Epidemiology and economics: 
*modelling the scenarios for the end of AIDS*

Controlling the HIV Epidemic with Antiretrovirals: 
from consensus to implementations 
London, England 
September 22, 2013

Reuben Granich, MD, MPH 
Senior Advisor, Care and Treatment 
UNAIDS
Outline

- HIV modelling and policy (twins separated at birth?)
- HIV modelling and financing the response
- Strategy
  OODA loop and the dreaded retrospectoscope
- Conclusion
Predicting the future is easier than we think

Discussing modelling, economics and the end of AIDS in 15 minutes is more of a challenge
Climate change modelling has provided us with options
Epidemiological parameters of HIV transmission

Roy M. Anderson* & Robert M. May†

*Parasite Epidemiology Research Group, Department of Pure and Applied Biology, Imperial College, London University, London SW7 2BB, UK
†Biology Department, Princeton University, Princeton, New Jersey 08540, USA

Epidemiological data on the main determinants of the transmission process are accumulating, but many uncertainties remain.
A Tale of Two Futures: HIV and Antiretroviral Therapy in San Francisco

S. M. Blower, H. B. Gershengorn, R. M. Grant

The effect of antiretroviral therapy (ART) in preventing human immunodeficiency virus (HIV) infections and averting acquired immunodeficiency syndrome (AIDS) deaths in the San Francisco gay community over the next 10 years was predicted. A transmission model was coupled with a statistical approach that enabled inclusion of a high degree of uncertainty in the potential treatment effects of ART (in terms of infectivity and survival), increase in risk and rate of emergence of drug resistance. Increasing the usage of ART in San Francisco would decrease the AIDS death rate and could substantially decrease the incidence rate.
Can Highly Active Antiretroviral Therapy Reduce the Spread of HIV?

A Study in a Township of South Africa

Bertran Auvert, MD, PhD,SY Sylvia Males,† Adrian Puren, MD, PhD,† Dirk Taljaard,† Michel Caroër, PhD,‡ and Brian Williams, PhD**

### TABLE 2. Estimates of the Potential Impact of HAART on the Annual Risk of HIV-1 Transmission

<table>
<thead>
<tr>
<th>Plasma HIV-1 RNA load (copies/mL)</th>
<th>&lt;399</th>
<th>400–3499</th>
<th>3500–9999</th>
<th>10,000–49,999</th>
<th>&gt;49,999</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual risk of HIV-1 transmission (person/y)</td>
<td>0</td>
<td>0.04</td>
<td>0.12</td>
<td>0.14</td>
<td>0.23</td>
<td>NA</td>
</tr>
<tr>
<td>Percentage of HIV-1–positive population (%)</td>
<td>3.1 (1.1–6.5)</td>
<td>8.2 (4.7–12.9)</td>
<td>12.2 (8.0–17.7)</td>
<td>25.5 (19.6–32.2)</td>
<td>51.1 (43.8–58.2)</td>
<td>100</td>
</tr>
<tr>
<td>Weighted annual risk of HIV-1 transmission without HAART (person/y)</td>
<td>0 (0.00188–0.00516)</td>
<td>0.0147 (0.00960–0.0212)</td>
<td>0.0357 (0.0274–0.0451)</td>
<td>0.118 (0.101–0.134)</td>
<td>0.171 (0.1591–0.183)</td>
<td></td>
</tr>
<tr>
<td>Percentage of HIV-1–positive population with CD4⁺ counts &gt;200 cells/mm³</td>
<td>3.1 (1.1–6.5)</td>
<td>8.2 (4.7–12.9)</td>
<td>12.2 (8.0–17.7)</td>
<td>23.5 (17.5–30.0)</td>
<td>43.4 (36.3–50.6)</td>
<td>90.3 (85.3–94.1)</td>
</tr>
<tr>
<td>Weighted annual risk of HIV-1 transmission with HAART (person/year)</td>
<td>0 (0.00188–0.00516)</td>
<td>0.0147 (0.00960–0.0212)</td>
<td>0.0329 (0.0245–0.0420)</td>
<td>0.0997 (0.0835–0.116)</td>
<td>0.151 (0.136–0.165)</td>
<td></td>
</tr>
</tbody>
</table>

The table gives estimates of the annual risk of HIV-1 transmission as a function of plasma HIV-1 RNA load, the proportion of the present population falling into each plasma HIV-1 RNA load band, the weighted annual risk of HIV-1 transmission, the proportion of the population that will not receive HAART under present guidelines, and the weighted annual risk of HIV-1 transmission with the provision of HAART. The decrease in the annual risk of HIV-1 transmission from 0.171/person/y without HAART to 0.151/person/y with HAART corresponds to a reduction of 11.9% (7.1%–17.0%).

NA, not applicable.
Montaner Lancet 2006

Extent to which low-level use of antiretroviral treatment could curb the AIDS epidemic in sub-Saharan Africa

Evan Wood, Paula Braitstein, Julio S G Montaner, Martin T Schechter, Mark W Tyndall, Michael V O'Shaughnessy, Robert S Hogg

Montaner Lancet 2006

The case for expanding access to highly active antiretroviral therapy to curb the growth of the HIV epidemic

Julio S G Montaner, Robert Hogg, Evan Wood, Thomas Kerr, Mark Tyndall, Adrian R Levy, P Richard Harrigan

Wood Lancet 2000
Granich, Gilks, Dye, De Cock, Williams *Lancet* 2008
Estimated and projected funding and costs:
We appear to be in the right ball park....

Blue: 17% global funding (UNAIDS)
Brown: 17% projected funding (UNAIDS)
Green: Universal testing + immediate ART
Red: <350 with universal voluntary testing

Annual cost savings

UNAIDS. Financial resources required to achieve universal access to HIV prevention, treatment, care and support.
Figure: AIDS spending requirements in 2015 for selected low-income and middle-income countries.
Circle size is proportional to a country's total projected AIDS spending needs in 2015, calculated on the basis of the rapid scale-up scenario.
Figure 3

EXPANDING ACCESS TO HIV TREATMENT IS A SMART INVESTMENT

Granich, Kahn PlosOne 2010
Towards an improved investment approach for an effective response to HIV/AIDS

Bernhard Schwartlander, John Stover, Timotheo Hallett, Rifat Atun, Carlos Avila, Eleanor Gouws, Michael Bartos, Peter Djeha, Marjorie Opuni, David Bar, Ramzi Abdalaq, Lori Bellinger, Marcelo de Fritos, Geoffrey Garnett, Charles Holmes, Ken Legins, Yogan Pillay, Anderson Eduardo Stanciel, Craig McClure, Gottfried Hirnschall, Maria Lage, Nancy Podder, on behalf of the Investment Framework Study Group

Schwartlander Lancet 2011
2nd generation economics
HIV Treatment as Prevention: Systematic Comparison of Mathematical Models of the Potential Impact of Antiretroviral Therapy on HIV Incidence in South Africa

Jeffrey W. Eaton¹, Leigh F. Johnson², Joshua A. Salomon³, Till Bärnighausen³,⁴, Eran Bendavid⁵, Anna Bershteyn⁶, David E. Bloom³, Valentina Cambiano⁷, Christophe Fraser⁸, Jan A. C. Hontelez⁹,¹⁰, Salai Humal¹¹, Daniel J. Klein⁶, Elsa F. Long¹², Andrew N. Phillips⁷, Carel Pretorius¹³, John Stover¹³, Edward A. Wenger⁶, Brian G. Williams¹⁴, Timothy B. Hallett¹

1 Department of Infectious Diseases Epidemiology, Coller Research Centre, London School of Hygiene & Tropical Medicine, London, United Kingdom. 2 Centre for Infectious Disease Epidemiology and Research, University of the Witwatersrand, Johannesburg, South Africa. 3 Department of Biostatistics, Harvard School of Public Health, Boston, Massachusetts, USA. 4 Department of Mathematics, Imperial College London, London, United Kingdom. 5 Department of Epidemiology, The Hebrew University, Jerusalem, Israel. 6 Department of Evidence Based Policy, RAND, Santa Monica, California, USA. 7 Department of Global Health, University of Washington, Seattle, Washington, USA. 8 Department of Epidemiology, London School of Hygiene & Tropical Medicine, London, United Kingdom. 9 Department of Immunology, University of Washington, Seattle, Washington, USA. 10 Department of Infectious Disease Epidemiology, London School of Hygiene & Tropical Medicine, London, United Kingdom. 11 Department of Public Health, University of the Witwatersrand, Johannesburg, South Africa. 12 Department of Global Health, University of Washington, Seattle, Washington, USA. 13 Department of Global Health, University of California, Los Angeles, California, USA. 14 Department of Economics, University of California, Los Angeles, California, USA.

A

<table>
<thead>
<tr>
<th></th>
<th>Year 2020</th>
<th>Year 2050</th>
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<tbody>
<tr>
<td>BBH</td>
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</table>

% increase in prevalence

- 2006
- 2007
- 2008
- 2009
- 2010
- 2011

% reduction in incidence

- CD4 HIV/ART
- Granich
- Eaton
- STDSIM
- Fraser
- STI–HIV
- Goals
Third generation economics: significantly higher employment at CD4≥500 among adults

- Compared to CD4<200, CD4≥500 associated with
  - 5.8 more days/month
  - 2.2 more hours/day (40% more than ref. mean of 5.5)

Regression model coefficients

<table>
<thead>
<tr>
<th>Outcome</th>
<th>(1) Days worked in the past month</th>
<th>(2) Hours worked on usual day in past</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD4&lt;200 Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>CD4 200-349</td>
<td>2.7</td>
<td>1.8</td>
</tr>
<tr>
<td>CD4 350-499</td>
<td>4.8</td>
<td>0.9</td>
</tr>
<tr>
<td>CD4 ≥500</td>
<td>5.8**</td>
<td>2.2*</td>
</tr>
</tbody>
</table>

Observations 107 107

- Linear regression model with age, age-squared, and sex included as controls
- ** p<0.05, * p<0.10
- Reference group has CD4<200

Those with CD4≥500 worked nearly 1 week/month more than those with CD4<200, and as much as HIV-uninfected adults

Thirumurthy, Health Affairs, 2012
How do we spend the money?
PEPFAR BLUEPRINT: CREATING AN AIDS-FREE GENERATION

HIV Infections Averted by Intervention

Percentage of HIV infections averted by intervention

Uganda Adult HIV Incidence Rate

Number of new adult HIV infections per 100,000 population

PEPFAR Per-Patient ART Cost vs. No. of Direct ART Patients

Rapid Scale Up of Combination Prevention Can Reduce Resource Needs and Support Sustainability (Uganda)
REVIEW OF HIV/AIDS, TUBERCULOSIS AND MALARIA LANDSCAPE
FOR THE GLOBAL FUND STRATEGY 2012-2016

Exhibit 5: HIV/AIDS – Likelihood and impact of new interventions

<table>
<thead>
<tr>
<th>Type</th>
<th>Existing</th>
<th>Anticipated</th>
<th>Timing</th>
<th>Likelihood</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccine</td>
<td>N/A</td>
<td>RV144, HVTN 505</td>
<td>2020+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevention</td>
<td>Condoms, Male Circumcision</td>
<td>Treatment as Prevention (discordant couples)</td>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oral PReP (for MSMs)</td>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male circumcision devices</td>
<td>2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatments</td>
<td>ARV</td>
<td>Treatment, 2.0</td>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnostics</td>
<td>CD4, viral load</td>
<td>Point of care</td>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Couples testing</td>
<td>2011</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When to start policy varies by country

- **≤200 cells/mm³**
  - Malaysia
  - Dominican Republic
  - El Salvador
  - Cape Verde
  - Pakistan
  - Peru

- **≤200 (200-350) cells/mm³**
  - Ivory Coast
  - (200-350) Ukraine
  - (200-350) Russia
  - (200-350) Afghanistan
  - Cuba
  - Cameroon

- **≤350 cells/mm³**
  - Brazil
  - Burundi
  - Chile
  - DRC
  - Ecuador
  - Guatemala
  - Namibia
  - Nigeria
  - Swaziland
  - Thailand
  - Venezuela
  - Zimbabwe

- **Consider at ≤500**
  - Uganda
  - Botswana
  - Cambodia
  - Britain
  - Mozambique
  - Myanmar
  - Nepal
  - South Africa
  - Tanzania
  - Zimbabwe

- **Irrespective of CD4 count**
  - U.S.A
  - Vancouver
  - Bolivia
  - Argentina
  - France
  - Italy

- **≤500 & consider at ≤500**
  - Guinea
  - Uruguay
  - Guinea

- **≤200 (200-350) cells/mm³**
  - Comoros
  - Liberia
  - Bhutan
  - Ethiopia
  - Lao PDR
  - Colombia
  - Philippines

- **≤350**
  - Bangladesh
  - Haiti
  - India
  - Indonesia
  - Kenya
  - Malawi
  - Malaysia
  - Mexico
  - Panama
  - Paraguay
  - Paraguay
  - Viet Nam

- **≤200**
  - El Salvador
  - Guyana
  - Lesotho
  - Russia
  - China
  - Ghana
  - Djibouti
  - Bolivia
  - Brazil
  - Burundi
  - Chile
  - DRC
  - Ecuador
  - Guatemala
  - Namibia
  - Nigeria
  - Swaziland
  - Thailand
  - Venezuela

When to start policy varies by country.
One size does not fit all….

Rapid transitioning to Option B+

Legend
- Green: Actively implementing or phased roll-out underway
- Yellow: MOH endorsed, preparing for roll-out
- Orange: Operational planning, piloting, or costing underway
- Red: Considering B+
- Light red: No immediate plans to implement B+

Source: PEPFAR PMTCT/Pediatrics TWG, Updated February 28, 2013

Option B+: early 2013

Slide courtesy of CDC
Comparison between the current situation and proposed strategy of ART initiation at < 500 CD4 and test-to-treat for MSM and CSW

Over a 5 year period, a 5.2% increase in costs* would result in 12.7% additional deaths averted and a 28.4% decrease in new infections**

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**Deaths averted**

![Deaths averted graph]

- Current strategy
- CD4 500 + test-treat KP
- 6,391 deaths averted

**Number of new infections**

![Number of new infections graph]

- Current strategy
- CD4 500 + test-treat KP
- 7,586 fewer new infections

**Total costs difference between current strategy and proposed best case scenario**

![Total costs difference graph]

- Current strategy
- CD4 500 + test-treat KP
- $12.7M

**Investing an additional 12.7M $ would result in**

- 6,391 deaths averted and
- 7,586 fewer new infections

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* Additional costs may be underestimated as current resources were assumed to be able to absorb the new ART and pre-ART patients. ** EPI impact calculated with Spectrum, with conservative assumptions.
However beautiful the strategy, you should occasionally look at the results

--Winston Churchill
High level political support for TasP (Vancouver 2013)

Transition from “does it work” to “how do we expand”
The OODA Loop: speed matters…and we are very slow
HIV in South Africa: test and treat starting in 1995

Williams 2010
Conclusion

• Models are very useful but are not sufficient to change policy—science, politics, and finance and leadership are essential
• Better data, better clarity when framing questions
• Better feedback loops—OODA loop is weak and slow
• Improve and accelerate policy making AND implementation to end AIDS
Public health is purchasable. Within a few natural and important limitations any community can determine its own health.

--Hermann M. Biggs

(29 Sep 1859 - 28 Jun 1923)
New York City's Public Health Officer and public health pioneer
Thank You

- Brian Williams
- Julio Montaner
- Badara Samb
- Brad Hersh
- Debbi Birx
- Somya Gupta
- Amitabh Suthar
- Swarup Sarkar
- Mona Sfeir

Views expressed in this presentation are those of the author and do not necessarily represent the views of the Joint United Nations Programme on HIV/AIDS (UNAIDS).
Periodic testing & immediate ART significantly reduces new HIV infections and AIDS deaths in the context of Vietnam’s HIV epidemic

- Annual new HIV infection
- Annual AIDS death
- ART and HTC cost

Periodic testing and immediate treatment (PTIT)

Kato M et al. JID 2013
ART coverage at <350 varies and is related to policy
Considering earlier treatment? Rwanda is not alone

- Zanzibar earlier testing and treatment for PWID and SWs?
- Cote d’Ivoire treating all SWs in selected clinics?
- Kenya MSM test and treat research study? Earlier treatment for other key populations? Test and treat in parts of Nyanza?
- South Africa considering move to <500?
- Thailand testing and treatment for MSM?
- Cambodia targeting elimination (3/100,000 incidence) with emphasis on treatment for sex workers
- Viet Nam considering offering immediate treatment for drug users and sex workers in selected provinces
- Brazil considering national or sub-national level test and treat