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ORIGINAL ARTICLE

Racial, Socioeconomic, and Geographic Disparities in Preamputation Vascular Care for Patients With Chronic Limb-Threatening Ischemia

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BACKGROUND: Black patients, those with low socioeconomic status (SES), and those living in rural areas have elevated rates of major lower extremity amputation, which may be related to a lack of subspecialty chronic limb-threatening ischemia care. We evaluated the association between race, rurality, SES, and preamputation vascular care.

METHODS: Among patients aged 66 to 86 years with fee-for-service Medicare who underwent major lower extremity amputation for chronic limb-threatening ischemia from July 2010 to December 2019, we compared the proportion who received vascular care in the 12 months before amputation by race (Black versus White), rurality, and SES (dual eligibility for Medicaid versus no dual eligibility) using multivariable logistic regression adjusting for clinical and demographic covariates.

RESULTS: Among 73 237 patients who underwent major lower extremity amputation, 40 320 (55.1%) had an outpatient vascular subspecialist visit, 60 109 (82.1%) had lower extremity arterial testing, and 28 345 (38.7%) underwent lower extremity revascularization in the year before amputation. Black patients were less likely to have an outpatient vascular specialist visit (adjusted odds ratio [adjOR], 0.87 [95% CI, 0.84–0.90]) or revascularization (adjOR, 0.90 [95% CI, 0.86–0.93]) than White patients. Compared with patients without low SES or residing in urban areas, patients with low SES or residing in rural areas were less likely to have an outpatient vascular specialist visit (adjOR, 0.62 [95% CI, 0.60–0.64]; low SES versus nonlow SES; adjOR, 0.82 [95% CI, 0.79–0.85]; rural versus urban), lower extremity arterial testing (adjOR, 0.78 [95% CI, 0.75–0.81]; low SES versus nonlow SES; adjOR, 0.90 [95% CI, 0.0.86–0.94]; rural versus urban), or revascularization (adjOR, 0.65 [95% CI, 0.63–0.67]; low SES versus nonlow SES; adjOR, 0.89 [95% CI, 0.86–0.93]; rural versus urban).

CONCLUSIONS: Black race, rural residence, and low SES are associated with failure to receive subspecialty chronic limb-threatening ischemia care before amputation. To reduce disparities in amputation, multilevel interventions to facilitate equitable chronic limb-threatening ischemia care are needed.

Key Words: amputation, surgical ■ chronic limb-threatening ischemia ■ health services accessibility ■ healthcare disparities ■ peripheral arterial disease

Peripheral artery disease (PAD), defined as partial or complete occlusion of at least 1 major peripheral artery by atherosclerotic vascular disease, affects 10% to 20% of older adults worldwide.[1–3] As a disease process caused by the accumulation of atherosclerotic plaque, PAD progresses slowly over many years, with numerous opportunities to slow its progression through the management of vascular risk factors.[4,5] Chronic limb-threatening ischemia (CLTI) is a late-stage complication of PAD and is characterized by rest pain, nonhealing

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WHAT IS KNOWN

- Black patients, those with low socioeconomic status, and those residing in rural areas are more likely to undergo major lower extremity amputation.
- Many patients with chronic limb-threatening ischemia, for whom subspecialty vascular care could prevent major lower extremity amputation, do not receive subspecialty vascular care in the year before amputation.

WHAT THE STUDY ADDS

- Black patients are less likely than White patients to see a primary care provider or vascular specialist and less likely to undergo lower extremity revascularization in the year before major lower extremity amputation.
- Patients living in rural areas and those with low socioeconomic status are less likely than those living in urban areas or without low socioeconomic status to see a primary care provider or vascular specialist, undergo lower extremity arterial testing, or undergo lower extremity revascularization in the year before major lower extremity amputation.
- Median times from lower extremity arterial testing and chronic limb-threatening ischemia diagnosis to amputation were shorter for Black patients, those living in rural areas, and those with low socioeconomic status.

Nonstandard Abbreviations and Acronyms

CLTI	chronic limb-threatening ischemia
ICD-9	*International Classification of Diseases, Ninth Edition*
ICD-10	*International Classification of Diseases, Tenth Edition*
PAD	peripheral artery disease
PCP	primary care provider
RUCC	Rural-Urban Continuum Code
SES	socioeconomic status

wounds, gangrene, and a high risk for major lower extremity amputation.[6–9] The cornerstone of treatment for CLTI is lower extremity revascularization to reperfuse the foot and lower the risk of amputation.[10] However, pathways for diagnosis and management of CLTI are complex: before undergoing revascularization, a patient with CLTI usually must see a primary care provider (PCP), be referred to a vascular subspecialist, and undergo invasive or noninvasive vascular testing to confirm the presence of PAD and CLTI. As a result, many patients are diagnosed with CLTI at an advanced stage with limited or no options for limb salvage and undergo amputation without an attempt at revascularization.[11,12] With preamputation vascular care and earlier diagnosis, many of these amputations could be prevented.

Gaps in CLTI management may be further widened by racial and socioeconomic inequities, and non-White patients, those residing in rural areas, and those with low socioeconomic status (SES) have disproportionately lower rates of limb salvage and higher rates of major amputation.[13–16] To determine whether these groups are less likely to receive subspecialty vascular care, we used a large cohort of fee-for-service Medicare beneficiaries with CLTI who ultimately underwent major lower extremity amputation to describe the extent to which rates of PAD care in the year before amputation differed by race, rurality, and SES. In addition to preamputation revascularization, we specifically examined disparities in preamputation PCP visits, outpatient vascular subspecialist visits, and lower extremity arterial testing. We focused on care in the year before amputation because it is likely that there was some opportunity to intervene in this window and prevent the amputation. Amputations without vascular care in the year prior, therefore, represent amputations potentially preventable by better design of systems of CLTI care, and disparities in preamputation vascular care represent potentially modifiable targets for improving disparities in PAD outcomes.

METHODS

This study was determined to be exempt from review by the institutional review board at the University of Pennsylvania because deidentified patient information was used in the analysis. Consent was not obtained from individual patients, given the use of an administrative dataset. Data used for this study are covered by a data use agreement with the Centers for Medicare & Medicaid Services. Data are not available for distribution by the authors but can be obtained from the Centers for Medicare & Medicaid Services with an approved data use agreement.

Data Source and Patient Population

We assembled a cohort of fee-for-service Medicare patients with CLTI using inpatient and outpatient Medicare claims data (ie, the Chronic Limb Threatening Ischemia Process Performance cohort) as we have previously described.[9] Briefly, we identified a cohort of individuals aged between 66 and 86 years with the *International Classification of Diseases, Ninth Edition* (*ICD-9*) or *International Classification of Diseases, Tenth Edition* (*ICD-10*) diagnosis codes consistent with CLTI between July 1, 2010, and December 31, 2019. The coding scheme for identifying CLTI was based on an algorithm that used *ICD-9* codes and had 75% sensitivity compared with a gold standard of chart review and a kappa value of 0.80.[17] Because publicly available tools for translating *ICD-9* codes to *ICD-10* may not be fully accurate,[18] we manually reviewed *ICD-9* and *ICD-10* codes. The lower age limit was chosen to allow at least a 6-month administrative data lookback to identify relevant comorbidities because Medicare becomes universal at the age of 65 years; the upper age limit was chosen to exclude patients in whom

age and frailty might significantly influence the decision to offer revascularization.

We then used *ICD-9* and *ICD-10* diagnosis codes and Current Procedural Terminology codes to identify patients in the cohort who underwent major lower extremity amputation, defined as amputation above the ankle (see Table S1 for codes used to identify diagnostic and therapeutic procedures).[9] Toe and forefoot amputations were excluded. For patients with multiple major amputations during the study period, we defined the index as the earliest amputation. As we were focused on the use of diagnostic and therapeutic procedures in the 12 months before amputation, we required continuous enrollment in fee-for-service Medicare for 12 months before the index amputation.

Outcomes

Elements of preamputation PAD care were outpatient PCP visits, outpatient vascular subspecialist visits, lower extremity arterial testing, and revascularization in the 12 months before major lower extremity amputation. Outpatient encounters were defined based on Healthcare Common Procedure Coding System codes 99201 to 99215. Visits with PCPs were defined as those with Medicare physician specialty codes 01 (general practice), 08 (family practice), 11 (internal medicine), and 38 (geriatric medicine). Visits with vascular subspecialists were defined as those with Medicare physician specialty codes 06 (cardiology), 94 (interventional radiology), 76 (peripheral vascular disease), and 77 (vascular surgery).[11] Arterial testing was defined using Current Procedural Terminology codes for ankle-brachial index, arterial duplex ultrasound, computed tomographic angiography, invasive angiography, magnetic resonance angiography, and endovascular revascularization as previously described.[9] Endovascular revascularization was included as a test for PAD since some patients may have undergone diagnostic angiography followed by ad hoc revascularization, and administrative claims may not have captured the diagnostic angiography procedure. Revascularization included both endovascular and surgical procedures and was defined using *ICD-9*, *ICD-10*, and Current Procedural Terminology codes, as previously described.[9]

Independent Variables

Race was captured from Medicare denominator files. Because Medicare's enrollment race and ethnicity data are less accurate for beneficiaries identified as American Indian/Alaska Native, Asian/Pacific Islander, or Hispanic,[19] analyses focused on comparisons between Black and White patients. Patients with low SES were defined as those with dual eligibility for Medicare and Medicaid, a strong marker of poverty and a proxy for social risk.[20] Rural/urban residence was defined using Rural-Urban Continuum Codes (RUCCs): individuals living in ZIP codes classified as RUCCs 1, 2, and 3 were defined as living in urban areas, and those living in ZIP codes classified as RUCCs 4–9 were defined as living in rural areas. In 2 separate sensitivity analyses, we (1) defined ZIP codes classified as RUCCs 5–9 as rural and RUCCs 1–4 as urban and (2) used the Rural-Urban Commuter Area classifications, defining rural ZIP codes as those eligible for Rural Health Grants from the Federal Office of Rural Health Policies.[21] Other demographic and clinical comorbidities were captured from Medicare data, as previously described.[9] Given how variables were defined, no data elements were missing.

Statistical Analysis

We first described the baseline characteristics of our overall study cohort by whether or not they had a PCP visit, vascular subspecialist visit, lower extremity arterial testing, or revascularization in the year before amputation. Categorical variables were reported as frequencies with percentages and compared using χ^2 tests, while continuous variables were reported as means with standard deviations and compared using *t* tests.

We then determined the raw proportion of patients who had a PCP visit, outpatient vascular subspecialist visit, lower extremity arterial testing, and revascularization in the year before amputation overall and compared these proportions by race (White versus Black), SES (dual eligible for Medicare/Medicaid versus not dual eligible), rurality (urban versus rural), and comorbidities (PAD alone, PAD plus chronic kidney disease, PAD plus diabetes, and PAD plus chronic kidney disease and diabetes) using *Z* tests. We described the median time from patients' first lower extremity imaging test to amputation and the median time from patients' CLTI diagnosis to amputation by race, rurality, and SES and compared them using Wilcoxon signed-rank tests.

Multivariable logistic regression was then used to identify adjusted associations between race, SES, rural residence, and preamputation vascular care. We included the following variables in our multivariable models: age, gender, race, year of CLTI diagnosis, SES, rural versus urban residence, US geographic region, weighted Elixhauser comorbidity score, and relevant comorbidities, including congestive heart failure, hypertension, diabetes with and without complications, renal failure, hyperlipidemia, coronary artery disease, cerebrovascular disease, and tobacco use. We report odds ratios and 95% CIs, which represent the adjusted odds of having preamputation vascular care, with values <1 indicating lower odds of undergoing preamputation vascular care. To examine the interactions between race, rurality, and SES, we repeated these models separately in patients from rural and urban areas, patients with and without low SES, and White and Black patients.

To see whether racial and socioeconomic inequities existed even in major metropolitan areas, where patients have close geographic proximity to vascular specialists, we repeated these multivariable analyses among patients living in core-based statistical areas with over 1 million inhabitants (n=56). For these analyses, we used generalized estimating equations to account for clustering at the core-based statistical areas level. To confirm the extent to which patients living in these areas had access to vascular care, we calculated the proportion of all-cause hospital admissions for Medicare beneficiaries living in each ZIP code that went to hospitals that offered lower extremity endovascular revascularization and reported summary statistics at the ZIP code level.

Because our outcomes of preamputation vascular care in the 12 months before amputation could capture revascularization procedures or lower extremity arterial testing performed very shortly before amputation and too late to avert the amputation or amputations caused by complications of a revascularization procedure, we performed sensitivity analyses excluding lower extremity arterial testing or revascularization procedures performed 1 or 2 weeks before the amputation.

All *P* values were 2-sided, and $\alpha<0.05$ was defined as statistically significant. All analyses were completed using SAS, version 9.4.

RESULTS

Among 1 999 924 patients aged between 66 and 86 years with *ICD-9* or *ICD-10* codes consistent with CLTI during the study period, 73 237 (3.7%) underwent major lower extremity amputation and were included in the study population. Of these patients, 20 654 (28.2%) were Black, 16 928 (23.1%) lived in rural areas, and 33 225 (45.4%) had dual eligibility for Medicare and Medicaid at the time of their amputation and were defined as low SES. The mean (±SD) age was 75.4±6.0 years; 29 200 patients (39.9%) were female. Clinical and demographic characteristics of the overall patient population and the subgroups who did and did not have preamputation vascular care are shown in Table 1 and Table S2.

Compared with White patients and those without low SES, Black patients and those with low SES who ultimately underwent amputation were more likely to have Rutherford class 6 CLTI at the time of their initial diagnosis (39.7% versus 31.5% for Black versus White; *P*<0.001; 36.7% versus 32.5% for low SES versus nonlow SES; *P*<0.001); there was no significant difference in CLTI severity at presentation for patients residing in rural versus urban areas (35.2% versus 34.2%; *P*=0.05).

Rates of Preamputation Vascular Care

Overall, 43 657 (59.6%) patients had a PCP visit in the year before amputation, 40 320 (55.1%) had an outpatient vascular subspecialist visit, 60 109 (82.1%) had lower extremity arterial testing, and 28 345 (38.7%) underwent lower extremity revascularization (Figure 1). Most vascular subspecialist visits were with cardiologists or vascular surgeons; in the year before amputation, 24 899 patients (34.0%) had a cardiologist visit, 25 936 (35.4%) had a vascular surgeon visit, 702 (1.0%) had an interventional radiology visit, and 378 (0.5%) had a vascular medicine visit. When we excluded lower extremity arterial tests and revascularizations performed in the 2 weeks before amputation, 50 066 (68.4%) underwent

Table 1. Clinical and Demographic Characteristics of Patients With Lower Extremity Amputation Overall and Among Those Who Did and Did Not Undergo Preamputation Outpatient Vascular Subspecialist Visit and Revascularization

Variable	Overall	Vascular specialist visit			Revascularization		
		No (n=32 917)	Yes (n=40 320)	*P* value	No (n=44 892)	Yes (n=28 345)	*P* value
Age, y	75.4 (6.0)	75.1 (6.0)	75.6 (6.0)	<0.0001	75.5 (6.1)	75.2 (6.0)	<0.0001
Female	29 200 (39.9)	13 276 (40.3)	15 924 (39.5)	0.02	17 555 (39.1)	11 645 (41.1)	<0.0001
Race				<0.0001			<0.0001
White	47 746 (65.2)	20 437 (62.1)	27 309 (67.7)		28 624 (63.8)	19 122 (67.5)	
Black	20 654 (28.2)	10 177 (30.9)	10 477 (26.0)		13 499 (30.1)	7155 (25.2)	
Hispanic	2151 (2.9)	1008 (3.1)	1143 (2.8)		1204 (2.7)	947 (3.3)	
Other/unknown	2686 (3.7)	1295 (3.9)	1391 (3.4)		1565 (3.5)	1121 (4.0)	
Urban	56 309 (76.9)	24 443 (74.3)	31 866 (79.0)	<0.0001	34 134 (76.0)	22 175 (78.2)	<0.0001
Low SES	33 225 (45.4)	17 063 (51.8)	16 162 (40.1)	<0.0001	22 104 (49.2)	11 121 (39.2)	<0.0001
Region				<0.0001			<0.0001
Midwest	14 872 (20.3)	6620 (20.1)	8252 (20.5)		8955 (19.9)	5917 (20.9)	
Northeast	12 835 (17.5)	5078 (15.4)	7757 (19.2)		8020 (17.9)	4815 (17.0)	
South	36 084 (49.3)	16 896 (51.3)	19 188 (47.6)		22 429 (50.0)	13 655 (48.2)	
West	9446 (12.9)	4323 (13.1)	5123 (12.7)		5488 (12.2)	3958 (14.0)	
Heart failure	45 571 (62.2)	18 032 (54.8)	27 539 (68.3)	<0.0001	27 335 (60.9)	18 236 (64.3)	<0.0001
Hypertension	71 405 (97.5)	31 466 (95.6)	39 939 (99.1)	<0.0001	43 350 (96.6)	28 055 (99.0)	<0.0001
Diabetes	54 954 (75.0)	23 594 (71.7)	31 360 (77.8)	<0.0001	33 348 (74.3)	21 606 (76.2)	<0.0001
Diabetes with complication	51 899 (70.9)	22 169 (67.3)	29 730 (73.7)	<0.0001	31 343 (69.8)	20 556 (72.5)	<0.0001
Renal failure	45 531 (62.2)	18 515 (56.2)	27 016 (67.0)	<0.0001	27 249 (60.7)	18 282 (64.5)	<0.0001
Hyperlipidemia	62 077 (84.8)	25 127 (76.3)	36 950 (91.6)	<0.0001	36 124 (80.5)	25 953 (91.6)	<0.0001
Ischemic heart disease	57 045 (77.9)	22 335 (67.9)	34 710 (86.1)	<0.0001	32 943 (73.4)	24 102 (85.0)	<0.0001
Cerebrovascular disease	54 956 (75.0)	23 119 (70.2)	31 837 (79.0)	<0.0001	32 255 (71.9)	22 701 (80.1)	<0.0001
Tobacco abuse	25 153 (34.3)	10 972 (33.3)	14 181 (35.2)	<0.0001	13 567 (30.2)	11 586 (40.9)	<0.0001
Elixhauser comorbidity score	21.9 (11.2)	20.8 (11.2)	22.7 (11.1)	<0.0001	21.7 (11.2)	22.1 (11.1)	<0.0001

SES indicates socioeconomic status.

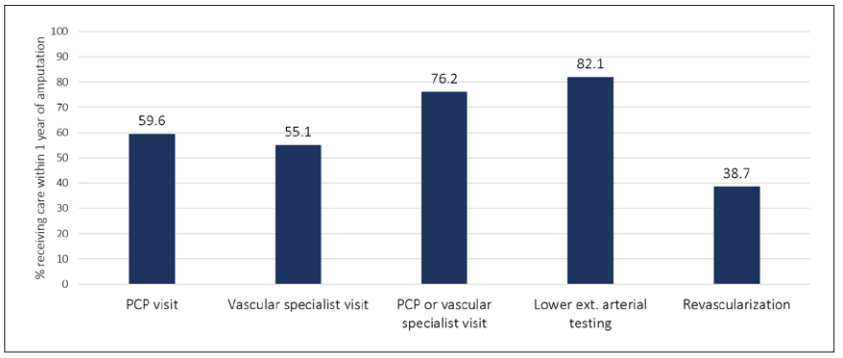

Figure 1. Unadjusted rates of vascular care in the year before amputation. Among fee-for-service Medicare patients with chronic limb-threatening ischemia, 40% did not have a primary care provider (PCP) visit, 55% did not have a vascular subspecialist visit, 18% did not have a lower extremity (ext.) arterial test, and 63% did not undergo revascularization in the year before major lower ext. amputation.

lower extremity arterial testing and 24 401 (33.3%) underwent revascularization.

In the year before amputation, Black patients were less likely to have a PCP visit, outpatient vascular specialist visit, PCP, or vascular specialist visit or undergo revascularization than White patients ($P<0.001$ for all comparisons; Figure 2A); much of the difference in vascular subspecialty visits was driven by fewer cardiologist visits (27.8% versus 36.8% of Black and White patients had a cardiologist appointment; $P<0.001$; 34.4% versus 36.3% had a vascular surgeon visit; $P<0.001$; Table S3). There were no significant differences between Black and White patients in the rate of preamputation lower extremity arterial testing; however, the median time from the first lower extremity arterial test to amputation was shorter for Black versus White patients (92 versus 109 days; $P<0.0001$), as was median time from CLTI diagnosis to amputation (92 versus 134 days; $P<0.0001$). Compared with patients residing in urban areas, patients residing in rural areas were less likely to have a PCP visit, outpatient vascular specialist visit, PCP or vascular specialist visit, lower extremity arterial testing, and revascularization in the year before amputation (Figure 2B); much of the difference in vascular subspecialty visits was driven by fewer vascular surgeon visits (29.8% versus 37.1% of patients residing in rural versus urban areas had a vascular surgeon visit; $P<0.001$; 31.1% versus 34.9% had a cardiologist visit; $P<0.001$). The median time from the first lower extremity arterial test to amputation was shorter for patients living in rural versus urban areas (90 versus 108 days; $P<0.0001$), as was the median time from CLTI diagnosis to amputation (92 versus 129 days; $P<0.0001$). Findings were similar when we used alternative definitions to define rural areas (Table S4). Compared with patients who were not dual eligible for Medicare and Medicaid, patients with low SES were less likely to have a PCP visit, outpatient vascular specialist visit, PCP or vascular specialist visit, lower extremity arterial testing, or revascularization in the year before amputation ($P<0.001$ for all comparisons; Figure 2C). The median time from the first lower extremity arterial test to amputation was shorter in patients with low SES (94 versus 112 days; $P<0.0001$), as was the median time from CLTI diagnosis to amputation (108 versus 131 days; $P<0.0001$). Patients with low SES were substantially less likely than patients without low SES to have both vascular surgeon (31.9% versus 38.3%; $P<0.001$) and cardiologist (26.7% versus 40.1%; $P<0.001$) visits in the year before amputation.

Compared with patients who did not have diabetes or chronic kidney disease, patients with diabetes, chronic kidney disease, or both of these comorbidities were more likely to have a PCP visit, outpatient vascular specialist visit, PCP or vascular specialist visit, lower extremity arterial testing, or revascularization in the year before amputation ($P<0.001$ for all comparisons; Figure 2D).

Rates of Preamputation Vascular Care Adjusted for Clinical and Demographic Characteristics

After adjustment for clinical and demographic characteristics (including SES and rural/urban residence), Black race remained significantly associated with lower odds of preamputation PCP visit, vascular subspecialist visit, and revascularization but not lower extremity arterial testing (Table 2). Similarly, rural residence remained significantly associated with lower odds of preamputation PCP visits, outpatient vascular subspecialist visits, lower extremity arterial testing, and revascularization after adjustment for clinical and demographic characteristics including race and SES. Findings were similar regardless of which rural definition was used (Table S5). Low SES was also associated with significantly lower odds of all 4 preamputation vascular care parameters.

We report the associations between race and SES separately among patients from rural and urban areas, rurality and race separately among patients with low and nonlow SES, and rurality and SES separately among Black and White patients in Tables S6 through S8. Results were generally consistent for patients from rural and urban areas, patients with and without low SES, and Black and White patients.

Results were similar in sensitivity analyses excluding lower extremity arterial testing and revascularizations performed within 1 and 2 weeks of major lower extremity amputation (Tables S9 and S10).

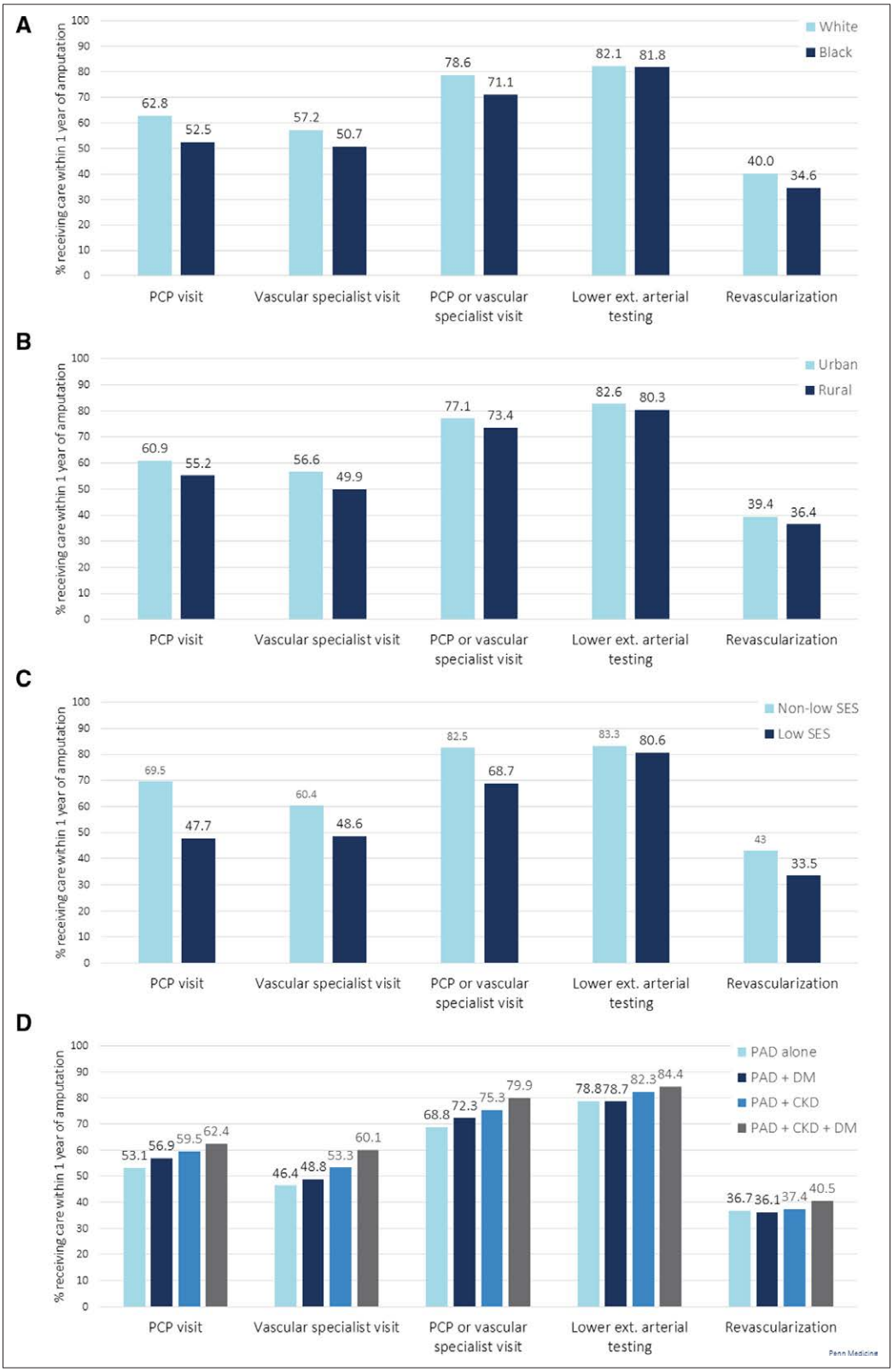

Figure 2. Unadjusted rates of preamputation vascular care by race, rurality, socioeconomic status (SES), and comorbidities. Unadjusted rates of preamputation vascular care by (**A**) race, (**B**) rurality, (**C**) SES (with low SES defined as dual eligibility for Medicaid), and (**D**) comorbidities (presence or absence of chronic kidney disease and diabetes [DM]). Black patients, rural patients, and those with low SES were less likely to have preamputation vascular care. CKD indicates chronic kidney disease; ext., extremity; PAD, peripheral artery disease; and PCP, primary care provider.

Table 2. Adjusted Association Between Race, Rural/Urban Residence, SES, and Preamputation Vascular Care

Comparison	Odds ratio (95% CI)	*P* value
Black (vs White)		
PCP visit	0.76 (0.73–0.78)	<0.0001
Outpatient vascular specialist visit	0.87 (0.84–0.90)	<0.0001
PCP or outpatient vascular specialist visit	0.78 (0.74–0.81)	<0.0001
Lower extremity arterial testing	1.03 (0.99–1.08)	0.18
Revascularization	0.90 (0.86–0.93)	<0.0001
Rural (vs urban)		
PCP visit	0.79 (0.76–0.82)	<0.0001
Outpatient vascular specialist visit	0.82 (0.79–0.85)	<0.0001
PCP or outpatient vascular specialist visit	0.85 (0.82–0.89)	<0.0001
Lower extremity arterial testing	0.90 (0.86–0.94)	<0.0001
Revascularization	0.89 (0.86–0.93)	<0.0001
Low SES (vs nonlow SES)		
PCP visit	0.39 (0.38–0.41)	<0.0001
Outpatient vascular specialist visit	0.62 (0.60–0.64)	<0.0001
PCP or outpatient vascular specialist visit	0.45 (0.44–0.47)	<0.0001
Lower extremity arterial testing	0.78 (0.75–0.81)	<0.0001
Revascularization	0.65 (0.63–0.67)	<0.0001

All models were adjusted for age, sex, year of chronic limb-threatening ischemia diagnosis, region, ethnicity, heart failure, hypertension, diabetes, diabetes with complications, ischemic heart disease, cerebrovascular disease, tobacco use, and Elixhauser comorbidity score. Comparisons by race additionally adjusted for rural vs urban residence and SES; comparisons by rural vs urban race additionally adjusted for race and SES; and comparisons by SES additionally adjusted for race and rural/urban race. PCP indicates primary care provider; and SES, socioeconomic status.

Table 3. Adjusted Association Between Race, SES, and Preamputation Vascular Care Among Residents of Metropolitan Areas With >1 Million Residents

Comparison	Odds ratio (95% CI)	*P* value
Black (vs White)		
PCP visit	0.76 (0.72–0.81)	<0.0001
Outpatient vascular specialist visit	0.83 (0.77–0.89)	<0.0001
Lower extremity arterial testing	1.02 (0.90–1.15)	0.74
Revascularization	0.87 (0.80–0.94)	0.0008
Low SES (vs nonlow SES)		
PCP visit	0.35 (0.33–0.38)	<0.0001
Outpatient vascular specialist visit	0.60 (0.56–0.64)	<0.0001
Lower extremity arterial testing	0.82 (0.76–0.88)	<0.0001
Revascularization	0.64 (0.60–0.68)	<0.0001

All models were adjusted for age, sex, year of chronic limb-threatening ischemia diagnosis, ethnicity, region, heart failure, hypertension, diabetes, diabetes with complications, ischemic heart disease, cerebrovascular disease, tobacco use, and Elixhauser comorbidity score. Comparisons by race additionally adjusted for SES and comparisons by SES additionally adjusted for race. PCP indicates primary care provider; and SES, socioeconomic status.

Associations Between Race, SES, and Preamputation Vascular Care in Large Metropolitan Areas

Overall, 32 313 (44.1%) patients who underwent amputation lived in metropolitan areas with >1 million residents. Among all patients living in these ZIP codes, 92.4% of hospital admissions were to hospitals that performed lower extremity revascularization procedures, and in 98% of ZIP codes, at least half of all hospital admissions were to hospitals that performed lower extremity revascularization procedures, indicating that residence in a metropolitan area with >1 million residents is a reasonable proxy for geographic access to PAD care services.

In these major metropolitan areas, results for the association between race and SES and receipt of preamputation vascular care paralleled the overall results (Table 3), with lower rates of preamputation vascular care in Black patients and those with low SES.

DISCUSSION

In this nationwide observational study of >73 000 patients with CLTI who underwent major lower extremity amputation, we found that Black patients, those with low SES, and those living in rural areas had lower odds of obtaining vascular care within 12 months before amputation, including outpatient vascular specialist visits, PCP visits, attempts at revascularization, and, for low SES and rural patients, lower extremity arterial testing. Patients with dual eligibility for Medicare and Medicaid, who made up nearly half of the cohort of patients with CLTI who underwent amputation, were particularly unlikely to receive preamputation vascular care. Even in major metropolitan areas, where nearly all patients are admitted to a hospital that offers subspecialty vascular care, low SES and Black race remained associated with lower rates of preamputation vascular care. Together, these findings illustrate the challenges that vulnerable and historically marginalized patients with CLTI face in obtaining vascular care and may help explain higher amputation rates observed in rural, Black, and low SES populations.[13]

Our study is in line with multiple previous studies that show low rates of arterial testing and revascularization before major lower extremity amputation in the United States. Among Medicare beneficiaries who underwent major lower extremity amputation from 2000 to 2010, 30% did not undergo preamputation arterial testing.[11] Furthermore, among Medicare beneficiaries undergoing major lower extremity amputation between 2003 and 2006, 70% did not undergo preamputation revascularization, with higher rates of amputation without revascularization in Black patients.[15] Though our study shows an overall improvement in the rates of preamputation lower extremity arterial testing and revascularization, large fractions of patients still do not have these potentially limb-saving procedures performed. Furthermore, our analysis builds on the findings of these studies by (1) establishing that Black race, rural residence, and low SES all

independently reduce the odds of receiving preamputation vascular care; (2) showing that Black patients and those with low SES living in large metropolitan areas are less likely to receive preamputation vascular care despite almost universally living in close geographic proximity to hospitals delivering subspecialty vascular care; and (3) extending the paradigm of missed opportunities in preamputation vascular care to include PCP visits and outpatient vascular subspecialist visits. The slow progression of PAD affords numerous opportunities to slow or stop the disease process, and an amputation reflects years of health system and societal failures to deliver primordial, primary, or secondary prevention.[22] Lack of care in the year before amputation represents a fraction of these missed opportunities, during a time when the disease process is advanced but still may be modifiable.

Lower rates of preamputation care for Black patients, those residing in rural areas, and those with low SES are reflective of broader dysfunction within the US health system, which too often fails to provide effective chronic disease care for marginalized patient populations due to both cultural and structural racism.[23,24] Cultural racism manifests as individual-level unconscious bias by clinicians and other members of the healthcare team toward members of marginalized patient populations, which is associated with failure to provide appropriate treatment and poor patient-provider communication.[24–26] In the case of preamputation vascular care, this might manifest as failure to effectively communicate the importance of a vascular subspecialist visit resulting in the patient not attending the visit, failure to proceed with lower extremity revascularization due to concerns that the patient may not be adherent to antiplatelet therapy or wound care, or failure of patients to seek medical care due to fear of being racially stereotyped.[27] Even in the absence of individual-level discrimination, structural racism, defined as laws, policies, and other practices deeply embedded in society that collectively produce and perpetuate unfair treatment of people of color, may affect the receipt of preamputation vascular care. Residential racial segregation, 1 manifestation of structural racism, has led to disproportionate numbers of Black individuals living in areas of concentrated poverty with fewer job and educational opportunities, increased exposure to chemical and psychosocial stressors, and less investment by government and the private sector. Less investment by the government and the private sector makes it difficult for individuals living in areas of concentrated poverty to practice healthy behaviors (eg, the creation of food deserts[28]) and to obtain primary care, subspecialty care, and pharmacy services. Much of the extent to which race is associated with worse health outcomes is driven by the strong association between race and SES.[24]

The effects of structural racism, thus, manifest both in higher rates of PAD in Black patients and those with low SES, regardless of whether they live in urban or rural areas, due to challenges with engaging in primordial and primary prevention,[27,29,30] as well as leaks in the pipeline from development of PAD and CLTI to delivery of appropriate care targeted toward limb salvage. In urban areas, Black patients and White patients are largely served by different PCPs,[31] and PCPs who care for Black patients have fewer referral relationships with subspecialists, including cardiologists and general surgeons.[32] Once patients are referred to vascular subspecialists, if they cannot afford transportation (or to take time off of work or away from family care responsibilities) to attend a lower extremity testing appointment or subspecialist appointment or cannot afford a copayment for either of these services, then they may not receive timely and appropriate CLTI care. Receipt of vascular care may also depend on patient factors including medical literacy and trust in physicians and the medical establishment, as some patients may decline PAD testing or treatment for fear that these measures will hasten limb loss.[27,33,34] In the United States, these barriers and beliefs are more likely to affect Black patients, those living in rural areas, and those with low SES.[23,24,31,35] Importantly, our study shows that patients with low SES in large urban areas less often receive vascular subspecialty care although they have health insurance and live near hospitals offering subspecialty vascular care, highlighting the overriding importance of poverty in determining patients' ability to obtain care. Though individuals with low SES living in large urban areas may be near hospitals that offer vascular subspecialty care, transportation may still be a barrier to receiving care, as people with low SES may be reliant on public transportation and low-income neighborhoods are less well-served by public transit.[36,37] Nearly half of patients undergoing amputations for CLTI live in these large urban areas, and closing gaps for these patients will require a different set of clinical and policy solutions than closing gaps in rural areas. While increasing the number of vascular surgeons and other vascular specialists practicing in rural areas may help reduce rural/urban disparities,[38] reducing barriers to accessing primary care, streamlining referrals to vascular subspecialists, improving public transit, developing services to help multimorbid older adults attend appointments, educating clinicians who care for patients in these communities about relevant barriers to PAD care, and creating culturally sensitive PAD educational events and materials featuring trusted community members are likely to be more useful in urban areas.

Our study demonstrates stark disparities in receipt of subspecialty PAD care by race, rurality, and SES. Closing this gap is challenging but amenable to quality improvement efforts. Hospitals and health systems can lead the way in developing PAD and CLTI systems of care to efficiently move patients from CLTI diagnosis to revascularization. The development of quality measures surrounding timely and evidence-based CLTI care may

help reduce disparities, as the advent of quality measures targeted at improving processes of care has reduced disparities in myocardial infarction, stroke, and heart failure treatment.[39–49]

Limitations

First, patients were required to have diagnosis codes consistent with CLTI to enter our cohort. It is likely that some patients may have undergone amputation without a formal diagnosis of PAD or CLTI. If these patients were less likely to receive subspecialty CLTI care before amputation (as seems likely), then our study overestimates the rates at which patients receive preamputation subspecialty care. In addition, we assessed whether patients had visits with cardiologists, vascular surgeons, or other vascular specialists, but we could not determine whether these visits were dedicated to the management of lower extremity PAD, and our results may overestimate outpatient visits dedicated to subspecialty management of PAD. Conversely, Black patients and those with low SES or living in rural areas may be more likely to seek care from the emergency department or inpatient setting and may, therefore, have received PAD care without an outpatient visit with a PCP or vascular subspecialist. We focused on outpatient visits because care for CLTI through the emergency department may not be as efficient or effective as outpatient care and because patients who are admitted to the hospital for PAD care are likely to have very advanced PAD. Second, our study cohort only includes individuals aged between 66 and 86 years with fee-for-service Medicare insurance, and we cannot comment on preamputation processes of care for younger patients, older patients, or those who do not have fee-for-service Medicare insurance. However, fee-for-service Medicare continues to cover approximately half of all adults aged >65 years in the United States, who comprise a large proportion of patients undergoing major lower extremity amputation.[50,51] Third, we are not able to assess which clinicians ordered vascular imaging tests, where tests were ordered, or how clinicians responded to the results of tests. It is possible that superficially similar rates of preamputation vascular testing between Black and White patients, for example, obscure important differences in the circumstances of how these tests are performed or interpreted. Finally, though this study shows differences in utilization of subspecialty CLTI care before amputation by race, rurality, and SES, it is unable to determine a causal link to worse outcomes due to the observational nature of the data.

Conclusions

Black race, rural residence, and low SES are associated with failure to receive subspecialty CLTI care before amputation. To reduce the burden of amputations in these high-risk communities, multilevel interventions to facilitate equitable CLTI care are needed.

ARTICLE INFORMATION

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Supplemental Material

Tables S1–S10

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