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Low Socioeconomic Status is an Independent Risk Factor for Survival After Abdominal Aortic Aneurysm Repair and Open Surgery for Peripheral Artery Disease

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WHAT THIS PAPER ADDS

In this study the influence of low socioeconomic status (SES) on severity of disease at presentation and survival following vascular surgery was assessed. The present data underline the importance of socioeconomic deprivation as a risk factor for delayed presentation and the prognosis of vascular surgical patients independent of healthcare disparities. Therefore, increasing focus on low SES as a risk factor may improve outcome of socioeconomically deprived patients undergoing vascular surgery.

Objective/Background: The association between socioeconomic status (SES), presentation, and outcome after vascular surgery is largely unknown. This study aimed to determine the influence of SES on post-operative survival and severity of disease at presentation among vascular surgery patients in the Dutch setting of equal access to and provision of care.

Methods: Patients undergoing surgical treatment for peripheral artery disease (PAD), abdominal aortic aneurysm (AAA), or carotid artery stenosis between January 2003 and December 2011 were retrospectively included. The association between SES, quantified by household income, disease severity at presentation, and survival was studied using logistic and Cox regression analysis adjusted for demographics, and medical and behavioral risk factors.

Results: A total of 1,178 patients were included. Low income was associated with worse post-operative survival in the PAD cohort ($n = 324$, hazard ratio 1.05, 95% confidence interval [CI] 1.00–1.10, per 5,000 Euro decrease) and the AAA cohort ($n = 440$, quadratic relation, $p = .01$). AAA patients in the lowest income quartile were more likely to present with a ruptured aneurysm (odds ratio [OR] 2.12, 95% CI 1.08–4.17). Lowest income quartile PAD patients presented more frequently with symptoms of critical limb ischemia, although no significant association could be established (OR 2.02, 95% CI 0.96–4.26).

Conclusions: The increased health hazards observed in this study are caused by patient related factors rather than differences in medical care, considering the equality of care provided by the study setting. Although the exact mechanism driving the association between SES and worse outcome remains elusive, consideration of SES as a risk factor in pre-operative decision making and focus on treatment of known SES related behavioral and psychosocial risk factors may improve the outcome of patients with vascular disease.

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INTRODUCTION

The association between socioeconomic deprivation and poor health in the general population is well documented. Low socioeconomic status (SES) also negatively affects the prognosis and outcome of treatment for a variety of diseases, such as colon carcinoma and pulmonary disease.[1,2] A limited number of studies have demonstrated a similar association between low SES and poor outcome for vascular

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diseases, including stroke and critical limb ischemia (CLI), as well as for vascular surgery.[2–5]

Many of these studies have been performed in the USA, where SES related disparity in access to and provision of healthcare exists and is extensively affected by income.[2,6,7] Consequently, the relationship between low SES and poor outcome is often ascribed to healthcare disparities.[5,7,8] Alternatively, as the prevalence of conventional cardiovascular risk factors and poor lifestyle is higher in socially deprived regions, the association between SES and outcome may also be mediated through patient factors.[9] Owing to healthcare inequality, the impact of SES related patient factors on outcome remains largely undetermined.

Healthcare in the Netherlands is publicly provided and has been credited with being the most equally accessible healthcare system in the world.[10,11] Therefore, minimal differences could be expected in access to and provision of care, including screening and access to medication, both in hospital and in primary care settings. Hence, as opposed to the US system, the Dutch healthcare system provides the opportunity to study the association between SES and outcome irrespective of healthcare disparities.

The objective of this study was to determine SES as a predictor for survival following surgical treatment for peripheral artery disease (PAD), abdominal aortic aneurysm (AAA), and carotid artery stenosis (CAS). Additionally, the study aimed to assess whether SES is associated with severity of disease at presentation.

PATIENTS AND METHODS

Patients undergoing elective open or endovascular surgery under general or locoregional anesthesia for PAD, abdominal aortic aneurysm (AAA), or carotid artery stenosis (CAS) in the Erasmus University Medical Center between January 2003 and December 2011 were retrospectively included. Patients undergoing completely percutaneous procedures under local infiltration analgesia (i.e., carotid artery stenting, lower extremity angioplasty and/or stenting, or percutaneous endovascular aneurysm repair) or open surgical procedures performed under local infiltration analgesia were not included in this study. Identification was done using operation codes and surgical reports. When a patient underwent multiple vascular procedures within the study period, the first operation in this period was defined as the index operation, and survival was assessed from that moment onward. Baseline characteristics were obtained from the medical records and included age at index operation, sex, comorbidities, prior vascular interventions, smoking status (current, former, or never), and body mass index (BMI). Patients without registered and/or obtainable household income (e.g., owing to illegal residency) were excluded. Institutional approval for this study was obtained, and no informed consent was required according to local directives for retrospective studies. The study complied with the principles of the Declaration of Helsinki.

Definitions

Diabetes mellitus was recorded if diabetes was mentioned in the medical history or if patients used insulin or oral diabetic medication. Hypertension was defined as blood pressure >140/90 mmHg or the use of antihypertensive medication, and a history of cancer was defined as past or current malignant neoplastic disease, except for basal cell carcinoma. Further, severity of PAD at presentation was classified as claudication or CLI (Fontaine stages III and IV), and smoking alludes to all active and former smokers. Cerebrovascular disease was defined as mentioning of symptomatic cerebrovascular disease (i.e., transient ischemic attack [TIA] or stroke) and/or a carotid endarterectomy (CEA) or stenting procedure in the medical history. Ischemic heart disease was considered if one of the following was present: reference to previous cardiac ischemic events in cardiology notes, prior coronary intervention, or evidence of myocardial ischemia in provocative pre-operative tests (dobutamine stress echocardiography or myocardial scintigraphy). Finally, prior vascular interventions were defined as either surgical or percutaneous vascular treatment prior to the index operation, not including coronary revascularization.

Follow up

Survival status was obtained by inquiry of the civil registry. The latest date of follow up was considered to be 31 December 2012.

SES

Income is one of the most widely accepted and used methods to quantify SES and was found to provide a superior reflection of SES related health disparities than other approaches such as educational status.[12–14] The income data used for this study were the gross household income earned in 2003, which included every form of income of all people sharing a household or place of residence combined. The household income was not adjusted for household size. However, it has been demonstrated that adjustment for number of members in a household does not improve predictability of the associated health disparities.[13] Incomes were assigned percentiles and quartiles in accordance with the national income distributions, with the first quartile being the lowest income group and the fourth quartile including households with the highest incomes. The annual earnings were obtained from the Dutch Central Bureau of Statistics (CBS) (study ID: 7465). To obtain information on SES, a database consisting of medical data on all study participants was anonymized by authorized data managers employed by CBS and matched to the household income dataset maintained by this entity. Income data are documented on an individual and household basis. According to Dutch privacy legislation, data analysis was only allowed to authorized researchers (KU and FBG) from designated institutions inside a secure environment after approval from the institutional ethical committee. Furthermore, output

Table 1. Descriptive statistics of the peripheral artery disease (PAD) cohort (n = 324).

Variable	Baseline characteristics				
Quartiles	1 (n = 95)	2 (n = 99)	3 (n = 75)	4 (n = 55)	p
SES					
Median gross household income (€)	15,873	28,286	50,243	79,746	—
Demographics					
Female sex	42 (44.2)	28 (28.3)	24 (32.0)	16 (29.1)	.09
Age (y, mean ± SD)	67.0 ± 11.2	63.9 ± 12.3	60.8 ± 9.9	61.2 ± 8.0	< .01
Cardiovascular risk factors					
Diabetes mellitus	35 (36.8)	27 (27.3)	27 (36.0)	11 (20.0)	.10
Hypertension[a]	65 (69.1)	64 (64.6)	55 (74.3)	37 (67.3)	.59
Smoking[a]	85 (90.4)	86 (86.9)	66 (88.0)	48 (87.3)	.88
BMI (kg/length^2, mean ± SD)	25.4 ± 5.4	25.0 ± 3.8	27.2 ± 4.1	25.9 ± 4.9	.01
Comorbidities					
History of cancer[a]	18 (19.1)	15 (15.2)	14 (18.7)	2 (3.7)	.06
Ischemic heart disease	47 (49.5)	47 (47.5)	29 (38.7)	22 (40.0)	.43
PAD	95 (100)	99 (100)	75 (100)	55 (100)	—
Cerebrovascular disease	19 (20.0)	16 (16.2)	10 (13.3)	5 (9.1)	.32
History of vascular interventions	43 (45.3)	48 (48.5)	34 (45.3)	30 (54.5)	.72
Severity of symptoms at presentation					
CLI[b]	61 (67.0)	51 (53.1)	40 (54.8)	26 (47.3)	.09

Note. Data are n (%) unless otherwise indicated. SES = socioeconomic status; BMI = body mass index; CLI = critical limb ischemia.
[a] Missing values ≤ 1%.
[b] Missing values 2—3%.

was checked by the CBS for privacy violations before it was allowed for publication purposes.

End points

The primary end point was overall post-operative mortality. Secondary end points were severity of disease at presentation for AAA patients (i.e., rupture vs. non-rupture) and PAD patients (i.e., CLI vs. claudication). Severity of disease at presentation was not studied among CAS patients because carotid revascularization in asymptomatic patients is only rarely performed in our hospital, in accordance with clinical guidelines.[15]

Statistical methods

Income percentiles corresponding to the national gross income distribution were separated in quartiles. To clarify, first income quartile patients included members of a household with an annual salary that corresponds to 0—25% gross household incomes of the Dutch population. Baseline characteristics were described as counts and percentages (dichotomous variables), or means and SD (continuous variables). Income is presented as median and interquartile range (IQR), because of the skewness of the data distribution. Differences between quartiles at baseline were determined using Pearson's chi-square analysis and analysis of variance, where appropriate.

Cox regression analyses were used to assess the predictive value of income for survival following treatment. The multivariate analyses were performed in two stages: in the first stage the model was adjusted for demographics only (age and sex), whereas in the second stage the full model included comorbidities and behavioral risk factors (diabetes, cancer, ischemic heart disease, hypertension, smoking status, and BMI). In order to determine the type of association between income and post-operative survival, analyses were done both continuously, by hazard ratio (HR) per 5,000 Euro decrease in gross household income, and categorical, by HR of the individual income quartiles compared with the fourth quartile (75—100%). Exponential properties in the relationship between annual earnings and outcome were tested by including the quadratic term of household income in the regression model.

To investigate the relationship between income and severity of disease, odds ratios (OR) and 95% confidence intervals (CI) were calculated by logistic regression analyses. Similar to the primary end point, multivariate analyses for the secondary objective were done using a two stage method. Covariates included in the multivariate model were identical to the Cox proportional hazards model. Ruptured AAA cases were only included in univariate and step 1 multivariate analyses for severity of disease at presentation, owing to the number of missing values at baseline. Both regression models were tested for interactions. All tests were two sided and significance was considered when $p < .05$. Statistical analysis was performed using IBM SPSS Statistics 20 (IBM Inc., Armonk, NY, USA).

RESULTS

A total number of 1,260 patients underwent surgical treatment for AAA, CAS, or PAD between January 2003 and December 2011. The inquiry yielded the income of 1,178 patients (93.5%): 577 with AAA, 277 with CAS, and 324 with PAD. The cohort consisted of 915 men (77.6%) and 263 women (22.3%). The median gross household income was €30,889 annually (IQR 21,779—51,620). The overall 5 year survival was 69%, with a median follow up time of 3.84 years (excluding patients treated for rAAA).

Table 2. Descriptive statistics of the intact abdominal aortic aneurysm cohort ($n = 440$).

Variable Quartiles	Baseline characteristics 1 ($n = 86$)	 2 ($n = 188$)	 3 ($n = 92$)	 4 ($n = 74$)	 p
SES					
Median gross household income (€)	17,452	28,041	46,201	82,765	—
Demographics					
Female sex	19 (22.1)	20 (10.6)	8 (8.7)	7 (9.5)	0.02
Age (y, mean ± SD)	74.4 ± 6.7	74.3 ± 5.9	67.5 ± 7.9	68.2 ± 7.0	< .01
Cardiovascular risk factors					
Diabetes mellitus	16 (18.6)	26 (13.8)	20 (21.7)	10 (13.5)	.304
Hypertension	53 (61.6)	133 (70.7)	66 (71.7)	50 (67.5)	.423
Smoking[a]	69 (80.2)	150 (81.5)	76 (83.5)	59 (79.7)	.922
BMI (kg/length^2, mean ± SD)	25.3 ± 4.4	26.2 ± 4.1	26.5 ± 4.2	26.3 ± 3.8	.266
Comorbidities					
History of cancer	17 (19.8)	49 (26.1)	13 (14.1)	15 (20.3)	.14
Ischemic heart disease	41 (47.7)	92 (48.9)	34 (37.0)	38 (51.4)	.21
PAD	13 (15.1)	27 (14.4)	26 (28.3)	12 (16.2)	.03
Cerebrovascular disease	21 (24.4)	37 (19.7)	18 (19.6)	10 (13.5)	.39
History of vascular interventions	9 (10.5)	24 (12.8)	10 (10.9)	8 (10.8)	.93

Note. Data are *n* (%) unless otherwise indicated. SES = socioeconomic status; BMI = body mass index; PAD = peripheral artery disease.
[a] Missing values 1%.

Baseline characteristics

Patients in the first and second income quartiles were older compared with the higher two quartiles ($p \leq .01$; Tables 1–3). Additionally, BMI differed across the income quartiles in the PAD cohort ($p = .01$), although no clear pattern was observed. In the AAA cohort, patients in the first quartile were more frequently female compared with the higher three quartiles (22% vs. 11%, 9%, and 9%, respectively; $p = .02$ [Table 2]). Further, the third income quartile AAA patients more often suffered from PAD (28% vs. 15%, 14%, and 16%, respectively; $p = .03$). No additional differences were found in the PAD and CAS cohorts at baseline (Tables 1 and 3).

PAD

Surgical revascularization for limb ischemia was performed in 324 patients. During a median follow up of 3.60 years, 96 deaths occurred with a 5 year survival rate of 69% (Table 4). The median income among PAD patients was €33,248 (IQR 19,802–55,353). With income as a continuous variable, adjusted analysis proved that low income was significantly associated with worse survival (step 2 HR 1.05, 95% CI 1.00–1.10, per 5,000 euro decrease; Table 5). Regarding the hazard expressed per income quartile, a similar linear relation with increasing hazard as income decreased was observed in the first two quartiles compared with the fourth quartile (first quartile: step 2 HR 3.05, 95% CI 1.25–7.44; second quartile: HR 2.50, 95% CI 1.03–6.07), while no significant association was found for the third quartile (HR 2.47, 95% CI 0.98–6.24; $p = .06$).

In terms of disease severity, patients in the first income quartile presented more often with CLI, although no significant association could be established in step 2

Table 3. Descriptive statistics of the carotid artery stenosis cohort ($n = 277$).

Variable Quartiles	Baseline characteristics 1 ($n = 63$)	 2 ($n = 96$)	 3 ($n = 71$)	 4 ($n = 47$)	 p
SES					
Median gross household income (€)	17,886	26,116	46,371	83,308	—
Demographics					
Female sex	23 (36.5)	32 (33.3)	20 (28.2)	9 (19.1)	.21
Age (y, mean ± SD)	71.8 ± 9.3	72.2 ± 8.5	64.9 ± 9.5	63.7 ± 8.2	< .01
Cardiovascular risk factors					
Diabetes mellitus	13 (20.6)	21 (21.9)	16 (22.5)	11 (23.4)	.99
Hypertension	42 (66.7)	67 (69.8)	46 (64.8)	35 (74.5)	.71
Smoking[a]	50 (80.6)	73 (76.0)	59 (84.3)	44 (93.6)	.07
BMI (kg/length^2, mean ± SD)	26.6 ± 4.1	26.4 ± 4.1	26.2 ± 3.6	26.2 ± 2.8	.94
Comorbidities					
History of cancer[a]	11 (17.7)	11 (11.7)	8 (11.3)	6 (12.8)	.67
Ischemic heart disease	26 (41.3)	44 (45.8)	22 (31.0)	15 (31.9)	.18
PAD	5 (7.9)	17 (17.7)	15 (21.1)	6 (12.8)	.17
Cerebrovascular disease	63 (100)	96 (100)	71 (100)	47 (100)	—
History of vascular interventions	6 (9.5)	10 (10.4)	10 (14.1)	6 (12.8)	.83

Note. Data are *n* (%) unless otherwise indicated. SES = socioeconomic status; BMI = body mass index; PAD = peripheral artery disease.
[a] Missing values ≤ 1%.

Table 4. Follow up of the study cohort (n = 1,041, excluding patients with ruptured abdominal aortic aneurysms [AAA]).

Indication	Death, *n* (%)	Percentage 5 year survival (± SE)	Median follow up, y (IQR)
PAD	96 (27.2)	69.2 (± 3.0)	3.60 (1.90—5.60)
AAA	159 (36.1)	62.1 (± 2.8)	3.17 (1.75—5.17)
CAS	64 (23.1)	78.8 (± 2.7)	4.77 (3.39—6.04)

Note. PAD = peripheral artery disease; CAS = carotid artery stenosis; IQR = interquartile range.

multivariate analysis (OR 2.02, 95% CI 0.96—4.26; $p = .06$ [Table 6]).

AAA

Of the 577 patients with AAA, 440 (76.3%) received treatment for non-ruptured AAA. During a median follow up of 3.17 years, 159 patients died, which resulted in a 5 year survival of 62% among elective AAA patients. The median income was €31,232 (IQR 22,653—51,230). In multivariate quartile analyses, low income was not significantly associated with worse survival following AAA repair. With income as a continuous variable, however, there was an exponential increase in mortality hazard associated with a decrease in income ($p = .01$). The quadratic relationship implies that the negative effect on survival for which low SES is responsible is more severe in the lowest percentiles and diminishes exponentially as income increases. This indicates that only survival of patients with non-ruptured AAA in the lowest income regions within the first quartile is affected by low SES.

Regarding the relationship between income and severity of disease at presentation, low household income was associated with more severe presentation. After adjusting for demographics, patients in the first quartile were more likely to present with a ruptured aneurysm than those in the fourth quartile (OR 2.12, 95% CI 1.08—4.17). The second step multivariate analysis was not performed because of the missing baseline characteristics in the rAAA group.

CAS

The median follow up period of the 277 patients who underwent a CEA was 4.77 years, during which 64 patients died, resulting in a 5 year survival of 79%. The median income was €31,796 (IQR 22,054—51,604). Low income was not associated with worse survival. Severity of disease at presentation was not studied, as carotid revascularization is only rarely performed in asymptomatic patients in the Netherlands, according to clinical guidelines.[15]

DISCUSSION

Previous reports of socioeconomic deprivation and its association with cardiovascular disease (CVD) have demonstrated increased lifetime cumulative risks of acute myocardial infarction, stroke, heart failure, coronary death, and PAD in deprived patients.[16] The current study demonstrates that, in addition to an increased risk of a range of CVD presentations, SES—as determined by income—also negatively affects survival after vascular surgery.

The different income quartiles, as defined by the national income distribution, were—by approximation—equally represented in the present cohort, indicating that this patient group is a good reflection of the national socioeconomic situation. Low SES was associated with worse postoperative survival among PAD and AAA patients, even after adjusting for demographics, conventional cardiovascular risk factors, and comorbidities. The relationship between low SES and poor outcome was strongest in patients who underwent surgical revascularization for PAD. Patients in the lowest income quartile were three times more likely to die after surgery than those in the highest income group. Although the exact reasons are unclear, the importance of SES for, in particular, PAD patients has been demonstrated in previous studies.[16] In AAA patients a similar relationship was present, albeit only in patients with the lowest income. Although it has been reported that SES affects mortality after stroke,[17] no association between mortality hazard and

Table 5. Association between income and survival (hazard ratio per quartile, relative to the fourth quartile [75—100%]).

	Continuous	Quartile 1	Quartile 2	Quartile 3	Quartile 4
PAD					
Deaths, *n* (%)		38 (40)	32 (32)	20 (27)	6 (11)
Univariate	1.08 (1.03—1.13)	4.74 (2.00—11.22)	3.29 (1.38—7.87)	3.01 (1.21—7.50)	—
Multivariate step 1	1.06 (1.01—1.11)	3.89 (1.62—9.33)	3.05 (1.27—7.32)	3.23 (1.30—8.07)	—
Multivariate step 2	1.05 (1.00—1.10)	3.05 (1.25—7.44)	2.50 (1.03—6.07)	2.47 (0.98—6.24)	—
AAA					
Deaths, *n* (%)		41 (48)	76 (40)	26 (28)	16 (22)
Univariate	Quadratic ($p < .01$)	2.07 (1.16—3.69)	1.76 (1.03—3.02)	1.14 (0.61—2.12)	—
Multivariate step 1	Quadratic ($p < .01$)	1.56 (0.86—2.85)	1.32 (0.76—2.29)	1.15 (0.62—2.14)	—
Multivariate step 2	Quadratic ($p = .01$)	1.50 (0.80—2.81)	1.33 (0.75—2.38)	1.34 (0.71—2.55)	—
CAS					
Deaths, *n* (%)		17 (27)	24 (25)	15 (21)	8 (17)
Univariate	1.03 (0.98—1.09)	1.39 (0.60—3.23)	1.31 (0.59—2.91)	1.03 (0.44—2.43)	—
Multivariate step 1	1.02 (0.96—1.07)	1.06 (0.44—2.58)	0.97 (0.42—2.25)	0.97 (0.41—2.30)	—
Multivariate step 2	1.02 (0.96—1.07)	1.02 (0.41—2.50)	1.00 (0.43—2.33)	1.05 (0.44—2.49)	—

Note. PAD = peripheral artery disease; AAA = abdominal aortic aneurysm; CAS = carotid artery stenosis.

Table 6. Association between income and the severity of symptoms at presentation (odds ratio per quartile, relative to the fourth quartile [75—100%]).

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
PAD				
CLI, *n* (%)	61 (67)	51 (53)	40 (55)	26 (47)
Univariate	2.27 (1.14—4.51)	1.26 (0.65—2.46)	1.35 (0.67—2.73)	—
Multivariate step 1	2.00 (0.99—4.02)	1.18 (0.60—2.31)	1.38 (0.68—2.79)	—
Multivariate step 2	2.02 (0.96—4.26)	1.16 (0.58—2.34)	1.28 (0.61—2.70)	—
AAA				Reference
Ruptures	40 (32)	55 (23)	25 (21)	17 (19)
Univariate	2.03 (1.06—3.87)	1.27 (0.69—2.34)	1.18 (0.60—2.35)	—
Multivariate step 1	2.12 (1.08—4.17)	1.30 (0.69—2.47)	1.18 (0.59—2.35)	—

Note. PAD = peripheral artery disease; CLI = critical limb ischemia (Fontaine stage III, IV); AAA = abdominal aortic aneurysm.

gross household income in patients undergoing CEA for symptomatic CAS was found in the present study.

The present data underline the importance of socioeconomic deprivation as a risk factor for the prognosis of people with established CVD. But which factors drive the relationship between low SES and poor health? Studies conducted in the USA have shown a clear link between income, insurance status, and outcome. For example, uninsured patients were four times more likely to die following AAA repair.[8,18,19] Discrepancies in mortality hazards associated with insurance status and low SES are generally attributed to poor access to and/or low quality of healthcare. However, the present study was conducted in the Dutch setting, where patients have equal access to and the same quality of healthcare, irrespective of income.[10] Hence, the association between income and postoperative survival that was demonstrated in the present study cannot be attributed to inequality in healthcare resources. In addition, low income as a predictor of poor outcome was found to be independent of conventional cardiovascular risk factors, such as age, smoking status, diabetes, and obesity, as well as common comorbidities, including cancer and ischemic heart disease, as these factors were corrected for in multivariate analyses.

Several alternative factors may mediate the association between SES and poor survival. First, psychosocial risk factors implicated in the etiology of CVD, such as psychological stress, depression, and social isolation, are more often observed in individuals with a low SES.[20—23] Second, socioeconomic disadvantage has been established as a risk factor for poor compliance with medication, diet, and lifestyle restrictions.[24—28] Third, SES has been shown to be an important determinant of physical activity and exercise,[29] which, in turn, is associated with health status and life expectancy.[29,30] Fourth, even in developed countries, material deprivation in people from disadvantaged backgrounds is increasingly associated with poorer diet quality.[31—34] Fifth, patients of lower SES more often live in disadvantaged neighborhoods with higher concentrations of harmful air pollutants and worse housing conditions, which are associated with worse health outcomes.[35—37] Additionally, physical demand, low decision latitude and high job strain, which are more common in lower employment grades, may explain some of the excess risk among disadvantaged groups.[38] Finally, a recent study suggests that perhaps even epigenetic factors among lower socioeconomic classes may play a role in SES related health disparities.[39] Although the interaction between SES and poor prognosis is complex, a better understanding of these acquired health hazards may attenuate the health inequalities. In addition, increased physician awareness and consideration of SES in clinical practice, for example by incorporating a number of voluntary questions to existing questionnaires (e.g., employment of the patient and his or her partner, residential area, and household income category), and focus on treatment of these established SES related risk factors may help to improve outcome of vascular patients of low SES. Although this study shows the relationship between SES and outcome and the potential benefit of its consideration, further study is needed on how to integrate SES with current decision models for risks of restenosis, amputation, and survival.

In line with previous reports,[4,5,19,40] AAA patients with a low income were more likely to present with a ruptured aneurysm, while PAD patients with lower annual earnings more often presented with symptoms of CLI. These results indicate that the severity of disease at presentation is also affected by SES. As patients with lower SES tend to postpone seeking healthcare, even in the absence of financial barriers, a lack of disease awareness and knowledge in lower socioeconomic classes is likely to be responsible for delayed presentation.[41] Regarding PAD patients, it is well recognized that the prognosis for patients presenting with CLI is worse than for those with claudication. Therefore, additional analyses to determine the relative influence of SES and disease severity were performed. These analyses showed that both income and disease severity at presentation independently influenced survival in the present cohort (data not shown). Considering that delayed presentation also appeared to be associated with SES, a lack of awareness and knowledge may also partially account for SES related disparities in the outcome of vascular surgery patients.

This study has several limitations, which must be considered. First, the study was performed retrospectively, which comes with its inherent disadvantages. Second, local law prohibits the documentation of ethnicity, unless explicit approval is provided. Although we assume most patients to be of Western European origin, the ethnicity was not obtainable for this study, making racial differences in our analyses inaccessible. Another limitation was the missing data among the patients with ruptured AAA. Owing to a high number of missing baseline data, we could not include these patients in multivariate analysis beyond step one (age and sex adjusted). Also, it should be considered that only patients who underwent surgery were identified. Patients who were treated conservatively, or patients with prohibitive surgical risks due to severe comorbidity, were not included in this study. As a result, a selection bias towards patients suited for surgery may be present. Further, patients undergoing endovascular procedures under local infiltration analgesia were not included in this study. As endovascular treatment approaches are increasingly utilized, further study is warranted to assess the importance of SES in the outcome of patients undergoing less invasive endovascular procedures. In addition, treatment indication for carotid revascularization (i.e., TIA or stroke) was not graded in this study. Some studies have noted different peri-operative complication rates for different treatment indications.[42,43] However, for long-term survival, which was the primary end point in the present study, the impact of treatment indication is not well established.[44–46] Finally, gross household income was acquired for all patients in 2003, suggesting that the income used for analyses may be the income earned several years prior to surgery. However, the mean age in the cohort was 69 years, meaning that major differences between the income used in the analyses and the actual income at the time of surgery are not very likely.

In conclusion, this study demonstrates that socioeconomic deprivation is a predictor of adverse outcome after vascular surgery independent from conventional risk factors, in particular for PAD. For AAA patients, the association was of an exponential nature, indicating that the mortality hazards rapidly decrease as income rises, while for PAD patients the relation followed a linear path. Although the precise mechanisms accounting for this risk remain elusive, the increased health hazards observed in this study are caused by patient related factors rather than differences in medical care, considering the equality of care provided by the study setting. Consideration of SES, for example assessed by household income, as a risk factor in pre-operative decision making and focus on treatment of the associated behavioral and psychosocial risk factors may improve the outcome of patients with vascular disease.

CONFLICT OF INTEREST

None.

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