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Ethnic differences in lower limb revascularisation and amputation rates. Implications for the aetiopathology of atherosclerosis?☆,☆☆

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ABSTRACT

Objective: Peripheral arterial disease, as a result of atherosclerosis, is the commonest reason for lower limb revascularisation and amputation in England. We describe the prevalence rate of these procedures among the White, South Asian and Black populations living in England and describe the association of ethnicity to amputation, both with and without, revascularisation.
Method: We extracted data from 90 million English hospital admissions between 2003 and 2009 and calculated prevalence rates among 50–84 year olds using census data. Logistic regression demonstrated whether ethnicity was related to amputation, both with and without revascularisation, independent of demographic (age, sex, social class) and disease risk factors (diabetes, hypertension, hypercholesterolaemia, coronary and cerebral vascular disease, smoking).
Results: There were 25 308 amputations and 136 215 revascularisations. The age adjusted prevalence rate for amputation was 26/100 000 and revascularisation 142/100 000. The prevalence ratio (95% confidence intervals) (White British = 100) of amputation in the Asian and Black populations was; 60 (54–66) and 169 (155–183) respectively with revascularisation ratios; 89 (86–92) and 94 (89–98) respectively. South Asians had approximately half the risk of amputation both with and without a revascularisation than Whites despite much higher rates of known atherosclerotic risk factors. The odds of having an amputation without any revascularisation was 63% higher in Blacks but fully attenuated by demographic and disease risk factors.
Conclusion: South Asians experience the lowest rate of both major lower limb amputation and revascularisation in England. The association cannot be explained by demographic or cardiovascular risk factors. This may have implications in the aetiopathology of atherosclerosis.

1. Introduction

Peripheral arterial disease (PAD), as a result of atherosclerosis of the lower limbs, has a prevalence of 15–20% in people over 70 [1,2] with over 70% of the 5000 annual major leg amputations undertaken in England attributable to it [3]. There has been very little research into the prevalence of the disease among the 9 million ethnic minorities living in England [4]. One pilot study into the two main ethnic groups, South Asian (origins from India, Pakistan and Bangladesh) and Black (origins from Africa or the Caribbean) found it to be lower in both at 12% [5].

Internationally, most prevalence studies are from the United States with a recent review highlighting prevalence between 6 and 20% in African Americans, 3 and 13% in Non-Hispanic Whites and 2 and 14% in Hispanics [6]. The only study on people from the Indian Subcontinent determined the prevalence to be 3% [7].

Ethnic differences in coronary heart disease, however, are well recognised with the high rate in South Asians [8] leading to a national strategy in England [9]. Only one study has linked coronary and lower limb revascularisations and found the ratio of the two procedures in England to be 1:1.4 [10]. The ratio was similar rate in Blacks (1:1.1), but much lower in South Asians (1:0.3) [10].

In the absence of accurate epidemiological data describing ethnic differences in peripheral vascular disease, prevalence of procedures used to treat the disease, (analysed in light of coronary heart disease data), may have implications for both the aetiopathology of atherosclerosis and public health. We describe ethnic differences in the prevalence rate of both lower limb amputation and revascularisation among the White, South Asian and Black

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populations aged 50–84 living in England and demonstrate differences that are independent of demographic and disease risk factors.

2. Methods

2.1. Calculation of prevalence rates

Prevalence rates for both amputation and revascularisation procedures used Hospital Episode Statistics (HES) [11] as the numerator with the denominator population derived from the Office National Statistics (ONS) mid year population estimates [12].

The HES database captures every hospital patient encounter in England with approximately 52 million in and outpatient episodes added each year [11]. Information regarding patient demography, risk factors, diagnosis and intervention is collected. A subset of this main database covering in-patient admissions between 1st April 2003 and 31 March 2009 (approximately 90 million episodes) was created.

From this anonymised database, patients aged 50–84 who underwent major lower limb amputation and revascularisation (endovascular and surgical), as defined by the Office of Population, Census and Surveys (OPCS) 4.5 classification [13] (Table 1) were identified. All 10 operative field codes were searched. Demographic and co-morbidity data were then extracted for these patients. Risk factor data based on ICD-10 classification were extracted from all 20 fields. The risk factors extracted were diabetes (E10–E14), hypertension (I10–I13), hypercholesterolaemia (E14), coronary heart disease (I20–I25), cerebrovascular disease and transient ischaemic attack (I63–I67 and G45), and smoking (F17, Z72).

Social class was defined using the Indices of Multiple Deprivation (IMD) score [14]. This scoring system is based on 37 indicators grouped into 7 domains (income, employment, health deprivation and disability, education skills and training, barriers to housing and services, crime, and living environment). Areas were then grouped into quintiles from 'most deprived' to least deprived'. The index is based on an area covering approximately 400 households and 1000 people.

Crude rates were calculated using the combined number of procedures over the six year period as the numerator with the denominator derived by combining the mid year population estimates between 2003 and 2008. 95% Confidence intervals were based on 5 year age bands with the overall rate age standardised to the England and Wales 2001 population using standard techniques [15]. Rates for each ethnic group were similarly calculated with minority rates expressed as a ratio (prevalence ratio) of the White British group.

Table 1
Procedure codes used to extract amputation and revascularisations procedures from National Hospital Data.

Procedure	Area	Code	Description
Amputation	Leg	X09	All leg amputations (above ankle)
Endovascular	Aorta	L26	Percutaneous angioplasty/ stent of aorta
	Iliac	L54	Percutaneous angioplasty/ stent of Iliac artery
	Femoral	L63	Percutaneous angioplasty/ stent of femoral/popliteal artery
	Other	L66	Other therapeutic transluminal operations/stent on artery
Surgery	Iliac	L51	Bypass of iliac artery (vein or prosthesis)
		L52	Reconstruction of iliac artery (endarterectomy)
	Femoral	L59	Bypass of femoral artery (vein or prosthesis)
		L60	Reconstruction of femoral artery (endarterectomy)

2.2. Ethnic group classification

Ethnicity coding in HES is self defined by patients on admission and is currently around 80% complete [16]. We analysed data from 2003 onwards because the change in ethnicity classification that accompanied the 2001 census (compared to the 1991 census) led, in the initial years, to classification inconsistency. We combined certain ethnic groups into their parent category to increase numbers e.g. 'Indian', 'Pakistani', 'Bangladeshi' and 'Asian Other' were combined into 'All Asian'. 'Black African', 'Black Caribbean' and 'Black Other' were combined into 'All Black'. Where numbers allowed, results for component ethnic groups have been presented.

2.3. Linkage of procedures and calculation of odds ratios

The amputation and revascularisation procedures (Table 1) were linked to determine exposure to vascular services. The outcome variables, 'amputation with revascularisation' was created if both procedures occurred within the same 6 year time frame in patients with the same unique HES identifier and ethnic group. Where linkage was not possible 'amputation without revascularisation' was assigned. To improve linkage we used 2 rather than 4 digit intervention codes although this potentially led to amputation procedures being linked to investigation rather than solely revascularisation procedures. However, as investigations for PAD are mainly performed as outpatients therefore not generating a hospital admission, we believe our linkage is more reflective of revascularisation.

Logistic regression was then used to identify predictors of these dichotomous outcomes using SPSS [17]. The odds of ethnicity demonstrating a relationship was performed unadjusted and repeated after controlling for demographic (age, sex, social class) and disease risk factors (diabetes, coronary heart disease, cerebrovascular disease, hypercholesterolaemia and smoking), by the forward stepwise selection method.

3. Results

There were 25 308 major lower limb amputations (males 17 341, females 7967) and 136 215 revascularisations (males 90 693, females 45 522) performed between April 2003 and March

Table 2
Number of major lower limb amputations and revascularisation; males and females; England: 2003–2009.

Ethnic group	Number procedures amputation		Number procedures revascularisation	
	Males	Females	Males	Females
All Asian[a]	225	77	1781	617
Indian	141	43	840	310
Pakistani	51	19	517	174
All Black[b]	258	172	817	508
African	178	126	545	329
Caribbean	38	29	144	98
Missing Ethnicity	2501 (14%)	1240 (16%)	15 100 (17%)	7702 (17%)
White British	13 496	6109	67 777	34 141
England	17 341	7967	90 693	45 522

[a] Includes Bangladeshi and 'Asian Other'.
[b] Includes 'Black Other'.

Table 3
Age adjusted prevalence rate of major lower limb amputations and revascularisation; males and females; England: 2003–2009.

Ethnic group	Amputation prevalence rate (95% confidence intervals)		Revascularisation prevalence rate (95% confidence intervals)	
	Males	Females	Males	Females
All Asian[a]	18.8 (16.2–21.3)	7.4 (5.6–9.3)	145.3 (138.3–152.3)	57.1 (52.2–62.0)
Indian	21.8 (18.1–25.5)	7.7 (5.1–10.2)	128.6 (119.6–137.7)	50.1 (44.1–56.1)
Pakistani	17.5 (12.5–22.5)	6.9 (3.4–10.4)	167.5 (152.6–182.4)	66.6 (55.6–77.6)
All Black[b]	42.7 (37.3–48.0)	32.3 (26.7–37.8)	132.6 (123.3–141.9)	83.9 (76.0–91.8)
African	23.8 (15.8–31.9)	25.3 (14.8–35.9)	99.5 (81.5–117.6)	63.5 (48.0–79.1)
Caribbean	40.4 (34.2–46.6)	31.8 (25.8–37.7)	122.2 (111.6–132.9)	75.9 (67.2–84.5)
White British	32.1 (31.5–32.6)	13.2 (12.9–13.5)	161.6 (160.4–162.8)	74.3 (73.5–75.1)
England	37.7 (37.1–38.2)	15.9 (15.5–16.2)	197.4 (196.1–198.7)	90.7 (89.9–91.5)

[a] Includes Bangladeshi and 'Asian Other'.
[b] Includes 'Black Other'.

2009 (Table 2). Table 3 shows the overall prevalence rate for amputations to be 26/100 000 (males 37.7, females 15.9) and revascularisations 142/100 000 (males 197.4, females 90.7). Compared with the White British group, Blacks had higher and Asians lower rates of amputation with revascularisation rates lower in both groups (Table 3). Proportional prevalence differences are illustrated in Fig. 1.

There was some evidence of heterogeneity within ethnic groups with Black Caribbeans demonstrating higher rates of both amputation and revascularisation than Black Africans with Indians having higher amputation and lower revascularisation rates than Pakistanis. Ethnic classification was, however, missing overall in 15% of amputations and 17% of revascularisations.

The combined male and female proportional prevalence of amputation was 69% higher in Blacks and 40% lower in Asians compared with their White British counterparts with revascularisation rates significantly lower in both groups (Fig. 1).

The unadjusted and adjusted odds ratio of each ethnic group, relative to the majority white population, having an 'amputation without any revascularisation' and 'amputation with any revascularisation' is shown in Table 4.

The odds of having an amputation without a revascularisation was significantly higher in Blacks (63%) but fully attenuated after controlling demographic and disease risk factors. The odds of having an amputation with a revascularisation was again significantly higher in Blacks (83% higher) but not fully attenuated by demographic and disease risk factors. The odds of both outcomes were approximately half in Asians and are independent of demographic and disease risk factors.

4. Discussion

Our overall prevalence rates, allowing for differences in definition and age group, are broadly in line with the National Amputee Statistical Database [3] and McCaslin et al. [18]. We have found that ethnic differences exist in lower limb amputation and revascularisation rates with South Asians experiencing the lowest rates that are independent of demographic and disease risk factors.

There were also significant gender differences across all ethnic groups as the rate of amputation and revascularisation was approximately double in males compared with females. The prevalence of peripheral arterial disease in males and females was not significantly different in the Edinburgh Arterial Study [19] although the Framingham Heart Study [20] has suggested that men have nearly double the risk of developing intermittent claudication compared with women. These highlighted sex differences, although not explaining ethnic differences are of public health importance and require further investigation.

4.1. South Asians

These are people of 'Indian', 'Pakistani', 'Bangladeshi', or 'Asian other' origin. They are known to have a greater incidence [21], prevalence [22] and mortality [23] from coronary heart disease which appear to be related to greater levels of atherosclerosis risk factors, particularly diabetes [8]. Our much lower levels of PAD interventions in this group are therefore surprising but may be explained by variations in the profile of either patients or the disease.

Asians are generally younger than the majority population with the proportion aged 50 and over only 15% (Whites 37%) [24]. The competing risk of coronary heart disease and potential higher mortality may explain lower PAD in this ethnic group. However, recent Scottish data suggest incidence of Myocardial Infarction although higher in South Asians, particularly Pakistanis, does not translate into higher rates of mortality [25]. The higher coronary rates occurring within a younger demographic may potentially increase the time on disease modifying drugs e.g. statins. Lower rates of intervention may also be a result of disparities in service utilisation as has been found in coronary heart disease revascularisation [26]. Lower rates of intervention and amputation may also result from the 'salmon effect'. This is when the elderly first generation return to their home country in their retirement resulting in these diagnoses and outcomes not showing up in UK statistics [27].

Evidence for a difference in presentation of atherosclerosis is limited. Chaturvedi et al. showed that for a given level of coronary artery calcification, Asians had less femoral artery calcification than

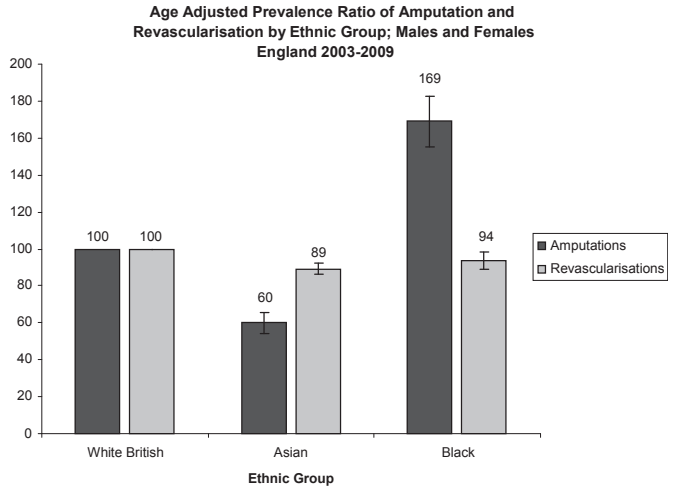

Fig. 1. Prevalence ratio* of lower limb amputation and revascularisation by ethnic group; England 2003–2009. *Relative to the majority White British group (100).

Table 4
Odds ratio (unadjusted and adjusted) for an amputation with and without revascularisation relative to the White British population.

Procedure group	Ethnic group	Odds ratio (95% confidence intervals)		
		Unadjusted	Adjusted for demography[a]	Adjusted for demographic and disease risk factors[b]
Amputation without any lower limb revascularisation	Asian	0.68 (0.59–0.78)	0.68 (0.59–0.79)	0.54 (0.46–0.62)
	Black	1.63 (1.43–1.85)	1.45 (1.27–1.66)	1.07 (0.93–1.23)
Amputation with any lower limb revascularisation	Asian	0.54 (0.43–0.68)	0.54 (0.43–0.68)	0.46 (0.36–0.58)
	Black	1.83 (1.54–2.17)	1.67 (1.40–1.99)	1.35 (1.13–1.61)

[a] Age, sex, social class (defined by IMD quintile).
[b] Diabetes, hypertension, hypercholesterolaemia, coronary heart disease, stroke/TIA and smoking.

Whites [28]. Lower levels of PAD have also been used to explain fewer diabetes related amputations [29] Chow et al. showed that hypercholesterolaemia and diabetes were particularly associated with carotid atherosclerosis in Asians than Australian Whites with the protective effect of HDL not apparent in Asians [30].

4.2. Black

This population is self defined as 'Black African', 'Black Caribbean', and 'Black Other'. Our study has shown this group to have disproportionately high rates of major leg amputation with lower rates of revascularisation than the White and South Asian populations. This is especially true of Black women where rates of amputation are 2.4 times greater than White British women. Earlier UK studies, combined the African and Caribbean populations and determined the prevalence of diabetes related lower extremity amputation to be lower than Europeans with a relative risk of 0.67 [31]. These lower rates may result from improved pockets of local services within the National Health Service. The higher odds of primary amputation were fully attenuated by demographic and disease risk factors whereas the odds of having an amputation with a revascularisation remained significantly higher than the White population. More failed revascularisations may be a result of more aggressive poplitaeal trifurcation disease [32].

Most data regarding Black and White differences come from the United States and are not directly comparable with the UK as definitions of Black and White have not been given. This is a common theme in much comparative ethnic health research [27]. However, important differences have been found which are consistent with our results.

Resnick et al. [33] measured incidence of amputations by following up a cohort of the National Health and Nutrition Examination Survey between 1971 and 1992. They found the age adjusted proportional incidence of all lower extremity amputations in Blacks compared to Whites to be higher at 2.78. However, the higher rates were attenuated by controlling for education, hypertension and smoking, suggesting the higher rates are not related to ethnicity. This is in contrast to Collins et al. [34] who found race was an independent predictor for amputation in patients with peripheral vascular disease after controlling for diabetes although they did not control for social factors. Criqui et al. [35] also found Black ethnicity was a strong and independent risk factor of peripheral vascular disease after controlling for diabetes, hypertension and body mass index (again not demographic factors), where the odds ratio in relation to the Non Hispanic White population was 2.34.

4.3. Data validity

15% of data had the ethnicity classification missing with the completed ethnic classification not tested for validity. However, when linking amputation and revascularisation procedures, our linkage code only worked when both procedures had the same ethnic group. Our definition of 'all major leg amputations' also included those not related to peripheral vascular disease e.g. trauma and cancer although these numbers were small (approximately 5%) [3]. We chose the 50–84 year age group as people under 50 are more likely to have a lower limb amputation due to non peripheral arterial related causes (e.g. trauma), and those over 84 are more likely to have an amputation without revascularisation [3]. Morbidity coding in HES has not been formally investigated, however, our own on going audit has shown no significant difference between local hospital and HES coding except for smoking and hypercholesterolaemia [36]. Other risk factors not actively coded from hospital discharge records may be responsible for ethnic differences e.g. hyperhomocysteinaemia, lipoprotein a, increased platelet activity and hypercoagulability [6]. Finally, although we performed our logistic regression analysis on a large dataset and in layers i.e. unadjusted and then controlled for demographic and finally demographic and disease risk factors, our use of the forward stepwise selection method, although widely used, has its criticisms [37]. This is a potential source of bias as its predictive ability has sensitivity and specificity impaired as it ignores covariate exposure associates [37].

4.4. Conclusions and implications of findings

We have demonstrated significant differences in lower limb amputation and revascularisation rates among the White, South Asian and Black populations living in England. The higher rate in the Black population is explained by demographic and disease factors whereas South Asians experience much lower rates which are independent of these causes. The low rate of PAD interventions in South Asians in the context of high rates of atherosclerotic risk factors and coronary interventions may imply atherosclerosis preferentially affects the coronary arteries of South Asians. Further study, including a long term incidence study into the development of atherosclerotic disease across ethnic groups living in England may help explore the issue further.

Conflicts of interest

None declared.

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