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Occupational characteristics and the progression of carotid artery intima-media thickness and plaque over 9 years: the Multi-Ethnic Study of Atherosclerosis (MESA)

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Abstract

Objectives—The role of occupation in the development of cardiovascular disease (CVD) remains a topic of research because few studies have examined longitudinal associations, and because occupation can be an indicator of socioeconomic position (SEP) and a proxy for hazard exposure. This study examines associations of occupational category as an SEP marker and selected occupational exposures with progression of the subclinical carotid artery disease.

Methods—A community-based, multiethnic sample (n=3109, mean age=60.2) provided subclinical CVD measures at least twice at three data collection points (mean follow-up=9.4 years). After accounting for demographic characteristics, SEP, and traditional CVD risk factors, we modelled common carotid intima-media thickness, carotid plaque scores, and carotid plaque shadowing as a function of occupational category, physical hazard exposure, physical activity on the job, interpersonal stress, job control and job demands. These job characteristics were derived from the Occupational Resource Network (O*NET). Random coefficient models were used to account for repeated measures and time-varying covariates.

Results—There were a few statistically significant associations at baseline. After all covariates were included in the model, men in management, office/sales, service and blue-collar jobs had 28–

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44% higher plaque scores than professionals at baseline (p=0.001). Physically hazardous jobs were positively associated with plaque scores among women (p=0.014). However, there were no significant longitudinal associations between any of the occupational characteristics and any of the subclinical CVD measures.

Conclusions—There was little evidence that the occupational characteristics examined in this study accelerated the progression of subclinical CVD.

INTRODUCTION

While the link between occupation and cardiovascular disease (CVD) has been long recognised,[1] it is still unresolved what role occupation plays in the progression of subclinical CVD. Subclinical CVD, measured as the intima-media thickness (IMT) and carotid plaques, has a strong association with incident CVD events.[2] Thus a better understanding of factors that accelerate the progression of subclinical CVD will help identify intervention targets. The relationship between occupation and subclinical CVD is still unclear partly because few studies have examined occupation and subclinical CVD longitudinally. Another reason is that in these studies it is often unclear if occupation is considered solely as an indicator of the person's socioeconomic position (SEP) or as a source of potentially health-compromising exposures. In the former approach, occupational differences provide evidence of a socioeconomic gradient in CVD risk. In the latter approach, occupation is used as a proxy for exposure to hazards that may lead to CVD.

The socioeconomic gradient in CVD risk has been documented in several large-scale, longitudinal epidemiological studies.[3–6] However, only two examined occupation (rather than income or education) and subclinical CVD progression, and their findings are not consistent. In the Malmö Diet and Cancer Study, Rosvall *et al*[6] reported that with a median follow-up of 2 years, unskilled manual workers had a greater yearly progression of carotid IMT (a marker of subclinical arterial injury and CVD risk) compared with high-level/medium-level non-manual workers. In contrast, in the Young Finns Study, Kestilä *et al*[3] found no association between occupation and IMT progression over 6 years. These two studies considered occupation as an SEP indicator and did not control for income or education. Therefore, it is not clear if occupation has a unique contribution to the progression of subclinical CVD net of income and education.

Occupation can be a source of hazardous physical, chemical, biological and psychosocial exposures; however, very few studies have examined these occupational characteristics as potential predictors for subclinical CVD progression.[47] Results from these few studies suggest that occupational characteristics may impact subclinical CVD progression, at least for men, independent from income levels. Lynch *et al*[4] demonstrated that the accumulation of undesirable working conditions (eg, troubles with the supervisor and coworkers, risk of accidents, risk of unemployment, irregular work schedules) was significantly associated with accelerated progression of subclinical CVD over 4 years among low-income male workers. Physically strenuous jobs were associated with a greater progression of IMT over 11 years among middle-aged men after controlling for their income.[7]

In the current study, we distinguish the role of occupation as an SEP indicator and as a source of hazard exposure. Using longitudinal data from a large, multiethnic, community sample of men and women, the current study contributes to this small literature in several ways. First, we examine occupational category as a predictor of subclinical CVD progression after income, education and traditional CVD risk factors are taken into account. This clarifies whether occupation has a unique role in the progression of subclinical CVD above and beyond other SEP indicators. Second, we examine several job characteristics as predictors of subclinical CVD progression while accounting for occupational category and other SEP indicators as well as traditional CVD risk factors. This provides evidence as to whether specific working conditions or exposures at work are related to the progression of subclinical CVD.

METHODS

Participants and data collection

The data come from the Multi-Ethnic Study of Atherosclerosis (MESA), a prospective cohort study designed to investigate the prevalence and progression of subclinical CVDs.[8] Between 2000 and 2002, participants were recruited from six US communities in six US states (North Carolina, New York, Maryland, Minnesota, Illinois and California). At the time of enrolment, they were 45–84 years of age and free of clinical CVD. The participation rate was 60% among those eligible, and women accounted for 51% of the cohort. The original cohort included a wide range of occupations and four racial/ethnic groups, with minorities oversampled: Caucasians (38%), Chinese American (11%), African-Americans (28%) and Hispanics (23%).

The participants were asked to come to one of the six field centres in their community for a study examination. Since the baseline examination (Exam 1), four follow-up examinations were conducted (Exams 2–5) approximately every 2 years. Subclinical CVD measures were taken at Exams 1, 4 and 5. Only those who provided the data at least at two time points were included in this study (n=3441). Of those, 147 were excluded because they did not provide any occupational information, and an additional 185 were excluded because the information on the measuring location for IMT across different time points was missing. Thus this analysis used a sample of 3109 participants, which represents 66% of Exam 5 participants (mean follow-up=9.4 years, SD=0.48). Compared with those who were excluded in this analysis, included participants were on average 3.8 years younger, more likely to be Caucasian (40% vs 37%) and belong to a professional job category (29% vs 23%).

All study participants provided informed consent. The MESA study protocol was approved by the Institutional Review Board (IRB) in each of the six field centres and the National Heart, Lung and Blood Institute (NHLBI). The protocol for this analysis was approved by the IRB of the National Institute for Occupational Safety and Health (NIOSH).

Subclinical CVD measures

We used the common carotid artery (CCA) IMT, carotid plaque score and carotid plaque shadowing as our outcome measures.[9] B-mode ultrasound longitudinal images of the right and left CCA, bifurcation and internal carotid artery segments were recorded on a Super-VHS videotape with a Logiq 700 ultrasound system using the M12L transducer (General Electric Medical Systems, CCA frequency 13 MHz). Video images were digitised using a Medical Digital Recording device (PACSGEAR, Pleasanton, California, USA) and converted into DICOM digital records. The same ultrasound system and digitising equipment were used at each examination, but at Exam 5 the video output was directly digitised using the same recorder settings without a videotape. Trained and certified sonographers from all 6 MESA sites used preselected reference images from Exam 1 to match the scanning conditions of the initial study, including display depth, angle of approach, internal landmarks, degree of jugular venous distension and ultrasound system settings. Ultrasound images were reviewed and interpreted by the MESA Air Carotid Ultrasound Reading Center (UW AIRP, Madison, Wisconsin, USA). Digitised images were imported into *syngo* Ultrasound Workplace 3.5B reading stations loaded with Arterial Health Package software (Siemens Medical, Malvern, Pennsylvania, USA) for carotid IMT measurement, plaque scoring and assessment of plaque shadowing.

The distal CCA was defined as the distal 10 mm of the vessel. IMT was defined as the IMT measured as the mean of the left and right mean far wall distal CCA wall thicknesses. Carotid plaque burden was defined by the carotid plaque scored as the number of plaques (0–12) in the internal, bifurcation and common segments of both carotid arteries. Carotid plaque was defined as a discrete, focal wall thickening ≥1.5 cm or focal thickening at least 50% greater than the surrounding IMT.[10] Acoustic shadowing was defined as an absence or reduction in the amplitude of ultrasound echoes caused by plaques with high beam, high attenuation.[11] The presence or absence of plaque acoustic shadowing was evaluated visually and recorded as a binary variable.

The intraclass correlation coefficient (ICC) for *intra*-reader reproducibility for mean CCA IMT was 0.99 (ie, only 1% of the variability is due to measurement error). The ICC for *inter*-reader CCA IMT reproducibility was 0.95. Scan–rescan reproducibility was 0.94. For carotid plaque presence and score, the *intra*-reader reproducibility was κ=0.83 (95% CI 0.70 to 0.96) and *inter*-reader reproducibility was κ=0.89 (95% CI 0.72 to 1), both values representing ‘almost perfect’ agreement.[12]

Occupational category

Occupational information was collected in a self-administered questionnaire at Exam 1. Four questions modelled on the US Census occupation questions were asked to determine the participant’s current occupation. In this cohort of older adults, 37% were no longer working. They reported the main job before they stopped working. Responses to open-ended questions were coded by trained personnel at NIOSH using the Census 2000 Occupation Codes. Our sample represented 354 jobs, which were then categorised into seven Census occupational categories: (1) management (48 jobs, n=561), (2) professional (96 jobs, n=900), (3) service (46 jobs, n=446), (4) sales/office and administrative support (58 jobs, n=655), (5) farming, fishing and forestry (1 job, n=1), (6) construction, extraction and maintenance (40 jobs, n=153) and (7) production, transportation and material moving (65 jobs, n=393). Since the latter three categories included a rather small number of participants in this sample, they were combined into one category of 'blue-collar jobs.' Occupational information was updated at each subsequent examination if the participant reported a change in the employment situation. During the study period, 8.8% of the participants reported at least one current job that was different from the one reported at baseline, but only a small fraction (3.5%) changed jobs across categories (eg, from service to management) during the study period. Therefore, we used the occupation reported at Exam 1 as a time-invariant variable in this analysis. As a sensitivity analysis, we ran the same models with only those who reported a single occupation throughout the study period.

Job characteristics

The 354 Census 2000 Occupation Codes were also used to derive occupational exposures from the Occupational Resources Network (O*NET) V.17, a database developed by the US Department of Labor. It provides detailed descriptive information about over 900 unique jobs. The descriptions were obtained from current job holders and occupational analysts, who provided their ratings of the job on 277 questions (eg, "How often does your current job require you to work outdoors, exposed to all weather conditions?" "To what extent does this occupation allow workers to make decisions on their own?").[13] Owing to its comprehensive coverage of jobs and wide range of characteristics measured, O*NET has been used as a job exposure matrix.[14,15] We used the Census 2000 Occupation Codes to connect O*NET data to our sample. For this analysis, we focused on the following O*NET derived characteristics: physical hazard exposure, occupational physical activity, interpersonal stress, job control and job demands.

Physical hazard exposure was the mean score of 7 O*NET items addressing physical hazards traditionally studied as occupational hazards: sounds and noise levels that are distracting and uncomfortable; pollutants, gases, dusts or odors; very hot (above 90°F) or very cold (under 32°F) temperatures; extremely bright or inadequate lighting conditions; high places (eg, working on poles, scaffolding, catwalks or ladders); an environment that is not controlled (ie, without air conditioning); outdoors under cover; and outdoors exposed to all weather conditions. Cronbach's α for the 7 items was 0.96. A Cronbach's α >0.70 is considered as an indication of high internal consistency of the items (ie, the items together describe the characteristic, in this case the likelihood of physical hazard exposure, in a reliable manner).[16]

For *physical activity on the job*, we used 3 items: time spent sitting (reverse item), the importance of using arms and legs and moving the whole body in performing the job, and the level of general physical activities needed to perform the job. We calculated the mean of O*NET scaled means for the three variables. Cronbach's α was 0.86.

For *interpersonal stressors*, we calculated the mean of 6 items: the importance of resolving conflicts and negotiating with others, frequency of conflict situations as part of the job, dealing with unpleasant, angry or discourteous people, dealing with physically aggressive people, the importance of maintaining composure and keeping emotions in check, and the importance of accepting criticisms and dealing calmly with high-stress situations. Cronbach's α was 0.88.

For *psychological job demands* and *job control*, we used the same items used by Cifuentes *et al*.[14a] Specifically, psychological job demands included four items addressing the ability to shift back and forth between tasks, the ability to concentrate on a task, the seriousness of the error and the importance of being accurate. We calculated the mean of the four items. Cronbach's α was 1.68. As for *job control*, we used four O*NET items asking the extent to which the job makes use of workers' abilities and allows workers to try out their own ideas, to make decisions on their own and to plan their work. Cronbach's α was 0.97.

Employment status

Employment status (ie, employed full-time, employed part-time, retired, unable to work/out of work) was also asked at each examination. While 75% of the participants reported no change in employment status over the study period, 11% retired, 4% re-entered the workforce, 4% experienced unemployment and 3% reduced their work from full-time to part-time. Thus, employment status was included in the analysis as a time-varying covariate.

Covariates

Additional covariates included age at Exam 1, sex, race/ethnicity (Caucasian, African-American, Hispanic, Chinese American), nativity (born in one of the 50 states, outside of the 50 states), family history of heart attack (yes, no, do not know), socioeconomic indicators (ie, education, household income), smoking status (current, former, never), and pack-years for current and former smokers. The information was collected in the self-administered questionnaire at each examination. In addition, during the clinical examination, information was obtained on body mass index (BMI, weight (kg)/height (m^2)), systolic and diastolic blood pressure, and total/high-density lipoprotein (HDL) cholesterol ratio. Regular medication was reviewed at each examination, and medication use (yes=1, no=0) for dyslipidemia and hypertension was included in the analysis. Diabetes was assessed by the fasting plasma glucose level: normal (<110 mg/dL), impaired fasting glucose (from 110 to 125 mg/dL) and untreated diabetes (>125 mg/dL).[17] If participants were taking insulin or oral hypoglycaemic medication, we categorised them as 'treated diabetes.' All of these traditional CVD risk factors as well as the household income data were updated at each examination; thus, these variables were treated as time-varying covariates.

Statistical analysis

Because a large body of the literature on occupation and CVD has documented that men and women tend to show different associations between occupational characteristics and CVD,[18] all analyses were conducted separately for men and women. Descriptive statistics by sex and occupational group were calculated for the 3109 participants included in this analysis. In order to examine the association of occupational characteristics with subclinical CVD over time, we modelled repeat measures of subclinical CVD measures as a function of time since baseline in years, occupational characteristics at baseline, and an interaction term between occupational characteristics and time. Models also included a random intercept for each person and an interaction term between baseline age (mean-centred) and time. The following covariates were treated as time-invariant: baseline age, race/ethnicity, nativity, family history, education, field centre. Time-varying covariates included current employment status, income, smoking status, pack-years, BMI, systolic and diastolic blood pressure, diabetes, total/HDL cholesterol ratio, and medication use for hypertension and dyslipidemia. For the IMT models, we also included a covariate for right versus left carotid artery. PROC MIXED was used for common carotid IMT and GLIMIXX was used for carotid plaque score (count variable, Poisson model) and plaque shadowing (binary variable with a high proportion of 'cases', Poisson model). Occupation was included as dummy variables (for occupational categories) or in SD units (for the O*NET job characteristic variables). Each of the occupational variables was studied separately.

For all outcome variables, we first estimated the effect of the occupational variable and its interaction with time while only age, sex, race/ethnicity, nativity and family history were included as covariates (Model 1). Then we added other SEP indicators and traditional CVD risk factors (Model 2).

RESULTS

The characteristics of the sample are presented in table 1. The average age was 60.3 (SD=9.3) for men and 59.8 (SD=9.4) for women. For both sexes, blue-collar workers had a slightly higher average age than managers and service workers. Income and education levels differ by occupation, which confirms that occupational category does overlap with these other SEP indicators. In addition, blue-collar workers were less likely to be working full time at the time of baseline data collection. For women, the carotid artery measures did not have a statistically significant bivariate association with occupation. For men, the mean carotid IMT and plaque shadowing did not differ by occupation, but plaque scores were lower for professional and sales/ office workers than other occupations. On average IMT increased by 0.012 mm for men and 0.011 mm for women per year, the plaque scores increased by 7.6% for men and 8% for women per year, and the prevalence of plaque shadowing increased by 8.1% for men and 9.9% for women per year.

Adjusted associations of the occupational category with the three subclinical CVD measures are shown in table 2. At baseline, occupational category was not significantly associated with IMT or plaque shadowing. However, there was evidence of differences in the plaque score associated with occupation in men: Compared with professional jobs, all other jobs were associated with a higher number of sites with a plaque by 28% to 44%, even after all covariates were included in the model. Occupation was not associated with yearly progression in any of the subclinical CVD measures for either men or women.

Table 3 presents the association between each of the O*NET-derived job characteristics and subclinical CVD measures after accounting for occupational category. Job characteristics were largely not associated with subclinical CVD measures either cross-sectionally at baseline or longitudinally. After traditional CVD risks and SEP indicators were included in the model, only one association was statistically significant: a 1-SD increase in physical hazards on the job was associated with a 15% increase in plaque score in women ($p=0.014$). As sensitivity analyses, we ran the same models with only those who had a high matching score for the location of ultrasound measures across three time points, and also with only those who reported only one occupation during the study period. In either case, the findings did not differ substantively.

DISCUSSION

This study examined longitudinal associations of CCA IMT and carotid plaque measures with occupational category and job characteristics. We found no evidence that occupational category or job characteristics play a role in the progression of subclinical CVD, independently of other SEP indicators in the model. We also found little evidence of cross-sectional associations of occupation with baseline measures: the only exceptions were plaque scores and occupational category in men, and plaque scores and physically hazardous jobs for women. These findings are in line with our previous cross-sectional analysis, which found that after traditional CVD risk factors and SEP were accounted for, blue-collar jobs were associated with a greater IMT only in the internal carotid arteries, where plaques are more common, and not in the common carotid arteries where plaques are less commonly found.[19]

Our non-significant findings for longitudinal associations of occupational category and subclinical CVD are not consistent with the Malmö study, which investigated occupation as an SEP marker and reported a greater yearly progression of IMT for unskilled manual workers compared with high-level/mid-level non-manual workers.[6] One reason may be that the way we categorised occupations does not capture aspects of SEP that are important to health. In fact, Braveman *et al*[20] point out that the US Census occupation categories are “not intended to—and do not appear to be meaningful—as SES measures” (p.2883). The Malmö study categorised occupations based on educational prerequisites, the level of responsibility and the nature of tasks. This categorisation differentiated, for example, construction workers (skilled manual) from building custodians (unskilled manual) and found statistically significant differences between them. These occupations were grouped together in our analysis. The Young Finns Study[3] found no association between occupation and IMT progression, similar to our study. They categorised occupation as manual, lower non-manual and higher non-manual. These two studies, together with our findings, suggest that the aspect of SEP that matters to subclinical CVD progression is the difference between skilled and unskilled manual work. In the USA, no classification system is readily available that captures the difference; thus, it is a challenge to investigate occupation as an SEP indicator in the US population. Contrary to previous studies,[47] our analysis found no associations between job characteristics and progression of subclinical CVD. While the two previous studies analysed self-report data of occupational physical activity[7] and undesirable working conditions,[4] we used the O*NET to impute job characteristics. Even though the utility of O*NET as a job exposure matrix has been proposed,[14] only few studies have examined O*NET-derived job characteristics with objective measures of health,[1521] and none with subclinical CVD measures longitudinally. Because O*NET captures the characteristics of the job for a typical worker (eg, female nurse, Caucasian male architect),[13] if a study sample consists of not-so-typical workers, the measurement error becomes greater. In this study, nearly a third of the participants were immigrants to the USA. Their experience at work may not be captured by O*NET variables as accurately as their native-born American colleagues’ experience in the same job. This may have made it difficult to detect an association between O*NET job characteristics and subclinical CVD.

There are some other possible reasons for our largely null findings. Job characteristics change over time[2223] thus use of baseline only job characteristics was an additional source of bias towards the null. In our sample, 8.8% had a different job at some point during the study period. However, the sensitivity analysis without them produced the same results. In addition, 32.5% of the sample did not work during the study period (many had most likely retired). After retirement, the effects of job characteristics on CVD risk are diminished.[24] Another source of bias towards the null in this sample is the exclusion of participants (due to missing data) who were older (and thus at higher risk of subclinical CVD) and more likely to be blue-collar. Finally, Model 2 was a conservative test of the study hypotheses because a number of potential mediators of the association of occupational characteristics and CVD were controlled for (eg, smoking, BMI, diabetes, blood pressure and hypertension medication). Also, certain demographic characteristics (eg, race/ethnicity, nativity) can be factors that lead individuals into certain types of jobs; however, in our sample, removing race/ ethnicity and nativity from Model 1 did not change the results for occupational categories. Nevertheless, analyses involving pre-employment factors, occupational factors as well as behavioural and physiological mediators may be necessary to fully understand the role of occupation in the development of CVD.

This study had a large sample size and included a wide range of occupations, large proportions of racial/ethnic minority groups, and current and former workers. Because all MESA participants were free of clinical CVD at the time of enrolment, those who were affected by work-related CVD were not included in the analysis, which would lead us to underestimate the association between occupation and CVD. At the same time, information on job tenure was not available for those who were no longer working at Exam 1; and for those who were working at Exam 1, it was not known if the job was the main job in life or a postretirement job. A more precise work history for each individual would have helped clarify the association between occupational characteristics and subclinical CVD progression.

In conclusion, this analysis provided little evidence that occupational category or job characteristics are associated with carotid IMT or plaque at baseline and no evidence that they play a role in progression of subclinical CVD. Given the limitations in the data, the finding should be examined in other studies.

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What this paper adds

- ▶ The role of occupation in the progression of subclinical cardiovascular disease (CVD) remains a topic of research because few studies have examined longitudinal associations.
- ▶ Using longitudinal data from a community-based, multiethnic sample, we examined occupational categories and job characteristics as a predictor of subclinical CVD progression.
- ▶ Male professionals had lower plaque scores than all other occupational groups at baseline, and physically hazardous jobs were positively associated with plaque scores among women.
- ▶ However, there were no significant longitudinal associations between any of the occupational characteristics and subclinical CVD measures.

Table 1

Baseline characteristics of study participants by sex and occupational category

	Men (n=1499)						Women (n=1610)					
Characteristic	**Management**	**Professional**	**Service**	**Sales/office**	**Blue-collar**	**p Value§**	**Management**	**Professional**	**Service**	**Sales/office**	**Blue-collar**	**p Value§**
N	343	403	165	207	381		218	497	281	448	166	
Age, mean (SD)	59.4 (9.2)	61.0 (9.2)	58.9 (8.8)	60.5 (9.2)	61.1 (9.5)	0.015	58.2 (9.5)	59.6 (9.2)	59.6 (9.1)	60.3 (9.7)	61.8 (9.2)	0.004
Age category, years, %						0.223						0.058
45–54	36.7	29.3	34.5	30.4	31.2		42.7	36.2	35.2	35.3	26.5	
55–64	31.8	30.8	34.5	33.8	27.6		31.7	30.6	33.8	27.7	32.5	
65–74	23.9	32.5	25.5	27.5	32.3		19.3	27.6	24.2	29.0	31.9	
75–84	7.6	7.4	5.5	8.2	8.9		6.4	5.6	6.8	8.0	9.0	
Race/ethnicity, %						<0.0001						<0.0001
Caucasian	56.0	54.3	12.1	43.0	27.0		49.5	48.7	16.4	44.4	16.9	
Chinese American	13.7	17.4	15.8	11.1	10.5		9.2	8.1	12.5	11.2	19.9	
African-American	20.1	19.1	28.5	25.1	26.8		33.9	33.2	34.2	25.9	18.1	
Hispanic	10.2	9.2	43.6	20.8	35.7		7.3	10.1	37.0	18.5	45.2	
Foreign-born, %	23.6	26.3	53.3	26.6	36.0	<0.0001	15.1	19.3	59.8	25.2	55.4	<0.0001
Education, %						<0.0001						<0.0001
Less than high school	2.3	1.5	30.9	5.3	25.7		2.8	2.4	36.3	6.5	45.8	
High school diploma	5.5	2.0	28.5	15.9	27.3		10.1	4.6	26.3	31.0	30.1	
Some college	22.5	15.9	27.3	43.5	37.0		29.4	22.1	30.3	45.8	17.5	
Bachelors degree	32.1	24.3	10.3	26.6	7.6		24.8	27.4	5.3	14.3	6.0	
Graduate/professional degree	37.6	56.3	3.0	8.7	2.4		33.0	43.5	1.8	2.5	0.6	
Household income, %						<0.0001						<0.0001
<$12 000	2.9	3.5	16.6	5.8	9.3		3.7	3.6	23.3	7.8	20.3	
$12 000–$24 999	4.1	7.5	24.5	10.7	23.7		7.8	11.9	24.0	20.5	36.8	
$25 000–$49 999	15.0	22.7	30.1	33.0	34.8		25.4	32.4	37.3	39.1	31.3	
$50 000–$74 999	22.9	20.5	17.2	20.4	20.7		24.0	21.1	10.8	17.2	9.2	
$75 000–$99 999	15.8	13.7	6.1	13.1	8.8		14.3	11.3	3.2	7.8	1.2	
≥$100 000	39.3	32.2	5.5	17.0	2.7		24.9	19.6	1.4	7.6	1.2	
Employment status, %						0.018						<0.0001

Characteristic	Men (n=1499) Management	Professional	Service	Sales/office	Blue-collar	p Value§	Women (n=1610) Management	Professional	Service	Sales/office	Blue-collar	p Value§
Working full-time	58.0	52.9	57.0	52.2	45.4		50.5	42.7	43.1	42.6	28.9	
Working part-time	8.8	7.7	9.7	7.7	5.8		9.2	14.7	19.6	10.7	4.8	
On-leave or unemployed	2.0	3.5	3.6	3.9	4.7		1.8	1.8	2.1	2.9	7.2	
Retired, but still working	5.8	9.7	5.5	7.7	7.1		4.6	5.2	3.9	5.6	1.8	
Retired, no longer working	25.4	26.3	24.2	28.5	37.0		33.9	35.6	31.3	38.2	57.2	
Smoking status, %						<0.0001						<0.0001
Never smoker	47.8	52.4	46.1	37.7	33.1		50.0	56.9	68.7	56.9	72.3	
Former smoker	42.6	39.2	38.8	50.7	49.9		37.2	35.6	19.9	29.2	19.9	
Current smoker	9.6	8.4	15.2	11.6	17.1		12.8	7.4	11.4	13.8	7.8	
Pack-years, median¶	12.0	14.4	18.0	18.6	17.8	0.027	14.4	12.4	7.9	15.0	12.4	0.086
Diabetes, %						0.058						0.0001
Normal*	75.8	77.1	72.1	75.7	68.2		84.3	86.5	74.6	79.6	76.5	
Impaired fasting glucose*	15.5	15.5	18.8	13.6	16.6		11.5	7.7	13.9	12.1	9.0	
Untreated diabetes*	2.6	0.8	1.8	1.9	2.9		0.5	0.8	0.4	1.8	2.4	
Treated diabetes†	6.1	6.7	7.3	8.7	12.4		3.7	5.1	11.1	6.5	12.1	
BMI (kg/m^2), mean (SD)	27.7 (4.2)	27.2 (4.1)	27.7 (4.5)	28.0 (4.3)	28.3 (4.2)	0.009	28.4 (5.9)	28.0 (6.2)	29.4 (5.8)	28.6 (5.9)	28.6 (5.6)	0.026
BMI category, %						0.082						0.007
<25	26.8	33.5	29.7	24.2	21.8		29.4	37.4	23.8	30.4	26.5	
25–29.9	47.8	41.2	40.6	48.8	47.8		39.9	31.6	33.5	35.0	41.0	
30–39.9	24.5	24.6	29.1	25.6	29.1		25.2	26.0	37.4	29.7	28.3	
≥40	0.9	0.7	0.6	1.5	1.3		5.5	5.0	5.3	4.9	4.2	
Systolic blood pressure (mm Hg), mean (SD)	123.5 (17.6)	122.0 (18.6)	124.1 (16.3)	125.6 (17.9)	125.7 (19.4)	0.046	120.1 (19.8)	121.6 (21.8)	124.6 (21.3)	125.7 (20.6)	129.3 (24.9)	<0.0001
Diastolic blood pressure (mm Hg), mean (SD)	75.7 (9.4)	74.0 (9.4)	75.6 (8.5)	75.7 (9.1)	75.5 (8.8)	0.050	67.8 (9.9)	68.3 (10.2)	69.3 (9.6)	69.3 (10.2)	70.0 (9.6)	0.112
Hypertension, %	39.4	36.5	38.2	44.0	39.6	0.502	33.9	38.0	46.6	43.5	44.6	0.017
Hypertension medication use‡, %	32.7	33.3	27.3	40.6	34.4	0.102	33.0	31.4	41.6	35.4	36.1	0.067
Total cholesterol (mg/dL), mean (SD)	186.8 (33.3)	185.6 (34.1)	190.0 (32.9)	187.4 (31.7)	187.5 (35.5)	0.713	197.8 (33.5)	198.8 (33.4)	200.2 (39.4)	201.0 (35.6)	202.5 (36.0)	0.631
HDL cholesterol (mg/dL),	44.6 (11.6)	45.5 (11.8)	44.3 (11.4)	43.9 (11.0)	44.4 (10.6)	0.461	56.9 (15.1)	59.7 (15.7)	56.3 (15.3)	57.2 (15.5)	53.2 (14.4)	<0.0001

	Men (n=1499)						Women (n=1610)					
Characteristic	**Management**	**Professional**	**Service**	**Sales/office**	**Blue-collar**	**p Value§**	**Management**	**Professional**	**Service**	**Sales/office**	**Blue-collar**	**p Value§**
mean (SD)												
Lipid-lowering medication use‡, %	16.3	20.1	11.5	19.3	17.1	0.140	13.8	13.9	12.5	15.9	23.5	0.020
Family history of heart attack, %	37.5	40.6	37.7	45.9	37.7	0.308	42.0	49.9	41.6	51.5	40.4	0.011
Mean IMT at Exam 1 (mm), mean (SD)	0.758 (0.176)	0.777 (0.216)	0.771 (0.215)	0.788 (0.174)	0.792 (0.186)	0.178	0.715 (0.153)	0.723 (0.163)	0.726 (0.145)	0.736 (0.162)	0.750 (0.177)	0.202
Plaque present at Exam 1, %	52.8	43.7	46.7	49.8	54.3	0.024	40.4	41.7	43.1	47.8	45.8	0.271
Plaque score at Exam 1 (range 0–12), mean	1.41	1.02	1.38	0.99	1.41	0.005	0.78	0.88	1.14	0.89	1.02	0.112
Plaque shadowing present at Exam 1, %	25.1	19.4	18.8	24.6	23.9	0.207	16.1	17.1	15.0	21.7	20.5	0.124

BMI, body mass index; HDL, high-density lipoprotein; IFG, impaired fasting glucose IMT, intima-media thickness.

*Assessed by the fasting plasma glucose level: normal (<110 mg/dL), IFG (110–125 mg/dL) and untreated diabetes (>125 mg/dL).

†Insulin or oral hypoglycaemic medication identified in the medication review.

‡Identified in the medication review.

§Indicates for differences across occupational categories.

¶Indicates for current and former smokers only.

Table 2

Mean differences in subclinical CVD measures at baseline and mean differences in annual change associated with occupational category at baseline by sex

	Common carotid IMT				Carotid plaque score				Prevalence of carotid plaque shadowing			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Mean difference, mm	(95% CI)	Mean difference, mm	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)
Men												
Difference at baseline												
Management	−0.005	(−0.031 to 0.022)	−0.005	(−0.032 to 0.021)	48.6	(22.6 to 80.2)	43.7	(18.9 to 73.8)	35.2	(1.4 to 80.2)	34.1	(0.1 to 79.6)
Professional (ref.)	0.000		0.000		0.0		0.0		0.0		0.0	
Sales/office	0.012	(−0.019 to 0.043)	0.007	(−0.025 to 0.040)	46.6	(17.3 to 83.1)	36.1	(9.3 to 69.5)	34.0	(−3.4 to 85.8)	26.0	(−10.3 to 77.0)
Service	0.005	(−0.029 to 0.040)	0.002	(−0.036 to 0.040)	35.7	(4.8 to 75.8)	28.3	(−1.0 to 66.3)	34.4	(−8.3 to 97.0)	29.8	(−13.9 to 95.7)
Blue-collar	0.000	(−0.027 to 0.027)	−0.006	(−0.037 to 0.025)	50.1	(23.5 to 82.4)	40.6	(15.5 to 71.1)	26.1	(−5.3 to 67.9)	23.7	(−9.2 to 68.5)
	p=0.891		p=0.919		p=0.001		p=0.001		p=0.242		p=0.361	
Difference in annual change												
Management	0.001	(−0.001 to 0.003)	0.001	(−0.001 to 0.003)	−1.7	(−3.4 to -0.1)	−1.6	(−3.3 to 0.1)	−1.9	(−5.6 to 1.9)	−1.9	(−5.6 to 2.0)
Professional (ref.)	0.000		0.000		0.0		0.0		0.0		0.0	
Sales/office	0.002	(−0.001 to 0.004)	0.001	(−0.002 to 0.004)	−0.4	(−2.3 to 1.5)	−0.3	(−2.3 to 1.6)	−1.9	(−6.1 to 2.5)	−1.8	(−6.0 to 2.7)
Service	0.002	(−0.001 to 0.005)	0.002	(−0.001 to 0.004)	0.2	(−2.2 to 2.5)	0.2	(−2.1 to 2.6)	−1.8	(−6.7 to 3.3)	−1.3	(−6.3 to 4.1)
Blue-collar	0.001	(−0.001 to 0.003)	0.000	(−0.002 to 0.003)	−1.0	(−2.7 to 0.6)	−1.1	(−2.8 to 0.5)	−0.4	(−4.1 to 3.4)	−0.5	(−4.2 to 3.4)
	p=0.589		p=0.784		p=0.242		p=0.238		p=0.820		p=0.857	
Women												
Difference at baseline												
Management	0.006	(−0.019 to 0.030)	0.005	(−0.020 to 0.029)	1.5	(−19.8 to 28.6)	−7.1	(−26.3 to 17.1)	13.0	(−20.7 to 61.1)	5.2	(−26.8 to 51.0)
Professional (ref.)	0.000		0.000		0.0		0.0		0.0		0.0	
Sales/office	0.008	(−0.012 to 0.028)	0.001	(−0.021 to 0.023)	21.2	(0.9 to 45.5)	7.2	(−10.6 to 28.5)	14.8	(−12.9 to 51.2)	2.0	(−24.0 to 36.8)
Service	0.006	(−0.019 to 0.030)	−0.008	(−0.034 to 0.019)	16.7	(−6.6 to 46.0)	1.4	(−18.7 to 26.6)	4.3	(−25.8 to 46.6)	−9.7	(−37.4 to 30.3)
Blue-collar	0.017	(−0.012 to 0.046)	0.005	(−0.026 to 0.035)	13.3	(−12.6 to 46.9)	−0.4	(−22.7 to 28.3)	2.6	(−29.8 to 49.8)	−12.6	(−41.7 to 31.2)
	p=0.825		p=0.911		p=0.267		p=0.806		p=0.878		p=0.896	
Difference in annual change												
Management	0.001	(−0.001 to 0.003)	0.001	(−0.001 to 0.003)	0.5	(−1.7 to 2.8)	0.8	(−1.5 to 3.2)	−1.9	(−6.4 to 2.8)	−1.8	(−6.4 to 3.0)

	Common carotid IMT				Carotid plaque score				Prevalence of carotid plaque shadowing			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Mean difference, mm	(95% CI)	Mean difference, mm	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)
Professional (ref.)	0.000		0.000		0.0		0.0		0.0		0.0	
Sales/office	0.000	(−0.002 to 0.002)	0.000	(−0.002 to 0.002)	−0.3	(−1.9 to 1.4)	−0.5	(−2.2 to 1.2)	0.6	(−2.9 to 4.3)	0.1	(−3.4 to 3.8)
Service	−0.002	(−0.004 to 0.000)	−0.002	(−0.004 to 0.000)	−0.2	(−2.1 to 1.9)	0.0	(−2.0 to 2.1)	0.4	(−3.8 to 4.8)	0.4	(−3.9 to 4.9)
Blue-collar	0.000	(−0.003 to 0.002)	−0.001	(−0.003 to 0.002)	0.4	(−1.9 to 2.8)	0.3	(−2.0 to 2.7)	1.9	(−2.9 to 6.9)	2.0	(−2.9 to 7.1)
	p=0.213		p=0.281		p=0.957		p=0.813		p=0.746		p=0.793	

Model 1 is adjusted for age, race/ethnicity, nativity, family history of heart attack, employment status at each data collection, time since baseline, field centre and the interaction of age and time. In addition Model 2 includes education, household income, smoking status, pack-years for ever smokers, body mass index, systolic and diastolic blood pressure, total/HDL cholesterol ratio, diabetes, dyslipidemia medication and hypertension medication. For the IMT models, the left and right carotid arteries are also accounted for.

CVD, cardiovascular disease; HDL, high-density lipoprotein; IMT, intima-media thickness.

Table 3

Mean differences in subclinical CVD measures at baseline and mean differences in annual change associated with 1-SD increase in O*NET-derived occupational characteristics at baseline by sex

	Common carotid IMT				Carotid plaque score				Prevalence of carotid plaque shadowing			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Mean difference, mm	(95% CI)	Mean difference, mm	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)
Men												
Physical hazards												
Difference at baseline	0.001	(−0.007 to 0.009)	0.004	(−0.007 to 0.016)	8.4	(2.3 to 14.9)	6.3	(−1.8 to 15.1)	5.3	(−3.1 to 14.4)	4.3	(−6.0 to 15.6)
Difference in annual change	0.000	(−0.000 to 0.001)	0.000	(−0.000 to 0.001)	0.0	(−0.5 to 0.5)	0.0	(−0.5 to 0.5)	0.2	(−0.9 to 1.3)	0.2	(−0.9 to 1.4)
Physical activity												
Difference at baseline	0.005	(−0.005 to 0.015)	0.009	(−0.005 to 0.022)	8.9	(1.6 to 16.7)	8.6	(−1.1 to 19.3)	3.6	(−6.3 to 14.4)	1.9	(−9.7 to 15.0)
Difference in annual change	0.000	(−0.001 to 0.001)	0.000	(−0.001 to 0.001)	0.0	(−0.5 to 0.7)	0.1	(−0.5 to 0.7)	0.4	(−0.9 to 1.7)	0.5	(−0.9 to 1.8)
Interpersonal stress												
Difference at baseline	−0.001	(−0.010 to 0.009)	−0.004	(−0.014 to 0.007)	−3.0	(−9.7 to 4.1)	−2.8	(−9.9 to 4.9)	−2.5	(−12.1 to 8.1)	−1.6	(−11.9 to 9.9
Difference in annual change	0.000	(−0.000 to 0.001)	0.000	(−0.000 to 0.001)	0.2	(−0.5 to 0.8)	0.1	(−0.5 to 0.8)	0.1	(−1.2 to 1.5)	0.1	(−1.3 to 1.5)
Job demands												
Difference at baseline	−0.005	(−0.016 to 0.006)	−0.005	(−0.016 to 0.006)	−5.0	(−11.9 to 2.4)	−4.8	(−12.0 to 2.9)	−5.5	(−15.3 to 5.6)	−4.8	(−15.3 to 6.9)
Difference in annual change	0.001	(−0.000 to 0.001)	0.001	(−0.000 to 0.001)	0.3	(−0.3 to 1.0)	0.3	(−0.4 to 1.0)	0.5	(−1.0 to 2.0)	0.5	(−1.0 to 2.0)
Job control												
Difference at baseline	0.002	(−0.009 to 0.014)	0.006	(−0.009 to 0.022)	−8.5	(−15.6 to −0.9)	−2.4	(−12.0 to 8.3)	−5.6	(−15.3 to 5.6)	−3.8	(−15.9 to 10.1)
Difference in annual change	0.000	(−0.001 to 0.001)	0.000	(−0.001 to 0.001)	−0.2	(−0.9 to 0.4)	−0.2	(−0.9 to 0.5)	−0.4	(−1.8 to 1.1)	−0.4	(−1.9 to 1.1)
Women												
Physical hazards												
Difference at baseline	0.001	(−0.007 to 0.009)	0.000	(−0.012 to 0.013)	13.2	(1.9 to 25.9)	15.3	(3.0 to 29.1)	3.3	(−11.7 to 20.9)	2.6	(−13.1 to 21.1)
Difference in annual change	0.000	(−0.000 to 0.001)	0.000	(−0.001 to 0.001)	−0.5	(−1.4 to 0.5)	−0.5	(−1.5 to 0.5)	0.0	(−2.1 to 2.1)	0.1	(−1.9 to 2.2)
Physical activity												
Difference at baseline	0.002	(−0.006 to 0.011)	0.005	(−0.006 to 0.016)	5.7	(−2.1 to 14.1)	7.8	(−1.7 to 18.2)	−4.0	(−14.2 to 7.4)	−4.3	(−15.7 to 8.6)
Difference in annual change	0.000	(−0.001 to 0.001)	0.000	(−0.001 to 0.001)	0.0	(−0.7 to 0.7)	0.1	(−0.6 to 0.8)	0.6	(−0.9 to 2.0)	0.6	(−0.8 to 2.1)
Interpersonal stress												
Difference at baseline	−0.001	(−0.010 to 0.009)	−0.002	(−0.007 to 0.010)	4.5	(−3.0 to 12.6)	7.8	(−0.4 to 16.7)	5.1	(−5.8 to 17.3)	10.3	(−2.0 to 24.1)

	Common carotid IMT				Carotid plaque score				Prevalence of carotid plaque shadowing			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Mean difference, mm	(95% CI)	Mean difference, mm	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)	Difference, %	(95% CI)
Difference in annual change	0.001	(0.000 to 0.002)	0.001	(0.000 to 0.002)	−0.3	(−0.9 to 0.4)	−0.2	(−0.9 to 0.5)	−0.5	(−1.9 to 0.9)	−0.8	(−2.2 to 0.7)
Job demands												
Difference at baseline	−0.003	(−0.011 to 0.005)	−0.005	(−0.013 to 0.004)	4.5	(−3.2 to 12.8)	5.0	(−3.0 to 13.6)	1.6	(−15.2 to 21.7)	4.9	(−7.0 to 18.4)
Difference in annual change	0.000	(−0.001 to 0.001)	0.000	(−0.000 to 0.001)	0.0	(−0.7 to 0.7)	0.1	(−0.7 to 0.8)	−0.4	(−2.6 1.8)	−0.2	(−1.7 to 1.3)
Job control												
Difference at baseline	−0.005	(−0.014 to 0.005)	0.002	(−0.010 to 0.014)	−8.5	(−15.9 to -0.6)	3.2	(−7.2 to 14.7)	−14.6	(−28.8 to 2.4)	12.1	(−2.5 to 28.9)
Difference in annual change	0.001	(−0.000 to 0.002)	0.001	(0.000 to 0.002)	0.1	(−0.7 to 0.8)	0.0	(−0.7 to 0.8)	0.5	(−1.6 to 2.8)	−0.6	(−2.2 to 0.9)

Each job characteristic is tested separately, except for job demands and job control, which are tested together. Model 1 is adjusted for age, race/ethnicity, nativity, family history of heart attack, employment status at each data collection, time since baseline, field centre and the interaction between age and time. In addition Model 2 includes education, household income, occupational category, smoking status, pack-years for ever smokers, body mass index, systolic and diastolic blood pressure, total/HDL cholesterol ratio, diabetes, dyslipidemia medication and hypertension medication. For the IMT models, the left and right carotid arteries are also accounted for.

CVD, cardiovascular disease; HDL, high-density lipoprotein; IMT, intima-media thickness; O*NET, Occupational Resources Network.