. Stroke incidence, recurrence, and case-fatality in relation to socioeconomic position: a population-based study of middle-aged Swedish men and women. *Stroke* 2008;39:2191–2196.

[5] Matthews KA, Schwartz JE and Cohen S. Indices of socioeconomic position across the life course as predictors of coronary calcification in black and white men and women: coronary artery risk development in young adults study. *Soc Sci Med* 2011;73:768–774.

[6] Nam GE, Cho KH, Park YG, et al. Socioeconomic status and dyslipidemia in Korean adults: the 2008–2010 Korea National Health and Nutrition Examination Survey. *Prev Med* 2013;57:304–309.

[7] Hiscock R, Bauld L, Amos A, et al. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci* 2012;1248:107–123.

[8] Stalsberg R and Pedersen AV. Effects of socioeconomic status on the physical activity in adolescents: a systematic review of the evidence. *Scand J Med Sci Sports* 2010;20:368–383.

[9] Allen AJ, McNeely JM, Waldstein SR, et al. Subjective socioeconomic status predicts Framingham cardiovascular disease risk for whites, not blacks. *Ethn Dis* 2014;24:150–154.

[10] Agyemang C, van Oeffelen AA, Bots ML, et al. Socioeconomic inequalities in acute myocardial infarction incidence in migrant groups: has the epidemic arrived? Analysis of nation-wide data. *Heart* 2014;100:239–246.

[11] Fischbacher CM, Cezard G, Bhopal RS, et al. Measures of socioeconomic position are not consistently associated with ethnic differences in cardiovascular disease in Scotland: methods from the Scottish Health and Ethnicity Linkage Study (SHELS). *Int J Epidemiol* 2014;43:129–139.

[12] Marmot MG, Adelstein AM and Bulusu L. Lessons from the study of immigrant mortality. *Lancet* 1984;1:1455–1457.

[13] Dinesen C, Nielsen SS, Mortensen LH, et al. Inequality in self-rated health among immigrants, their descendants and ethnic Danes: examining the role of socioeconomic position. *Int J Public Health* 2011;56:503–514.

[14] Piepoli MF, Hoes AW, Agewall S, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: the Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts): Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). *Eur Heart J* 2016;37:2315–2381.

[15] Cardiovasculair risicomanagement(Tweede herziening), www.nhg.org/standaarden/volledig/cardiovasculair-risicomanagement2012 (accessed 9 November 2015).

[16] Brindle P, May M, Gill P, et al. Primary prevention of cardiovascular disease: a web-based risk score for seven British black and minority ethnic groups. *Heart* 2006;92:1595–1602.

[17] Woodward M, Brindle P and Tunstall-Pedoe H; SIGN group on risk estimation. Adding social deprivation and family history to cardiovascular risk assessment: the ASSIGN score from the Scottish Heart Health Extended Cohort (SHHEC). *Heart* 2007;93:172–176.

[18] Nierkens V, de Vries H and Stronks K. Smoking in immigrants: do socioeconomic gradients follow the pattern expected from the tobacco epidemic? *Tob Control* 2006;15:385–391.

[19] Agyemang C, van Valkengoed I, Hosper K, et al. Educational inequalities in metabolic syndrome vary by ethnic group: evidence from the SUNSET study. *Int J Cardiol* 2010;141:266–274.

[20] Stronks K, Snijder MB, Peters RJ, et al. Unravelling the impact of ethnicity on health in Europe: the HELIUS study. *BMC Public Health* 2013;13:402.

[21] Conroy RM, Pyorala K, Fitzgerald AP, et al. Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. *Eur Heart J* 2003;24:987–1003.

[22] Wendel-Vos GC, Schuit AJ, Saris WH, et al. Reproducibility and relative validity of the short questionnaire to assess health-enhancing physical activity. *J Clin Epidemiol* 2003;56:1163–1169.

[23] Mackenbach JP and Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Soc Sci Med* 1997;44:757–771.

[24] Winckers AN, Mackenbach JD, Compernolle S, et al. Educational differences in the validity of self-reported physical activity. *BMC Public Health* 2015;15:1299.
[25] Nicolaou M, Gademan MG, Snijder MB, et al. Validation of the SQUASH Physical Activity Questionnaire in a multi-ethnic population: the HELIUS study. *PLoS One* 2016;11:e0161066.
[26] Hassoy H, Ergin I and Kunst AE. Socioeconomic inequalities in current daily smoking in five Turkish regions. *Int J Public Health* 2014;59:251–260.
[27] Nejjari C, Benjelloun MC, Berraho M, et al. Prevalence and demographic factors of smoking in Morocco. *Int J Public Health* 2009;54:447–451.
[28] Amos A and Haglund M. From social taboo to 'torch of freedom': the marketing of cigarettes to women. *Tob Control* 2000;9:3–8.
[29] Bostean G, Roberts CK, Crespi CM, et al. Cardiovascular health: associations with race-ethnicity, nativity, and education in a diverse, population-based sample of Californians. *Ann Epidemiol* 2013;23:388–394.
[30] Boykin S, Diez-Roux AV, Carnethon M, et al. Racial/ethnic heterogeneity in the socioeconomic patterning of CVD risk factors in the United States: the multi-ethnic study of atherosclerosis. *J Health Care Poor Underserved* 2011;22:111–127.