Do Differences in Hospital and Surgeon Quality Explain Racial Disparities in Lower-Extremity Vascular Amputations?

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Objective: To understand whether racial disparities in surgery for lower-extremity arterial disease are minimized by high-quality providers, or instead, differential treatment of otherwise similar patients pervades all settings.

Summary Background Data: Black patients are substantially more likely than whites to undergo amputation rather than revascularization for lower-extremity arterial disease. Because their care is disproportionately concentrated among a small share of providers, some have attributed such disparities to the quality and capacity of these sites.

Methods: We evaluated all 86,865 white or black fee-for-service Medicare beneficiaries 65 and older who underwent major lower-extremity vascular procedures. Using generalized linear mixed models with random effects, we computed risk-adjusted odds of amputation by race overall, and after serial substratification by salient patient and provider characteristics.

Results: Blacks were far more likely to undergo amputation (45% vs. 20%). Their procedures were performed more often by nonspecialists (41% vs. 27%; $P < 0.001$), in low-volume hospitals (40% vs. 32%; $P < 0.001$), with high amputation rates (53% vs. 29%; $P < 0.001$). Controlling for differences in comorbidity, disease severity, and surgeon and hospital performance, blacks' odds of amputation remained 1.7 times greater (95% confidence interval: 1.6–1.9). Even among highest-performing providers—vascular specialists in high-volume, urban teaching hospitals with angioplasty facilities—racial gaps persisted (risk-adjusted amputation rates: 7% for blacks vs. 4% for whites, $P < 0.001$; odds ratio: 1.8, 95% confidence interval: 1.5–2.1).

Conclusions: Black patients with critical limb ischemia face significantly higher risk of major amputation, even when treated by providers with highest likelihoods of revascularization. Increased referral to high-performing providers might increase limb-preservation, but cannot eliminate disparities until equitable treatment can be ensured in all settings.

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There are important racial and ethnic disparities in the United States healthcare system,[1] and many of the most salient examples involve surgery.[2–4] Black patients are less likely than whites to undergo surgical intervention for coronary artery disease,[5,6] osteoarthritis of the knee,[4,7] and many other conditions.[2,8] These gaps are generally not explained by differences in clinical condition[4,5]; they extend to procedures with both high and low degree of physician's discretion[9]; and they have persisted over time,[2] suggesting that important structural factors in the delivery of surgical care are responsible.

Increasingly, policy makers have focused on the site of care as both an important explanation for healthcare disparities, and a novel opportunity to remedy them.[10–16] Recent studies have shown that both hospital-based[11] and primary[16] care are highly segregated: care for black patients is concentrated among a small group of providers who have notably less resources and capacity to provide high quality care.[10,11,15–17] Black patients are less likely to receive surgical care among high procedure volume hospitals,[13,18–21] whose outcomes are often superior for many high-risk operations[19,20,22,23] and more likely to visit hospitals with worse risk-adjusted mortality rates for high-risk conditions.[13,14,24]

The Institute of Medicine has suggested that healthcare disparities resulting from provider-level segregation are further magnified by discrimination—differential treatment of otherwise similar patients, under similar circumstances, due to race.[1] If segregation were the primary driver, selective referral to high-performance institutions, despite its logistical challenges, would alleviate racial disparities in surgery.[13] If these gaps result, instead, primarily from discrimination, additional efforts to eliminate disparities across all settings will be necessary.

One area of disparities that is particularly troubling is the large racial differences in rates of lower extremity amputations. Black patients are far more likely than whites to receive an amputation rather than revascularization for lower extremity arterial vascular disease, even after accounting for differences in comorbid conditions, such as diabetes and renal failure.[8,25–35] Because these amputations produce substantial disability—few vascular amputees ever achieve independent ambulation thereafter[36]—it is critically important to understand which types of solutions hold promise for improving outcomes.

Previous studies of peripheral vascular disease[25,35] have lacked details about institutional and physician characteristics, and have thus been unable to evaluate whether site of care is an important determinant of poorer outcomes for blacks. We attempt to identify whether disparities in amputation rates are due primarily to segregation (differential performance between sites of care) or discrimination (differential treatment among the same institutions and/or physicians). Specifically, we sought to determine: (*a*) Do disparities in amputation rates persist after accounting for features of the hospital and expertise of available surgeons? (*b*) Are there subgroups of patients for whom disparities in amputation rates are eliminated? and (*c*) are there particular settings in which racial disparities in amputation rates are lessened and/or the absolute rates of revascularization for both blacks and whites are superior?

METHODS

Data Sources

We obtained 100% of the 2004 Medicare Inpatient Research Identifiable File, with claims data for all fee-for-service Medicare beneficiaries discharged from acute care hospitals in the United

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States that year. Multiple claims from any discharge were merged to generate a data set in which each record represented a single hospital admission, containing up to 10 diagnostic codes and 6 procedure codes from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9). Comorbid conditions were classified using the Healthcare Cost and Utilization Project Comorbidity Software, Version 3.0 (available at: http://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp).[37] We used the unique physician identification number to link each record with physicians' characteristics reported in the Medicare Physician Identification and Eligibility Registry. Finally, we linked these data with the American Hospital Association Survey to obtain information on hospitals' characteristics.

Racial concentration for each hospital was computed as the percentage of all discharges in the inpatient claims file in which the patient was black. As in previous studies,[11] we classified the top 5 percentile as having a "high proportion" of black patients; those in the >5 to 25 percentile range as "medium proportion"; and the others as "low proportion." We computed the hospital-level segregation index, which denotes the proportion of patients in each facility that would have to move to achieve an even racial distribution.[38]

Physician and hospital procedure volumes were computed from the complete inpatient claims file (regardless of race or indication for the procedure). We considered physicians to be specialists if they were vascular or cardiac surgeons, if they were cardiologists or interventional radiologists performing endovascular procedures, or if they were in the highest tercile of overall revascularization procedure volume.

Patient Sample

We excluded patients younger than 65 years of age, race other than white or black, not residing in the United States, or enrolled in a managed care plan for any portion of the year. We identified procedures of interest using ICD-9 codes: above-knee amputation (above-knee amputation: ICD-9 84.16, 84.17), below-knee amputation (below-knee amputation: 84.13, 84.15), lower-extremity arterial bypass (39.25, 39.29), percutaneous lower extremity arterial angioplasty (39.50) and/or stenting (00.55, 39.90). If a patient had more than one such procedure during the sample period, we selected only the first procedure performed for analysis.

We included all patients who underwent one or more of these procedures for any of the following diagnoses: diabetes with peripheral circulatory disorders (250.7×), lower extremity arterial atherosclerosis, stenosis, thromboembolism, and/or gangrene (440.2×, 400.3×, 443.81, 443.9, 444.22, 444.81, 447.1×, 785.4). In accordance with previous studies,[25,27–29,39] we did not include toe or forefoot amputations that preserved the heel for ambulation. For the main analyses, we classified procedures as either amputation (above-knee amputation or below-knee amputation) or revascularization (bypass, angioplasty, or stenting).

Statistical Analyses

We compared the demographic and comorbidity characteristics of black and white patients, as well as the characteristics of their surgeons and hospitals, using Pearson χ^2 tests for categorical variables and Wilcoxon rank sum tests for continuous variables. To account for patient-related predictors of amputation, we constructed race-specific and general multiple logistic regression models from a priori clinically-relevant comorbidity and risk factors, to predict each patient's expected probability of amputation. The race-specific and general models did not differ meaningfully, so we used the predicted probabilities from the general model. Despite the limitations of administrative data, c-statistic for the prediction score was 0.90, indicating excellent discrimination. We stratified patients by quartiles of these predicted likelihoods, and computed adjusted amputation rates by applying average parameter values to the fitted regression model.

Because of hierarchical structure of this data, we corrected regression coefficients and variance estimates for the effects of multilevel clustering, using generalized linear mixed models[40] in Proc GLIMMIX in SAS Version 9.1 (SAS Institute, Cary, NC). We treated physician-level and hospital-level predictors as random effects, to explicitly control for, and evaluate contributions of, specific provider characteristics.[41,42] Physicians who operated in multiple hospitals contributed random effects to each cluster in which they participated.

To assess the persistence of racial differences within subgroups, we stratified patients by salient characteristics—such as having diabetes or renal disease, or receiving care from a specialist physician in a high-volume institution—and computed adjusted likelihoods of amputation and adjusted odds ratios (AOR) comparing blacks and whites. Next, we serially substratified the sample, selecting patients treated by physicians and hospitals with characteristics predicting lowest odds of amputation: high-volume specialists in urban, high procedure-volume hospitals, teaching institutions, and angioplasty facilities. At each step of substratification, we again computed adjusted amputation rates and AOR by race. We repeated this approach using multiple other variable combinations with similar results, and therefore present only the substratification using characteristics associated with lowest amputation rates.

Even in these analyses, we were concerned that differential accrual by race of low-risk patients—such as those undergoing procedures for claudication rather than tissue loss—might produce residual confounding. Thus, we separately repeated the analyses on the higher-risk, but more clinically homogeneous, subgroup of patients with critical limb ischemia (CLI)—gangrene or lower extremity ulceration as the indication for their procedure—and compared their results with those of the entire sample.

The study was approved by the Harvard School of Public Health Human Subjects Committee and the Centers for Medicare and Medicaid Services Privacy Board.

RESULTS

There were 72,015 white and 14,850 black Medicare beneficiaries in 3051 hospitals who underwent one of the procedures of interest for lower-extremity arterial vascular disease in 2004 (Table 1). Blacks were far more likely to undergo lower-extremity amputation than whites (45% vs. 20%, $P < 0.001$). Among those who underwent amputations, blacks were more likely have an above-the-knee operation than whites (60% vs. 53%, $P < 0.001$); and among those who received revascularization, blacks were less likely to have an endovascular procedure than whites (46% vs. 51%, $P < 0.001$).

Patient Characteristics

Black patients in the sample were more likely to be female, and more likely to have congestive heart failure, neurologic disease, diabetes, or renal failure, but less likely to have coronary artery disease or chronic obstructive pulmonary disease (Table 1). Black patients resided in ZIP codes with significantly lower median income. Black patients were more likely than whites to require 3 or more hospital admissions during 2004 (46% of blacks vs. 36% of whites, $P < 0.001$), and to have been admitted for their procedure on an emergency basis (32% of blacks vs. 19% of whites, $P < 0.001$). The c-statistic for the risk prediction score, derived from patient-related characteristics alone, was 0.90, indicating excellent discrimination for amputation.

Physician Characteristics

Blacks were less likely than whites to be treated by vascular surgeons or endovascular proceduralists (55% vs. 68%, $P < 0.001$),

TABLE 1. Characteristics of Patients, by Race of the Patient

	White N = 72,015	Black N = 14,850
Procedure		
Above-knee amputation	7510 (10)	3999 (27)
Below-knee	6682 (9)	2663 (18)
Open bypass	28,225 (39)	4434 (30)
Endovascular	29,598 (41)	3754 (25)
Sex		
Female	33,361 (46)	8707 (59)
Male	38,654 (54)	6143 (41)
Age		
65–74	32,698 (45)	6962 (47)
75–84	30,101 (42)	5486 (37)
≥85	9216 (13)	2402 (16)
Diabetes	22,772 (32)	6223 (42)
Renal failure	8107 (11)	3640 (25)
Gangrene	20,437 (28)	8485 (57)
Lower-extremity ulcer	17,504 (24)	4073 (27)
CHF	13,147 (18)	3085 (21)
CAD	31,123 (43)	4542 (31)
COPD	18,518 (26)	2315 (16)
Paralysis or other neurologic disease	4061 (6)	1723 (12)
ZIP code income (mean ± SD)	43,355 ± 15,489	34,042 ± 12,756
Hospitalizations in 2004		
1	26,133 (36)	4074 (27)
2–3	32,021 (44)	6736 (45)
≥4	13,861 (19)	4040 (27)
Status of operation		
Elective	41,862 (58)	6468 (44)
Urgent	16,486 (23)	3607 (24)
Emergency	13,667 (19)	4775 (32)

All differences are significant with $P < 0.001$. SD indicates standard deviation.

TABLE 2. Characteristics of Providers, by Race of the Patient

	White N = 72,015	Black N = 14,850
Physician characteristics		
Experienced vascular proceduralist*	52,675 (73)	8762 (59)
Vascular surgeon or nonsurgical endovascular proceduralist	48,804 (68)	8165 (55)
Highest volume tercile	24,589 (34)	3990 (27)
Surgeon age		
<40	11,273 (16)	2447 (16)
40–49	28,946 (40)	5426 (37)
50–59	23,262 (32)	4849 (33)
≥60	8376 (12)	2096 (14)
Foreign medical graduate	13,438 (19)	2887 (19)
Hospital characteristics		
Hospital racial concentration†		
High concentration black	1376 (2)	2944 (20)
Medium concentration black	18,349 (25)	8628 (58)
Low concentration black	52,290 (73)	3278 (22)
Hospital revascularization procedure volume		
Lowest tercile (≤50)	23,321 (32)	5897 (40)
Middle tercile (51–127)	24,135 (34)	4510 (30)
Highest tercile (≥128)	24,559 (34)	4443 (30)
Angioplasty hospital	55,193 (77)	10,294 (69)
Council of teaching hospitals member	15,333 (21)	4018 (27)
Proportion of discharges with Medicaid as payer		
Lowest tercile (0%–11.7%)	25,641 (36)	3328 (22)
Middle tercile (11.7%–17.3%)	24,508 (34)	4307 (29)
Highest tercile (17.3%–89.6%)	21,866 (30)	7215 (49)
Nurse: census		
Lowest tercile (<4.9)	22,902 (32)	6088 (41)
Middle tercile (4.9–6.2)	24,286 (34)	4594 (31)
Highest tercile (>6.2)	24,927 (34)	4178 (28)
Metropolitan statistical area size		
Nonurban	8632 (12)	1653 (11)
<250,000 population	11,679 (16)	1795 (12)
250,000–999,999 population	21,395 (30)	3914 (26)
>1,000,000 population	30,309 (42)	7488 (50)
Region		
Northeast	14,177 (20)	2002 (13)
Midwest	19,768 (27)	2630 (18)
South	29,018 (40)	9509 (64)
West	9052 (13)	709 (5)

All differences are significant with $P < 0.001$.

*Experienced vascular proceduralist: either high volume, or specialty vascular, cardiothoracic surgery, or nonsurgical interventionist, such as cardiologist, or interventional radiologist.

†High concentration: top 5 percentile; medium concentration: fifth through 25th percentile; low concentration: bottom 75 percentile.

and less likely to be treated by high-volume physicians (27% vs. 34%, $P < 0.001$; Table 2). Blacks were somewhat more likely to receive treatment from older physicians and from foreign medical graduates (Table 2).

Hospital Characteristics

The hospitals in the top quartile for proportion of black patients cared for nearly 80% of black patients and just over 25% of white patients (Table 2). The segregation index was 0.54, indicating marked separation between the institutions in which blacks and whites underwent these procedures, although the index was comparable to the national estimates for segregation for inpatient care overall.[43]

Black patients were less likely than white patients to receive care in hospitals that perform a high volume of revascularization procedures (30% vs. 34%, $P < 0.001$) or have an angioplasty facility (69% vs. 77%, $P < 0.001$). Even when their care took place in high-volume hospitals, blacks were more likely than whites to be treated by low-volume nonvascular specialists (26% vs. 13%, $P < 0.001$). Other differences in hospital characteristics are detailed in Table 2.

Multilevel Models

In multivariable analyses accounting for the effects of clustering within physicians and hospitals, racial differences in odds of amputation were substantially attenuated by controlling for patient-related factors, but less so for physician and hospital characteristics (Table 3). Adjusting only for patient-related demographic and comorbidity variables, odds of amputation were 1.8 times greater for blacks than whites (95% confidence interval [CI]: 1.6–1.9). Compared with the unadjusted racial difference (unadjusted OR: 3.3,

95% CI: 3.1–3.5), correcting for patient-level covariates explained 67% of the racial difference in amputation rates. Further adjusting for physician and hospital characteristics did not meaningfully alter the racial difference in odds of amputation (AOR: 1.7, 95% CI: 1.6–1.9).

Racial Differences Within Subgroups

We did not identify any subgroup in which the racial difference in risk-adjusted odds of amputation was eliminated (Figs. 1A, B). Across all categories examined, black patients had substantially greater adjusted odds of amputation, whether they were treated by experienced vascular proceduralists (AOR: 1.7, 95% CI: 1.6–1.8) or low-volume nonspecialists (AOR: 1.6, 95% CI: 1.5–1.7); in hospitals with high procedure volume (AOR: 1.7, 95% CI: 1.6–1.9) or low procedure volume (AOR: 1.6, 95% CI: 1.4–1.7). Differences were present even in hospitals with a high proportion of black patients (AOR: 1.5, 95% CI: 1.2–1.7). As seen in Figure 1A, even after we stratified patients by quartiles of their predicted likelihood of amputation (based on patient-specific characteristics), amputation rates within each stratum were significantly higher for blacks than whites—AORs for blacks versus whites were 1.6 (95% CI: 1.5–1.7) in the highest-risk quartile, and 2.8 (95% CI: 2.0–3.9) in the lowest quartile.

When we examined serially substratified groups of patients receiving care from physicians and hospitals with characteristics predicting lower overall rates of amputation, we found that racial gaps persisted. Figure 2 presents the selection of patients who received care in urban, teaching, high procedure volume hospitals with angioplasty facilities, with procedures performed by high-volume specialists. The racial differences in adjusted odds of amputation were no different among patients in this low-risk substratum (AOR: 1.8, 95% CI: 1.5–2.1) than among the sample as a whole (AOR: 1.7, 95% CI: 1.6–1.9), although the overall amputation rates fell dramatically, for both blacks (from 23% to 7%, $P < 0.001$) and whites (from 15% to 4%, $P < 0.001$). Other serial substratification processes produced similar results.

TABLE 3. Multivariable Analyses

Model	Odds Ratio (95% CI)	
	Complete Sample (N = 86,865)	Critical Limb Ischemia Subset (N = 40,891)
Unadjusted	3.3 (3.1–3.5)	2.3 (2.2–2.5)
Adjusted for patient-level variables	1.8 (1.6–1.9)	1.6 (1.5–1.8)
Adjusted for patient-level and physician-level variables	1.7 (1.6–1.8)	1.6 (1.5–1.7)
Adjusted for patient-level, physician-level and hospital-level variables	1.7 (1.6–1.9)	1.6 (1.5–1.7)

Results of multiple logistic regression, using generalized linear mixed models and treating both physician-level and hospital-level predictors as random effects. As physician and hospital effects are added to the model, proportions, and confidence intervals are adjusted to account for clustering at each level. The critical limb ischemia subset includes only those patients with gangrene and/or lower extremity skin ulceration as indication for their procedure.

Patients With Critical Limb Ischemia

Among 40,891 patients (47% of the overall sample) whose procedure was performed for CLI, absolute racial differences in crude amputation rates were similar to the overall sample—42% of whites and 63% of blacks with CLI underwent amputation. The unadjusted odds ratio by race was smaller for CLI patients than the overall cohort (Table 3, Column 3), but there was little difference between CLI patients and the rest of the sample in AOR for any of the multilevel models. In serial substratification, racial differences among CLI patients receiving care from the best-performing providers were also similar to those of the overall sample (AOR: 1.6, 95% CI: 1.5–1.7).

DISCUSSION

The surgical management of lower extremity arterial disease is heavily influenced by characteristics of both the patients and their providers, and in many clinical scenarios, there is substantial clinical discretion about the best approach. In this context, we found alarming differences in the likelihood that black and white patients are subjected to amputation rather than revascularization: nearly half of black Medicare beneficiaries in our sample had an amputation, while

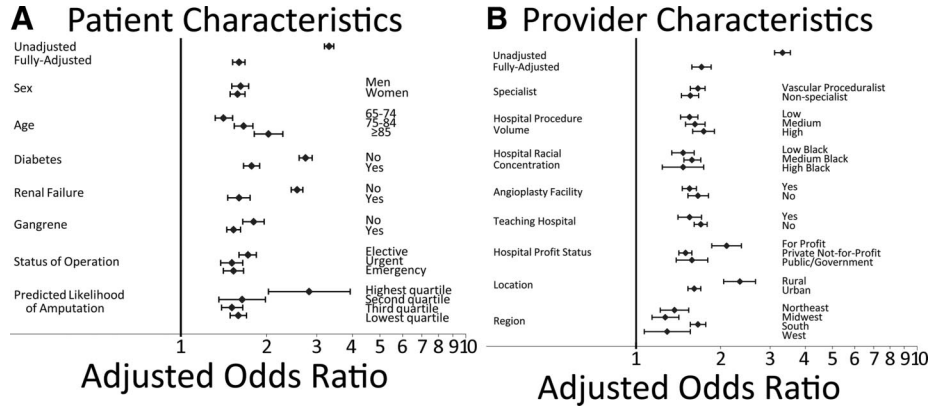

FIGURE 1. Adjusted odds ratios (AOR) for undergoing amputation, comparing black versus white patients within subgroups divided by (A) patient characteristics and (B) provider characteristics. Each data point and error bar represents the AOR and 95% confidence interval among individuals within the patient, physician, or hospital characteristic indicated. All values (except for the 1 unadjusted data point indicated) are adjusted for age, sex, congestive heart failure, coronary artery disease, gangrene, lower extremity skin ulceration, diabetes, a diabetes sex interaction term, renal failure, chronic obstructive pulmonary disease, total number of hospital admissions in 2004, status of admission (elective, urgent, or emergency), ZIP code median income, and 13 other significant comorbid conditions as classified by the Healthcare Cost and Utilization Project Comorbidity Software, Version 3.0.[37]

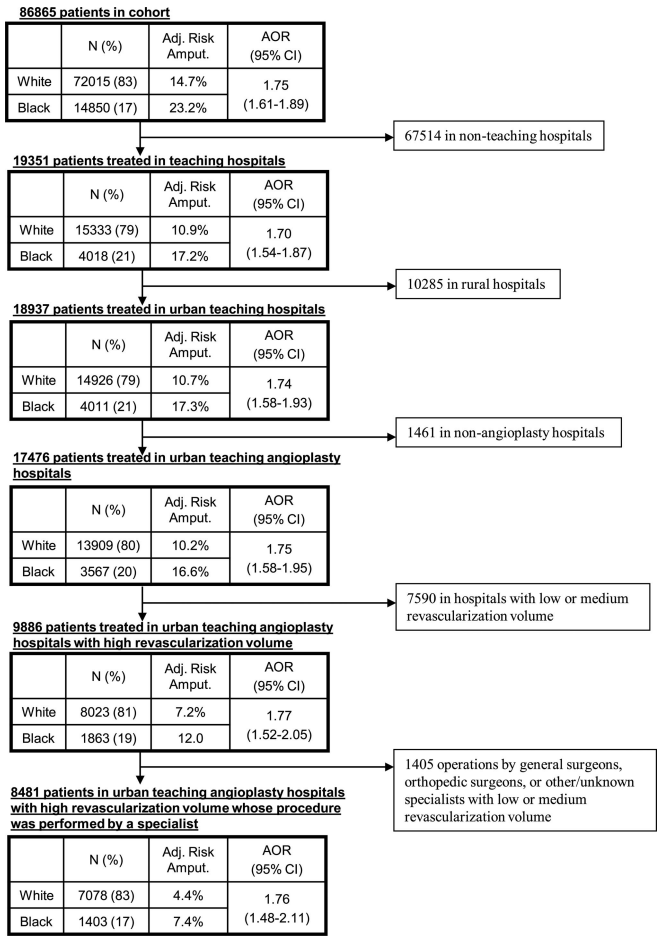

FIGURE 2. Adjusted rates of amputation and adjusted odds ratios (AOR) for undergoing amputation, comparing black versus white patients among serially substratified groups of patients who received care from physicians and hospitals with characteristics predictive of low amputation rates. All values are adjusted for age, sex, congestive heart failure, coronary artery disease, gangrene, lower extremity skin ulceration, diabetes, a diabetes sex interaction term, renal failure, chronic obstructive pulmonary disease, total number hospital admissions in 2004, status of admission (elective, urgent, or emergency), ZIP code median income, and 13 other significant comorbid conditions as classified by the Healthcare Cost and Utilization Project Comorbidity Software, Version 3.0.[37]

less than a quarter of white patients did. We found evidence for both segregation and discrimination: site of care was an important factor in a patient's likelihood of amputation, yet racial gaps persisted even after accounting for differences in the providers caring for black and white patients. These findings are consistent with a recent study from the Dartmouth Atlas Project, which reported 10-fold regional variation in leg amputation rates, but consistent racial differences, regardless of geography.[26]

A large portion of this gap clearly reflects differences in patient characteristics: black patients were more likely to have diabetes and renal failure, and come to surgical attention having already developed gangrene. These differences may be due in part to lower incomes,[35] lower educational attainment, and poorer access to high quality primary care[16] among black patients, even those insured through Medicare.[35,44] Improving access to primary care, preventive health management for diabetes and hypertension, and attention to foot and wound care, remain essential to eliminating racial gaps in amputations.[45,46]

Even after accounting for patient characteristics, however, we found that black patients with peripheral arterial disease had 75% greater odds of amputation than whites when they came to surgical attention. We were initially concerned that the differences might be explained by white patients being more likely to undergo procedures for low-risk indications such as claudication. However, the differences persisted in all subgroups examined, including high-risk patients with CLI. Further, the gap was just as wide, if not wider, among patients for whom physicians have greatest discretion—those with the lowest predicted likelihoods of amputation, without complicating risk factors such as diabetes, gangrene, or emergency surgery—suggesting that discrepancies in clinical decision-making and management likely play an important role. And because we evaluated only the first procedure performed, the disparities may be more attributable to clinical decision-making and availability of surgical expertise (rather than patient condition and compliance) than would be the case if we had evaluated only ultimate rates of limb salvage. It is this differential treatment that is particularly worrisome to policy makers and the public.[9]

We also found strong evidence that the setting of care contributes to high rates of amputations for blacks: access to angiography facilities, vascular surgery specialists, hospitals with a major teaching commitment, and/or a high volume of experience with revascularization procedures, afforded markedly lower amputation rates. In a setting with all of these features, the risk-adjusted likelihood of facing amputation rather than revascularization fell dramatically, for all patients. However, blacks were generally less likely to receive care from these providers.

Lesser access to high-performing settings results in part from the marked racial segregation of surgical care for peripheral arterial disease. The observed segregation index of 0.54 means that more than half of all patients would have to transfer care to another hospital to achieve uniform integration.[38] Indeed, the hospitals with the highest concentration of black patients were less likely to have angioplasty facilities, vascular specialists, or a high volume of experience with revascularization procedures. Targeted initiatives to improve capacity and performance in these institutions and increase referral of patients with CLI to highest-performing settings would disproportionately benefit black patients, even as they improve care for all who use these hospitals.

These policy strategies bring enormous challenges, but both could be expected to achieve significant reductions in amputation rates for black patients. Our findings caution, however, that selective referral alone is unlikely to overcome the contribution of discrimination to observed racial disparities. Even in the top-performing hospitals, blacks had 75% higher adjusted odds of amputation than whites. Differential treatment within institutions plays a role: even among hospitals performing a high volume of revascularizations, for example, black patients were more likely to be treated by low-volume providers and by general surgeons, whereas whites more often were treated by high volume vascular specialists. Thus, to ensure equity in the availability of revascularization and other services, institutions will need to first measure their procedure rates and outcomes, stratified by race and other factors, and then turn their attention to efforts to remediate residual disparities that persist within their walls.

There are important limitations to our study. First, our cohort was limited to elderly Medicare beneficiaries and our results may not extend to younger patients. Yet, Medicare enrollees comprise about 70% of lower extremity bypass operations,[20] and this uni-

formly-insured, age-limited cohort should bias our results toward the null hypothesis by limiting the contribution of these potential confounding variables. We may fail to capture some angioplasty procedures performed on an outpatient basis, but these represent a small minority of patients.[47] Because we rely on administrative data for risk adjustment, we lack some variables such as performance status[45] and smoking history.[46] However, our risk adjustment model includes most of the important clinical covariates identified by others,[48] and provided excellent discrimination, with a c-statistic of 0.90. Finally, recognizing that revascularization is not the right procedure for every patient,[49] we cannot determine with certainty whether racial differences are due to excess amputations in black patients who could have been revascularized, excess revascularizations in white patients who could have received medical management, or racial differences in clinical presentation,[29,31,39] vascular anatomy,[27,50] or expected likelihood of long-term graft patency,[39] for which we do not account in our models. Still, most clinicians agree that aggressive pursuit of revascularization should come first,[39,51] with primary amputation reserved for patients who have irreparable gangrene, poor wound healing, or inadequate distal vessels to support bypass.[45] Even looking within groups of patients with and without gangrene, diabetes, or other characteristics, we find differential treatment, with higher rates of amputations for blacks.

Our results suggest that effective strategies to reduce amputation rates for CLI would involve improvements in the facilities in which most black patients receive care and expanded access to high-performing providers—interventions which will meaningfully increase revascularization rates for patients of any race. However, elimination of disparities—a problem Americans are rightly embarrassed to see persisting—will require efforts across a variety of settings, from health literacy to primary care to specialty surgical referrals, as well as institutional surveillance to identify discrimination and ensure equitable treatment.

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Discussions

DR. STEVEN C. STAIN (ALBANY, NEW YORK): What I am most interested in is that the authors find that there is still a difference in amputations, even in urban, high procedure volume teaching hospitals with angioplasty facilities and when procedures are performed by high volume specialists. Many of us work in tertiary and quaternary care hospitals, but explaining why these differences in outcome remain even after controlling for patient physician characteristics is difficult. We all believe that we treat patients equally regardless of race. Are we wrong? The authors suggested that referring black patients to high volume hospitals and specialists could reduce the incidence of amputation. However, selective referral is unlikely to overcome the observed racial disparity and would not address the intra institutional bias.

Is it possible to control for patients who may have attempts at revascularization followed by amputation? In other words, would it sometimes be more appropriate to perform an amputation after a failed revascularization for a black patient with multiple co morbidities than on a white patient? Is it possible, from your data set, to ascertain that racial disparities persist even in those institutions with, presumably, the best outcomes, those with vascular surgery fellowships? The authors suggest that the transfer of patients to a high volume center would improve the care of all patients and disproportionately benefit black patients, and acknowledge that selective referral would not address the apparent bias within an institution. Do you have any suggestions on how to approach the fact that even in these top tier performing hospitals, black patients are still less likely to be treated by a high volume provider or vascular specialist?

DR. SCOTT E. REGENBOGEN (BOSTON, MASSACHUSETTS): We looked only at the first procedure the patient received, and we did that specifically because we were less interested in outcomes than in clinical decision making. Thus, we were interested in what was the first choice procedure for each patient. You mentioned that perhaps revascularization was inappropriate and perhaps white patients received inappropriate first revascularizations when they would have been better off with amputation and vice versa. No, we cannot really control for that.

Your second question was do I know whether fellowship contributes to some of the differences we see. Unfortunately, in the American Hospital Association data they do not mention vascular fellowships. To do that we would need to take a smaller subset and examine hospitals where we actually knew who they were. Third, you asked how I would approach the problem of residual disparity within the highest performing institutions, and this is what I find most stimulating about this research. We must decide as a society whether we are more interested in a rising tide that raises all boats, that is, are we interested in better care for everybody with the hope that it will improve the care for the most disadvantaged, or, are we interested in investing more in the question of equity, because there is probably a trade off. If the answer is the latter, that we are interested in investing in equity, the way we go about that, I think, is by specifically measuring within every hospital how we deal with patients of different races, different socioeconomic status, and different insurance status; using that as a target within our hospitals.

DR. ORLANDO C. KIRTON (HARTFORD, CONNECTICUT): Your findings are very troubling to me as an African American surgeon. An increasing number of individuals are making very robust academic careers identifying the pervasiveness of racial disparities in our health care delivery system at every level, but rarely identifying or proposing substantive solutions. Is it access? Is it the lack of health care literacy? Is it entrenched cultural mores or attitudes? The last line of your abstract I find most troubling; and I will quote, "increased referral to high performing providers might increase limb preservation, but will not eliminate disparities until equitable treatment is ensured in all settings." The high performance providers you allude to reside at institutions for which many in this august audience work and hold leadership positions. I keep hoping that a population based approach with performance metrics and penalties is a potential solution.

DR. SCOTT E. REGENBOGEN (BOSTON, MASSACHUSETTS): I note in particular the use of the word "troubling," and I used the same word in the manuscript. We found the results uncomfortable ourselves and took great pains in trying to understand how to discuss them. And to some extent, I agree with your point that we have been studying and identifying and describing disparities for decades, and our great interest here was in trying to understand whether proposed interventions might be likely to address those disparities. I believe this is where research will hopefully lead to the idea of defining, identifying and carefully designing interventions to eliminate disparities in race and socioeconomic status.

DR. JOHN J. RICOTTA (STONY BROOK, NEW YORK): Some of this relates to the status of the patient when they come in, and often the patient will leave with a successful revascularization, and then come

back with a complication. What I did not see was any reference to socioeconomic status. Is race a surrogate for socioeconomic status or is it an independent predictor?

DR. SCOTT E. REGENBOGEN (BOSTON, MASSACHUSETTS): Unfortunately, in the Medicare data we have very poor measures of socioeconomic status. However, that is what you need and within the patient factors we did at least control for geographically located socioeconomic status, which is a relatively weak means of control. I have no doubt that the actual color of the patient's skin does not explain the entire difference, and obviously, some of the difference will be due to socioeconomic status and other factors. In the end, we were less concerned about exactly what the factors responsible for disparity were than simply the concept that disparity would persist regardless of the setting.

DR. C. KEITH OZAKI (BOSTON, MASSACHUSETTS): I agree there are a multitude of factors that lead to this sort of complex problem, but one seems to be underemphasized in your discussion. Race is really just a surrogate marker for genetic factors, and increasingly we recognize genetic factors as a big factor in the aggressiveness of atherosclerosis and in the final phenotype of a patient. To what extent do your data analysis support genetic factors as perhaps something that should be considered?

DR. SCOTT E. REGENBOGEN (BOSTON, MASSACHUSETTS): I would say the data can neither confirm nor deny the role of genetic factors, nor can it confirm nor deny the role of differences in primary care and differences in referral patterns or late presentation. However, regardless of the actual explanation, we think it is worth addressing.

DR. A. BRENT EASTMAN (SAN DIEGO, CALIFORNIA): I found your paper both provocative and disturbing. My interest is in trauma systems, where we strive, through regionalization, to get the right patient to the right hospital and the right specialist at the right time (i.e. to the appropriate site). Therefore, I was encouraged to see that site selection did, in fact, make a difference, even though the disparity issue persisted. I would like to see this study extended into our trauma centers where amputation for trauma is also a major challenge.

DR. SCOTT E. REGENBOGEN (BOSTON, MASSACHUSETTS): I would like to see that as well.

DR. LAWRENCE W. WAY (SAN FRANCISCO, CALIFORNIA): It would be interesting as a control to look at VA hospitals. Having worked in the VA for 25 years, I think it is highly unlikely that black and white patients could possibly receive different care because of bias.

DR. SCOTT E. REGENBOGEN (BOSTON, MASSACHUSETTS): What I am most interested in is exactly that, what is the characteristic of a hospital that is capable of eliminating disparities? If it turns out there are lessons to be learned from the VA, and from other institutions, that would be profound.