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Relationship between regional spending on vascular care and amputation rate

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Abstract

Importance—While lower extremity revascularization is effective in preventing amputation, the relationship between spending on vascular care and regional amputation rates remains unclear.

Objective—To test the hypothesis that higher regional spending on vascular care is associated with lower amputation rates in patients with severe peripheral arterial disease (PAD).

Design—Retrospective cohort study.

Setting—United States Medicare patients, 2003-2010

Participants—18,463 patients who underwent major PAD-related amputation.

Exposures—Price-adjusted Medicare spending on revascularization procedures and related vascular care in the year before lower extremity amputation, across hospital referral regions.

Main Outcome Measure(s)—Correlation coefficient between regional spending on vascular care and regional rates of PAD-related amputation.

Results—Among patients ultimately subject to amputation, 64% were admitted to the hospital in the year prior to amputation for revascularization, wound-related care, or both; 36% were admitted only for their amputation. The mean cost of inpatient care in the year before amputation, including the amputation itself, was $22,405, but varied from $11,077 (Bismarck, North Dakota) to $42,613 (Salinas, California) (p<0.001). Patients in high-spending regions were more likely to undergo vascular procedures in crude analyses (12.0 procedures per 10,000 patients in the lowest quintile of spending, 20.4 procedures per 10,000 patients in the highest quintile of spending, p<0.0001), as well as in risk-adjusted analyses (adjusted OR for receiving a vascular procedure in highest quintile of spending = 3.5, 95 % CI 3.2-3.8, p<0.0001). While revascularization was associated

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with higher spending (R=0.38, p<0.001), higher spending was not associated with lower regional amputation rates (R=0.10, p=0.06). Regions most aggressive in the use of endovascular interventions which most likely to have high spending (R=0.42, p=0.002) and high amputation rates (R=0.40, p=0.004).

Conclusions—Regions that spend the most on vascular care is highest perform the most procedures, especially endovascular interventions, in the year before amputation. However, there is little evidence that higher regional spending is associated with lower amputation rates. This suggests an opportunity to limit costs in vascular care without compromising quality.

Keywords

Cardiovascular sugery; endovascular interventions; cost; peripheral vascular disease; health policy and outcomes research

Introduction

Health care costs attributable to critical limb ischemia, the most severe form of peripheral arterial disease (PAD), have been estimated at nearly 5 billion dollars annually in Medicare patients[1, 2]. Moreover, with the advent of less invasive endovascular techniques, the use of revascularization procedures for critical limb ischemia (CLI) has increased four-fold since 2003 [3]. Therefore, many believe that in recent years, vascular care aimed at preventing amputation has become increasingly intensive and expensive[4].

However, the costs of revascularization for patients who are at risk for amputation, as well as the costs of amputation procedure itself, remain uncertain. These costs vary significantly according to the type of treatments patients receive. For example, “plain old” balloon angioplasty requires catheters that cost a few hundred dollars each, while newer atherectomy devices, drug-coated balloons, and other endovascular adjuncts can exceed several thousand dollars for each artery treated[5]. Second, while leg bypass surgery is spared the device-related costs of endovascular interventions, the resultant hospital stay nearly always spans several days, and incurs significant expense[6-8]. And third, the costs related to the amputation procedure itself remain uncertain, and patients undergoing amputation commonly have post-operative complications and a prolonged hospital stay[9, 10]. A description of spending patterns for patients at risk for amputation, as well as a delineation of relationships between spending on vascular care and amputation risk, may help to guide physicians and policymakers towards establishing value-based guidelines for the treatment of severe PAD.

Therefore, we characterized Medicare spending related to severe PAD in the year prior to amputation, including costs related to the amputation procedure itself. To ensure we studied vascular care provided to patients with the most severe form of PAD, rather than the discretionary treatment of claudication, we studied care provided to patients in the year prior to major limb amputation as a result of PAD. Using across hospital referral regions as our unit of analysis[11], we examined risk-adjusted relationships between spending and amputation risk.

Methods

Databases

We used Medicare claims (2003-2010) to identify patients with severe PAD, and then examined the costs associated with vascular care in the year prior to amputation. We utilized CPT codes to define both revascularization procedures and leg amputation procedures (above and below-knee only) commonly utilized in the care of patients with severe PAD[12]. As in prior work, we also ensured that all patients had ICD-9 diagnosis codes for peripheral vascular disease, and underwent major above or below-knee amputation - an indicator of critical limb ischemia[3, 13]. We recorded the procedure, and age, gender, and race of the beneficiary receiving the procedure. Vital status was determined using the Denominator file, which contains information about eligibility by year for Part B and information about age, gender, and race of eligible beneficiaries (Figure 1).

We excluded patients under age 66, to allow a one-year "look-back" for comorbidity assessment. Similarly, records with missing values for gender, age, and race strata were also removed from the analysis. We recorded comorbidities including hypertension, diabetes, coronary disease, renal insufficiency, cerebrovascular disease, congestive heart failure, malignancy, measured both individually and in aggregate using the Charlson score. We identified each patient's zip code of residence and hospital referral region (HRR). as described by the Dartmouth Atlas of Healthcare[11]. Of the 20,058 patients in our dataset, cost data was unavailable in Medicare claims for 8% (1,595 patients). These patients were excluded from our analysis, but were similar in characteristics to those patients who remained in our cohort.

Studying cost in the year prior to amputation

The severity of PAD can vary significantly, from claudication to limb-threatening ischemia and gangrene. To study a population of patients with similar extent of PAD[13], we examined vascular care during the year prior to amputation. By intent, the extent of PAD is inherently similar across patients studied in this manner, as the risk of 1-year limb loss for the entire cohort is 100%[4, 14]. As reported in prior work, the use of this exposure variable (vascular care in the year prior to amputation) allows us to study care aimed specifically at the treatment of severe PAD, rather than the discretionary treatment of claudication[13, 14].

Calculating Price-Adjusted Medicare Spending in the Year Prior to Amputation

In this analysis, for a global assessment of the costs of critical limb ischemia, we studied inpatient costs during the year prior to amputation, including costs related to revascularization, wound debridement, as well as management of cellulitis. This encompassed both diagnostic (such as a diagnostic angiogram) and therapeutic invasive vascular procedures. We also studied costs incurred during the amputation procedure itself. Spending was aggregated at the level of the hospital referral region, as defined in the Dartmouth Atlas[11].

Costs were then adjusted for regional differences in Medicare payments, adjusted for inflation given the year of the procedure, and reported as "price-adjusted" Medicare spending[15]. Finally, to specifically consider the impact of revascularization procedures alone, we studied costs specifically associated with revascularization, exclusive of amputation-related care.

Calculating population-based regional major leg amputation rate

Population-based regional amputation rate was calculated across hospital referral regions, using the total number of major amputations as the numerator, and total number of patients in the region (determined from the mid-year census estimate) as the denominator. Toe amputations and forefoot amputations were not considered in this analysis.

Examining relationships between regional spending and rates of amputation

After defining regional spending in the year prior to amputation and calculating population-based regional rates of major amputation, we examined the associations between these two variables. These associations were displayed using scatter plots between the exposure variable and the outcome variable, at the regional level. Correlation coefficients were calculated between the exposure and outcome.

To adjust for differences in patient characteristics across regions, we generated quintiles of spending and population-based amputation rates, and adjusted for differences in comorbidities and Charlson score across quintiles of spending using backwards stepwise logistic regression models. Models adjusted for patient-level comorbidities as outlined in Table 1, and a cut-off of $p<0.20$ was established for model inclusion. We censored regions where fewer than 11 amputations occurred, in accordance with guidelines regarding preservation of patient confidentiality from the Centers for Medicare and Medicaid Services. All calculations were performed using SAS (Cary, NC) and STATA (College Station, Texas). Institutional Review Board approval was obtained from the Committee for Protection of Human Subjects from Dartmouth Medical School.

Results

Patient characteristics, revascularization, and hospitalization rates

We identified 18,463 patients who underwent major PAD-related amputation between 2003 and 2010. Overall, patients had a mean age of 78 years, and 51% of patients were male. Patients commonly had a history of diabetes (49%), heart failure (35%), and coronary disease (14%) (Table 1).

Within this cohort, 11,785 (64%) had a hospitalization during the year prior to amputation, while the remaining 36% were not admitted for a PAD-related reason during this same period. Of the 11,785 admitted to the hospital, 2,762 (15%) underwent an inpatient revascularization procedure, and 2,491 (14%) had a debridement procedure performed during a hospital admission in the year prior to amputation.

Overall, amputation-specific, and revascularization-based spending

The mean total cost of inpatient vascular care in the year prior to amputation, including the amputation itself, was $22,405 (95% CI $22,145-22,666) per patient. The hospital referral regions with the lowest mean spending on overall inpatient care in the year prior to amputation were Bismarck, North Dakota ($11,077, 95% CI $7,399-14,754), Lebanon, New Hampshire ($13,206, 95% CI $8,870-17,541), and Meridian, Mississippi ($14,120, 95% CI $10,320-17,921). Costs in the year prior to amputation were highest in Paterson, New Jersey ($35,040, 95% CI $23,658-46,421), Ridgewood, New Jersey ($38,070, 95% CI $7,123 - 69,017), and Salinas, California ($42,613, 95% CI $14,041-71,185) (Figure 2).

The mean regional spending on revascularization or debridement (exclusive of the amputation) in the year prior to amputation was $8,316 (95% CI $8,150-8,483) per patient. The regions with the lowest mean spending on revascularization or debridement were Muncie, Indiana ($1,277, 95% CI % $60-5,582), Duluth, Minnesota ($3,342 (95% CI $1,141-5,542) and Topeka, Kansas ($4,199, 95% CI $1,445-6,953) Regions with the highest mean spending were St. Paul, Minnesota (14,063, 95% CI $4,698-23,427), Toledo, Ohio ($14,107, 95% CI $9,763-18,450), and Harlingen, Texas ($14,120, 95% CI $10,553-17,686).

The mean spending for the amputation procedure itself was $14,088 (95% CI $13,898-14,278) per patient. The regions with the lowest mean spending on the amputation-related hospitalization were Lebanon, New Hampshire ($8,368, 95% CI $6,076-10,659), Meridian, Mississippi ($9,408, 95% CI $7,333-11,484), and Bismarck, North Dakota ($9,541, 95% CI $6,382-12,700). The hospital referral regions with the highest mean spending on the amputation procedure itself were Paterson, New Jersey ($22,725, 95% CI $12,859-32,590), Rapid City, South Dakota, ($25,448, 95% CI $3,605-47,292), and Salinas, California ($30,039, 95% CI $12,195-47,884).

Variation in the proportion of all costs related to revascularization

The proportion of all costs related to hospitalizations for revascularization, cellulitis, or debridement represented less than 10% of all costs in many regions, such as Pueblo, Colorado (7%), Grand Junction, Colorado (9%), and Redding, California (10%). However, revascularization and other procedural care represented more than 50% of all costs in Waterloo, Iowa (51%), Burlington, Vermont (52%), and Sun City, Arizona (53%). In 90 of the 307 hospital referral regions, more than 40% of spending in the year prior to amputation was attributable to revascularization, rather than wound care or the amputation procedure itself. There was a positive correlation between the proportion of patients treated with revascularization and the costs incurred in the year prior to amputation ($R=0.38$, $p<0.001$) (Figure 3).

Differences in patient characteristics, by quintile of spending

We examined differences in patient characteristics between high and low spending regions, across quintiles of spending (Table 1). In regions where spending was highest (mean spending of $27,395), patients undergoing amputation were more likely to be African-American (14% in very slow spending regions, 20% in very high spending regions), and were slightly more likely to have coronary artery disease (13% in very slow spending regions, 15% in very high spending regions). Charlson comorbidity scores were slightly higher in regions where spending was highest (3.0 in very slow spending regions, 3.6 in very high spending regions). As shown in Table 1, while many of these differences were statistically significant given our large sample, clinical differences in patients across quintiles of spending were small.

Use of invasive vascular care, by quintile of spending

In regions with higher spending, patients were more likely to be treated with invasive vascular care. For example, patients in higher spending regions were more likely to undergo a vascular procedure such as a diagnostic or therapeutic angiogram or open surgical procedure (12.0 procedures per 10,000 patients in the lowest quintile of spending, 20.4 procedures per 10,000 patients in the highest quintile of spending, $p<0.0001$) (Figure 4).

Adjustment for age, sex, race, diabetes, cardiac, and renal disease across quintiles of spending on vascular care accentuated these differences. Overall, patients living in regions in the highest quintile of spending were more than three times as likely to undergo a vascular procedure when compared to patients in regions in the lowest quintile of spending (adjusted OR for receiving a vascular procedure = 3.5, 95 % CI 3.2-3.8, $p<0.0001$) (Table 2). Similar trends were seen in both crude and adjusted analyses when individually examining open surgical revascularizations, therapeutic endovascular interventions, and diagnostic angiograms (crude rates are shown in Figure 4, and adjusted odds ratios demonstrated in Table 2). We also found that regions where spending on vascular procedures was high also had high spending on the amputation procedure itself ($R=0.82$, $p<0.001$)

Correlation between spending and amputation rate, by region

Despite the direct correlation between procedural care and overall spending, we did not find a direct relationship between overall spending in the year prior to amputation and regional amputation rate ($R=0.10$, $p=0.06$) (Figure 5). Even in risk adjusted comparisons, there was no significant relationship between the likelihood of being in the highest quintile of amputation rate and overall spending rate (adjusted OR 0.95, 95 %CI 0.9-1.1, $p=0.383$) (Table 2).

Across practice patterns, the regions that were most aggressive in the use of endovascular interventions (in the highest 20^{th} percentile) were likely to have high spending ($R=0.42$, $p=0.002$) as well as high amputation rates ($R=0.40$, $p=0.004$). Conversely, regions that were not aggressive in the use of endovascular interventions (in the lowest 20^{th} percentile) were not likely to be in the highest quintile of amputation rate ($R=0.10$, $p=0.36$).

Discussion

In this descriptive analysis, we demonstrate that costs of inpatient care in the year prior to amputation for patients with critical limb ischemia are over $20,000 per patient for inpatient care alone. Further, these costs vary more than two-fold across hospital referral regions in the United States. Much of this variation is driven by differences in the use of revascularization treatments, rather than differences in patient characteristics or costs related to amputation itself. Moreover, there is little evidence to suggest that higher spending on

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invasive vascular care, especially endovascular care, in the year prior to amputation is associated with lower regional rates of amputation.

Accurate measurement of the true cost of critical limb ischemia is difficult[2, 16, 17]. The chronic nature and broad spectrum of PAD, coupled with the far-reaching effects of limb loss on functional status and the ability to live independently, make it challenging to determine its financial impact. Prior studies have examined the inpatient costs of vascular care (Table 3). For example, the REACH registry investigators studied the two-year costs of 25,763 patients systemic atherosclerosis[18, 19]. For patients who underwent revascularization or amputation, costs easily averaged over $10,000 per patient during the two years following enrollment in the registry - a cost much higher than those patients with mild coronary disease. European patients enrolled in the REACH registry also demonstrated high costs when they required revascularization or amputation, but the magnitude of these costs was much less than in the United States[20]. Finally, investigators from Minnesota extrapolated costs from statewide data to provide national cost estimates for the impact of hospitalization for PAD on cost. Therefore, while our study is limited to only patients in Medicare, it provides cost estimates that are consistent with other estimates, and provide national-level detail for each individual region of the United States.

In our study, some regions spent less than $13,000, on average, in the year prior to amputation, while other regions spent $30,000 or more in the year prior to amputation. Using these “natural experiments”, we found little evidence to suggest that most expensive strategies are associated with better outcomes. While we acknowledge the well-known weaknesses of administrative claims[21, 22], patients were roughly similar in many important demographic and comorbidity variables across strata of spending, and adjustment for any statistical differences had little impact on our findings. Therefore, it appears unlikely that these large differences in spending can be explained simply by differences in patient characteristics.

This suggests that an important opportunity exists, given the right kind of evidence, to save money while still providing high quality care for patients with severe PAD. While much of this necessary evidence will come from clinical trials[23, 24], examination of the cost and effectiveness of these treatments in “real-world” settings will be important as well[9, 25, 26]. National registries, such as the Society for Vascular Surgery’s Vascular Quality Initiative (VQI)[27], the National Surgical Quality Improvement Program (NSQIP)[28], and the National Cardiovascular Data Registry[29], will need to incorporate the right endpoints. This means measuring both efficacy and cost to determine which strategies are effective in limiting amputation risk in patients with critical limb ischemia, in the most cost-effective manner.

Prior work by our group[14] and others[30, 31] suggested that more vascular care – as measured by any type of diagnostic or therapeutic vascular procedure in the year prior to amputation - is related to lower risks of amputation[14]. Are these findings discordant with those reported herein? We believe not. Dramatic differences in cost can exist related to the manner in which patients with critical limb ischemia are treated. For example, patients treated with simple “plain-old balloon angioplasty” or a single surgical revascularization will have a much lower costs when compared to patients receiving multiple rounds of atherectomy, drug

-eluting balloons, or other more expensive endovascular adjuncts[32-35]. Our current analyses found that the highest spending rates -and the highest amputation rates - occurred in regions where multiple endovascular interventions were used commonly.

Different interpretations of the spending patterns described in our study are plausible as well. For example, one might argue that a region could provide high-quality preventive and invasive vascular care, and thereby prevent many patients from ever requiring amputation. Within a region like this, overall spending on vascular care would be high, and amputation rates would be low. However, we found few regions where spending and the overall intensity (measured by the number of procedures[13]) of vascular care was high, and amputation rates were low. In fact, only 3 of 307 regions – (Fort Lauderdale and Fort Myers, Florida, and Madison, Wisconsin) fit this description. Therefore, while plausible, this alternative explanation does not appear to represent an alternative explanation for our findings.

Our study has several important limitations. First, as our work considered only inpatient costs, and does not directly capture outpatient care that may be provided in wound care centers, outpatient angiography suites, and ambulatory imaging centers[36-38]. Even though the significant burden of comorbidities carried by patients with critical limb ischemia most commonly necessitates hospital-based care, vascular care is increasingly provided in outpatient settings[39, 40]. Our future work will consider not only hospital-based care, but also care that is provided in ambulatory environments.

Second, our observational dataset derives from administrative claims, and cannot provide patient-level clinical detail as to the extent of peripheral arterial disease, or surgical-level specifics at the time of revascularization. However, our cohort was purposefully designed to consider only those patients with the most severe peripheral arterial disease, such that all patients studied had a limb-loss rate of 100%, an algorithm reflected in our prior publications[4,13, 14]. Third, as sidedness is not indicated on Medicare claims, we cannot be sure that revascularization procedures and amputations all occurred on the same limb. However, prior work by our group suggested that differential sides occur in fewer than 10% of procedures[41]. Fourth, our study examined price-adjusted spending among Medicare beneficiaries. Therefore, our results may not be readily generalizable to younger patients insured by non-federal payers. However, Medicare patients comprise more than 80% of patients at risk for amputation, and price-adjusted Medicare spending represents a well-proven measure to examine utilization on the national scale[42]. Therefore, we find little evidence to suggest that our findings are not readily applicable to most patients at risk for limb amputation.

In conclusion, Medicare spending on patients with severe PAD varies more than twofold across the United States, and regions where spending is highest perform the most revascularization procedures in the year prior to amputation. And while our prior work suggests that access to revascularization is a key component in preventing amputation, our current analysis offer little evidence to suggest that more expensive vascular care offers a marginal advantage over less expensive vascular interventions[14]. In the current era of accountable care organizations, where quality and cost must be equally considered[43-45], saving money and preventing amputation appear to be two achievable and complementary goals in the care of patients with peripheral arterial disease.

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Appendix

1. CPT and ICD-9 codes used to delineate the revascularization and amputation procedures in our cohort.

Appendix 1

CPT codes

OPEN	
Inflow:	**Outflow:**
35521 Bypass graft, with vein;axillary-femoral	35302 Thromboendarterectomy, including patch graft, if performed;superficial femoral artery
35351 Thromboendarterectomy, including patch graft, if performed;iliac	35303 Thromboendarterectomy, including patch graft, if performed;popliteal artery
35355 Thromboendarterectomy, including patch graft, if performed;iliofemoral	35304 Thromboendarterectomy, including patch graft, if performed;tibioperoneal trunk artery
35361 Thromboendarterectomy, including patch graft, if performed;combined aortoiliac	35305 Thromboendarterectomy, including patch graft, if performed;tibial or peroneal artery,
35363 Thromboendarterectomy, including patch graft, if performed;combined aortoiliofemoral	35306 Thromboendarterectomy, including patch graft, if performed;each additional tibial
35537: aortoiliac bypass	35371 Thromboendarterectomy, including patch graft, if performed;common femoral
35538 Bypass graft, with veln;aortobi-iliac	35372 Thromboendarterectomy, including patch graft, if performed;deep (profunda) femoral
35539 Bypass graft, with vein;aortofemoral	35533 Bypass graft, with vein;axillary-femoral-femoral
35540 Bypass graft, with vein;aortobifemoral	35556 Bypass graft, with vein;femoral-popliteal
35541 Bypass graft, with vein	35558 Bypass graft vein;femoral-femoral
35546 Aortofemoral bypass with vein.	35566 Bypass graft, with vein;femoral-anterior tibial, posterior tibial, peroneal artery
35539: Aortofemoral graft with vein.For aortofemoral graft with vein	35571 Bypass graft, with vein;popliteal-tibial, -peroneal artery or other distal vessels
35548 Bypass graft, with vein;aortoiliofemoral, unilateral	35583 In-situ vein bypass; femoral-popliteal
35549 Bypass graft, with vein;aortoiliofemoral, bilateral	35585 In-situ vein bypass; femoral-anterior tibial, posterior tibial, or peroneal artery
35551 Bypass graft, with vein;aortofemoral-popliteal	35587 In-situ vein bypass;popliteal-tibial, peroneal
35563 Bypass graft, with vein;ilioiliac	35656 Bypass graft, with other than vein;femoral-popliteal
35565 Bypass graft, with vein;iliofemoral	35666 Bypass graft, with other than vein;femoral-anterior tibial, posterior tibial, or personal artery
35621 Bypass graft, with other than vein;axillary-femoral	35671 Bypass graft, with other than vein;popliteal-tibial or -peroneal artery
35623 Bypass graft, with other than vein;axillary-popliteal or -tibial	35681 Bypass graft, composite, prostetic and vein
35637 Bypass graft, with other than vein;aortoiliac	35682 Bypass graft;autogenous composite, two segments of veins from two locations
35638 Bypass graft, with other than vein;aortobi-iliac	35683 Bypass graft;autogenous composite, three or more segments of vein
35646 Bypass graft, with other than vein;aortobifemoral	35879 Revision, lower extremity arterial bypass, without thrombectomy, open; with vein patch angioplasty
35647 Bypass graft, with other than vein;aortofemoral	35881 Revision, lower extremity arterial bypass, without thrombectomy, open;with segmental vein interposition
35651 Bypass graft, with other than vein;aortofemoral-popliteal	35883 Revision, femoral anastomosis of synthetic arterial bypass graft in groin, open; with nonautogenous patch graft
35654 Bypass graft, with other than vein;axillary-femoral-femoral	35884 Revision, femoral anastomosis of synthetic arterial bypass graft in groin, open;with autogenous vein patch graft

OPEN	
Inflow:	**Outflow:**
35661 Bypass graft, with other than vein;femoral-femoral	
35663 Bypass graft, with other than vein;ilioiliac	
35665 Bypass graft, with other than vein;iliofemoral	
	ENDO:
Inflow:	Outflow:
35452 Transluminal balloon angioplasty, open;aortic	35456 Transluminal balloon angioplasty, open;femoral-popliteal
35454 Transluminal balloon angioplasty, open;iliac	35459 Transluminal balloon angioplasty, open;tibioperoneal trunk and branches
35472 Transluminal balloon angioplasty, percutaneous;aortic	35470 Transluminal balloon angioplasty, percutaneous;tibioperoneal trunk or branches, each vessel
35473 Transluminal balloon angioplasty, percutaneous;iliac	35474 Transluminal balloon angioplasty, percutaneous;femoral-popliteal
35481 Transluminal peripheral atherectomy, open;aortic	35483 Transluminal peripheral atherectomy, open;femoral-popliteal
35482 Transluminal peripheral atherectomy, open;iliac	35485 Transluminal peripheral atherectomy, open;tibioperoneal trunk and branches
35491 Transluminal peripheral atherectomy, percutaneous;aortic	35493 Transluminal peripheral atherectomy, percutaneous;femoral-popliteal
35492 Transluminal peripheral atherectomy, percutaneous;iliac	35495 Transluminal peripheral atherectomy, percutaneous;tibioperoneal trunk and branches
	37205 Transcatheter placement of an intravascular stent(s), (except coronary, carotid, and vertebral vessel), percutaneous; initial vessel
	37206 Transcatheter placement of an intravascular stent(s), (except coronary, carotid, and vertebral vessel), percutaneous;each additional vessel
	37207 Transcatheter placement of an intravascular stent(s), (non-coronary vessel), open; initial vessel
	37208 Transcatheter placement of an intravascular stent(s), (non-coronary vessel), open;each additional vessel
	Diagnostic Only Endovascular Procedures:
36200	introduction of catheter, aorta
36245	selective catheter placement, arterial system, each first-order, lower- extremity
36246	selective catheter placement, arterial system, second-order, lower- extremity
36247	selective catheter placement, arterial system, third-order, lower- extremity
36248	selective catheter placement, arterial system, beyond third order, lower- extremity
CPT Code	Outcome Measure: Amputation
27590	Amputation, thigh, through femur, any level;

OPEN

Inflow:	**Outflow:**
27591	Amputation, thigh, through femur, any level; immediate fitting technique including first cast
27592	Amputation, thigh, through femur, any level; open, circular (guillotine)
27880	Amputation, leg, through tibia and fibula;
27881	Amputation, leg, through tibia and fibula; with immediate fitting technique
27882	Amputation, leg, through tibia and fibula; open, circular (guillotine)
28805	Amputation, foot; transmetatarsal

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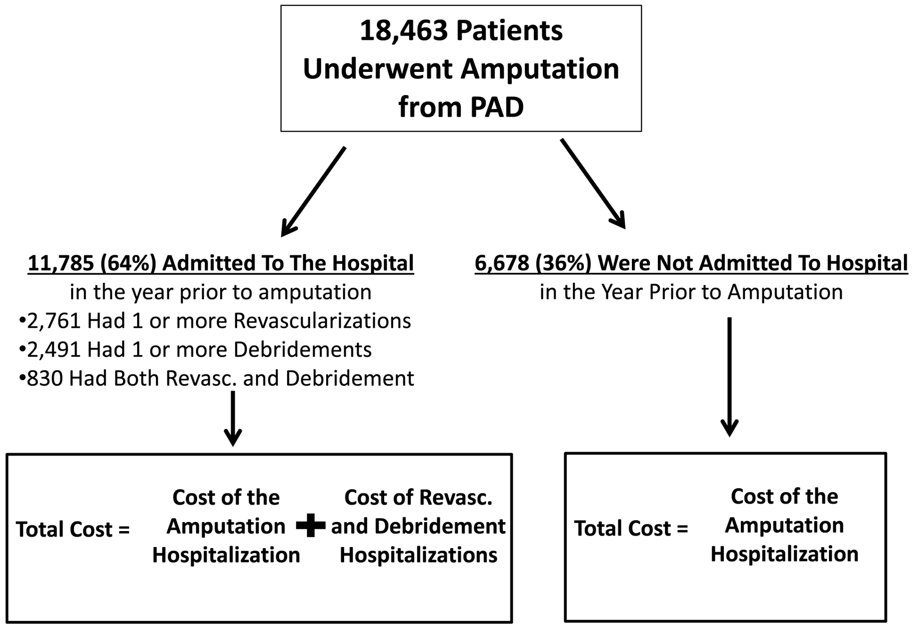

Figure 1.

Patients, procedures, and hospitalization cost data from the year prior to amputation in our cohort.

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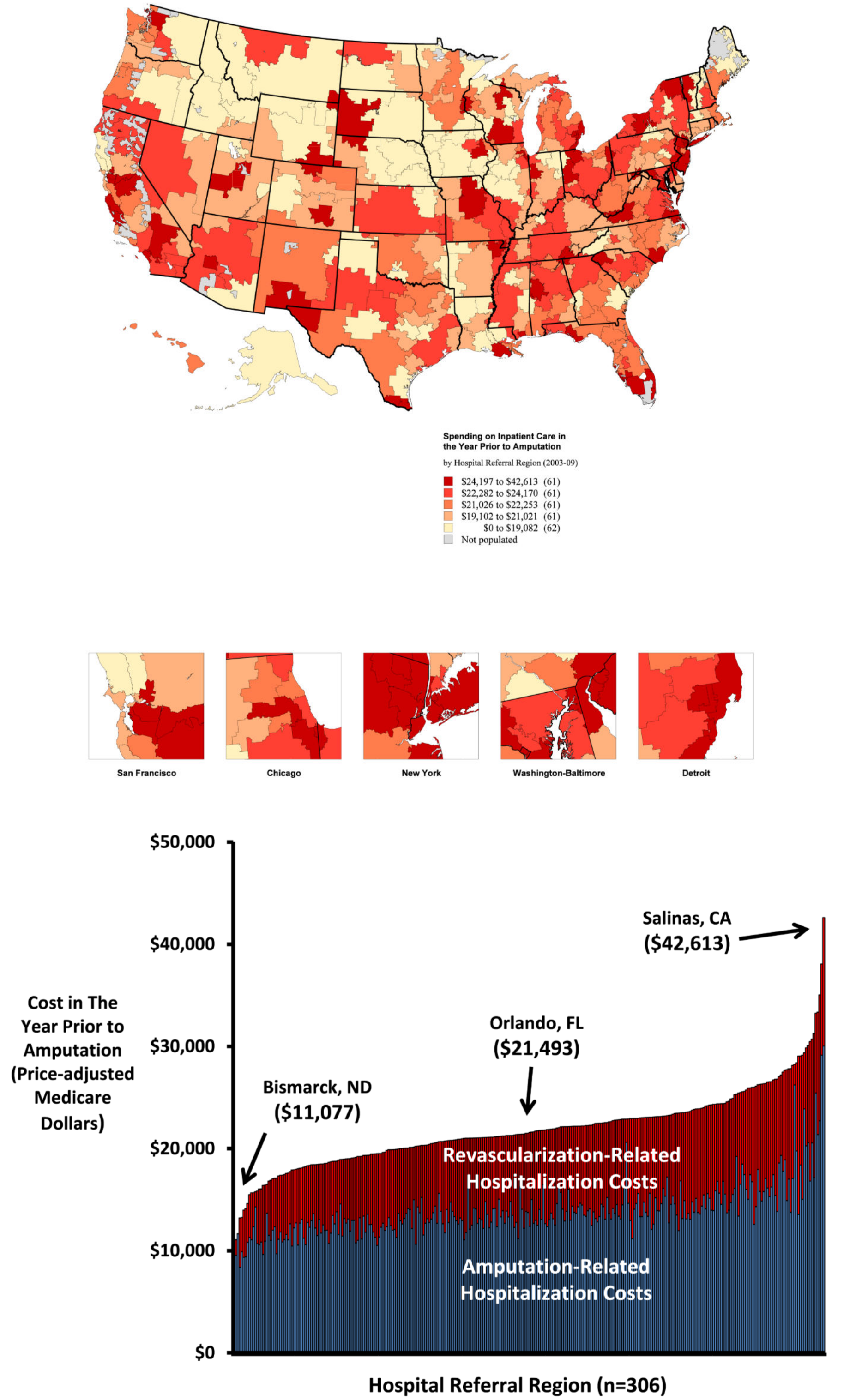

Figure 2.

National map (panel A) and histogram (panel B) demonstrating regional spending on vascular care and hospitalizations in the year prior to amputation, by hospital referral region.

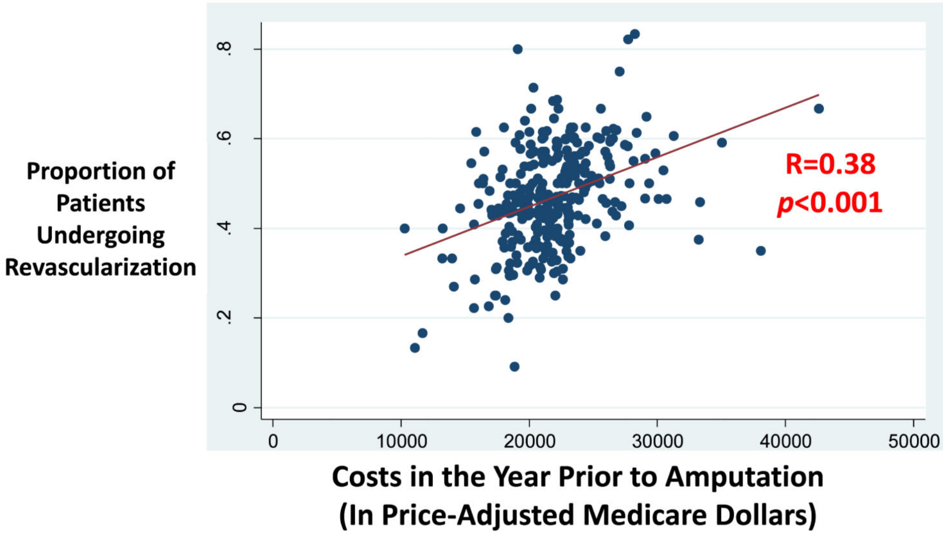

Figure 3.

Scatterplot depicting the relationship between regional spending rates and regional revascularization rate in the year prior to amputation.

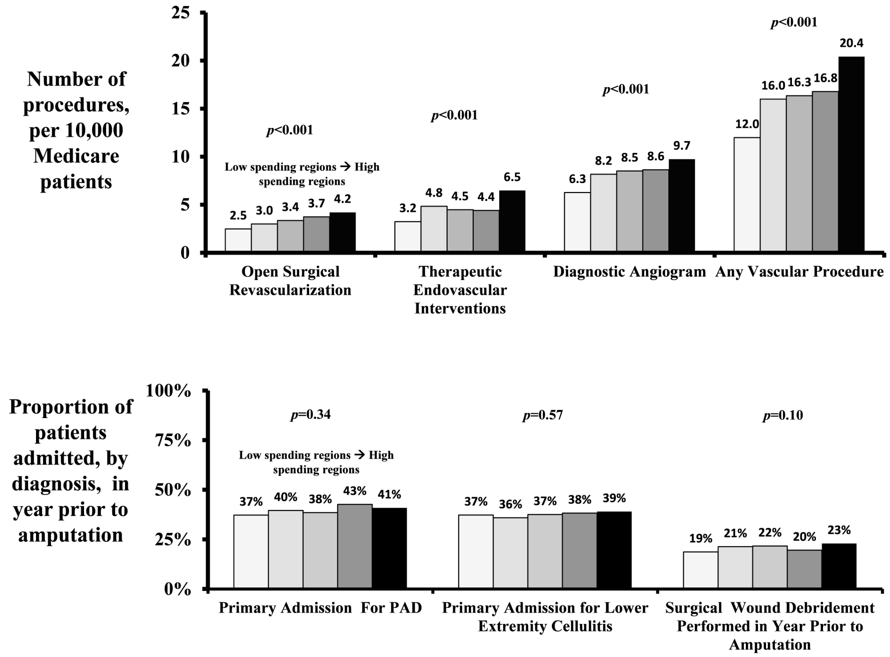

Figure 4.

Differences in revascularization and non-revascularization care, across quintile of hospital spending in the year prior to amputation.

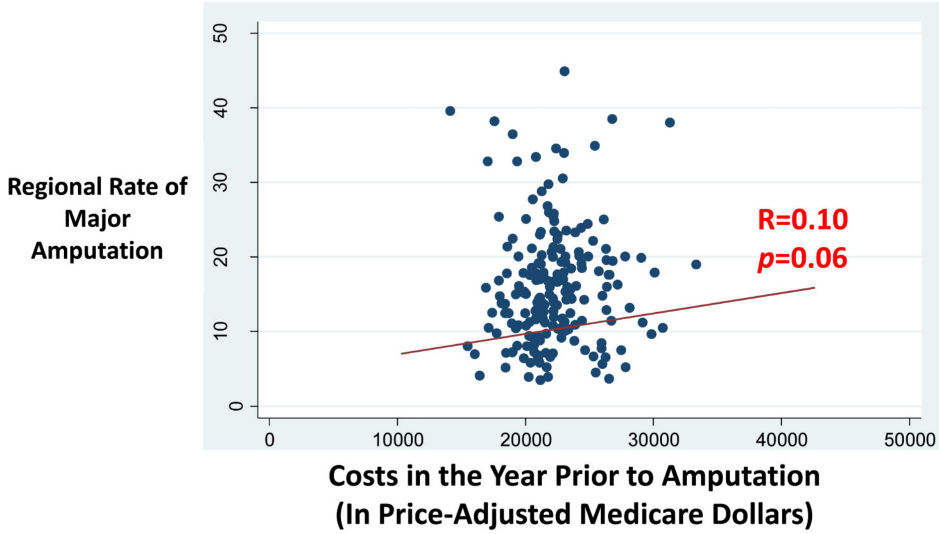

Figure 5.
Scatterplot depicting the relationship between regional spending rates and regional amputation rates.

Table 1

Characteristics of Vascular Amputees in Medicare Claims 2007-2009, by quintile of spending in year prior to amp on revasc/hosp. Patient characteristics of those undergoing amputation, by quintile of spend in the year prior to amputation.

		Quintile of spending						
	Overall (n=l 8,463) Very Low		Low	Medium	High	Very High	Ratio (Very High to Very Low)	p value (non-parametric test of trend)
Mean spending in this quintile ($)	$22,405	$17,134	$20,138	$21,612	$23,107	$27,395	1.60	0.001
Age (mean)	78.4	78.6	78.0	78.3	78.2	78.3	1.00	0.514
Proportion Male	50.7	52%	52%	53%	53%	53%	1.03	0.836
Proportion African American	28	14%	18%	22%	22%	20%	1.45	0.001
Proportion with Diabetes	49.1	48%	46%	50%	49%	49%	1.03	0.007
Proportion with Congestive Heart Failure	35.8	32%	35%	36%	35%	37%	1.14	0.001
Proportion with Coronary Artery Diseaes	13.6	13%	12%	14%	15%	15%	1.18	0.001
Proportion with Renal Insufficency	17.7	14%	17%	17%	17%	19%	1.29	0.001
Charlson Score	3.5	3.0	3.3	3.5	3.5	3.6	1.18	0.001
Proportion Undergoing invasive diagnostic or therapeutic vascular procedure	46.8	39.4	46.6	46.2	48.0	54.1	1.37	0.001
Per Capita Income ($)	$18,867	$18,707	$19,226	$18,721	$18,822	$18,857	1.01	0.001

Table 2

Multivariable models demonstrating the likelihood of a patient undergoing vascular procedures, across quintiles of spending, as well as the likelihood of being in the highest quintile of amputation rate.

Characteristic	Likelihood of Undergoing Any Vascular Procedure (Diagnostic/Therapeutic)				Likelihood of UndergoingAny Endovascular Procedure				Likelihood of UndergoingAny Open Surgical Procedure				Likelihood of Being in Highest Quintile of Amputation Rate			
	Odds Ratio	95% Conf. Interval		*p* Value	Odds Ratio	95% Conf. Interval		*p* Value	Odds Ratio	95% Conf. Interval		*p* Value	Odds Ratio	95% Conf. Interval		p Value
Quintile of Spending on Vascular Care																
Very Low Spending	referent				referent				referent				referent			
Low Spending	1.6	1.4	1.7	O.001	1.6	1.4	1.7	<0.001	1.2	1.0	1.4	0.011	1.0	0.9	1.2	0.54
Medium Spending	1.5	1.4	1.7	O.001	1.5	1.4	1.7	<0.001	1.2	1.0	1.4	0.024	1.0	0.9	1.2	0.554
High Spending	2.4	2.2	2.6	O.001	2.3	2.1	2.5	<0.001	2.4	2.1	2.7	<0.001	1.0	0.9	1.1	0.857
Very High Spending	3.5	3.1	3.8	O.001	3.2	2.9	3.5	<0.001	4.0	3.5	4.5	<0.001	0.9	0.8	1.1	0.383
Age																
Age 65-69	referent				referent				referent				referent			
Age 70-74	1.0	1.0	1.1	0.407	1.0	1.0	1.1	0.34	0.9	0.8	1.0	0.217	1.0	1.0	1.1	0.73
Age 75-79	1.0	0.9	1.1	0.497	1.0	0.9	1.1	0.966	1.0	0.9	1.1	0.422	1.0	0.9	1.1	0.913
Age 80-85	0.8	0.7	0.9	O.001	0.8	0.7	0.9	<0.001	0.7	0.6	0.8	<0.001	0.9	0.7	0.9	<0.001
Age>85	0.5	0.5	0.6	O.001	0.6	0.5	0.6	<0.001	0.5	0.4	0.5	<0.001	0.9	0.5	0.6	<0.001
Diabetes	1.1	1.0	1.1	0.053	1.1	1.0	1.2	0.005	1.2	1.1	1.3	0.001	0.8	0.8	0.9	<0.001
Coronary artery disease	1.3	1.1	1.4	O.001	1.2	1.1	1.3	<0.001	1.3	1.2	1.5	<0.001	1.0	0.9	1.1	0.912
Congestive heart failure	0.9	0.9	1.0	0.008	0.9	0.9	1.0	0.034	0.8	0.7	0.9	<0.001	1.0	0.9	1.1	0.586
Renal Insufficiency	1.3	1.2	1.5	<0.001	1.4	1.3	1.5	<0.001	0.8	0.7	0.9	<0.001	1.0	0.9	1.1	0.913
African American Race	0.8	0.7	0.8	<0.001	0.8	0.7	0.8	<0.001	0.8	0.8	0.9	<0.001	0.3	0.3	0.3	<0.001

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Table 3

Studies reporting cost estimates for inpatient care for patients with severe peripheral arterial disease. Studies examining inpatient costs in patients at risk for amputation from severe PAD.

	Study Author	Patinets (n)	Cost Estimate in Year Prior to Amputation	Comment
REACH (Europe) REACH (US) Minnesota state-based registry	Smolderens et al Mahoney et al Peacock et al	10,287 2,396 20 per 100,000	$4,136 $10,430 $32,129	Two year costs in Europe, calculated from Euros Two year costs in the US, among patients with severe disease Population-based estimates from Minnesota