The Demographic Impact of an Avian Flu Pandemic

Emile Stipp

13 May 2007
Overview

• Based on paper authored also by Dr Glenn Staples, Cassie Hamman and Jaco van der Merwe
• Influenza overview
• Avian Influenza
  – History
  – Current status
  – Clinical aspects: mortality, treatment, vaccination
• Modelling method
• Results:
  – Severe & mild scenarios
  – Impact of limited hospital beds
• Conclusion
Influenza

- Viral infection
- Orthomyxovirus
- Infects upper resp tract
- Mutates readily
  - Seasonal epidemics
  - Pandemics
- Antibiotics useless
Clinical (influenza)

- Respiratory droplet and contact spread
- Incubation: 18-72 hrs
- Highly infectious
- Typical symptoms
  - Fever; sore throat; muscle pain; nasal congestion
- Increased mortality:
  - Elderly
  - Very young
  - Other medical conditions
  - No clear evidence of worse effects in HIV + patients
Pandemic Influenza

- Every 20-50 yrs
- Due to antigenic shift
  - Co-infection with human and animal virus
  - No human immunity to new virus
- Always Type A virus
- 3 Pandemics in 20th Century:
  - 1918 (Spanish) 40-50 million deaths
  - 1957 2 million deaths
  - 1968 (Hong Kong) 1 million deaths
Avian Influenza

- Endemic in wild birds and poultry
- First human infection with H5N1 in 1998
- Escalating human infections since 2003
- Severe disease
  - >50 % mortality
Human cases

Avian Influenza A(H5N1)
as of 03 October 2006

- Azerbaijan = 8 (2006)
- Cambodia = 6 (2006=2; 2005=4)
- China = 21 (2006=12; 2005=8; 2003=1)
- Djibouti = 1 (2006)
- Egypt = 14 (2006)
- Indonesia = 69 (2006=50; 2005=19)
- Iraq = 2 (2006)
- Thailand = 24 (2006=2; 2005=5; 2004=17)
- Turkey = 12 (2006)
- Viet Nam = 93 (2005=61; 2004=28; 2003=3)

Disclaimer: The presentation of material on the maps contained herein does not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or areas or its authorities of its frontiers or boundaries.
## Human cases

<table>
<thead>
<tr>
<th>Country</th>
<th>2003 cases</th>
<th>2003 deaths</th>
<th>2004 cases</th>
<th>2004 deaths</th>
<th>2005 cases</th>
<th>2005 deaths</th>
<th>2006 cases</th>
<th>2006 deaths</th>
<th>Total cases</th>
<th>Total deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azerbaijan</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>5</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Cambodia</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>China</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>5</td>
<td>12</td>
<td>8</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>Djibouti</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Egypt</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>6</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>12</td>
<td>50</td>
<td>40</td>
<td>69</td>
<td>52</td>
</tr>
<tr>
<td>Iraq</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Thailand</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td>Turkey</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>4</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>3</td>
<td>3</td>
<td>29</td>
<td>20</td>
<td>61</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>93</td>
<td>42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4</strong></td>
<td><strong>4</strong></td>
<td><strong>46</strong></td>
<td><strong>32</strong></td>
<td><strong>97</strong></td>
<td><strong>42</strong></td>
<td><strong>105</strong></td>
<td><strong>70</strong></td>
<td><strong>252</strong></td>
<td><strong>148</strong></td>
</tr>
</tbody>
</table>
Treatment

- Anti-virals (Tamiflu & Relenza)
  - Reduce severity & duration
  - Prophylaxis
- Vaccination
  - Only effective means of control
  - Requires mutated virus for production
  - 3 month development time
  - Limited global production capacity
  - Herd immunity (>30%)
Modelling method

- Multi-state model
  - Needed to explicitly model the impact of limited resources
- States modelled:
  - Remain in a healthy state
  - Move into a symptomatic state, i.e. have flu symptoms but decide not to seek medical advice (self-treatment).
  - Flu symptoms may be more serious and therefore the individual visits a doctor and/or obtains medicine.
  - The individual requires hospitalisation
  - The individual shows severe influenza symptoms requires treatment in an ICU facility
  - The individual dies
Modelling method

• 3 modifications to transition matrix
  – Remove time-homogeneity: allow for herd immunity
    • Herd immunity threshold reached at 30% of population
  – Allow for demographic factors
  – Allow for limited hospital beds
Modelling method

• Most severe shortages will be:
  – ICU facilities
  – Nurses
• We did not allow for temporary facilities, as we doubt whether qualified staff would be available
• Allowed for HIV / AIDS, although not clear at all that mortality / infection would be higher
• Calibrated to fit experience of previous pandemics…

<table>
<thead>
<tr>
<th>Date</th>
<th>World population</th>
<th>per 100 000 people</th>
<th>Mortality rate</th>
<th>Actual estimated death toll</th>
<th>Comparative death toll for current world population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918</td>
<td>1.8 billion</td>
<td>3 500</td>
<td>3.50%</td>
<td>50-100 million</td>
<td>±225 million</td>
</tr>
<tr>
<td>1957</td>
<td>2.9 billion</td>
<td>50</td>
<td>0.05%</td>
<td>1-4 million</td>
<td>±3.5 million</td>
</tr>
<tr>
<td>1968</td>
<td>3.6 billion</td>
<td>25</td>
<td>0.025%</td>
<td>1-2 million</td>
<td>±1.5 million</td>
</tr>
</tbody>
</table>
Results: severe pandemic: no hosp limit

Cumulative number of infections

Total number of infections

Healthy recoveries  Flu (symptomatic)  Flu (Out-of-hospital)  Flu (In-hospital)  Flu (ICU)  Flu deaths

Week
Results: severe pandemic: with hosp limit

Comparison of number of cumulative flu deaths (base scenario vs alternative)

Week

Incremental flu deaths

Base scenario (no limit on hospital beds)  Alternative scenario (hospital beds limit)
Results: mild pandemic: with hosp limit

Cumulative number of infections

Healthy recoveries  Flu (symptomatic)  Flu (Out-of-hospital)  Flu (In-hospital)  Flu (ICU)  Flu deaths
Results: severe pandemic: w-shape mort

Comparison of number of cumulative flu deaths (base scenario vs alternative vs worst case)

- Base scenario (no limit on hospital beds)
- Alternative scenario (hospital beds limit)
- Worst case scenario (W-shape mortality)
Results: severe epidemic (W): hospital beds

Devastating scenario - Hospital bed occupancy

Occupancy rate

Week into pandemic

Eastern Cape
Free State
Gauteng
KwaZulu-Natal
Limpopo
Mpumalanga
North West
Northern Cape
Western Cape
Results: mild pandemic: hospital beds

Mild scenario - Hospital bed occupancy

Occupancy rate

- Eastern Cape
- Free State
- Gauteng
- KwaZulu-Natal
- Limpopo
- Mpumalanga
- North West
- Northern Cape
- Western Cape

Week into pandemic
Results: mortality rate comparison

Mortality rate comparison

- Before pandemic
- Base scenario (No hosp bed limit)
- Alternative scenario (Hosp bed limit)
- Mild pandemic scenario
- Worst case scenario (W-shape mortality)

Age category:
- 0-14
- 15-49
- 50-64
- 65+

Mortality rate:
## Results: sensitivity analysis

### Ignoring the effect of AIDS and with 25% herd immunity

<table>
<thead>
<tr>
<th>Pandemic scenario</th>
<th>Cumulative infection rate</th>
<th>Overall crude mortality</th>
<th>Number of flu deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe pandemic (No limit on hospital beds)</td>
<td>20.1%</td>
<td>1.008%</td>
<td>477 801</td>
</tr>
<tr>
<td>Severe pandemic (Limit on hospital beds)</td>
<td>20.1%</td>
<td>1.537%</td>
<td>728 507</td>
</tr>
<tr>
<td>Mild pandemic (Limit on hospital beds)</td>
<td>9.0%</td>
<td>0.117%</td>
<td>55 240</td>
</tr>
<tr>
<td>Worst case scenario (W-shape mortality)</td>
<td>21.8%</td>
<td>1.783%</td>
<td>844 815</td>
</tr>
</tbody>
</table>

### Allowing for the effect of AIDS and with 30% herd immunity

<table>
<thead>
<tr>
<th>Pandemic scenario</th>
<th>Cumulative infection rate</th>
<th>Overall crude mortality</th>
<th>Number of flu deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe pandemic (No limit on hospital beds)</td>
<td>20.3%</td>
<td>1.545%</td>
<td>732 077</td>
</tr>
<tr>
<td>Severe pandemic (Limit on hospital beds)</td>
<td>20.3%</td>
<td>2.066%</td>
<td>979 048</td>
</tr>
<tr>
<td>Mild pandemic (Limit on hospital beds)</td>
<td>9.1%</td>
<td>0.128%</td>
<td>60 713</td>
</tr>
<tr>
<td>Worst case scenario (W-shape mortality)</td>
<td>22.0%</td>
<td>2.491%</td>
<td>1 180 519</td>
</tr>
</tbody>
</table>
Conclusion

• Supply of health services will have significant impact on mortality: even in mild scenario, all available hospital beds occupied by week 4, but available again by week 7
• Hence timeous response could avert many deaths
• Should assume that vaccinations would not be available in South Africa until the second wave
• Depending on type of epidemic, impact varies
• Severe pandemic will have far-reaching demographic and economic consequences