Influenza Vaccine Program
Effectiveness in the United States

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Disclaimer

- The findings and conclusions in this presentation have not been formally disseminated by CDC and do not represent any agency determination or policy
- I have no financial conflicts of interest
2010: 50th Anniversary of First Influenza Vaccine Recommendation

Influenza Immunization

The high-risk groups who contribute most to the excess deaths and who the Public Health Service believes should be routinely immunized each year are:

1. Persons of all ages who suffer from chronic debilitating disease, in particular: (a) rheumatic heart disease, especially mitral stenosis; (b) other cardiovascular diseases, such as arteriosclerotic heart disease or hypertension—especially patients with evidence of frank or incipient insufficiency; (c) chronic bronchopulmonary disease, for example, chronic asthma, chronic bronchitis, bronchiectasis, pulmonary fibrosis, pulmonary emphysema, or pulmonary tuberculosis; (d) diabetes mellitus; (e) Addison's disease.
2. Pregnant women.
3. All persons 65 years or older.

Influenza vaccination recommendations over time

Before 2000:
- Persons aged 65 or older
- Persons with high-risk chronic medical conditions
- Pregnant women in the second or third trimester
- Household contacts of the above
- Health care workers

2000:
- Adults 50 and older

2004:
- Children aged 6—23 months
- Household contact of children aged 0—23 months
- Women who will be pregnant during influenza season

2006:
- Children aged 6—59 months
- Household contacts of children aged 0—59 months

2008:
- All children aged 6 months—18 years

2010:
- All persons > 6 months in the US
During the last decade…

- More people getting vaccinated with influenza vaccines
- Greater use of vaccines in persons at high risk of complications
- More awareness of the need for vaccination
- Some skepticism of the value of influenza vaccination

Are influenza vaccines effective in preventing influenza-associated illnesses each year?

Influenza Division program to measure influenza vaccine effectiveness in the U.S.

- New Vaccine Surv. Network
- Emerging Infections Program
- Marshfield Clinic
- US VE Network - 1
- Special studies
- US VE Network - 2

6 – 59 mo., OP, Hosp.
6 – 23 m Hosp.
6-59m Hosp.
Adults > 18 y Hosp.
Adults > 50 y Hosp.

ACIP recommended groups
MAARI

ACIP recommended groups - MAARI

HCWs, Peds., ICU, Pregnant

All Ages
MAARI
During the last decade...

- More people getting vaccinated with influenza vaccines
- Greater use of vaccines in persons at high risk of complications
- More awareness of the need for vaccination
- Some skepticism of the value of influenza vaccination

Are influenza vaccines effective in preventing influenza-associated illnesses each year?

Yes.

... but the effectiveness of vaccines varies by season, population, and outcome measured

And, communication of influenza vaccine effectiveness is difficult

Study results about how well a flu vaccine works can vary based on study design, outcome(s) measured, population studied and the season in which the vaccine was studied. These differences can make it difficult to compare one study’s results with another’s.

How well the flu vaccine works (or its ability to prevent influenza illness) can range widely from season to season and also can vary depending on who is being vaccinated.

While determining how well a flu vaccine works is challenging, in general, recent studies have supported the conclusion that influenza vaccination benefits public health, especially when the viruses in the vaccine and circulating viruses are well-matched. (See "Current Efforts to Study How Well Influenza Vaccines Work.")
Influenza Vaccine Program Effectiveness Project

- Question: Are influenza vaccine programs effective in reducing influenza-associated health outcomes in the population?

- Goal: Estimate the number of averted influenza-associated outcomes that result from influenza vaccination in the United States

Influenza Vaccine Program Effectiveness Project

- Advantages:
  - Consistent and systematic approach across seasons
  - Uses data collected as core program activities (Influenza Division and Immunization Services Division)
  - Estimates can be updated annually
  - Illness/outcomes averted may be easier and more meaningful way to communicate value of vaccine?
Project Phases

Phase 1: Develop the model
Phase 2: Apply the model to previous years’ data (2005-2010)
Phase 3: Run the model following each influenza season to estimate the effect of vaccination annually
Phase 4: Apply economic data to the model to estimate costs/costs averted
  Use the model to address programmatic questions (e.g. value of new vaccines vs. existing vaccines)

Influenza Vaccine Program Effectiveness Methods

1. Estimate observed annual burden of influenza-associated outcomes
2. Estimate observed risk of influenza-associated outcomes among susceptible individuals
   – Using data on annual vaccine coverage and vaccine effectiveness
3. Calculate expected burden of influenza-associated outcomes in population with no vaccination
4. Calculate difference in outcomes attributable to vaccination program
1. Estimating annual US burden of influenza

- Outcomes
  - Illness
  - Medically-attended illness
  - Hospitalization

- Stratified by month and age group

2. Risk of influenza outcomes if susceptible

- influenza-related outcomes occurred among persons at risk for influenza.

<table>
<thead>
<tr>
<th>Month</th>
<th>VE</th>
<th>VC*</th>
<th>Pop at risk</th>
<th>Est. Illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>60%</td>
<td>15%</td>
<td>1000*(1-60%*15%)</td>
<td>0</td>
</tr>
<tr>
<td>October</td>
<td>60%</td>
<td>10%</td>
<td>(910-0)*(1-60%*10%)</td>
<td>5</td>
</tr>
<tr>
<td>November</td>
<td>60%</td>
<td>5%</td>
<td>(855-5)*(1-60%*5%)</td>
<td>10</td>
</tr>
<tr>
<td>December</td>
<td>60%</td>
<td>5%</td>
<td>(825-10)*(1-60%*5%)</td>
<td>20</td>
</tr>
<tr>
<td>January</td>
<td>60%</td>
<td>2%</td>
<td>(790-20)*(1-60%*2%)</td>
<td>40</td>
</tr>
</tbody>
</table>

- Population at risk = population not protected from effective vaccination or having prior illness
- Effective vaccination = VE x VC

Example: Population at risk
### Example: Risk among susceptibles

<table>
<thead>
<tr>
<th>Month</th>
<th>Pop. at risk</th>
<th>Est. Illness</th>
<th>Risk of illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>910</td>
<td>0</td>
<td>0/910 = 0%</td>
</tr>
<tr>
<td>October</td>
<td>855</td>
<td>5</td>
<td>5/855 = 0.6%</td>
</tr>
<tr>
<td>November</td>
<td>825</td>
<td>10</td>
<td>10/825 = 1.2%</td>
</tr>
<tr>
<td>December</td>
<td>790</td>
<td>20</td>
<td>20/790 = 2.5%</td>
</tr>
<tr>
<td>January</td>
<td>761</td>
<td>40</td>
<td>40/761 = 5.3%</td>
</tr>
</tbody>
</table>

### 3. Estimated burden if no vaccination

- Apply same risk of outcome among susceptible persons, by month
- Greater population susceptible because no vaccination
  - Remove persons protected due to illness each month, but no longer remove persons vaccinated
### Example: Estimated burden without vaccination

<table>
<thead>
<tr>
<th>Month</th>
<th>Risk of illness</th>
<th>Pop. at risk (no vaccination)</th>
<th>Expected Illnesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>0%</td>
<td>1000</td>
<td>=1000 * 0% = 0</td>
</tr>
<tr>
<td>October</td>
<td>0.6%</td>
<td>1000</td>
<td>=1000 * 0.6% = 6</td>
</tr>
<tr>
<td>November</td>
<td>1.2%</td>
<td>994</td>
<td>= 994 * 1.2% = 12</td>
</tr>
<tr>
<td>December</td>
<td>2.5%</td>
<td>982</td>
<td>= 982 * 2.5% = 25</td>
</tr>
<tr>
<td>January</td>
<td>5.3%</td>
<td>957</td>
<td>= 957 * 5.3% = 50</td>
</tr>
</tbody>
</table>

4. Calculate net impact of vaccine program

- Difference between expected outcomes without vaccination and estimated annual burden

- Using the illness example presented earlier:
  - 93 expected without vaccination
  - 75 observed
  - 18 averted illnesses
Draft Results: Averted Outcomes

Influenza Vaccine Program Effectiveness Project

<table>
<thead>
<tr>
<th>Year</th>
<th>Illnesses</th>
<th>Medically-attended illness</th>
<th>Hospitalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>1,620,856</td>
<td>680,760</td>
<td>16,029</td>
</tr>
<tr>
<td>2006-07</td>
<td>873,539</td>
<td>366,886</td>
<td>7,273</td>
</tr>
<tr>
<td>2007-08</td>
<td>2,139,830</td>
<td>898,728</td>
<td>21,292</td>
</tr>
<tr>
<td>2008-09</td>
<td>1,713,955</td>
<td>719,861</td>
<td>11,621</td>
</tr>
<tr>
<td>2010-11</td>
<td>4,834,888</td>
<td>2,030,653</td>
<td>40,764</td>
</tr>
<tr>
<td><strong>Five Season Total</strong></td>
<td><strong>11,183,068</strong></td>
<td><strong>4,696,888</strong></td>
<td><strong>96,979</strong></td>
</tr>
</tbody>
</table>

Summary

- Substantial annual averted disease burden from the influenza vaccination program
  - Varies by season
  - Varies by age group
  - Due to variability in VC, VE, annual disease burden

- Expect that effects will be greater, as analysis does not yet account for any indirect protection of unvaccinated persons
Conclusions

• Having a standardized framework to evaluate program impact
  – Allows comparison across seasons to examine impact of changes in burden, VE, and VC
  – Helps identify and prioritize data needed to routinely evaluate program impact

• Program improvements will be made by
  – increasing coverage in non-elderly persons
  – improving effectiveness of vaccines, especially in elderly persons

Influenza Vaccine Program Effectiveness Team

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• Carrie Reed
• Po-Yung Cheng
• Martin Meltzer
• Paul Gargiullo
• In Kyu Kim
• David Shay
• Lyn Finelli
• Jim Singleton
• Joe Bresee
Questions?

BACKUP SLIDES
Annual and age-group variation in parameters

<table>
<thead>
<tr>
<th>Age group</th>
<th>Vaccine coverage</th>
<th>Vaccine effectiveness</th>
<th>Hospitalization rates (per 100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 mos–4 yrs</td>
<td>35–59%</td>
<td>35–63%</td>
<td>71–115</td>
</tr>
<tr>
<td>5–19 yrs</td>
<td>15–38%</td>
<td>35–63%</td>
<td>9.6–17</td>
</tr>
<tr>
<td>20–64 yrs</td>
<td>20–31%</td>
<td>35–63%</td>
<td>8.2–25</td>
</tr>
<tr>
<td>65+ yrs</td>
<td>66–70%</td>
<td>25–39%</td>
<td>39–203</td>
</tr>
</tbody>
</table>

Draft Results: Averted Illnesses

<table>
<thead>
<tr>
<th>Year</th>
<th>All ages</th>
<th>0-4 yrs</th>
<th>5-19 yrs</th>
<th>20-64 yrs</th>
<th>65+ yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>1,620,856</td>
<td>354,430</td>
<td>238,609</td>
<td>342,974</td>
<td>684,843</td>
</tr>
<tr>
<td>2006-07</td>
<td>873,539</td>
<td>260,233</td>
<td>168,409</td>
<td>214,505</td>
<td>229,391</td>
</tr>
<tr>
<td>2007-08</td>
<td>2,139,830</td>
<td>325,172</td>
<td>276,834</td>
<td>632,665</td>
<td>905,159</td>
</tr>
<tr>
<td>2008-09</td>
<td>1,713,955</td>
<td>485,677</td>
<td>554,869</td>
<td>424,402</td>
<td>249,007</td>
</tr>
<tr>
<td>2010-11</td>
<td>4,834,888</td>
<td>758,633</td>
<td>1,066,858</td>
<td>1,604,536</td>
<td>1,404,860</td>
</tr>
<tr>
<td>Five Season Total</td>
<td>11,183,068</td>
<td>2,184,145</td>
<td>2,305,579</td>
<td>3,219,082</td>
<td>3,473,260</td>
</tr>
</tbody>
</table>
### Draft Results: Medically-attended Illness

<table>
<thead>
<tr>
<th>Year</th>
<th>All ages</th>
<th>0-4 yrs</th>
<th>5-19 yrs</th>
<th>20-64 yrs</th>
<th>65+ yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>680,760</td>
<td>148,861</td>
<td>100,216</td>
<td>144,049</td>
<td>287,634</td>
</tr>
<tr>
<td>2006-07</td>
<td>366,886</td>
<td>109,198</td>
<td>71,152</td>
<td>90,092</td>
<td>96,344</td>
</tr>
<tr>
<td>2007-08</td>
<td>898,728</td>
<td>136,572</td>
<td>116,270</td>
<td>265,719</td>
<td>380,167</td>
</tr>
<tr>
<td>2008-09</td>
<td>719,861</td>
<td>203,984</td>
<td>233,045</td>
<td>178,249</td>
<td>104,583</td>
</tr>
<tr>
<td>2010-11</td>
<td>2,030,653</td>
<td>318,626</td>
<td>448,080</td>
<td>673,905</td>
<td>590,041</td>
</tr>
<tr>
<td>Five Season Total</td>
<td>4,696,888</td>
<td>917,241</td>
<td>968,763</td>
<td>1,352,014</td>
<td>1,458,769</td>
</tr>
</tbody>
</table>

### Draft Results: Hospitalizations

<table>
<thead>
<tr>
<th>Year</th>
<th>All ages</th>
<th>0-4 yrs</th>
<th>5-19 yrs</th>
<th>20-64 yrs</th>
<th>65+ yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>16,029</td>
<td>2,471</td>
<td>654</td>
<td>2,314</td>
<td>10,590</td>
</tr>
<tr>
<td>2006-07</td>
<td>7,273</td>
<td>1,814</td>
<td>465</td>
<td>1,447</td>
<td>3,547</td>
</tr>
<tr>
<td>2007-08</td>
<td>21,292</td>
<td>2,267</td>
<td>759</td>
<td>4,269</td>
<td>13,997</td>
</tr>
<tr>
<td>2008-09</td>
<td>11,621</td>
<td>3,386</td>
<td>1,521</td>
<td>2,864</td>
<td>3,850</td>
</tr>
<tr>
<td>2010-11</td>
<td>40,764</td>
<td>5,289</td>
<td>2,925</td>
<td>10,827</td>
<td>21,724</td>
</tr>
<tr>
<td>Five Season Total</td>
<td>96,979</td>
<td>15,227</td>
<td>6,324</td>
<td>21,721</td>
<td>53,708</td>
</tr>
</tbody>
</table>