Cost-Effectiveness of Influenza Vaccines

Considerations for Competing Resources

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Economic Evaluation

• Access the impact of public health programs

• Determine their (cost) effectiveness

• Enables decision making with scarce resources

• Combines economics, operations research, epidemiology, statistics, behavioral sciences, and more.
Economic Costs from Diseases

Direct

Individual (medical care):
- Outpatient care
- Inpatient care
- Healthcare worker protection, maintenance of facilities
- Administration

Community (public health):
- Public health measures
- Regulation and enforcement
- Research
- Education and training
- Administration

Indirect

Individual:
- Productivity losses (illness)
- Care for loved ones
- Burial and loss of future wages (death)

Community:
- Productivity losses from public health measures
- Enforced loss of work

Intangible

Opportunity costs
- Quality of life
- Pain and suffering
- Value of life

Resultant economic costs
- Demand side: travel, trade, goods and services, consumer confidence, investment, unemployment
- Supply side: production, logistics, utilities, employment

Phua and Lee, 2006
Study Designs

• Methods for analysis
  – Cost-benefit
    • “Gold standard”
    • Common metric ($$)
    • Controversial issues
  – Cost-effectiveness
    • Costs assessed by health outcomes
    • Easily understood but needs further deliberation on effectiveness
    • Common outcome needed
  – Cost-utility
    • Compare across outcomes through common metric
    • Quality Associated Life Years (QALY)
    • Subjective and population based
Cost-Effectiveness of Vaccines

- Efficacy of vaccines is not the only consideration

- Cost-effectiveness evaluation is important due to competing resources
  - Global supply is currently limited
  - National resources are limited
  - Maximize use of scarce resources

- Supply-induced demand
  - Vaccination uptake is often dependent on national policies including subsidies
Cost-Effectiveness of Vaccines

• Cost-effectiveness depends on several major factors among others IN THE LOCAL CONTEXT
  
  – Impact of the disease
    • Spread and Clinical Severity
    • Changes for every epidemic
  
  – Efficacy / effectiveness of the vaccine
    • To the actual circulating strain
  
  – Cost of the vaccine
    • Cost to society
    • Cost to the individual
  
  – Immediate use versus stockpiling
    • Likelihood of pandemic and availability
Table 2. Costs and outcomes for with changes in vaccine efficacy and strain mismatch (shown for vaccination within first stockpile)*†.

<table>
<thead>
<tr>
<th>Cost benefit (millions USD$)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0.0</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
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<tr>
<td>Vaccine Efficacy</td>
<td>0.0</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
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<tr>
<td>0.2</td>
<td>103 (66, 128)</td>
<td>116 (87, 138)</td>
<td>126 (105, 142)</td>
<td>139 (124, 150)</td>
<td>151 (144, 157)</td>
</tr>
<tr>
<td>0.4</td>
<td>39 (−35, 90)</td>
<td>65 (9, 109)</td>
<td>86 (44, 118)</td>
<td>111 (81, 134)</td>
<td>135 (121, 147)</td>
</tr>
<tr>
<td>0.6</td>
<td>−24 (−136, 52)</td>
<td>14 (−70, 80)</td>
<td>46 (−17, 93)</td>
<td>83 (38, 118)</td>
<td>119 (98, 137)</td>
</tr>
<tr>
<td>0.8</td>
<td>−88 (−237, 14)</td>
<td>−37 (−149, 51)</td>
<td>5 (−78, 69)</td>
<td>56 (−4, 102)</td>
<td>104 (75, 127)</td>
</tr>
<tr>
<td>1.0</td>
<td>−152 (−338, −24)</td>
<td>−88 (−228, 22)</td>
<td>−35 (−139, 45)</td>
<td>28 (−47, 86)</td>
<td>88 (52, 117)</td>
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<tr>
<td>Lives saved</td>
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<td>0.6</td>
<td>0.8</td>
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<tr>
<td>0.2</td>
<td>82 (41, 138)</td>
<td>64 (32, 108)</td>
<td>50 (25, 85)</td>
<td>33 (17, 54)</td>
<td>16 (8, 26)</td>
</tr>
<tr>
<td>0.4</td>
<td>165 (82, 277)</td>
<td>129 (63, 215)</td>
<td>101 (51, 171)</td>
<td>65 (33, 109)</td>
<td>32 (17, 53)</td>
</tr>
<tr>
<td>0.6</td>
<td>247 (123, 415)</td>
<td>193 (95, 323)</td>
<td>151 (76, 256)</td>
<td>98 (50, 163)</td>
<td>48 (25, 79)</td>
</tr>
<tr>
<td>0.8</td>
<td>330 (165, 553)</td>
<td>258 (127, 431)</td>
<td>201 (102, 341)</td>
<td>130 (66, 218)</td>
<td>65 (33, 105)</td>
</tr>
<tr>
<td>1.0</td>
<td>412 (206, 692)</td>
<td>322 (158, 539)</td>
<td>252 (127, 426)</td>
<td>163 (83, 272)</td>
<td>81 (42, 132)</td>
</tr>
<tr>
<td>Cost per life saved (millions, USD$)</td>
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<td></td>
<td>0.0</td>
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<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>0.2</td>
<td>1.78 (0.86, 3.19)</td>
<td>2.42 (1.16, 4.37)</td>
<td>3.24 (1.62, 5.81)</td>
<td>5.23 (2.72, 9.05)</td>
<td>10.94 (5.85, 18.72)</td>
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<tr>
<td>0.4</td>
<td>0.63 (0.17, 1.23)</td>
<td>0.94 (0.37, 1.81)</td>
<td>1.34 (0.60, 2.45)</td>
<td>2.31 (1.15, 4.09)</td>
<td>5.10 (2.69, 8.80)</td>
</tr>
<tr>
<td>0.6</td>
<td>0.24 (−0.12, 0.64)</td>
<td>0.44 (0.04, 1.00)</td>
<td>0.71 (0.23, 1.41)</td>
<td>1.34 (0.60, 2.50)</td>
<td>3.15 (1.60, 5.52)</td>
</tr>
<tr>
<td>0.8</td>
<td>0.05 (−0.29, 0.36)</td>
<td>0.2 (−0.18, 0.61)</td>
<td>0.39 (0.01, 0.88)</td>
<td>0.85 (0.32, 1.71)</td>
<td>2.18 (1.08, 3.87)</td>
</tr>
<tr>
<td>1.0</td>
<td>−0.06 (−0.41, 0.21)</td>
<td>0.05 (−0.32, 0.39)</td>
<td>0.20 (−0.14, 0.58)</td>
<td>0.56 (0.12, 1.22)</td>
<td>1.59 (0.75, 2.85)</td>
</tr>
</tbody>
</table>

*Mean values are shown with 5th and 95th percentiles.
†All healthcare costs are in 2007 Singapore dollars.
doi:10.1371/journal.pone.0007108.t002
<table>
<thead>
<tr>
<th>Attack rate</th>
<th>Impending pandemic</th>
<th>Vaccine effectiveness</th>
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<tbody>
<tr>
<td></td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>0.1</td>
<td>6.02 (4.13, 8.33)</td>
<td>11.8 (8.03, 16.2)</td>
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<tr>
<td>0.3</td>
<td>18.1 (12.4, 25.0)</td>
<td>35.5 (24.1, 48.5)</td>
</tr>
<tr>
<td>0.5</td>
<td>30.1 (20.7, 41.7)</td>
<td>59.2 (40.2, 80.9)</td>
</tr>
</tbody>
</table>

*† Annual insurance premium for pandemic scenarios with changes in vaccine effectiveness and attack rate.*
Cost-Effectiveness of Vaccines

• Stockpiling of pandemic vaccines
  – Certainty about influenza pandemics
    (death, taxes, influenza)
  – Insurance against a future pandemic
  – Guarantee adequate supplies during pandemic
  – Stimulate research and development
Lee et al., 2009
Table 4. Mean annual insurance premium for pandemic scenarios with changes in vaccine effectiveness, by age and risk groups*†.

<table>
<thead>
<tr>
<th>Impending pandemic</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccine effectiveness</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Low risk - children</td>
<td>9.43</td>
<td>18.9</td>
<td>28.3</td>
<td>37.7</td>
</tr>
<tr>
<td>Low risk - adult</td>
<td>12.8</td>
<td>25.6</td>
<td>38.4</td>
<td>51.2</td>
</tr>
<tr>
<td>Low risk - elderly</td>
<td>14.8</td>
<td>29.6</td>
<td>44.4</td>
<td>59.2</td>
</tr>
<tr>
<td>High risk - children</td>
<td>67.4</td>
<td>134.7</td>
<td>202.1</td>
<td>269.5</td>
</tr>
<tr>
<td>High risk - adult</td>
<td>57.3</td>
<td>114.6</td>
<td>172</td>
<td>229.3</td>
</tr>
<tr>
<td>High risk - elderly</td>
<td>45.7</td>
<td>90.9</td>
<td>136.4</td>
<td>181.8</td>
</tr>
<tr>
<td>Probability of pandemic occurring spread over 10 years</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaccine effectiveness</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Low risk - children</td>
<td>0.94</td>
<td>1.89</td>
<td>2.83</td>
<td>3.77</td>
</tr>
<tr>
<td>Low risk - adult</td>
<td>1.28</td>
<td>2.56</td>
<td>3.84</td>
<td>5.12</td>
</tr>
<tr>
<td>Low risk - elderly</td>
<td>1.48</td>
<td>2.96</td>
<td>4.44</td>
<td>5.92</td>
</tr>
<tr>
<td>High risk - children</td>
<td>6.74</td>
<td>13.47</td>
<td>20.21</td>
<td>26.95</td>
</tr>
<tr>
<td>High risk - adult</td>
<td>5.73</td>
<td>11.46</td>
<td>17.19</td>
<td>22.93</td>
</tr>
<tr>
<td>High risk - elderly</td>
<td>4.55</td>
<td>9.09</td>
<td>13.64</td>
<td>18.18</td>
</tr>
</tbody>
</table>
Seasonal Influenza Vaccines

- Ontario, Canada universal influenza program was found to be cost-effective (Sander et al, 2000)

- Elderly
  - Multiple studies in the USA, Canada, UK, France, Germany, The Netherlands, New Zealand, and Taiwan using CBA, CEA, CUA
    - Cost-effective and often cost saving (Nichols et al, 2003)
  
  - Cost per life year gained in FRA, GER, NED about 1149 to 6900 euros (Schuffham et al, 2002; Postma et al, 1999)

  - One vaccination campaign in Taiwan (Wang et al, 2002) found that vaccination reduced hospitalization and mortality, and that savings were 3 times the cost of vaccination

  - One Hong Kong study found no cost benefit – 3.78 times cost compared to savings (Fitzner et al, 2001)
Seasonal Influenza Vaccines

• Healthy Adults
  • Most studies in the USA, Canada, UK, France, and Brazil have also found that vaccination would be cost-effective and often cost saving

• Several studies showing no cost savings
  – Hong Kong (Fitzner et al, 2001)
  – USA in a manufacturing company found no cost savings in both good or bad vaccine matching years (Bridges et al 2000)
  – Finland due to high vaccine delivery costs (Kumpuleinen et al, 1997)
  – UK military (Demicheli et al, 1999)
Seasonal Influenza Vaccines

• Children
  – Studies in the USA and Argentina found vaccines to be cost-effective and often cost saving
  – Same study from Hong Kong found not cost saving
  – One study in the US found that vaccinating children earlier in the season in October and offering it until December saved costs and QALYs (Lee et al, 2010)
  – Luce et al (2008) found that in the US, LAIV had more cost savings compared to TIV due to the increased reduction of burden of disease
Pandemic Vaccination

• Pandemic prioritization – Miller et al (2008) proposed that depending on the pandemic scenario, vaccination policies should be adjusted in real-time (eg. 1918 for younger adults, and elderly for 1957/68)

• US study for the 2009 pandemic – early pandemic vaccination would be cost-saving if vaccines were available in a timely manner. Complete coverage is not necessary (Khazeni et al, 2009)

• Real-time study in the UK found that early availability and administration during the 2009 pandemic will reduce morbidity and mortality
  – Most cost-effective among high-risk individuals and children. Less pronounced in low-risk individuals (Baguelin et al, 2010)

• A study in Canada found that mass vaccination during the 2009 pandemic was cost-effective (Sander et al, 2010)
High Risk Group

• Pregnant women
  – Bregi et al (2010) found that vaccination is cost-effective in the USA for epidemics and pandemics if flu prevalence is ≥7.5% and influenza-attributable mortality is ≥1.05%
Future Studies

• More studies in other less-developed country settings
  – Lower resourced countries
  – Urban versus rural regions

• More transmission dynamics models backed by epidemiological field studies to determine the actual quantity of vaccines required
  – Important to determine availability and stockpiling
Thank You