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# Socioeconomic and Hospital-Related Predictors of Amputation for Critical Limb Ischemia

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## Abstract

**Objective—**Disparities in limb salvage procedures may be driven by socioeconomic status (SES) and access to high volume hospitals. We sought to identify SES factors associated with major amputation in the setting of critical limb ischemia (CLI).

**Methods—**The 2003–2007 Nationwide Inpatient Sample was queried for discharges containing lower extremity revascularization (LER) or major amputation, and chronic CLI (N=958,120). The Elixhauser method was used to adjust for co-morbidities. Significant predictors in bivariate logistic regression were entered into a multivariate logistic regression for the dependent variable of amputation vs. LER.

**Results—**Overall, 24.2% of CLI patients underwent amputation. Significant differences were seen between both groups in bivariate and multivariate analysis of SES factors, including race, income, and insurance status. Lower income patients were more likely to be treated at low LER volume institutions (OR 1.74, $P$<.001). Patients at higher LER volume centers (OR 15.16, $P$ <0.001), admitted electively (OR 2.19, $P$ <0.001) and evaluated with diagnostic imaging (OR 10.63, $P$ <0.001) were more likely to receive LER.

**Conclusions—**After controlling for co-morbidities, minority patients, those with lower SES, and patients with Medicaid were more likely receive amputation for CLI in low volume hospitals. Addressing SES and hospital factors may reduce amputation rates for CLI.

### Keywords

critical limb ischemia; amputation; race; socioeconomics; volume; outcomes

## INTRODUCTION

Major amputation for critical limb ischemia (CLI) disproportionately impacts Black and Hispanic patients and those with low income.[1–3] These disparities persist among patients



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seeking care at institutions with significant vascular surgery capacity.[2, 4–7] Patient-related factors such as a higher burden of diabetes (DM), small vessel occlusive disease, and delayed presentation in these patient populations are frequently cited as the mechanisms underlying the observed disparities.[1, 8–9] Beyond race and ethnicity, socioeconomic factors such as income and insurance serve as proxies for access to care.[10] The inter-relationships between risk of major amputation, race, income, insurance status, and hospital lower extremity revascularization (LER) case volume have not been explored simultaneously in a national database.[4] We hypothesize that minority race, low income, and non-private insurance remain significant predictors of major amputation despite adjusting for hospital LER case volume.

This paper seeks to identify patient socioeconomic status (SES) related and hospital-level factors that are predictive of major amputation in CLI patients. We will explore the possible relationship between SES and access to institutions with high LER volume as it relates to limb salvage in a nationally representative dataset with standardized income data.

## METHODS

The 2003–2007 Nationwide Inpatient Samples (NIS) were queried for discharges containing LER, major amputation, and a diagnosis of chronic CLI (weighted N=958,120). The NIS is the largest all-payer inpatient care database containing data from approximately 8 million inpatient stays annually. Using complex survey sampling methodology, the NIS is a 20% stratified sample of all U.S. community hospitals.[11] These records contain up to 15 diagnosis and 15 procedure codes from the ICD-9-CM in addition to demographic data, median household income for patient's zip code, insurance status, and hospital level characteristics.

Subjects were selected from the database if their discharge abstract contained ICD-9-CM codes for CLI and a procedure to treat CLI, including major lower extremity amputation, lower extremity bypass, or angioplasty (Appendix 1). Patients with procedure codes for revision of previous lower extremity bypasses, traumatic vascular injury, or both LER and major amputation during the same admission were excluded. This cohort was restricted to patients above the age of 21 years at admission. Since income was a primary predictor of interest, patients who did not have median household income for zip code recorded were excluded.

The primary outcome was major lower extremity amputation in patients admitted with a diagnosis of CLI and who had not undergone a LER procedure during the admission. The dataset was analyzed to find predictors of major amputation for CLI. Variables related to SES included age, race, income, insurance status, and urban-rural designation for patient's county of residence. Patients were grouped into quartiles by age (21–59, 60–69, 70–78, ≥79 years of age).

Race was coded as White, Black, Hispanic, Asian/Pacific-Islander, Native American, and other race in the NIS. Race was missing for 24% of discharge abstracts. Patients who did not have race recorded were excluded and re-weighting estimation equations were used to adjust survey weights of the remaining patients.[12] A logistic regression model was created to estimate parameters for the outcome that race was recorded and this model used three variables that were non-missing for all patient discharges in the dataset: median income, hospital region, and discharge year. The original survey weights for each patient who had race recorded were multiplied by the inverse of the parameter estimates from the logistic regression model in order to create new adjusted survey weights. Thus the patients with race recorded were upweighted to account for the probability that race was recorded in their discharge abstracts. The new weights were used in weighted logistic regression for the outcome of major amputation.

Income and insurance status were included as proxies for SES. We selected NIS data from 2003 onwards because these years consistently categorized median household income into quartiles rather than arbitrary categories that could not be used to assess trends over multiple years of the NIS.[11] The primary payer recorded in the NIS was used to assign insurance status to each discharge. Discharges recorded as self-pay or other and those with missing data for this variable were included in the uninsured category.

The urban-rural designation for a patient's county of residence for the 2003–2006 NIS was recorded as large metropolitan, small metropolitan, micropolitan, and non-metropolitan or non-micropolitan. In the NIS 2007, these categories were expanded. In order to compare data across years, the 2007 categories were collapsed using the 2003–2006 definitions.

To control for patient co-morbidities, we used the methodology developed as part of the Healthcare Cost and Utilization Project (HCUP), a Federal-State-Industry partnership sponsored by the Agency for Healthcare Research and Quality. This method is an algorithm that identifies co-morbidities based on secondary diagnosis ICD-9-CM codes unrelated to the primary reason for admission.[13] LER volume was calculated by summing the total number of lower extremity revascularization cases, including revisions of previous bypasses, performed at each hospital for any indication. Hospitals were categorized into quartiles of 0–11, 12–71, 72–248, ≥249 LER procedures per year.

Bivariate and multivariate logistic regression using the adjusted survey weights were carried out to examine relationships between SES, co-morbidities, hospital-level factors, and the outcome of major amputation. Significant predictors in bivariate logistic regression at the $P<0.05$ level were entered into a multivariate logistic regression for the dependent variable of amputation vs. LER. A backward selection method was employed to build the final logistic regression model. An alpha of 0.05, corresponding to $P=0.05$ and confidence interval (CI) of 95%, was used as criteria for statistical significance. All database linkages and analyses were performed with SAS 9.1 (SAS Institute, Cary, NC).

## RESULTS

A weighted total of 958,120 discharges contained procedure codes for LER or major amputation and diagnosis codes for CLI in persons over the age of 21 and who had household income recorded in the NIS from January 1, 2003 to December 31, 2007 (Table 1). Approximately one-fourth of the discharges underwent major amputation (24.24%, Standard Error (SE). ±0.59), with greater frequency in minority patients (Table 2), and one third of patients presented with ischemic gangrene (32.86% ±0.71).

Several indicators of low SES clustered by demographic group. Compared to White patients, Native American patients were the most likely to have income in the lowest quartile (Odds Ratio (OR) 3.507; 95% CI 2.108, 5.834; $P<.0001$). Similar lower median income was seen for Black (OR 2.535; 95% CI 2.023, 3.178; $P<.0001$) and Hispanic patients (OR 2.240, 95% CI 1.864, 2.691; $P<.0001$). Non-White patients were more likely to be on Medicaid (OR 2.696; 95% CI 2.442, 2.976; $P<.0001$) and those with Medicaid had lower income than patients with Medicare (OR for income in the lower three quartiles 2.451; 95% CI 2.156, 2.786; $P<.0001$). Patients in NIS who did not have insurance as their primary payer had lower income than those with Medicare (OR 1.703; 95% CI 1.489, 1.949; $P<.0001$) and were more likely to be members of a minority group (OR 1.395; 95% CI 1.192, 1.633; $P<.0001$).

These indicators of low SES were also more commonly seen among patients receiving care at low volume hospitals. Patients with median income in the lowest two quartiles were at higher odds of being treated at the hospitals performing the fewest LER cases (OR for lowest income quartile 3.792; 95% CI 2.736, 5.254; $P<.0001$; OR for second lowest income quartile 2.958; 95% CI 2.170, 4.033; $P<.0001$). Patients with Medicaid were at significantly higher odds of being admitted to the lowest volume hospitals compared to Medicare patients (OR 1.276; 1.076, 1.512; $P=0.005$). In contrast, patients with private insurance were at significantly lower odds of receiving care at low volume centers (OR 0.421; 95% CI 0.362, 0.489; $P<.0001$).

In bivariate analysis with major amputation as the dependent variable, several demographic trends emerged (Table 3). Factors associated with amputation (vs. LER) included older age, male gender, low income, Medicaid or no insurance, and minority race/ethnicity. The effect was strongest in patients identifying as Black or Native American, with smaller differences seen for persons identifying as Hispanic, Asian/Pacific Islander, or “other” race/ethnicity. Patient factors associated with amputation included emergent admission status, as well as many cardiovascular and non-cardiovascular co-morbidities, including complicated DM, as defined by the HCUP co-morbidity algorithm. Patients who did not receive an angiogram were also associated with amputation. Hospital factors associated with amputation included low LER-volume centers, rural setting, non-teaching hospital status, and Southern Region.

In multivariate analysis, associations between demographic factors were attenuated but remained significant (Table 4). Adjusting for other factors, the oldest patients were at higher odds of undergoing major amputation. Black and Native American patients remained at significantly higher odds of undergoing major amputation vs. LER. The relationship between gender and major amputation persisted after controlling for other factors. Women were at lower odds of having a major amputation than men in the multivariate analysis (OR 0.798, $P<.0001$) but women were at higher odds of undergoing a diagnostic angiogram (OR 1.107, $P<.0001$).

Patients with lower income and non-private insurance continued to have a higher likelihood of undergoing major amputation in the multivariate analysis. Compared to patients with the highest income, patients in the lower three income quartiles were at 11–34% higher odds of undergoing major amputation ($P<.05$ for all). Private insurance remained negatively associated with major amputation (OR 0.738; $P<.0001$) and patients with Medicaid were at slightly increased odds of major amputation (OR 1.257; $P<.0001$) compared to those with Medicare. Controlling for other factors did not change the relationship between being uninsured and the odds of major amputation (OR 1.052, $P=0.447$).

Co-morbidities related to peripheral arterial disease (PAD) continued to be significant risk factors for major amputation after adjusting for other factors. Patients with complicated DM (OR 2.167, $P<.0001$), renal failure (OR 1.194, $P<.0001$), and congestive heart failure (OR 3.281, $P<.0001$) were at increased odds of undergoing amputation. Patients admitted emergently were at higher odds of undergoing major amputation than those admitted electively (OR 2.192; $P<.0001$).

The protective effect of undergoing a diagnostic angiography was strengthened in the multivariate analysis. Patients evaluated with an angiogram were at 90% lower odds of having an amputation (OR 0.094, 95% CI 0.088, 0.101, $P<.0001$). The relationship between institutional LER case volume and odds of major amputation remained but was attenuated after adjusting for patient-level and hospital-level factors. In comparison to patients at the highest volume centers, patients at the lowest volume centers were at fifteen times higher odds of undergoing major amputation (OR 15.163; $P<.0001$). Patients in the second quartile were also at significantly increased odds of undergoing major amputation (OR 2.752; *P*<0.001) and those at hospitals in the third quartile were at 77% higher odds of undergoing major amputation compared to those at the highest volume centers (OR 1.767; *P*<.0001).

We suspect that patients who received an angiogram were at least considered for LER, as opposed to patients whose extensive infection, significant co-morbidites, or other clinical factors precluded them from LER and favored primary amputation. Thus we performed a sub-analysis of only those patients who underwent evaluation with an angiogram to test whether the SES effect was still significant in patients with initial consideration for LER (Table 5). Race, income, and insurance status remained significantly related to odds of major amputation however hospital LER procedure volume was less important.

Further analysis of the entire cohort demonstrated that patients with lower median household income, those with Medicaid, and patients who received care at hospitals with lower LER case volume were at significantly lower odds of undergoing angiogram (Table 6). This may be explained in part by the co-association of race and other SES factors and presentation with gangrene. In a separate multivariate analysis adjusting for the presence of gangrene, Black and Native American patients remained at increased odds of undergoing major amputation compared to white patients (OR for Black patients 1.539, 95% CI 1.427, 1.660, *P*<.0001; OR for Native American patients 1.807, 95% CI 1.291, 2.528, *P*=0.0060).

## DISCUSSION

The results of this analysis underscore the effect of patient SES factors including minority race or ethnicity, low income, non-private insurance and hospital factors related to processes of care, such as LER case volume, on the risk of major amputation for CLI in a large nationally representative study. Indicators of low SES were clustered among non-White persons and those with low income. This population of vulnerable patients are not only at higher risk of undergoing major amputation but are also more likely to receive care at institutions with lower LER operative volume. These findings were also seen in a sub-analysis of patients who received a diagnostic angiogram, and thus presumably were considered as candidates for limb salvage. We also found evidence to support relationships between the number of LER procedures performed annually at each institution and the likelihood of patients being evaluated for limb salvage and undergoing an LER procedure.

The patient cohort was unique in that elderly patients over age 78 represented a quarter of the patients included in the analysis. Incidence of PAD increases with age, as does peri-operative morbidity following open surgical LER procedures. As expected, older persons remained at higher risk for limb loss after adjusting for other patient and hospital level factors. A retrospective analysis of 344 patients undergoing LER procedures found that octogenarians might benefit more than younger patients following endovascular interventions, possibly because of the high morbidity following open procedures.[14]

This analysis demonstrated the increased risk of major amputation among minority patients in a multiethnic population while adjusting for income, insurance status, hospital-level factors, and LER volume. The estimated effect of non-White race persisted but was diminished in the multivariate analysis that included income level and insurance status, as well as hospital-level factors and LER volume. This can be attributed to the clustering of race, income, and insurance status. With small data sets, the effect of these indicators of SES may cancel out one another due to collinearity. One of the strengths of the NIS is the large number of inpatient discharges and weighted sample design that allow sufficient power to determine the separate effects of each of the SES factors of interest.

There are several potential explanations for the increased frequency of major amputation in minority populations. A higher prevalence of distal occlusive disease possibly due to DM or genetic variations, unsuitable autogenous conduits, and unreconstructable disease may account for the greater frequency of major amputation in Black and Hispanic patients.[8–9, 15–16] Although race or ethnicity may be a proxy for genetic polymorphisms that contribute to atherosclerotic disease, current knowledge of how some polymorphisms affect disease progression does not explain the heterogeneity in the severity of PAD between racial groups.[17–21]

Access to specialty care also varies by demographic group and may explain these disparities. Low income and minority patients are more likely to receive care at hospitals with fewer resources and limited vascular surgery and angiography capacity.[7] This may contribute to the higher risk of major amputation in these populations. In a study of patients with coronary artery disease or congestive heart failure receiving primary care at community practices affiliated with academic medical centers, women, Black, and Hispanic patients had reduced access to specialist cardiology consultations and these differences contributed to a gap in clinical performance measures.[22]

Income and insurance status are important determinants of access to care. Patients who have low income, have Medicaid as their primary insurance, or are uninsured are more likely to seek care in emergency departments and at community health centers with limited resources.[22–24] In our analysis, persons with low income, Medicaid, and Medicare were more commonly admitted to facilities that performed low numbers of LER procedures and these patients had higher odds of undergoing major amputation than LER. Patients without private insurance were also more commonly identified as members of minority groups and lower income. These results are corroborated by two studies reporting 44–91% increased risk of major amputation for patients with Medicare or Medicaid and those without insurance.[3–4]

Insurance status may be a proxy for quality of care for those with chronic diseases that are related to atherosclerosis such as DM. The presence of DM with complications was a significant predictor of major amputation in this analysis. Using administrative discharge abstracts and ICD-9-CM codes to indicate severity of a chronic disease, such as DM, has limitations. However, in the absence of laboratory data such as hemoglobin A1c measurements, these results are consistent with the notion that CLI severity is related to glycemic control and that better DM management improves chances of limb salvage.[25–26]

One of the strongest predictors in favor of LER for patients in this cohort was the presence of a procedure code for a diagnostic angiogram. Undergoing a pre-operative angiogram is negatively associated with major amputation.[2] Diagnostic angiogram may be an indicator of the level of aggressiveness with which a patient is evaluated for limb salvage. We found that Black patients and those with lower income were less likely to be evaluated with angiography during the index admission. Insurance type may be related to reimbursement for angiography. In a sub-analysis of patients who did have diagnostic angiograms, we found that disparities between patients with higher and lower income and between White and minority patients persisted. In addition to the availability of angiography facilities, operative volume is an imperfect but quantifiable measure of the vascular surgery capacity of a hospital. Hospital LER volume had a significant relationship to risk of major amputation. Compared to patients at the highest volume centers those at lower volume hospitals had up to 15.2 times higher odds of undergoing major amputation. These patients were also more commonly non-White and had lower income. Patients at low volume facilities were also less likely to undergo diagnostic angiogram during the discharge recorded in NIS. Our data is similar to other reports that patients with CLI who present to higher volume hospitals are more likely to undergo a limb salvage procedure than major amputation.[4] In evaluating the volume-outcome relationship for carotid endarterectomy and coronary artery bypass grafting, several authors have reported that that Black and Hispanic patients are more likely to be treated at the lowest-volume hospitals and by surgeons who perform fewer of these procedures.[27–28]

Higher volume hospitals may have more fellowship-trained vascular specialists, established protocols for peri-operative care of patients with CLI, and greater access to angiography facilities. Adjusted mortality is significantly lower for patients undergoing CEA, AAA, and LER in higher volume hospitals compared to those receiving care in the lowest volume centers although the differences in mortality following LER procedures may be a low as 2%.[29] While these findings are informative and demonstrate the need for further research, the healthcare system characteristics that are the driving forces behind this finding are not easily studied.[29–32] Surgeon training has also been found to be an important factor related to mortality and amputation rates. Vascular surgery training is associated with a 1.2% decrease in risk adjusted mortality rates and a 2.3% decrease in amputation rates.[33–34] Regional variability in amputation rates may be partially explained by the availability of vascular surgeons as fewer vascular surgeons choose to live and work in medically under-served areas.[35]

This study has several limitations. The first is the reliability of race and ethnicity in administrative datasets. Data on race is often collected in broad categories. Hispanic, Asian/Pacific Islander, and Native American persons may be under-represented or designated as "other" which dilutes any inferences made regarding non-White persons.[36] One study matched race and ethnicity data in Minnesota Medicaid enrollee files to self-report information from a telephone/mail survey and found the administrative data correctly classified 94% of cases.[37] A similar study corroborating race/ethnicity data recorded in the NIS has not been published although we assume a similarly high rate of reliability in this administrative dataset.

A second limitation is missing categorical data for race. Twenty-four percent of our sample had missing values for race. Because race is recorded in administrative data by self-report which may be influenced by any number of factors related to SES, co-morbidities, and geography, these data cannot be assumed to be missing at random or missing completely at random and as such, using multiple imputation methods to adjust for missing data have their own limitations. There are several methods in the literature to address this dilemma.[12] The first is to perform a complete case analysis and to exclude any discharges with missing values for a primary predictor such as race. This method would have decreased our sample size and statistical power. A second method is to create a seventh race/ethnicity category for patients with missing race data, designated as "missing race", and to retain them in the dataset. Lastly, re-weighted estimating equations can be used to adjust the survey sampling weights by the inverse probability that race would be "observed" for a patient. The data presented in this manuscript employed re-weighted estimating equations. A complete case analysis and an analysis conducted with a "missing race" categorical variable produced results that were similar in magnitude and direction but with potentially biased standard errors compared to the analysis using the re-weighted estimating equations.

The lack of detailed information regarding angiography presents another limitation. NIS is a cross-sectional dataset and does not reflect evaluation for limb salvage preceding the discharge recorded in NIS or evaluations occurring at institutions outside of the facility where the index discharge occurred. The ICD-9-CM diagnosis codes do not capture in specific detail the anatomic level of disease, presence of outflow vessels, or availability of suitable autogenous conduit. We attempted to address this issue by excluding patients who had ICD-9-CM diagnosis codes for atherosclerosis of a bypass graft or procedure codes for revision of a lower extremity bypass graft. NIS hospital level data does not indicate the availability of angiography facilities or staff trained in endovascular techniques at the hospital where the patient underwent the procedure. To account for the availability of angiography facilities and trained staff we conducted a sub-analysis of patients who underwent a diagnostic angiogram and found that the associations between patient-level factors and hospital-level factors persisted.

Barring these limitations, our work provides additional insight into the associations between SES, co-morbidities, and hospital-level factors as they relate to LER vs. major amputation for CLI patients. The observed clustering of factors is indicative of complex social issues affecting disadvantaged patients in the healthcare system beyond the CLI condition studied here. Patient access to primary and specialist care, perception of the disease process, health literacy, and cultural values may also influence when a person with CLI seeks treatment and how treatment options are chosen. A hospital's access to angiography facilities, the quality of peri-operative care for patients with multiple co-morbidities, and the vascular provider's level of training also impact the aggressiveness of patient evaluation and which procedures can be safely performed.

Studying the separate contributions of these factors to disparities using administrative data allows the benefit of a large national representative sample but requires the use of imperfect proxies to describe a patient's socioeconomic environment, access to care, and the vascular care capacity of the facilities where they are treated.[38] Race, income, and insurance status are useful indicators of SES and access to care. We have shown that after controlling for co-morbidities and hospital-level factors, patients who identify as Black or Native American, have low income, and those who have Medicare or Medicaid are at higher risk for major amputation than White patients and those who have higher income or private insurance. These findings suggest there are gaps in access to care despite controlling for hospital-level factors and procedural volume. Further analysis of datasets that contain information on referral patterns and utilization of outpatient healthcare could guide potential interventions which target patients at high risk for PAD and major amputation and lead the way for implementing screening protocols focused on risk factor modification and appropriate early vascular surgery referral pathways.

The inverse relationship between LER procedure volume and risk of major amputation for CLI highlights potential solutions for disparities related to hospital-level factors. Increasing state and local funding to facilities that provide care to patients at high risk for major amputation may improve professional resources. Given the highly positive impact of pre-operative angiography on the likelihood of undergoing an LER procedure, studying the factors influencing the clinical decision to evaluate revascularization options may illustrate reasons for the less frequent use of angiography in certain patient populations and help to more widely implement standard diagnostic protocols.

## CONCLUSIONS

Minority patients tend to have lower income, less insurance coverage, present with more co-morbidities such as diabetes and renal failure that influence treatment options, and are more likely to receive care at low-volume and potentially under-resourced hospitals. These factors, independently and in combination, are associated with a greater likelihood of major amputation, an outcome of CLI with profound functional and quality of life impact. Further exploration of these potential mechanisms of disparities at both at the patient and the hospital level may improve limb salvage for vulnerable populations.

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## Appendix: ICD-9-CM diagnosis and procedure codes

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| | |
|---|---|
| **Diagnosis:** | |
| Atherosclerosis of the native arteries | 440.20, 440.22, 440.23, 440.24, 440.29 |
| Chronic total occlusion of artery of the extremities | 440.4 |
| Peripheral vascular disease unspecified | 443.9 |
| Peripheral vascular disease due to diabetes or angiopathy | 443.81 |
| Lower extremity gangrene due to diabetes | 249.7, 250.7 |
| Ischemic gangrene | 785.4 |
| Lower extremity ulcer of the calf, the ankle, the heel or mid-foot, other part of the leg | 707.10, 707.12, 707.13, 707.14, 707.19 |
| **Major amputation:** | |
| Lower extremity amputation at the level of the ankle, below the knee, at the knee, above the knee | 84.14, 84.15, 84.16, 84.17 |
| **Lower extremity revascularization:** | |
| Aorta-iliac-femoral bypass | 39.25 |
| Other peripheral vascular shunt or bypass | 39.29 |
| Incision of a vessel of the lower limb arteries | 38.08 |
| Endarterectomy of the lower limb arteries | 38.18 |
| Resection of vessel with anastomosis of the lower limb arteries | 38.38 |
| Resection of vessel with replacement of the lower limb arteries | 38.48 |
| Repair of blood vessel with tissue patch graft of the lower limb arteries | 39.56 |
| Repair of blood vessel with synthetic patch graft of the lower limb arteries | 39.57 |
| Repair of blood vessel with unspecified type of patch graft of the lower limb arteries | 39.58 |
| Angioplasty or atherectomy of other non-coronary vessels | 39.50 |
| Insertion of non-drug eluting peripheral vessel stents | 39.90 |
| Adjunct vascular system procedures on a single, two, three, or four or more vessels | 00.40, 00.41, 00.42, 00.43 |
| Insertion of one, two, three, or four or more peripheral vascular stents | 00.45, 00.46, 00.47, 00.48 |
| **Excluded procedures and diagnoses:** | |
| Revision of previous lower extremity vascular bypasses | 39.49 |
| Lower extremity trauma or traumatic injury of blood vessels | 904.0, 904.1, 904.2, 904.3, 904.40–904.42, 904.50–904.54, 904.6, 904.7, 904.8, 904.9, 908.3, 908.6, 908.9, 958.8, 958.92 |

**Table 1**

Descriptive statistics for study cohort Weighted N = 958,120

| Variable | Weighted frequency (S.E.) |
|---|---|
| **Age in years (mean)** | 69.37 years (±0.10) |
| **Race:** | |
| White | 71.94% (±0.99) |
| Black | 16.26% (±0.81) |
| Hispanic | 8.15% (±0.55) |
| Asian/Pacific Islander | 1.11% (±0.11) |
| Native American | 0.54% (±0.08) |
| Other | 2.00% (±0.21) |
| Missing 24.33% | ± |
| **Female gender:** | 42.94% (±0.26) |
| | ± |
| **Median income by zip code:** | ± |
| Q1 | 31.26% (±0.97) |
| Q2 | 27.21% (±0.70) |
| Q3 | 23.13% (±0.55) |
| Q4 | 18.40% (±0.86) |
| **Primary payer:** | |
| Medicare | 72.93% (±0.35) |
| Private insurance | 17.42% (±0.30) |
| Medicaid | 6.12% (±0.20) |
| Uninsured | 3.51% (±0.19) |
| **Patient county of residence:** | |
| Large metropolitan | 51.10% (±2.07) |
| Small metropolitan | 28.52% (±1.61) |
| Micopolitan | 10.95% (±0.97) |
| Other | 8.48% (±0.55) |
| | ± |
| **Co-morbidity** | ± |
| Congestive heart failure | 12.76% (±0.31) |
| Vavular disease | 4.09% (±0.11) |
| Pulmonary circulation disorders | 0.73% (±0.03) |
| Peripheral vascular disorders | 59.25% (±0.69) |
| Hypertension | 69.94% (±0.35) |
| Paralysis | 2.65% (±0.08) |
| Neurological disorders | 4.83% (±0.12) |
| Chronic pulmonary disease | 22.79% (±0.30) |
| Diabetes mellitus, uncomplicated | 24.61% (±0.27) |

| Variable | Weighted frequency (S.E.) |
|---|---|
| Diabetes mellitus with chronic complications | 19.32% (±0.36) |
| Hypothyroidism | 7.14% (±0.14) |
| Renal failure | 21.30% (±0.34) |
| Liver disease | 1.06% (±0.04) |
| Peptic ulcer disease without bleeding | 0.04% (±0.01) |
| Acquired immune deficiency syndrome | 0.10% (±0.01) |
| Lymphoma | 0.30% (±0.02) |
| Metastatic cancer | 0.50% (±0.02) |
| Solid tumor without metastases | 1.02% (±0.03) |
| Rheumatoid arthritis/collagen vascular diseases | 2.01% (±0.05) |
| Coagulopathy | 2.50% (±0.07) |
| Obesity | 5.04% (±0.17) |
| Weight loss | 3.66% (±0.15) |
| Fluid and electrolyte disorders | 14.71% (±0.27) |
| Chronic blood loss anemia | 1.46% (±0.07) |
| Deficiency anemias | 17.74% (±0.41) |
| Alcohol abuse | 1.93% (±0.06) |
| Drug abuse | 0.63% (±0.03) |
| Psychoses | 1.48% (±0.05) |
| Depression | 5.27% (±0.15) |
| **Diagnostic angiogram** | 27.44% (±0.57) |
| **Admission status:** | |
| Elective | 49.58% (±0.91) |
| Non-elective | 50.42% (±0.91) |
| **LER volume:** | |
| Q1: 0–11/year | 2.46% (±0.15) |
| Q2: 12–71/year | 7.66% (±0.49) |
| Q3: 72–248/year | 24.89% (±1.37) |
| Q4: ≥ 249/year | 64.99% (±1.59) |
| **Hospital location:** | |
| Urban | 92.22% (±1.34) |
| Rural | 7.78% (±1.34) |
| **Hospital teaching status:** | |
| Teaching | 50.64% (±1.72) |
| Non-teaching | 49.36% (±1.72) |
| **Hospital bed size:** | |
| Small | 9.99% (±0.95) |
| Medium | 23.12% (±1.24) |
| Large | 66.89% (±1.48) |

| **Variable** | **Weighted frequency (S.E.)** |
|---|---|
| **Geographic region:** | |
| Northeast | 20.30% (±1.67) |
| Midwest | 23.93% (±1.42) |
| South | 40.59% (±1.65) |
| West | 15.18% (±1.08) |

## Table 2

Weighted frequency of major amputation by race/ethnicity

| Race/Ethnicity | % with Major Amputation (S.E.) |
|---|---|
| White | 19.26% (±0.52) |
| Black | 40.74% (±1.01) |
| Hispanic | 33.94% (±1.14) |
| Asian/Pacific Islander | 29.96% (±2.22) |
| Native American | 36.85% (±3.30) |
| Other race | 23.45% (±1.53) |

## Table 3

Bivariate results for the outcome of major amputation

| Variable | Odds ratio | 95% CI | P value |
|---|---|---|---|
| **Age** | | | |
| Q1: 21–61 years | Reference | | |
| Q2: 62–70 years | 0.725 | 0.694, 0.758 | <.0001 |
| Q3: 71–78 years | 0.736 | 0.700, 0.773 | <.0001 |
| Q4: ≥ 79 years | 1.125 | 1.066, 1.188 | <.0001 |
| **Race:** | | | |
| White | Reference | | |
| Black | 2.883 | 2.654, 3.131 | <.0001 |
| Hispanic | 2.154 | 1.940, 2.391 | <.0001 |
| Asian/Pacific Islander | 1.794 | 1.455, 2.212 | <.0001 |
| Native American | 2.447 | 1.864, 3.211 | <.0001 |
| Other | 1.284 | 1.089, 1.514 | 0.0029 |
| **Gender:** | | | |
| Male | Reference | | |
| Female | 0.961 | 0.929, 0.994 | 0.0212 |
| **Median income by zip code:** | | | |
| Q1 | 1.763 | 1.599, 1.943 | <.0001 |
| Q2 | 1.364 | 1.244, 1.496 | 0.0189 |
| Q3 | 1.172 | 1.084, 1.268 | <.0001 |
| Q4 | Reference | | |
| **Primary payer:** | | | |
| Medicare | Reference | | |
| Private insurance | 0.556 | 0.527, 0.586 | <.0001 |
| Medicaid | 1.623 | 1.524, 1.728 | <.0001 |
| Uninsured | 1.106 | 0.970, 1.260 | 0.1308 |
| **Patient county of residence:** | | | |
| Large metropolitan | Reference | | |
| Small metropolitan | 1.060 | 0.951, 1.182 | 0.2918 |
| Micopolitan | 1.076 | 0.871, 1.328 | 0.4986 |
| Other | 1.004 | 0.867, 1.162 | 0.9614 |
| **Co-morbidity** | | | |
| Congestive heart failure | 4.158 | 3.881, 4.454 | <.0001 |
| Vavular disease | 1.769 | 1.634, 1.915 | <.0001 |
| Pulmonary circulation disorders | 2.277 | 1.970, 2.632 | <.0001 |
| Peripheral vascular disorders | 0.422 | 0.395, 0.451 | <.0001 |
| Hypertension | 0.766 | 0.736, 0.797 | <.0001 |
| Paralysis | 3.611 | 3.325, 3.923 | <.0001 |

| **Variable** | **Odds ratio** | **95% CI** | **P value** |
|---|---|---|---|
| Neurological disorders | 2.963 | 2.797, 3.138 | <.0001 |
| Chronic pulmonary disease | 0.750 | 0.722, 0.780 | <.0001 |
| Diabetes mellitus, uncomplicated | 0.616 | 0.587, 0.646 | <.0001 |
| Diabetes mellitus with chronic complications | 2.791 | 2.646, 2.945 | <.0001 |
| Hypothyroidism | 0.894 | 0.845, 0.947 | 0.0001 |
| Renal failure | 2.006 | 1.913, 2.103 | <.0001 |
| Liver disease | 1.978 | 1.773, 2.206 | <.0001 |
| Peptic ulcer disease without bleeding | 1.788 | 1.022, 3.129 | 0.0418 |
| Acquired immune deficiency syndrome | 1.634 | 1.129, 2.365 | 0.0093 |
| Lymphoma | 1.212 | 0.981, 1.497 | 0.0755 |
| Metastatic cancer | 1.438 | 1.209, 1.712 | <.0001 |
| Solid tumor without metastases | 1.029 | 0.905, 1.168 | 0.6658 |
| Rheumatoid arthritis/collagen vascular diseases | 0.968 | 0.878, 1.067 | 0.5126 |
| Coagulopathy | 1.614 | 1.483, 1.757 | <.0001 |
| Obesity | 0.746 | 0.694, 0.802 | <.0001 |
| Weight loss | 4.857 | 4.375, 5.392 | <.0001 |
| Fluid and electrolyte disorders | 2.691 | 2.570, 2.818 | <.0001 |
| Chronic blood loss anemia | 1.905 | 1.699, 2.135 | <.0001 |
| Deficiency anemias | 2.468 | 2.349, 2.593 | <.0001 |
| Alcohol abuse | 1.184 | 1.077, 1.302 | 0.0005 |
| Drug abuse | 2.224 | 1.943, 2.547 | <.0001 |
| Psychoses | 2.540 | 2.313, 2.790 | <.0001 |
| Depression | 1.650 | 1.542, 1.766 | <.0001 |
| **Diagnostic angiogram** | 0.139 | 0.128, 0.150 | <.0001 |
| **Admission status:** | | | |
| Elective | Reference | | |
| Non-elective | 2.434 | 2.261, 2.622 | <.0001 |
| **LER volume:** | | | |
| Q1: 0–11/year | 22.430 | 18.730, 26.862 | <.0001 |
| Q2: 12–71/year | 3.454 | 3.051, 3.911 | <.0001 |
| Q3: 72–248/year | 2.057 | 1.851, 2.287 | <.0001 |
| Q4: ≥ 249/year | Reference | | |
| **Hospital location:** | | | |
| Urban | Reference | | |
| Rural | 1.741 | 1.114, 2.721 | 0.0150 |
| **Hospital teaching status:** | | | |
| Teaching | Reference | | |
| Non-teaching | 1.270 | 1.121, 1.438 | 0.0002 |
| **Hospital bed size:** | | | |

| Variable | Odds ratio | 95% CI | P value |
|---|---|---|---|
| Small | 1.068 | 0.845, 1.349 | 0.9862 |
| Medium | 1.145 | 1.001, 1.310 | 0.2082 |
| Large | Reference | | |
| **Geographic region:** | | | |
| Northeast | 0.759 | 0.636, 0.906 | 0.1135 |
| Midwest | 0.732 | 0.621, 0.864 | 0.0217 |
| South | Reference | | |
| West | 0.759 | 0.755, 1.060 | 0.3027 |

## Table 4

Multivariate results for the outcome of major amputation

| Variable | Odds ratio | 95% CI | P value |
|---|---|---|---|
| **Age** | | | |
| Q1: 21–61 years | Reference | | |
| Q2: 62–70 years | 0.759 | 0.720, 0.800 | <.0001 |
| Q3: 71–78 years | 0.818 | 0.770, 0.869 | <.0001 |
| Q4: ≥ 79 years | 1.192 | 1.117, 1.272 | <.0001 |
| **Race:** | | | |
| White | Reference | | |
| Black | 2.149 | 1.994, 2.316 | <.0001 |
| Hispanic | 1.600 | 1.464, 1.749 | 0.0814 |
| Asian/Pacific Islander | 1.302 | 1.079, 1.571 | 0.1197 |
| Native American | 2.002 | 1.519, 2.640 | 0.0107 |
| Other | 1.166 | 0.996, 1.364 | 0.0009 |
| **Gender:** | | | |
| Male | Reference | | |
| Female | 0.798 | 0.771, 0.826 | <.0001 |
| **Median income by zip code:** | | | |
| Q1 | 1.342 | 1.240, 1.453 | <.0001 |
| Q2 | 1.257 | 1.166, 1.356 | 0.0002 |
| Q3 | 1.115 | 1.037, 1.199 | 0.0145 |
| Q4 | Reference | | |
| **Primary payer:** | | | |
| Medicare | Reference | | |
| Private insurance | 0.738 | 0.696, 0.783 | <.0001 |
| Medicaid | 1.257 | 1.171, 1.349 | <.0001 |
| Uninsured | 1.052 | 0.923, 1.199 | 0.4477 |
| **Co-morbidity:** | | | |
| Congestive heart failure | 3.281 | 3.081, 3.495 | <.0001 |
| Vavular disease | 1.348 | 1.235, 1.472 | <.0001 |
| Pulmonary circulation disorders | 1.293 | 1.098, 1.522 | 0.0020 |
| Peripheral vascular disorders | 0.400 | 0.377, 0.425 | <.0001 |
| Hypertension | 0.771 | 0.739, 0.803 | <.0001 |
| Paralysis | 2.775 | 2.525, 3.049 | <.0001 |
| Neurological disorders | 2.178 | 2.031, 2.335 | <.0001 |
| Chronic pulmonary disease | 0.735 | 0.704, 0.768 | <.0001 |
| Diabetes mellitus, uncomplicated | 0.802 | 0.763, 0.842 | <.0001 |
| Diabetes mellitus with chronic complications | 2.167 | 2.050, 2.290 | <.0001 |
| Hypothyroidism | 0.930 | 0.872, 0.992 | 0.0285 |

| Variable | Odds ratio | 95% CI | P value |
|---|---|---|---|
| Renal failure | 1.194 | 1.138, 1.253 | <.0001 |
| Liver disease | 1.319 | 1.149, 1.513 | <.0001 |
| Metastatic cancer | 1.433 | 1.153, 1.779 | 0.0012 |
| Coagulopathy | 1.103 | 1.001, 1.215 | 0.0471 |
| Obesity | 0.808 | 0.747, 0.874 | <.0001 |
| Weight loss | 2.570 | 2.336, 2.827 | <.0001 |
| Fluid and electrolyte disorders | 1.642 | 1.568, 1.720 | <.0001 |
| Chronic blood loss anemia | 1.696 | 1.623, 1.772 | <.0001 |
| Deficiency anemias | 1.696 | 1.623, 1.772 | <.0001 |
| Drug abuse | 1.253 | 1.030, 1.524 | 0.0238 |
| Psychoses | 1.848 | 1.650, 2.070 | <.0001 |
| Depression | 1.653 | 1.536, 1.779 | <.0001 |
| Diagnostic angiogram | 0.094 | 0.088, 0.101 | <.0001 |
| **Admission status:** | | | |
| Elective | Reference | | |
| Non-elective | 2.192 | 2.060, 2.333 | <.0001 |
| **LER volume:** | | | |
| Q1: 0–11/year | 15.163 | 12.497, 18.397 | <.0001 |
| Q2: 12–71/year | 2.752 | 2.439, 3.105 | <.0001 |
| Q3: 72–248/year | 1.767 | 1.609, 1.940 | <.0001 |
| Q4: ≥ 249/year | Reference | | |
| **Hospital teaching status:** | | | |
| Teaching | 1.132 | 1.021, 1.254 | 0.0186 |
| Non-teaching | Reference | | |
| **Geographic region:** | | | |
| Northeast | 0.769 | 0.675, 0.875 | 0.0287 |
| Midwest | 0.807 | 0.704, 0.925 | 0.3041 |
| South | Reference | | |
| West | 0.831 | 0.737, 0.937 | 0.6399 |
| Model C statistic 0.865, R-square 0.8983 | | | |

## Table 5

Multivariate results for the outcome of major amputation in patients who underwent diagnostic angiogram

| Variable | Odds ratio | 95% CI | P value |
|---|---|---|---|
| **Age** | | | |
| Q1: 21–61 years | Reference | | |
| Q2: 62–70 years | 0.959 | 0.830, 1.108 | 0.5696 |
| Q3: 71–78 years | 1.092 | 0.941, 1.268 | 0.2468 |
| Q4: ≥ 79 years | 1.156 | 0.972, 1.376 | 0.1015 |
| **Race:** | | | |
| White | Reference | | |
| Black | 1.942 | 1.701, 2.217 | <.0001 |
| Hispanic | 1.575 | 1.352, 1.834 | <.0001 |
| Asian/Pacific Islander | 1.243 | 0.810, 1.907 | 0.3192 |
| Native American | 2.153 | 1.400, 3.309 | 0.0005 |
| Other | 1.491 | 1.085, 2.049 | 0.0138 |
| **Gender:** | | | |
| Male | Reference | | |
| Female | 0.873 | 0.792, 0.963 | 0.0065 |
| **Median income by zip code:** | | | |
| Q1 | 1.484 | 1.274, 1.729 | <.0001 |
| Q2 | 1.349 | 1.156, 1.574 | 0.0001 |
| Q3 | 1.205 | 1.025, 1.417 | 0.0237 |
| Q4 | Reference | | |
| **Primary payer:** | | | |
| Medicare | Reference | | |
| Private insurance | 0.818 | 0.686, 0.976 | 0.0256 |
| Medicaid | 1.125 | 0.929, 1.361 | 0.2271 |
| Uninsured | 1.038 | 0.789, 1.366 | 0.7893 |
| **Co-morbidity:** | | | |
| Congestive heart failure | 2.610 | 2.293, 2.971 | <.0001 |
| Vavular disease | 1.541 | 1.284, 1.850 | <.0001 |
| Pulmonary circulation disorders | 1.148 | 0.781, 1.686 | 0.4825 |
| Peripheral vascular disorders | 0.702 | 0.638, 0.773 | <.0001 |
| Hypertension | 0.901 | 0.811, 1.001 | 0.0527 |
| Paralysis | 1.438 | 1.114, 1.857 | 0.0053 |
| Neurological disorders | 1.407 | 1.165, 1.700 | 0.0004 |
| Chronic pulmonary disease | 0.915 | 0.811, 1.033 | 0.1505 |
| Diabetes mellitus, uncomplicated | 0.724 | 0.638, 0.822 | <.0001 |
| Diabetes mellitus with chronic complications | 1.122 | 0.990, 1.272 | 0.0716 |
| Hypothyroidism | 0.775 | 0.630, 0.953 | 0.0155 |

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| Variable | Odds ratio | 95% CI | P value |
|---|---|---|---|
| Renal failure | 1.434 | 1.294, 1.589 | <.0001 |
| Liver disease | 1.253 | 0.849, 1.849 | 0.2553 |
| Metastatic cancer | 1.025 | 0.599, 1.754 | 0.9291 |
| Coagulopathy | 1.281 | 1.007, 1.629 | 0.0435 |
| Obesity | 0.849 | 0.674, 1.069 | 0.1637 |
| Weight loss | 2.137 | 1.758, 2.597 | <.0001 |
| Fluid and electrolyte disorders | 1.517 | 1.333, 1.726 | <.0001 |
| Chronic blood loss anemia | 0.881 | 0.611, 1.270 | 0.4960 |
| Deficiency anemias | 1.348 | 1.212, 1.499 | <.0001 |
| Drug abuse | 1.252 | 0.702, 2.233 | 0.4464 |
| Psychoses | 1.715 | 1.283, 2.293 | 0.0003 |
| Depression | 1.515 | 1.257, 1.825 | <.0001 |
| **Admission status;** | | | |
| Elective | Reference | | |
| Non-elective | 2.671 | 2.296, 3.108 | <.0001 |
| **LER volume:** | | | |
| Q1: 0–11/year | 5.189 | 3.123, 8.620 | <.0001 |
| Q2: 12–71/year | 2.030 | 1.655, 2.490 | <.0001 |
| Q3: 72–248/year | 1.384 | 1.196, 1.603 | <.0001 |
| Q4: ≥ 249/year | Reference | | |
| **Hospital teaching status:** | | | |
| Teaching | 0.853 | 0.731, 0.995 | 0.0431 |
| Non-teaching | Reference | | |
| **Geographic region:** | | | |
| Northeast | 0.709 | 0.591, 0.851 | 0.0002 |
| Midwest | 0.849 | 0.697, 1.035 | 0.1056 |
| South | Reference | | |
| West | 0.756 | 0.614, 0.932 | 0.0086 |
| Model c statistic 0.779 | | | |

## Table 6

Bivariate analysis of predictors of diagnostic angiogram in the full cohort

| Variable | OR | 95% CI | P value |
|---|---|---|---|
| **Age** | | | |
| Q1: 21–61 years | Reference | | |
| Q2: 62–70 years | 1.043 | 1.004, 1.084 | 0.0296 |
| Q3: 71–78 years | 1.087 | 1.043, 1.133 | <.0001 |
| Q4: ≥ 79 years | 1.196 | 1.138, 1.256 | <.0001 |
| **Race:** | | | |
| White | Reference | | |
| Black | 0.969 | 0.897, 1.047 | 0.0483 |
| Hispanic | 1.099 | 1.007, 1.199 | 0.2104 |
| Asian/Pacific Islander | 0.991 | 0.864, 1.138 | 0.3698 |
| Native American | 1.154 | 0.926, 1.438 | 0.3093 |
| Other | 1.075 | 0.929, 1.245 | 0.6607 |
| **Gender:** | | | |
| Male | Reference | | |
| Female | 1.107 | 1.075, 1.141 | <.0001 |
| **Median income by zip code:** | | | |
| Q1 | 0.854 | 0.788, 0.925 | 0.1831 |
| Q2 | 0.803 | 0.744, 0.867 | <.0001 |
| Q3 | 0.874 | 0.822, 0.929 | 0.7025 |
| Q4 | Reference | | |
| **Primary payer:** | | | |
| Medicare | Reference | | |
| Private insurance | 0.971 | 0.928, 1.017 | 0.2098 |
| Medicaid | 0.914 | 0.862, 0.970 | 0.0029 |
| Uninsured | 0.931 | 0.841, 1.029 | 0.1621 |
| **LER volume:** | | | |
| Q1: 0–11/year | 0.123 | 0.095, 0.161 | <.0001 |
| Q2: 12–71/year | 0.668 | 0.586, 0.761 | <.0001 |
| Q3: 72–248/year | 0.957 | 0.863, 1.060 | 0.3960 |
| Q4: ≥ 249/year | Reference | | |