Costs Attributable to Diabetic Foot Ulcers: A Bottom-up Economic Model

Jonathan D. Bloom, MD[1] · Ryan W. Sadlo, MBA[1] · Simon J. Salgado, MBA[1] · Nicole J Neff, BS[1] · Brian J. Petersen, MS, MBA[1]
[1] Podimetrics, Inc, Somerville MA

Introduction

Approximately one in four patients with diabetes will suffer a lower extremity wound over a lifetime, resulting in staggering mortality, disability, and resource utilization. It has been reported that one third of all diabetes-related costs are attributable to the treatment of foot ulcers.

Unfortunately, studies characterizing the economic burden of diabetic foot complications exhibit considerable heterogeneity. Estimates vary depending on study methods, data source, care environment, study perspective, and whether (and how) incident or prevalent populations are considered. Chan and colleagues completed a systematic review in 2017 and identified only two studies reporting net disease-specific costs of foot ulcers: Ramsay 1999 ($54,887 over two years) and Rice 2014 ($19,058 over one year), each inflated to 2019 dollars.

To address the scarcity and limitations of existing top-down economic studies, we present a bottom-up economic model to characterize the costs attributable to diabetic foot ulcers.

Methods

Our model takes as input assumptions related to mix of ulcer severity at presentation, wound care treatment practice, daily inpatient costs, and healing, amputation, and mortality rates. To demonstrate the model's utility, we used input from more than 50 references to estimate the cost to treat a foot ulcer in the Veterans Health Administration. Costs were inflated to 2019 dollars using medical care Consumer Price Index. We then compared these costs under standard care to those that would hypothetically be incurred were veterans to practice once-daily foot temperature monitoring.

Methods (Continued)

Table 1: Key Model Inputs and Assumptions

Variable	Value	Source
DFU Incidence (standard of care)	24%	Lavery, 2007
Percentage of DFU that are superficial (standard of care)	47%	Oyibo, 2001
DFU Incidence (thermometry)	50%	assumption
Percentage of DFU that are superficial (thermometry)	95%	Isaac 2018
Patients Requiring Hospitalization for superficial DFU	22%	Prompers 2008
Average Hospitalization Days for superficial DFU	5	Prompers 2008
Patients Requiring Hospitalization for higher severity DFU	54%	Prompers 2008
Average Hospitalization Days for higher severity DFU	20	Prompers 2008
Percentage of DFU Requiring Hospitalization	35%	calculated
Percentage of DFU Requiring Hospitalization	38%	Reiber 2001
Average Hospital Days for DFU	5	calculated
Average Hospital Days for DFU	6	Ramsay 1999
Average Hospital Days for DFI	7	Todd 1996
Cost per Hospital Day (VHA medicine)	$3,328	HERC 2018
Cost per Hospital Day (VHA surgery)	$5,331	HERC 2018
Amputation Rate for Superficial DFU (6 months)	6%	Oyibo 2001
Amputation Rate for Higher Severity DFU (6 months)	28%	Oyibo 2001
Percentage of DFU that become DFI	60%	Glover 2004
Percentage of DFI requiring Amputation	20%	Franklin 2014
Total Amputation Rate for DFU	12%	calculated
Total Amputation Rate for DFU	16%	Allen 2017
Total Amputation Rate for DFU	18%	Reiber 2001
VHA Average Cost of Amputation (any level)	$73,430	Franklin 2014
Number of VHA Lower Limb Amputations	26,275	Etter 2015
Inpatient days prior to death	12.9	Angus 2004
% Patients with DFU Deceased within Year	10.7%	Treece 2004
% Patients with DFU Deceased within Year	5.6%	Reiber 2001

Results

We calculated net costs per DFU of $55,381 under standard care, the breakdown of which are shown in Table 2. This total of $55,381 compares favorably to Ramsay 1999. Consistent with Rice 2014, we estimated that approximately 59% of these costs would be incurred during inpatient stays. We estimated that foot temperature monitoring has the potential to eliminate 81% of DFU-attributable costs ($45,053). Approximately 23% of the savings are due to early identification and treatment, with the remainder due to prevention.

Table 2: Foot Ulcer Costs and Thermometry Savings

Cost Category	Standard of Care Ulcer Cost	Thermometry Ulcer Cost	Cost Savings for Thermometry
Inpatient	$16,671	$2,518	$14,153
Amputation	$14,807	$3,501	$11,307
Topical	$21,082	$3,259	$17,823
Prosthetic Limbs	$1,366	$323	$1,043
End of Life Care	$1,454	$727	$727
Total	**$55,381**	**$10,329**	**$45,053**

Conclusions

Use of this bottom-up economic model for the diabetic foot can augment existing cost-of-illness studies and enable decision-makers to explore the cost implications of emerging technologies and practices. Application of this model to data and assumptions consistent with standard care in the VA suggests that remote temperature monitoring has the potential eliminate 81% of DFU-attributable costs.