The Cost of the Diabetic Foot

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Disclosures

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• None
### The Diabetes Burden

Diabetic spends 2.3x more than non-diabetic
- $1 of every $5 spent on diabetic patient
- $1 of every $10 spent on diabetes

#### Diabetes costs 2007 – 2012

<table>
<thead>
<tr>
<th>Prevalence</th>
<th>Direct costs</th>
<th>Cost of Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>$116 B</td>
<td>$176 B</td>
</tr>
<tr>
<td>26% ↑</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40% ↑</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Diabetes Burden: DFU Costs

- **DM prevalence**
  - CDC 2014 (all ages, 2012)
  - 4%

- **DFU prevalence**
  - 1 - 7% annually

- **Cost per Episode**
  - Fife C. Wounds 2012
  - $5,391

- **Annual cost of DFU**
  - 1 - 7% = $1.6 B - $10.9 B
  - $6.3 B

What happens when diabetes prevalence is 1 in 3 Americans in 2050?
Cost of the Diabetic Foot

What makes up the cost?

• Inpatient vs. Outpatient
• Complications
• Technology
Inpatient vs. Outpatient

**DM with complications**
- 1.4% of national costs ($5.38B)
- Medicare = approx. 1/2 of costs

**Healthcare spending: Acute care**
All-cause = nearly 33%  Diabetes mellitus = 50%

**ED visits (2010)**

<table>
<thead>
<tr>
<th></th>
<th>Neurological</th>
<th>Peripheral Circulatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>% DM ED visits</td>
<td>36% (675,000)</td>
<td>0.8% (94,000)</td>
</tr>
<tr>
<td>% DM Admit from ED</td>
<td>41%</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

Change in U.S. Spending in Diabetes Mellitus

- Inpatient vs. Outpatient

- Excess $ per patient (in $100)

- % of growth

- ER/OTHER $/unit

- OUTPATIENT Volume

- INPATIENT $/unit

- RX Volume & $/unit

Inpatient vs. Outpatient

Hospitalization main cost driver in diabetic foot?

- 9-20% of DFU require hospitalization
- Accounts for 74-84% of total costs

The complications

**Diagnosis**
- Neurological
- Peripheral circulation
- Diabetic foot ulcer
- Infection

**Severity**
- Controlled vs. Uncontrolled
- PAD vs. CLI
- DPN vs. Charcot

**Co-morbidities**
- Chronic diseases
- Renal disease

**Procedures**
- Imaging tests
- Amputations
Diagnosis & Co-morbidities

Foot related complications

- Diabetic foot: 337,932
- DM normal foot: 1,461,398

18.8%

Higher costs with a diabetic foot complication
$17,373 vs. $9,958

74.5%

1.75x ↑ mortality during hospital stay

Chronic conditions
82.9% ↑

Unpublished data - CA OSHPD Public Discharge Files 2010-2013
**The Diabetic Foot**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Cost</th>
<th>LOS</th>
<th>Chronic conditions</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>No complication</td>
<td>1,461,398</td>
<td>9,958</td>
<td>3.5</td>
<td>5.3</td>
<td>0.67%</td>
</tr>
<tr>
<td>Complication</td>
<td>337,932</td>
<td>17,373</td>
<td>6.4</td>
<td>9.7</td>
<td>1.17%</td>
</tr>
<tr>
<td>% Difference</td>
<td></td>
<td>74.5%</td>
<td>84.0%</td>
<td>83.0%</td>
<td>74.6%</td>
</tr>
</tbody>
</table>

**The Hemodialysis Effect**

<table>
<thead>
<tr>
<th></th>
<th>DM no complication</th>
<th>DM + complication</th>
<th>DM + DPN</th>
<th>DM + PAD</th>
<th>DM + DFU</th>
<th>DM + Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-) HD</td>
<td>$ 9,958</td>
<td>$ 17,373</td>
<td>$ 13,673</td>
<td>$ 20,579</td>
<td>$ 18,977</td>
<td>$ 16,783</td>
</tr>
<tr>
<td>(+) HD</td>
<td>$ 12,779</td>
<td>$ 26,222</td>
<td>$ 16,473</td>
<td>$ 27,610</td>
<td>$ 26,987</td>
<td>$ 28,381</td>
</tr>
<tr>
<td>% Difference</td>
<td>28.3%</td>
<td>50.9%</td>
<td>20.5%</td>
<td>34.2%</td>
<td>42.2%</td>
<td>69.1%</td>
</tr>
</tbody>
</table>

Unpublished data - CA OSHPD Public Discharge Files 2010-2013
## Cost and Utilization by Diagnosis

<table>
<thead>
<tr>
<th></th>
<th>DM + complication</th>
<th>DM + DPN</th>
<th>DM + PAD</th>
<th>DM + DFU</th>
<th>DM + Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>337,932</td>
<td>195,204</td>
<td>60,790</td>
<td>80,528</td>
<td>112,044</td>
</tr>
<tr>
<td>Cost</td>
<td>$17,373</td>
<td>$13,673</td>
<td>$20,579</td>
<td>$18,977</td>
<td>$16,783</td>
</tr>
<tr>
<td>LOS</td>
<td>6.4</td>
<td>5.0</td>
<td>6.6</td>
<td>7.2</td>
<td>6.9</td>
</tr>
<tr>
<td>Chronic Conditions</td>
<td>9.7</td>
<td>9.8</td>
<td>11.5</td>
<td>10.5</td>
<td>8.9</td>
</tr>
<tr>
<td>Amputation</td>
<td>10.0%</td>
<td>4.3%</td>
<td>24.6%</td>
<td>22.7%</td>
<td>20.6%</td>
</tr>
<tr>
<td>Mortality</td>
<td>1.2%</td>
<td>0.5%</td>
<td>1.3%</td>
<td>0.9%</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

Unpublished data - CA OSHPD Public Discharge Files 2010-2013
Diabetic Foot Ulcers

Most expensive chronic wound ($5,391 per patient)
- 2x cost of other chronic ulcers
- Cost drivers: Rx (systemic Abx, pain meds)
  - Comorbidities (renal failure, ≥ 2 comorbidities)
  - Current tobacco

Inpatient costs ($13,258)
- Increasing mean cost/patient YoY 2005-2010
- Factors: Increased co-morbidities, revascularization, minor LEA
- Likely sicker patient population with greater attempt at limb salvage

2nd highest readmission rate

Gangrene

Source: HCUP Statistical Briefs #154, Readmissions to U.S. Hospitals by Procedure, 2010
Procedures: Amputations

<table>
<thead>
<tr>
<th>Amputation</th>
<th>N</th>
<th>Cost</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amputation</td>
<td>31,919</td>
<td>$28,193</td>
<td>9.3</td>
</tr>
<tr>
<td>No Amputation</td>
<td>1,735,492</td>
<td>$12,211</td>
<td>4.4</td>
</tr>
<tr>
<td>Minor</td>
<td>23,769</td>
<td>$26,214</td>
<td>8.6</td>
</tr>
<tr>
<td>Major</td>
<td>13,726</td>
<td>$34,671</td>
<td>11.4</td>
</tr>
</tbody>
</table>

25% of amputations needed multiple OR visits
- LOS 47.2% ↑
- Hospital charges 60.2% ↑

Unpublished data - CA OSHPD Public D/C Files 2010-2013; Ashry et al. 1998
Revascularization

Revascularization (endovascular or bypass) ± limb salvage is *cost-effective* compared to amputation

- Improved years of function
- Improved years of limb salvage
- Improved QALY

---

### Table: Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>Revascularization</th>
<th>Amputation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PAD, No revascularization</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endovascular</td>
<td>$37,589</td>
<td>$26,214</td>
</tr>
<tr>
<td>Surgical</td>
<td>$39,552</td>
<td>$34,671</td>
</tr>
<tr>
<td><strong>COST</strong></td>
<td>$15,540</td>
<td></td>
</tr>
</tbody>
</table>

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*Barshes 2012; Barshes 2014*
**Procedures**

*Highest* readmission rate (30 most common procedures)

Lower extremity amputation

**% Readmitted**

- Debridement wound, infection, or burn: 19.1%
- LE vascular bypass: 20.7%
- Amputation of lower extremity: 22.8%

**11th highest readmission rate by procedure**: 19.1%

28,394 readmissions

Source: HCUP Statistical Briefs #154, Readmissions to U.S. Hospitals by Procedure, 2010
**Severity**

**Diabetic Foot Ulcers**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Cost (Adequate vs. Inadequate)</th>
<th>Vascular</th>
<th>Age (&lt;65 vs 65+)</th>
<th>Progress higher severity (No progress vs. Yes progress)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>$1,892 $1,716 $2,433 $2,772 $1,597 $1,892 $14,009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>$4,345 $3,269 $6,762 $5,776 $3,756 $3,848 $30,381</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>$12,255 $11,258 $14,003 $14,518 $10,861 $9,083 $30,528</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV/V</td>
<td>$27,721 $11,686 $34,845 $33,502 $25,518</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>$13,065 $5,218 $23,372 $16,390 $11,925 $3,063 $20,136</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Statistically significant

N = 2,253

22% progressed to higher grade ulcer

24% ulcer-related hospitalization = 77% of charges

30% amputation rate

### Severity: DPN vs. Charcot Foot

#### Amputations

<table>
<thead>
<tr>
<th>Complication</th>
<th>Minor</th>
<th>Major</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Cost</td>
</tr>
<tr>
<td>DPN</td>
<td>6,869</td>
<td>$22,932</td>
</tr>
<tr>
<td>Charcot Foot</td>
<td>423</td>
<td>$28,820</td>
</tr>
</tbody>
</table>

#### Cost and Adjusting for Chronic Disease

<table>
<thead>
<tr>
<th></th>
<th>DPN</th>
<th>Charcot Foot</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td># chronic conditions</td>
<td>10.37</td>
<td>11.08</td>
<td>0.71 (6.8%)</td>
</tr>
<tr>
<td>Cost of chronic disease</td>
<td>$18,118</td>
<td>$21,242</td>
<td>$3,124 (17.2%)</td>
</tr>
</tbody>
</table>

*Each additional chronic disease contributes $842.46 in total costs in DPN patients (R²=0.798)*

<table>
<thead>
<tr>
<th></th>
<th>DPN</th>
<th>Charcot Foot</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted cost</td>
<td>$18,717</td>
<td>$21,242</td>
<td>$2,525 (13.9%)</td>
</tr>
</tbody>
</table>

*Other significant cost drivers in Charcot: DFU, Infection, Osteomyelitis*
Does technology drive the cost of care?

- Medical technology explains 27-48% of healthcare spending

*The trade-off*

- Expedited recovery vs. Cost of medical advancement
## Technology: Skin graft substitutes

### Modeling Cost Effectiveness

<table>
<thead>
<tr>
<th>Study</th>
<th>Graft</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steinberg et al., 2002</td>
<td>Apligraf vs. Saline moist gauze</td>
<td>$6,683 / ulcer-free months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$86,226 / amputations or resections avoided</td>
</tr>
<tr>
<td>Segal &amp; John, 2002</td>
<td>Dermagraft vs. SOC</td>
<td>$12,500 before Dermagraft treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$4,682 after starting Dermagraft</td>
</tr>
<tr>
<td>Redekop et al., 2003</td>
<td>Wound care vs. Wound care + Apligraf</td>
<td>1.3 more ulcer free months over 1 year = savings of $894 per</td>
</tr>
<tr>
<td></td>
<td></td>
<td>additional ulcer healed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitive to # applications, amputation costs, &amp; infection rate</td>
</tr>
</tbody>
</table>
Technology: Skin graft substitutes

Graft Size

Resource utilization

Apligraf (cm²)
- purchased: 159
- applied: 5,546
- Total: 5,705

Epifix (cm²)
- purchased: 68.2
- applied: 154
- Total: 222.2

Cost Minimization (not CEA)

Grafts/person
- EpiFix®: 2.15
- Apligraf®: 6.2

Cost/person
- EpiFix®: $1,669
- Apligraf®: $9,216

Significant decrease in resource utilization caused decrease cost despite expense of equipment

- Apelqvist, AM J Surg, 2008

Other studies ➔ Revenue neutral (NPWT = higher material cost, lower nursing time)
Depression prevalence in diabetic inpatient care in CA, 2010-2013

- No foot complication: 6.4%
- Foot complication: 11.1%

Inpatient foot complications ± depression

- 5.6% increased cost
- LOS 31.2% longer

Depression prevalence 10.7% - 16.7% in outpatient DFU (Vileikyte 2009; Vedhara K, 2010)

Unpublished data - CA OSHPD Public Discharge Files 2010-2013
Opportunity Costs

Financial hardship a major issue
- DFU ➔ 50-79% unemployed or unable to work

HRQOL

Diabetes lower than general population
- Higher than most other chronic illness
- Presence of complications is most important variable
  - Foot ulcers/Foot infections lower all physical and psychosocial domains
  - Active ulcer lower QoL than healed ulcer or minor amputation

• Increasing prevalence expect higher total costs
• Inpatient, severity of health, Rx, and amputations drive costs
• High personal & societal cost

Thank You
The Cost of the Diabetic Foot

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