Association of Neighbourhood Deprivation with Risks of Major Amputation and Death Following Lower Limb Revascularisation

Katriina Heikkilä[1,2], Ian M. Loftus[3], Sam Waton[4], Amundeep S. Johal[4], Jonathan R. Boyle[5], David A. Cromwell [1,4]

[1] Department of Health Services Research and Policy, London School of Hygiene and Tropical Medicine, London, United Kingdom

[2] Finnish Institute for Health and Welfare, Helsinki, Finland

[3] St. George's Vascular Institute, St. George's Healthcare NHS Trust, London, United Kingdom

[4] Clinical Effectiveness Unit, the Royal College of Surgeons of England, London, United Kingdom

[5] Cambridge Vascular Unit, Cambridge University Hospitals, NHS Trust, Cambridge, United Kingdom

Corresponding author:

Katriina Heikkilä, Department of Health Services Research and Policy, London School of Hygiene and Tropical Medicine, 15-17 Tavistock Place, London WC1H 9SH, United Kingdom

Email: katriina.heikkila@thl.fi

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Abstract

Background and aims Individual-level socioeconomic deprivation is associated with an increased risk of adverse patient outcomes following cardiovascular disease interventions, but the role of area-level socioeconomic circumstances as a predictor for treatment outcomes is unclear. we have examined the association of neighbourhood socioeconomic deprivation with risks of major lower limb amputation and death following surgical and endovascular lower limb revascularisation due to peripheral artery disease (PAD).

Methods Patients aged 50+ years who underwent surgical or endovascular lower limb revascularisation for PAD were identified from Hospital Episode Statistics, a nationwide hospital data warehouse in England. Major amputations and deaths within a year of revascularisation were ascertained from HES and national mortality register, respectively. Index of Multiple Deprivation (IMD) was used to measure neighbourhood deprivation. Flexible parametric competing risks models were used to estimate sub-distribution hazard ratios (SHRs) for amputation and death.

Results In all, 65,806 patients underwent endovascular and 20,072 underwent surgical revascularisation. The covariate-adjusted 1-year risk of major amputation was higher among patients from the most deprived compared to least deprived neighbourhoods following endovascular revascularisation (SHR: 1.24, 95% confidence interval, CI:1.10 to 1.38) and surgical revascularisation (SHR:1.28, 95% CI: 1.09 to 1.51). The risk of death was higher in most deprived compared to the least deprived neighbourhoods following both procedures.

Conclusions We found an association between neighbourhood deprivation with amputation and death outcomes following lower limb revascularisation for PAD. These findings suggest there may be opportunities for targeted interventions to improve care of PAD patients in deprived neighbourhoods.

Introduction

Socioeconomic circumstances, at individual- and area-levels, are important determinants of human health. Many manifestations of atherosclerotic cardiovascular disease, including coronary heart disease, heart failure and stroke, are socioeconomically patterned, with a higher prevalence and incidence in socioeconomically disadvantaged groups and areas (1-5). Individual- and area-level socioeconomic deprivation is also associated with an increased risk of developing peripheral artery disease (PAD)(6, 7).

Socioeconomic circumstances impact not only on the incidence of cardiovascular disease but also on patient outcomes. Studies from the United States and the Netherlands have shown that individual-level socioeconomic position, marked by low income, is associated with an increased risk of lower limb amputation among PAD patients (8-10). An association of low income with an increased risk of death following surgical intervention for PAD has also been reported in one study (10), but not corroborated in another (11). However, the extent to which area-level socioeconomic deprivation is implicated in patient outcomes in PAD is largely unknown. A study of US military veterans suggests that area deprivation is associated with an increased risk of major amputations among PAD patients (12), but the generalisability of the findings to other populations or healthcare systems not clear.

The aim of our investigation was to examine the association of neighbourhood deprivation with the risks of major lower limb amputation and death among patients undergoing endovascular or surgical revascularisation for lower limb PAD. To do this, we used data from Hospital Episode Statistics (HES), a data warehouse containing records of all patients admitted to National Health Service hospitals in England.

Patients and methods

Our analyses were based on data from women and men aged 50 years and older, who underwent endovascular (angioplasty with or without stent) or surgical (endarterectomy, profundaplasty or bypass) revascularisation for PAD between 1^{st} Jan 2010 and 31^{st} Dec 2015. The outcomes were major lower limb amputation (above the ankle; ipsilateral or contralateral) or death from any cause within one year of the revascularisation. The predictor of interest was neighbourhood deprivation, operationalised as the Index of Multiple Deprivation (IMD), a ranked score based on information on income, employment, education, health, crime, housing and the environment (13). Covariates were patient age and sex, indication for the intervention and the Royal College of Surgeons (RCS) Charlson comorbidity score (14).

All data were obtained from HES, apart from deaths, which were ascertained from the Office for National Statistics death register. Revascularisations and amputations were identified using a combination of International Classification of Disease (ICD) version 10 diagnostic codes indicating PAD and Office for Population Censuses and Surveys (OPCS) procedure codes indicating surgical or endovascular lower limb revascularisation (Online Supplement, Tables S1-S3). IMD was analysed as quintiles, from 1^{st} (least deprived) to 5^{th} (most deprived). The RCS Charlson score (0, 1 or 2+ comorbidities) and the indication for intervention (intermittent claudication or limb ischaemia *without* record of tissue loss, and severe limb ischaemia *with* a record of tissue loss) were defined using ICD-10 codes (Online Supplement, Tables S4 and S5). Flexible parametric competing risks regression was used to estimate sub-distribution hazard ratios (SHRs) for major amputation and death, with the other outcome as the competing risk (15). All analyses were conducted using Stata MP 15 (Stata Corporation, College Station, Texas, US).

This study is exempt from United Kingdom National Research Ethics Committee approval as it involved secondary analysis of anonymised data. HES data were made available by NHS Digital (Copyright© 2015).

Results

In all, 65,806 patients underwent endovascular and 20,072 underwent surgical lower limb revascularisation in 2010-2015. Patients' median age was 71 years (interquartile range: 63 to 88); 65% were men. Endovascular revascularisations were slightly more common among patients living in affluent neighbourhoods and surgical interventions among those living in deprived neighbourhoods (Table). During the year after revascularisation, 4,937 patients underwent a major amputation (4.9% in the endovascular and 8.4% of those in the surgical group) and 9,682 died (11.0% and 12.2% in the endovascular and surgical groups, respectively). Following both revascularisation types, the SHRs for major amputation increased with greater neighbourhood deprivation, independently of covariates (Figure). The SHRs for death following either procedure were also higher among patients living in more deprived neighbourhoods (Figure). To explore potential interactions between procedure type and IMD, we modelled covariate-adjusted associations of procedure type with amputation and death, stratified by IMD quintile. In these analyses, the risks of amputation and death were consistently lower among patients undergoing endovascular revascularisation compared to those undergoing surgical procedures in all IMD quintiles (Table).

Discussion

Our findings, based on data from a nationwide, administrative dataset in England, suggest that neighbourhood socioeconomic deprivation is associated with an increased risk of major amputation following endovascular and surgical revascularisation alike. These observations are in agreement with those reported in US military veterans and small case-control study of PAD patients at one district hospital in England, which suggest that neighbourhood deprivation is associated with an increased risk of major amputation in this patient group (12, 16). However, previous studies have not examined the association separately by revascularisation type.

The IMD is a weighted score, consisting of information on income (22.5% weight), employment (22.5%), education (13.5%), health and disability (13.5%), crime (9.3%), housing and services (9.3%) and living environment (9.3%). We hypothesise that the association between the quintiles of IMD and outcomes of lower limb revascularisation are mainly driven by the two key domains, income and employment. In a similar vein, it may be that our finding of endovascular revascularisation being slightly more common than surgical revascularisation among PAD patients living in less deprived neighbourhoods reflects these patients' ability to manage their disease better. This hypothesis is supported by the notion that patients from less deprived neighbourhoods undergo their first revascularisation at an older age and have a smaller number of comorbidities than those living in more deprived neighbourhoods (Table).

Previous research suggests that individual-level socioeconomic deprivation is a risk factor for adverse patient outcomes following revascularisation for PAD (8-10). Individual-level socioeconomic position, however, does not present an easy interventional target. Area-level socioeconomic circumstances, on the other hand, could be targets in themselves, or be used as indicators of areas where interventions, such as smoking cessation initiatives or diabetic footcare programmes to improve prognosis for PAD patients, should be directed. As our investigation is based on a register data, albeit from a nationwide dataset with good coverage of procedures and outcomes in England, our findings alone cannot form a basis for specific policy or healthcare interventions. Together with the larger burden of disease and risk factors in deprived areas, as well as the later presentation to health services among PAD patients from deprived neighbourhoods (17), our findings and those of previous studies suggest that there might be opportunities for targeted health interventions to improve the care and outcomes for PAD patients living in deprived neighbourhoods.

An important strength of our research is that we used individual-level data from HES, which captures information on all revascularisation procedures conducted in NHS hospitals in England and has been shown to have good coverage, accuracy and completeness of cardiovascular procedure and outcome data for the study period. (18, 19) We used flexible parametric competing risks models to examine the risks of major amputation and death separately from one another, which is important in order to accurately estimate the risks of these competing outcomes. Unfortunately, HES does not include data on individual-level socioeconomic position, pack-years of smoking, obesity or physical activity, and we were therefore unable to examine their roles in the association between neighbourhood deprivation and outcomes of revascularisation. Previous studies of other cardiovascular outcomes have, however, demonstrated that area-level socioeconomic deprivation contributes to the risk of these outcomes independently of established clinical and behaviour-related risk factors and individual-level socioeconomic position (20, 21).

Conclusion

Our findings suggest that area deprivation is associated with an increased risk of major amputation following endovascular and surgical revascularisation.

Conflict of interest

None declared.

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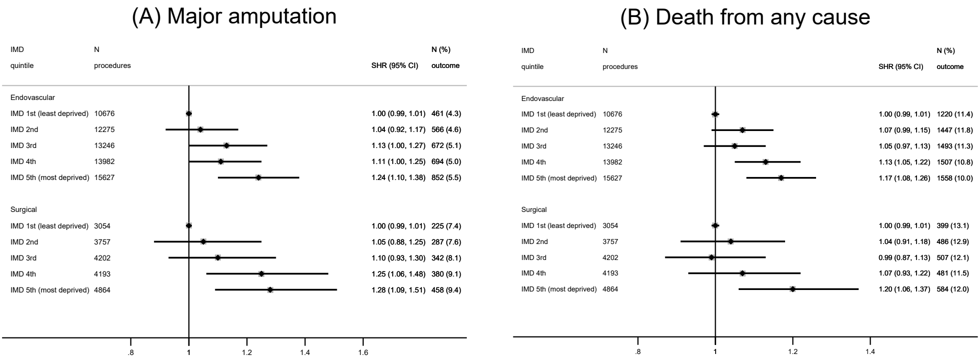
Figure legend

Figure. Outcomes of lower limb revascularisation, by quintiles of Index of Multiple Deprivation: (A) Major amputation (B) Death from any cause

Table. Procedures, patient characteristics and outcomes by IMD quintile

N (%) patients	IMD 1st *Least deprived*	IMD 2nd	IMD 3rd	IMD 4th	IMD 5th *Most deprived*	p trend
All patients	13,730	16,032	17,450	18,175	20,491	
Procedure type						
Endovascular (n=65,806)	10,676 (77.8)	12,275 (76.6)	13,246 (75.9)	13,982 (76.9)	15,627 (76.3)	*0.023*
Surgical (n=20,072)	3,054 (22.2)	3,757 (23.4)	4,202 (24.1)	4,193 (23.1)	4,864 (23.7)	*0.023*
Patient characteristics						
Age (mean, SD)	73.8 (10.1)	72.8 (10.2)	72.1 (10.3)	70.3 (10.4)	68.4 (10.3)	*<0.0001*
Women	4,944 (36.0)	5,752 (35.9)	6,303 (36.1)	6,373 (35.1)	7,014 (34.2)	*<0.0001*
Indication for intervention[a]						
IC/SLI *without* tissue loss	10,422 (75.9)	12,180 (76.0)	13,153 (75.4)	13,900 (76.5)	15,825 (77.2)	*0.001*
SLI *with* tissue loss	3,308 (24.1)	3,852 (24.0)	4,297 (24.6)	4,275 (23.5)	4,666 (22.8)	
RCS Charlson score						
0	8,239 (60.00	9,248 (57.7)	9,851 (56.5)	10,226 (56.3)	11,331 (55.3)	*<0.0001*
1	4,175 (30.4)	5,028 (31.4)	5,690 (32.6)	5,892 (32.4)	6,817 (33.3)	
2+	1,316 (9.6)	1,756 (11.0)	1,909 (10.9)	2,057 (11.3)	2,343 (11.4)	
Major lower limb amputation						
Endovascular	461 (4.3)	566 (4.6)	672 (5.1)	694 (5.0)	852 (5.5)	*<0.0001*
Surgical	225 (7.4)	287 (7.6)	342 (8.1)	380 (9.1)	458 (9.4)	*<0.0001*
Death from any cause						
Endovascular	1,220 (11.4)	1,447 (11.8)	1,493 (11.3)	1,507 (10.8)	1,558 (10.0)	*<0.0001*
Surgical	399 (13.1)	486 (12.9)	507 (12.1)	481 (11.5)	584 (12.0)	*0.1*
SHR[b] for amputation (95% CI)						
Endovascular	0.57 (0.48 to 0.66)	0.57 (0.49 to 0.66)	0.59 (0.52 to 0.68)	0.53 (0.47 to 0.60)	0.58 (0.52 to 0.66)	
Surgical	1 (ref. cat.)	1 (ref. cat.)	1 (ref. cat.)	1 (ref. cat.)	1 (ref. cat.)	
SHR[b] for death (95% CI)						
Endovascular	0.78 (0.70 to 0.87)	0.81 (0.73 to 0.89)	0.85 (0.77 to 0.94)	0.84 (0.76 to 0.94)	0.78 (0.71 to 0.86)	
Surgical	1 (ref. cat.)	1 (ref. cat.)	1 (ref. cat.)	1 (ref. cat.)	1 (ref. cat.)	

[a] IC: intermittent claudication; SLI: severe limb ischaemia. [b] Adjusted for patient age, sex, indication for intervention and RCS Charlson score.


(A) Major amputation
IMD quintile
N procedures
SHR (95% CI)
N (%) outcome
Endovascular
IMD 1st (least deprived) 10676 1.00 (0.99, 1.01) 461 (4.3)
IMD 2nd 12275 1.04 (0.92, 1.17) 566 (4.6)
IMD 3rd 13246 1.13 (1.00, 1.27) 672 (5.1)
IMD 4th 13982 1.11 (1.00, 1.25) 694 (5.0)
IMD 5th (most deprived) 15627 1.24 (1.10, 1.38) 852 (5.5)
Surgical
IMD 1st (least deprived) 3054 1.00 (0.99, 1.01) 225 (7.4)
IMD 2nd 3757 1.05 (0.88, 1.25) 287 (7.6)
IMD 3rd 4202 1.10 (0.93, 1.30) 342 (8.1)
IMD 4th 4193 1.25 (1.06, 1.48) 380 (9.1)
IMD 5th (most deprived) 4864 1.28 (1.09, 1.51) 458 (9.4)
.8
1
1.2
1.4
1.6
(B) Death from any cause
IMD quintile
N procedures
SHR (95% CI)
N (%) outcome
Endovascular
IMD 1st (least deprived) 10676 1.00 (0.99, 1.01) 1220 (11.4)
IMD 2nd 12275 1.07 (0.99, 1.15) 1447 (11.8)
IMD 3rd 13246 1.05 (0.97, 1.13) 1493 (11.3)
IMD 4th 13982 1.13 (1.05, 1.22) 1507 (10.8)
IMD 5th (most deprived) 15627 1.17 (1.08, 1.26) 1558 (10.0)
Surgical
IMD 1st (least deprived) 3054 1.00 (0.99, 1.01) 399 (13.1)
IMD 2nd 3757 1.04 (0.91, 1.18) 486 (12.9)
IMD 3rd 4202 0.99 (0.87, 1.13) 507 (12.1)
IMD 4th 4193 1.07 (0.93, 1.22) 481 (11.5)
IMD 5th (most deprived) 4864 1.20 (1.06, 1.37) 584 (12.0)
.8
1
1.2
1.4