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## Fifteen-Year Trends in Lower Limb Amputation, Revascularization, and Preventive Measures Among Medicare Patients

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Although severe lower extremity peripheral arterial disease affects more than 12 million people in the United States,<sup>1,2</sup> secular trends in the risk of amputation remain unexplored in recent years. Using national billing and survey data sets from the Centers for Medicare and Medicaid Services and the Behavioral Risk Factor Surveillance System, we examined trends in lower extremity amputation rates, diagnostic and therapeutic vascular procedures, and the

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**Author Contributions:** Dr Goodney had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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*Acquisition, analysis, or interpretation of data:* Goodney, Tarulli, Faerber, Schanzer.

*Drafting of the manuscript:* Goodney, Tarulli.

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*Statistical analysis:* Goodney, Faerber.

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use of preventive measures aimed at limiting the use of amputation procedures in the United States between 1996 and 2011.

## Methods

## Results

From 1996 to 2011, the rate of lower limb amputations decreased by 45%, from 196 to 119 procedures per 100 000 patients (rate ratio [RR], 0.60 [95% CI, 0.59–0.61];  $P < .001$ ) (Figure 1). These changes were driven by a 48% decrease in the rate of above-knee amputations (from 91 to 47 procedures per 100 000 patients; RR, 0.52 [95% CI, 0.51–0.52];  $P < .001$ ) and a 39% decrease in the rate of below-knee amputations (from 82 to 50 procedures per 100 000 patients; RR, 0.61 [95% CI, 0.60–0.62];  $P < .001$ ). Rates of minor amputations (toe or forefoot) also decreased slightly during the study period (from 23 to 21 procedures per 100 000 patients; RR, 0.90 [95% CI, 0.90–0.91];  $P = .01$ ). While overall rates of amputation decreased during the study period, amputations remained common in high-risk subgroups such as African American patients with diabetes (555 procedures per 100 000 African American patients in 2011), especially when compared with low-risk subgroups (24 procedures per 100 000 nonblack, nondiabetic patients).

Use of peripheral endovascular interventions also increased during the study period (Figure 2). For example, the rate of diagnostic lower extremity arteriographic procedures increased by 165% from 1996 to 2011 (from 451 to 1124 procedures per 100 000 patients; RR, 1.65 [95% CI, 1.56–1.73];  $P < .001$ ). The rate of therapeutic endovascular interventions increased significantly as well (from 138 to 584 interventions per 100 000 patients; RR, 4.23 [95% CI, 4.17–4.28];  $P < .001$ ). The rate of surgical bypass procedures decreased by 61% (from 201 to 83 procedures per 100 000 patients; RR, 0.39 [95% CI, 0.38–0.41];  $P < .001$ ).

Last, the prevalence of diabetes increased from 1996 to 2010 (from 16 to 26 cases per 100 patients; RR, 1.53 [95% CI, 1.23–1.91]), while the smoking rate remained unchanged (14 smokers per 100 patients; RR, 1.08 [95% CI, 0.96–1.21]). However, the use of preventive measures aimed at limiting the use of amputation procedures increased significantly; the number of diabetic patients treated with a routine foot examination increased by 70% (from 40 to 68 diabetic patients per 100 patients; RR, 1.70 [95% CI, 1.13–2.57]), and routine blood glucose testing increased by 76% (from 41 to 72 tests per 100 patients; RR, 1.76 [95% CI, 1.03–3.02]).

## Discussion

The lower limb amputation rate has decreased by 45% over the last 15 years among Medicare patients, and the largest improvements have occurred in above- or below-knee amputations. During this same time period, significant increases have also occurred in the use of vascular procedures (both diagnostic and therapeutic) and preventive care.

Our observational findings cannot imply causation, and we recognize that our study presents no direct causative experimental evidence to explain the decrease in amputation risk.

However, it is evident that the increasing use of vascular and preventive care, especially among patients with diabetes, has been temporally associated with lower rates of major amputation.<sup>3</sup> While many debate whether open surgery, endovascular interventions, or hybrid strategies are most effective in limiting amputation,<sup>4,5</sup> the importance of preventive measures has likely been underestimated. Future work examining relationships between preventive measures, revascularization, and amputation is necessary to help clinicians better define optimal strategies for limiting amputation.

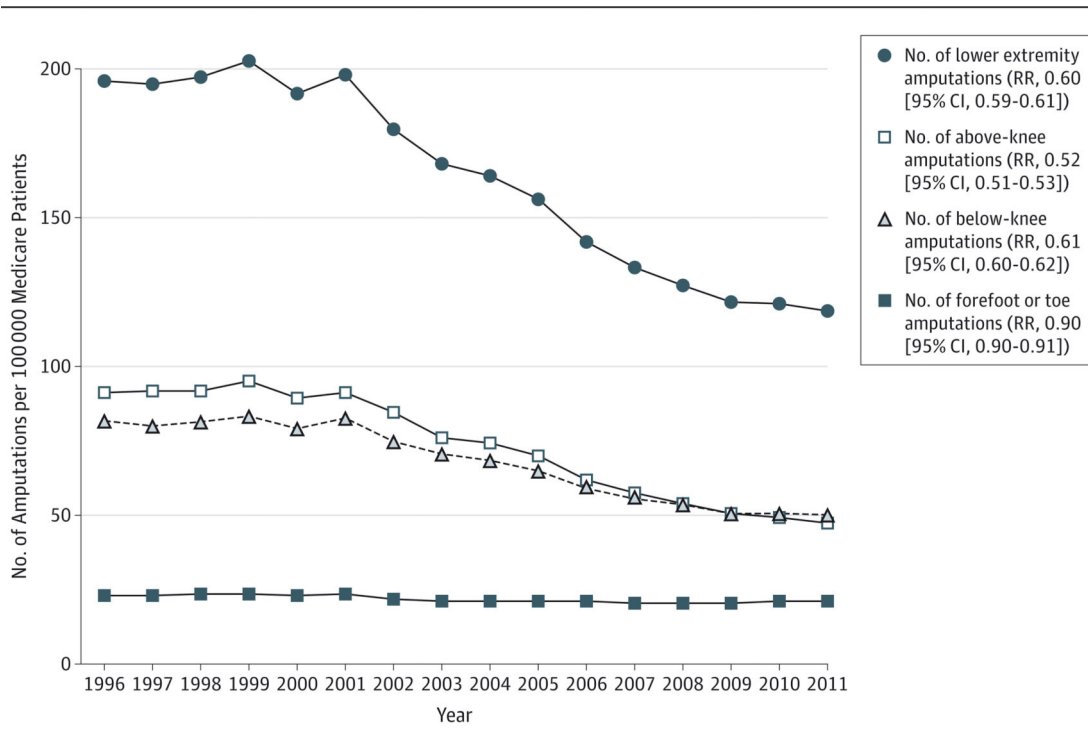
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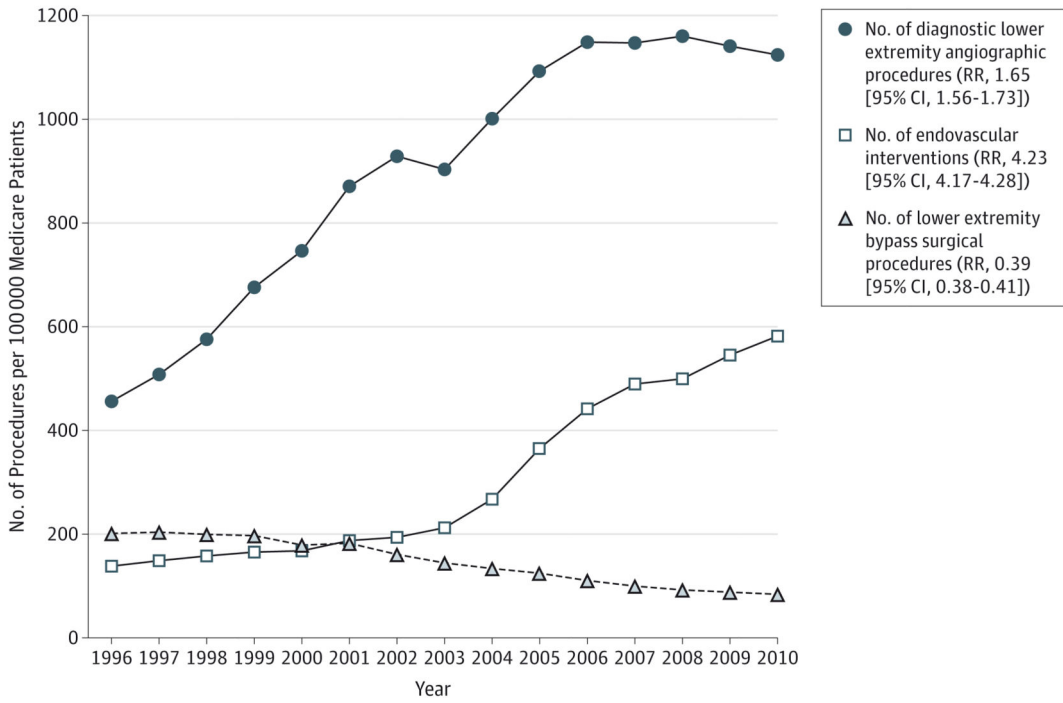
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RR indicates rate ratio.

**Figure 1.**  
Trends in Major Amputation, by Amputation Type and Year, 1996–2011  
RR indicates rate ratio.



RR indicates rate ratio.

**Figure 2.** Trends in Diagnostic Angiography, Therapeutic Endovascular Interventions, and Lower Extremity Bypass Surgery, 1996–2010  
RR indicates rate ratio.