Pertussis Epidemiology and Vaccination in the United States

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National Vaccine Advisory Committee
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## 20th Century and Current Annual Vaccine-Preventable Disease Morbidity

<table>
<thead>
<tr>
<th>Disease</th>
<th>20th Century Annual Morbidity †</th>
<th>2011 Reported Cases † †</th>
<th>Percent Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smallpox</td>
<td>29,005</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>21,053</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Measles</td>
<td>530,217</td>
<td>212</td>
<td>&gt; 99%</td>
</tr>
<tr>
<td>Mumps</td>
<td>162,344</td>
<td>370</td>
<td>&gt; 99%</td>
</tr>
<tr>
<td><strong>Pertussis</strong></td>
<td><strong>200,752</strong></td>
<td><strong>15,216</strong></td>
<td><strong>92%</strong></td>
</tr>
<tr>
<td>Polio (paralytic)</td>
<td>16,316</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Rubella</td>
<td>47,745</td>
<td>4</td>
<td>&gt; 99%</td>
</tr>
<tr>
<td>Congenital Rubella Syndrome</td>
<td>152</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Tetanus</td>
<td>580</td>
<td>9</td>
<td>98%</td>
</tr>
<tr>
<td><strong>Haemophilus influenzae</strong></td>
<td><strong>20,000</strong></td>
<td><strong>8</strong></td>
<td><strong>&gt; 99%</strong></td>
</tr>
</tbody>
</table>

†Source: JAMA. 2007;298(18):2155-2163
†† Source: CDC. MMWR January 6, 2012;60(51):1762-1775. (provisional 2011 data)
* **Haemophilus influenzae** type b (Hib) < 5 years of age. An additional 14 cases of Hib are estimated to have occurred among the 237 reports of Hi (< 5 years of age) with unknown serotype.
Reported NNDSS pertussis cases: 1922-2011

Number of cases

- DTP
- DTaP
- Tdap

Year


0 50,000 100,000 150,000 200,000 250,000 300,000

*2011 data are provisional.

* 2010 NNDSS data are provisional

SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System and 1922-1949, passive reports to the Public Health Service
Annual incidence by State, 2010

2010* incidence 9.0
(n=27,555; 4,298 infants)

Incidence is per 100,000 population
CDC Wonder Population Estimates (Vintage 2009)
Annual incidence by State, 2011*

2011 incidence 5.0
(n=15,216)

Incidence

- White: 0.4-2.0
- Gray: 2.1-4.5
- Yellow: 4.6-7.7
- Red: 7.8-15.2

*2011 data are provisional. Incidence is per 100,000 population
Source: CDC National Notifiable Disease Surveillance System, 2011
CDC Wonder Population Estimates (Vintage 2009)
Reported pertussis incidence by age group - 1990-2011*

SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System

*2011 data are provisional.
## Reported pertussis-related deaths by age-groups, U.S., 1980-2009

<table>
<thead>
<tr>
<th>Age-Group</th>
<th>1980-1989(^1)</th>
<th>1990-1999(^1)</th>
<th>2000-2009(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 month</td>
<td>38</td>
<td>68</td>
<td>152</td>
</tr>
<tr>
<td>2-3 month</td>
<td>11</td>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>4-5 month</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>6-11 month</td>
<td>7</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1-4 years</td>
<td>13</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5-10 years</td>
<td>1</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>11-18 years</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>&gt;18 years</td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>77(^*)</strong></td>
<td><strong>103</strong></td>
<td><strong>194</strong></td>
</tr>
</tbody>
</table>

Includes one case with unknown age

\(^2\) National Notifiable Diseases Surveillance System, CDC, 2009
Pertussis Immunization in the US

• Whole-cell vaccines/DTwP (1940s)
• DTaP (1990s)
  – Infants at 2, 4, 6 months (1997)
  – Toddlers at 15-18 months (1992)
  – Pre-school at 4-6 years (1992)
• Tdap
  – Adolescents at 11-12 years (2005)
  – Adults who have not received (2005)
DTaP coverage among children aged 19 through 35 months — 2004–2010

CDC National Immunization Survey
Tdap coverage among adolescents aged 13–17 years — 2006–2010

CDC. National, State, and Local Area Vaccination Coverage among Adolescents Aged 13-17 Years - United States, 2009 MMWR 2010;59(32);1018-1023.
Incidence of reported pertussis — 1990–2010

CDC unpublished data
Accelerated decline of pertussis

Rate ratios of pertussis incidence among adolescents 11-18 years, 1990-2008

**Absence of Indirect Effects of Tdap**

Mean incidence of reported pertussis among infants

<table>
<thead>
<tr>
<th></th>
<th>1990-2003 (pre-peak)</th>
<th>2006-2009 (post-peak)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean incidence (per 100,000)</td>
<td>52.1</td>
<td>55.4</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Reported pertussis incidence by age group — 1990–2010

SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System
<table>
<thead>
<tr>
<th>Model *</th>
<th>Case (n)</th>
<th>Control (n)</th>
<th>VE, %</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall VE, All Ages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 dose</td>
<td>53</td>
<td>19</td>
<td>Ref</td>
<td>--</td>
</tr>
<tr>
<td>5 doses</td>
<td>629</td>
<td>1,997</td>
<td>88.7</td>
<td>79.4 – 93.8</td>
</tr>
<tr>
<td>Time since 5&lt;sup&gt;th&lt;/sup&gt; dose</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 doses</td>
<td>53</td>
<td>19</td>
<td>Ref</td>
<td>--</td>
</tr>
<tr>
<td>&lt; 12 months</td>
<td>19</td>
<td>354</td>
<td>98.1</td>
<td>96.1 – 99.1</td>
</tr>
<tr>
<td>12 – 23 months</td>
<td>51</td>
<td>391</td>
<td>95.3</td>
<td>91.2 – 97.5</td>
</tr>
<tr>
<td>24 – 35 months</td>
<td>79</td>
<td>366</td>
<td>92.3</td>
<td>86.6 – 95.5</td>
</tr>
<tr>
<td>36 – 47 months</td>
<td>108</td>
<td>304</td>
<td>87.3</td>
<td>76.2 – 93.2</td>
</tr>
<tr>
<td>48 – 59 months</td>
<td>141</td>
<td>294</td>
<td>82.8</td>
<td>68.7 – 90.6</td>
</tr>
<tr>
<td>60+ months</td>
<td>231</td>
<td>288</td>
<td>71.2</td>
<td>45.8 – 84.8</td>
</tr>
</tbody>
</table>

Accounting for clustering by county and provider
Alternate Hypotheses for Disease Emergence in Children

- Changes in circulating strains
  - Vaccine–antigen mismatch occurs
  - Pertussis toxin promoter 3 (ptxP3)\(^1\)
  - *However*, short-term effectiveness excellent

- Reduction in transmission and limited boosting\(^2\)
  - *However*, inter-epidemic periods persist

- Surveillance bias
  - *However*, cohort effect evident

- Vaccine factors
  - Brand, manufacture, antigen content, co-administration/combinations
  - Remains to be assessed

\(^1\)Mooi et al. EID 2009;15:1206-1213.
Summary and Conclusions

- Pertussis incidence has increased since 1980s
- Tdap has reduced the burden of pertussis in adolescents
- No evidence for “herd immunity” from Tdap
- Excellent initial DTaP vaccine effectiveness
- Moderate and immediate waning of DTaP immunity
Short term strategy/ Maximize current vaccination program

- Minimizing barriers to Tdap uptake
- Vaccinating to protect infants
- Improving awareness
Shifting the timing of mother’s Tdap dose

- “Cocooning” programs difficult to implement
- Provides earlier protection to mother and therefore indirect protection to infant
- High levels of transplacental maternal antibodies transferred to infants may provide direct protection
Pertussis communications focus

- General public and providers
  - Signs and symptoms
  - Vaccine recommendations (prevention and control)
  - Seriousness of infant disease and need for rapid treatment

- Providers
  - Diagnosis consideration among all ages; atypical presentations
  - Appropriate use and interpretation of diagnostic tests
  - Treatment and prophylaxis of high-risk groups
Communications elements

- Process and impact evaluation
- Formative research
- Partners
- Paid media
- Earned media
- Web and social media
- Materials and message development
- Education/outreach to healthcare workers
CDC Website

- 1.1 million hits in 2011
- Pertussis “Fast Facts” 4th most syndicated CDC page

**Vaccine protection for pertussis, tetanus, and diphtheria fades with time, so adults need a booster shot. Experts recommend adults receive a tetanus and diphtheria booster (called Td) every 10 years and substitute a Tdap vaccine for one of the boosters. The dose of Tdap can be given earlier than the 10-year mark. **

**Getting vaccinated with Tdap – at least two weeks before coming into close contact with an infant – is especially important for adults who are around infants.** Adults 65 years and older (grandparents, child care providers, and healthcare providers) who have close contact with infants should get a dose of Tdap, following the newest vaccine recommendations.

Remember that even fully-vaccinated adults can get pertussis. If you are caring for infants, check with your healthcare provider about what's best for your situation.
Selected Current and Future MVPD Activities

- Improving diagnostic testing to improve surveillance
- **Enhanced Pertussis Surveillance sites**
  - Enhanced case ascertainment and improved data quality
  - Platform for analyses and studies
- **Evaluating effectiveness of cocooning/maternal vaccination**
- Evaluating Tdap duration of protection
- Assessing temporal trends in susceptibility/infection
  - Serosurvey
  - Modeling
- Increasing the evidence base for new vaccines or strategies
The Future of Pertussis Control

- **Improve Tdap coverage**
  - Goal is no infant deaths

- **Sustain DTaP coverage**
  - Changes to DTaP schedule might shift rather than reduce disease

- **ACIP to consider lifespan vaccination**
  - Unclear potential for herd immunity

- **Modify current vaccines**
  - Antigens
  - Adjuvants

- **Novel vaccines**
  - Immunologic correlates of protection
  - Pathway to licensure