A Public Policy Tool for Predicting the Epidemiological Dynamics of Drug-Resistant HIV

David Gerberry and Sally Blower
Semel Institute of Neuroscience and Human Behavior
David Geffen School of Medicine
University of California, Los Angeles

9th European Workshop on HIV and Hepatitis: Treatment Strategies and Antiviral Drug Resistance
23 March 2011

Presented at the 9th Eu. Workshop on HIV & Hepatitis – 25 – 27 March 2011, Paphos, Cyprus
- Modeled dynamics for MSM community of San Francisco, USA
- Resistance classes for each class of ARV

Our Objective

To model the epidemiological dynamics of drug-resistant HIV in order to:

1. Further inform current levels of drug-resistant HIV (specifically TDR),
2. Predict future levels of drug resistance in a variety of possible scenarios,
3. Illustrate the effect that different factors have on the emergence of drug resistance.

Provide a robust tool that can be easily applied to a variety of settings and can be used without modeling expertise.
Model Simplifications, Adjustments and Solution

\[ p(t) = \text{Proportion of those with CD4 < 350 on ART at time t} \]
\[ q(t) = \text{Proportion of DR individuals on ART at time t} \]

Solutions:

\[ E(t) = \nu H(0) \int_0^t \xi(t-t) d\tau + \frac{E(0)}{\xi(t)}, \quad R(t) = \int_0^t \gamma kp(\tau) E(\tau) e^{\left(1-\frac{\tau}{T_G}\right)(\tau-t)} d\tau \]
Model: implemented in MS Excel

<table>
<thead>
<tr>
<th>MODEL INPUTS:</th>
<th>1st line</th>
<th>2nd line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting: Botswana</td>
<td>Initial 0%</td>
<td>80%</td>
</tr>
<tr>
<td>HIV Prevalence: 25.0%</td>
<td>Year 1 17%</td>
<td>80%</td>
</tr>
<tr>
<td>Population: 1,080,000</td>
<td>Year 2 29%</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>Year 3 45%</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>Year 4 56%</td>
<td>90%</td>
</tr>
<tr>
<td>Year of ART Initiation: 2003</td>
<td>Year 5 61%</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Year 6 72%</td>
<td>90%</td>
</tr>
<tr>
<td>Relative transmissibility of DR strains: 80%</td>
<td>Year 7 83%</td>
<td>90%</td>
</tr>
<tr>
<td>% of 1st-line ART patients with virological failure (per year): 25%</td>
<td>Year 8 #N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>% of 2nd-line ART patients with virological failure (per year): 35%</td>
<td>Year 9 #N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>% of those with virological failure that develop resistance (per year): 85%</td>
<td>Year 10 #N/A</td>
<td>#N/A</td>
</tr>
</tbody>
</table>

---

*Presented at the 9th Eu. Workshop on HIV & Hepatitis – 25 – 27 March 2011, Paphos, Cyprus*
Illustrating the Influence of Particular Factors on Drug Resistance: Zambia

Varying annual 1st line ART virological failure rate 15% to 25% to 35%.

Varying 2nd line ART coverage from 50% to 75% to 100%.
• “Test and Treat” (a.k.a “ART as Prevention”) Strategy
  – Costing analysis assumed 3% of those on ART, at any time, will be drug-resistant

  – Even under optimistic assumptions, prevalence of drug resistance in South Africa is already higher than 3%.
Conclusions

• A tool for simulating the epidemiology of drug-resistant HIV

• Poster Session
  – A few more details on the math
  – Comparisons with recently reported TDR data
  – The model itself