Human and Economic Burden of Adult Vaccine-preventable Disease (VPD)

California, 2010

John M. McLaughlin, PhD, MSPH
Director, Institutional Outcomes Research Scientist
Pfizer Specialty Care Medicines Development Group

e. john.mclaughlin@pfizer.com
p. 614-505-6142
f. 646-348-8228
Research Questions

• What is the human and economic burden of adult vaccine-preventable disease from a societal perspective?
  – *The problem is not the problem. The problem is your attitude about the problem.* - Capt. Jack Sparrow

• Can we answer this in straight-forward, population-based manner?
  – *Don’t let perfect be the enemy of good.* - Voltaire

• Can we customize results?
  – *Ever notice that anyone going slower than you is an idiot, but anyone going faster is a maniac?* - George Carlin
Model Tenets: Providing Base-Case and My-Case Scenarios

- **Simplicity**
  - Backbone formula makes intuitive sense
  - Not too many bells and whistles

- **Transparency**
  - Model engine is visible and customizable
  - All base-case references are listed

- **Applicability**
  - Can be applied to different populations
  - Limitations highlighted / sensitivity
Adult VPD Model: the four diseases

1) Influenza

2) Pneumococcal
   • Invasive Disease (bacteremia & meningitis)
   • Non-bacteremic Pneumococcal Pneumonia (NPP)

3) Herpes Zoster

4) Pertussis
Adult VPD Model: the four inputs

1) Population Data
   • 2010 US Census Data
   • American Fact-Finder Website

2) Est. Incidence Rates (per 100,000)*
   • Conservative estimates from large population-based studies

3) Est. Direct Costs (per case)*
   • Preventive, diagnostic, and treatment services related to a particular condition from the peer-reviewed literature

4) Est. Indirect Costs (per case)*
   • Value of income lost from decreased productivity, restricted activity, absenteeism, and bed days
   • Does NOT include mortality costs or leisure time costs

*all estimates derived from the peer-reviewed literature and age-adjusted where possible
VPD Model Backbone

- \( N \times IR \times (Cost_{dir} + Cost_{ind}) \approx Cost_{total} \)
  - For each disease
  - Age-adjust to population where possible
  - All costs adjusted to 2010 US Dollars using CPI

- **Where:**
  - \( N \) = the # of persons
  - \( IR \) = est. incidence rate
  - \( Cost_{dir} \) = est. direct cost per case
  - \( Cost_{ind} \) = est. indirect cost per case
  - \( Cost_{total} \) = est. total population cost
If you hate mathematical formulas...
# Base-Case Assumptions

## Influenza, Pertussis, and Herpes Zoster, California, 2010

<table>
<thead>
<tr>
<th>Disease &amp; Age Group</th>
<th># Persons* (in 1,000s)</th>
<th>Incidence Rate (per 100,000)</th>
<th>Est. Direct Costs (per case)</th>
<th>Est. Indirect Costs (per case)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Influenza</strong>&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>27,959</td>
<td>6,310</td>
<td>$140</td>
<td>$377</td>
</tr>
<tr>
<td>18 or older</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pertussis</strong>&lt;sup&gt;h,i&lt;/sup&gt;</td>
<td>27,959</td>
<td>196</td>
<td>$395</td>
<td>$542</td>
</tr>
<tr>
<td>18 or older</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Herpes Zoster</strong>&lt;sup&gt;f,g&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-59</td>
<td>4,767</td>
<td>460</td>
<td>$1,094</td>
<td>$2,636</td>
</tr>
<tr>
<td>60-69</td>
<td>3,136</td>
<td>690</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70-79</td>
<td>1,739</td>
<td>950</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 or older</td>
<td>1,204</td>
<td>1,090</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*total aged ≥50 years is 2,907 (in 1,000s)
### Invasive Pneumococcal Disease, California, 2010

<table>
<thead>
<tr>
<th>Disease &amp; Age Group</th>
<th># Persons* (in 1,000s)</th>
<th>Incidence Rate (per 100,000)</th>
<th>Est. Direct Costs (per case)</th>
<th>Est. Indirect Costs (per case)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteremia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-64</td>
<td>6,599</td>
<td>20</td>
<td>$24,814</td>
<td>$1,923</td>
</tr>
<tr>
<td>65-74</td>
<td>2,275</td>
<td>37</td>
<td>$23,426</td>
<td>$597</td>
</tr>
<tr>
<td>75-84</td>
<td>1,370</td>
<td>50</td>
<td>$20,849</td>
<td>$143</td>
</tr>
<tr>
<td>85 or older</td>
<td>601</td>
<td>64</td>
<td>$17,259</td>
<td>$112</td>
</tr>
<tr>
<td><strong>Meningitis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-64</td>
<td>6,599</td>
<td>1</td>
<td>$30,518</td>
<td>$2,036</td>
</tr>
<tr>
<td>65-74</td>
<td>2,275</td>
<td>2</td>
<td>$32,256</td>
<td>$698</td>
</tr>
<tr>
<td>75-84</td>
<td>1,370</td>
<td>3</td>
<td>$28,584</td>
<td>$168</td>
</tr>
<tr>
<td>85 or older</td>
<td>601</td>
<td>4</td>
<td>$18,819</td>
<td>$117</td>
</tr>
</tbody>
</table>

*total aged ≥50 years is 2,907 (in 1,000s)
## Base-Case Assumptions

### Non-Bacteremic Pneumococcal Pneumonia (NPP), California, 2010

<table>
<thead>
<tr>
<th>Disease &amp; Age Group</th>
<th># Persons* (in 1,000s)</th>
<th>Incidence Rate (per 100,000)</th>
<th>Est. Direct Costs (per case)</th>
<th>Est. Indirect Costs (per case)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inpatient NPP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-64</td>
<td>6,599</td>
<td>57</td>
<td>$16,264</td>
<td>$1,493</td>
</tr>
<tr>
<td>65-74</td>
<td>2,275</td>
<td>193</td>
<td>$15,189</td>
<td>$485</td>
</tr>
<tr>
<td>75-84</td>
<td>1,370</td>
<td>566</td>
<td>$14,191</td>
<td>$123</td>
</tr>
<tr>
<td>85 or older</td>
<td>601</td>
<td>1,056</td>
<td>$12,917</td>
<td>$105</td>
</tr>
<tr>
<td><strong>Outpatient NPP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-64</td>
<td>6,599</td>
<td>186</td>
<td>$507</td>
<td>$710</td>
</tr>
<tr>
<td>65-74</td>
<td>2,275</td>
<td>370</td>
<td>$578</td>
<td>$225</td>
</tr>
<tr>
<td>75-84</td>
<td>1,370</td>
<td>620</td>
<td>$632</td>
<td>$56</td>
</tr>
<tr>
<td>85 or older</td>
<td>601</td>
<td>907</td>
<td>$695</td>
<td>$47</td>
</tr>
</tbody>
</table>

*total aged ≥50 years is 2,907 (in 1,000s)
## Model Output, ≥50 years

### California, 2010

<table>
<thead>
<tr>
<th>Disease &amp; Age</th>
<th># Cases</th>
<th>Dir Cost (per case)</th>
<th>Indir Cost (per case)</th>
<th>Total Cost (millions)</th>
<th>Dir Cost (millions)</th>
<th>Indir Cost (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influenza</td>
<td>684,355</td>
<td>140</td>
<td>377</td>
<td>353.8</td>
<td>95.8</td>
<td>258.0</td>
</tr>
<tr>
<td>Pneumococcal Bacteremia</td>
<td>60,302</td>
<td>23,516</td>
<td>1,290</td>
<td>491.9</td>
<td>447.5</td>
<td>44.4</td>
</tr>
<tr>
<td>Meningitis</td>
<td>3,231</td>
<td>29,898</td>
<td>1,382</td>
<td>80.5</td>
<td>76.3</td>
<td>4.3</td>
</tr>
<tr>
<td>NPP Inpt.</td>
<td>22,254</td>
<td>15,549</td>
<td>1,009</td>
<td>369.9</td>
<td>347.0</td>
<td>23.0</td>
</tr>
<tr>
<td>NPP Outpt.</td>
<td>34,639</td>
<td>551</td>
<td>478</td>
<td>35.9</td>
<td>19.0</td>
<td>16.9</td>
</tr>
<tr>
<td>Herpes Zoster</td>
<td>19,878</td>
<td>1,034</td>
<td>2,636</td>
<td>268.7</td>
<td>75.7</td>
<td>193.0</td>
</tr>
<tr>
<td>Pertussis</td>
<td>19,088</td>
<td>395</td>
<td>542</td>
<td>17.9</td>
<td>7.5</td>
<td>10.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>843,924</strong></td>
<td></td>
<td></td>
<td><strong>1132.3</strong></td>
<td><strong>626.6</strong></td>
<td><strong>505.7</strong></td>
</tr>
</tbody>
</table>
All ≥50 Burden of Adult VPD
Est. Total Cost California, 2010: $1132M

COST

- Pertussis (≥50) $17.9M 2%
- Pneumococcal (≥50) $491.9M 43%
- Herpes Zoster (≥50) $268.7M 24%
- Influenza (≥50) $353.8M 31%

INCIDENCE

- Pertussis (≥50) 19,088 2%
- Herpes Zoster (≥50) 73,208 9%
- Pneumococcal (≥50) 60,302 7%
- Influenza (≥50) 684,355 82%
All ≥50 Burden of Adult VPD

Est. Total Cost California, 2010: $1132M

- Pertussis (≥50)
- Herpes Zoster (≥50)
- S. Pneumo: NPP outpatient (≥50)
- S. Pneumo: NPP inpatient (≥50)
- S. Pneumo: Meningitis (≥50)
- S. Pneumo: Bacteremia (≥50)
- Influenza (≥50)
Proportion Direct/Indirect Costs
Total Cost, California, 2010

All On-Label
- Indirect: 929.2, 54%
- Direct: 789.7, 46%

All ≥50 Years
- Indirect: 505.7, 45%
- Direct: 626.6, 55%
Proportion Direct/Indirect Costs: All ≥50 Population

<table>
<thead>
<tr>
<th>Disease</th>
<th>Indirect</th>
<th>Direct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influenza</td>
<td>27%</td>
<td>73%</td>
</tr>
<tr>
<td>Pneumococcal</td>
<td>91%</td>
<td>9%</td>
</tr>
<tr>
<td>Herpes Zoster</td>
<td>28%</td>
<td>72%</td>
</tr>
<tr>
<td>Pertussis</td>
<td>42%</td>
<td>58%</td>
</tr>
</tbody>
</table>
Sensitivity Analysis: all ≥50

Total Cost of Four Adult VPDs (2010 $US in millions)

- Influenza - Incidence Rate
- Influenza - Indirect Costs
- Influenza - Direct Costs
- NPP Inpatient - Incidence Rate
- NPP Inpatient - Direct Costs
- Herpes Zoster - Incidence Rate
- Pertussis - Incidence Rate
- Herpes Zoster - Indirect Costs
- Pertussis - Indirect Costs
- Pertussis - Direct Costs
- Herpes Zoster - Direct Costs
- Bacteremia - Incidence Rate
- Bacteremia - Direct Costs
- NPP Outpatient - Incidence Rate
- NPP Outpatient - Direct Costs
- NPP Inpatient - Indirect Costs
- Meningitis - Incidence Rate
- Meningitis - Direct Costs
- NPP Outpatient - Indirect Costs
- Bacteremia - Indirect Costs
- Meningitis - Indirect Costs

20% Increase
20% Reduction
Limitations

All models are wrong... but some are useful.
(George Box, 1987)

• The model reflects only the burden of disease attributable to the four adult VPDs included in the analysis. Because no vaccine is 100% effective, this model does not reflect the actual amount of disease that would necessarily be prevented with vaccination and should instead be interpreted as the burden of disease in 2010, human and economic, attributable to each disease included in the model.

• Although the model does age-adjust where possible for differences in state population demographics, it does not account for differences in other characteristics (e.g., race/ethnicity, health care access, population density, rural/urban mix) that may affect overall incidence rates or costs from state-to-state.

• In addition, though the model did include the four major adult VPDs, other adult VPDs (e.g., HPV and hepatitis) were not included and should be examined in the future.
Summary

- Estimated economic impact of 4 major adult VPDs was considerable ($1719M all on-label, $1132M aged ≥50).

- Among aged ≥50, pneumococcal disease made up 7% of cases, but 43% of costs—more than the estimated cost of influenza—with the large majority (83%) of pneumococcal burden due to NPP.

- Likewise, although herpes zoster only made up 9% of cases of adult VPD (among ≥50), it represented 24% of costs.

- Broadening adult immunization efforts beyond influenza only may help reduce the economic burden of disease.

- A pneumococcal vaccination effort, primarily focused on reducing the burden of NPP, may be a logical place to start (esp. if focus is on direct medical costs).
the road ahead...

- policy
- mindset and culture
- tools
- define and measure progress
References


\[b\] Adapted from Nichol KL. Cost-benefit analysis of a strategy to vaccinate healthy working adults against influenza. Arch Intern Med. Mar 12 2001;161(5):749-759. Average costs were estimated from a weighted average of age- and risk profile-specific direct and indirect costs and incidence. Leisure time and indirect costs from mortality were not included in indirect costs.

\[c\] The number of cases were based on estimates from the 2010 U.S. Census and pneumococcal pneumonia estimates from Weycker D, Strutton D, Edelsberg J, Sato R, Jackson LA. Clinical and economic burden of pneumococcal disease in older US adults. Vaccine. Jul 12 2010;28(31):4955-4960. Number of cases were estimated from a weighted average of age- and risk profile-specific incidence rates (see Table 1 in Weycker et al.). Leisure time and indirect costs from mortality were not included in indirect costs.

\[d\] Adapted from Weycker D, Strutton D, Edelsberg J, Sato R, Jackson LA. Clinical and economic burden of pneumococcal disease in older US adults. Vaccine. Jul 12 2010;28(31):4955-4960. Average costs were estimated from a weighted average of age- and risk profile-specific direct and indirect costs (see Table 1 in Weycker et al.). Leisure time and indirect costs from mortality were not included in indirect costs.

\[e\] Number of cases based on 2010 U.S. Census estimates for persons over age 50 and assumes a herpes zoster incidence rate of 4.6, 6.9, 9.5, and 10.9 per 1,000 person years for persons aged 50 to 59, 60-69, 70-79, and ≥80, respectively, based on Insinga RP, Itzler RF, Pellissier JM, Saddier P, Nikas AA. The incidence of herpes zoster in a United States administrative database. J Gen Intern Med. Aug 2005;20(8):748-753.

\[f\] Adapted from Pellissier JM, Brisson M, Levin MJ. Evaluation of the cost-effectiveness in the United States of a vaccine to prevent herpes zoster and postherpetic neuralgia in older adults. Vaccine. Nov 28 2007;25(49):8326-8337. Assumes 12-32% of Herpes Zoster patients develop PHN and that 4.3-5.7%, 3.2-5.9%, 1.1-2.9%, and 0.4-2.5% of patient develop ocular, neurological, cutaneous, or other complications, respectively. Average costs were estimated from a weighted average of age-specific costs and incidence. Leisure time and indirect costs from mortality were not included in indirect costs.

\[g\] Number of cases based on 2010 U.S. Census estimates for persons over age 18 and assumes a conservative pertussis incidence rate of 176 per 100,000 person years for persons aged ≥18 based on Nennig ME, Shinefield HR, Edwards KM, Black SB, Fireman BH. Prevalence and incidence of adult pertussis in an urban population. JAMA. Jun 5 1996;275(21):1672-1674.
