The Economics of AIDS

ECON 40565
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HIV/AIDS Basics

• Crucial immune cells CD4+ T cells or “T-helper cells” are reduced by HIV
  – Healthy person usually has 800-1200 CD4+ T cells per cubic millimeter of blood
  – During HIV infection, the number of CD4+ T cells gradually declines

Definition of AIDS

• T-cell count falls below 200/mm3 or

• AIDS-defining illness
  – opportunistic infection
  – AIDS-related cancer
  – severe wasting
  – Dementia, etc.
Global estimates for adults and children, 2005

- People living with HIV 38.6 million (33.4 – 46.0 million)
- New HIV infections in 2005 4.1 million (3.4 – 6.2 million)
- Deaths due to AIDS in 2005 2.8 million (2.4 – 3.3 million)
HIV Prevalence Rates
Adults 15-49

- Burkina Faso 1.8%
- Cameroon 5.5%
- Cote d'Ivoire 4.7%
- Ethiopia 1.4%
- Ghana 2.2%
- Lesotho* 23.5%
- Malawi* 11.8%
- Rwanda 3.0%

- Uganda 6.4%
- Zambia* 15.6%
- Zimbabwe* 18.1%

* Southern Africa

Economic research questions

- Why is AIDS so much more prevalent in Africa than other parts of the world?
- What has the drop in life expectancy done to human capital accumulation?
- Impact of AIDS on economic growth?
- What has happened to AIDS orphans?
- Given the rise in effective treatments for AIDS, do people take more risks?
- How AIDS has changed bargaining power within the household in Africa?
- How AIDS has transformed the sex trade?
- ‘Magic Johnson’ effect on behavior.
- Why is AIDS more prevalent in the Black community? Prisons?
- Productivity/profitability of African employers providing ARVs to workers
Behavioral response

- Can think of HIV and other STDs as a “price” of unsafe sex
- Demand for unsafe sex should change as the price is altered
- Could also shift the demand by the introduction of ARVs, etc.
- 1st — some data — there is a behavioral response
- Next — build a model that has this as a prediction
### US High School Students

<table>
<thead>
<tr>
<th></th>
<th>1991</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever had sex</td>
<td>54.1%</td>
<td>46.8%</td>
</tr>
<tr>
<td>4+ partners in lifetime</td>
<td>18.7%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Use condom last time</td>
<td>46.2%</td>
<td>62.8%</td>
</tr>
<tr>
<td>Had sex in past 3 months</td>
<td>37.4%</td>
<td>33.9%</td>
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</tbody>
</table>

### Figure 13a and b: Behavior change in Uganda from 1989 to 1995

#### Figure 13a
- Percent of women 18-24 years who had first sex before age 16, by DHS survey period

#### Figure 13b
- Youth Aged 15-19 Reporting Virginity
- Adults Reporting Multiple Partners in Last
- Ever Used Condom (Women Only)
Reversal of trends

- UK: 1998 and 2003, % MSM reporting high-risk sexual behavior with casual partner increased 6.7% to 16.1%
  - Always use condom: 70 to 61%
  - Multiple partners and unprotected sex:
    - 23.6% to 33.3%

Risk taking and HIV

- Let $\sigma$ be risk taking in sexual practices
- $U(\sigma)$ and $U'>0$
- The ‘price’ of risky sexual activity is infection ($h$)
- The greater the infection rate, the less demand for risk taking
- Demand for $\sigma$ is downward sloping in $h$
Formal Model

- 2 periods
- In each period, derive utility from income ($Y_i$) and # sexual partners ($\sigma_i$)
- $U_i = U(Y_i, \sigma_i)$
- $U_y > 0$ and $U_{\sigma} > 0$
- $U_{yy} < 0$ and $U_{\sigma\sigma} < 0$
- Table assumption about $U_{y\sigma}$ for now

There is a probability one will die before period 2, $p$ is the exogenous probability of survival in the absence of AIDS

- Lifetime utility
  - $U = U(Y_1, \sigma_1) + p \cdot U(Y_2, \sigma_2)$
  - $Y$ is exogenously determined – at $Y$ for both periods
- Now AIDS is introduced into the population
  - If contract AIDS in the 1st period you die so

Probability of contracting aids is function of
- Prevalence rate $h$
- # sexual partners $\sigma$
- Transmission rate $\beta$

- Probability you contract AIDS in period 1 is then $\sigma_1 h \beta$
- Probability you survive AIDS is then
  - $1 - \sigma_1 h \beta$
• Probability you survive into second period is \((1 - \sigma_1 h \beta)p\)

• Lifetime utility

\[ U_l = U(Y, \sigma_1) + p(1 - \sigma_1 h \beta)U(Y, \sigma_2) \]

• What are choice variables:
  – # sexual partners in each period
  – Everything else is fixed

• But, choice of \(\sigma_2\) cannot occur if and when you make it to period 2

• How to maximize utility: utility is maximized when derivative equals 0

• Research question: what happens to risk-taking behavior when outside factors change

• Differentiate FOC with respect to change in exogenous factors

• What is \(d\sigma_1/dh???)
• \( U_\sigma(Y, \sigma_1) - p\beta hU(Y, \sigma_2) = 0 \)
• \( U_\sigma(Y, \sigma_1)(d\sigma_1/dh) - p\beta U(Y, \sigma_2) = 0 \)
• \( d\sigma_1/dh = p\beta U(Y, \sigma_2)/U_\sigma(Y, \sigma_1) < 0 \)
• Numerator is >0
• Denominator is < 0 [\( U_\sigma<0 \)]

As HIV prevalence rates increases, risky behavior declines

• As HIV prevalence rates increases, risky behavior declines

What happens if your life expectancy increases?
• \( U_\sigma(Y, \sigma_1) - p\beta hU(Y, \sigma_2) = 0 \)
• Differentiate with respect to \( p \) (use chain rule)
• \( U_\sigma(Y, \sigma_1)d\sigma_1/dp - \beta hU(Y, \sigma_2) = 0 \)
• \( d\sigma_1/dp = \beta hU(Y, \sigma_2)/U_\sigma(Y, \sigma_1) < 0 \)

What about change in \( \beta \)?
• \( U_\sigma(Y, \sigma_1) - p\beta hU(Y, \sigma_2) \)
• \( U_\sigma(Y, \sigma_1)d\sigma_1/d\beta - phU(Y, \sigma_2) = 0 \)
• \( d\sigma_1/d\beta = phU(Y, \sigma_2)/U_\sigma(Y, \sigma_1) < 0 \)
• Increase in the transmission rate will decrease risky sexual activity
How does risk taking vary with $p$?

- $d[d\sigma_1/dh]/dp = ???$
- $d[d\sigma_1/dh]/dp = \beta U(Y, \sigma_2)/ U_{\sigma\sigma} (Y_1, \sigma_1) < 0$

Why are these results important?

- $d\sigma_1/dh$ – demand for risky sex downward sloping in HIV incidence
- However, holding $h$ constant, we expect shifts in the demand based on changes in external conditions
- Consider an introduction of ARVs – reduce the chance of transmission
  - $d\sigma_1/d\beta < 0$
  - Since $d\beta < 0$, so $d\sigma_1 > 0$
  - Shift out in the demand curve
Complete the Market

• To determine the market, need a supply curve
• The supply curve in this case is just a technical function
• The steady state infection rate should be an increasing function of risk taking
  – The greater risk taking, the more infection

Introduce ARVs

• Demand
  – At given level of risky sex, decrease the transmission rate
  – Can withstand more risk taking at any level of transmission rate
  – “Income” effect
• Supply
  – At any given level of \( \sigma \), transmission rates are lower

Highly Active Antiretroviral Therapy (HAART)

• Aggressively suppresses viral replication and progress of HIV disease
• Usual HAART regime combines three or more different drugs
• Can reduce amount of virus so that it becomes undetectable in patient’s blood
• Heterogeneity in treatment benefits across patients
Who should be on HAART?

• Expert opinion
  – Start when CD4+ count < 350 cells/mm3 at any viral load
  – Consider starting sooner with heightened viral load
• No proven clinical benefit when CD4+ count > 200 cells/mm3
• Should see sicker HIV-positive patients on HAART

3 types of ARVs

• NRTI
  – nucleoside reverse transcriptase inhibitors
  – first approved in 1987
• PI
  – protease inhibitors
  – first approved in 1995
• NNRTI
  – non-nucleoside RTI
  – first approved in 1996

Spread of HAART

• Drugs received expedited review from FDA
  – Law requires evidence of efficacy and safety
  – FDA used data on biomarkers (CD4 and viral load) rather than mortality as outcome
  – Approved in months rather than years
• 5 new drugs released between 11/95 and 7/96

• Nationwide, use of new drugs increases rapidly
  – 60% of HIV patients on PIs by end of 1996
  – 80% AIDS patients in urban areas on HAART by 97
  – 50-70% use by AIDS patients on Medicaid by 98
### Key New Releases

<table>
<thead>
<tr>
<th>Drug</th>
<th>Type</th>
<th>Approval</th>
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<tbody>
<tr>
<td>Epivir</td>
<td>NRTI</td>
<td>11/17/95</td>
</tr>
<tr>
<td>Invirase</td>
<td>PI</td>
<td>12/6/95</td>
</tr>
<tr>
<td>Norvir</td>
<td>PI</td>
<td>3/1/96</td>
</tr>
<tr>
<td>Crixivan</td>
<td>PI</td>
<td>3/14/96</td>
</tr>
<tr>
<td>Viramune</td>
<td>NNRTI</td>
<td>6/21/96</td>
</tr>
</tbody>
</table>

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### Use of Epivir/PI and AIDS Mortality Rate

![Graph showing the use of Epivir/PI and AIDS mortality rate over time.](image-url)

### Mathematical Expressions

\[
h \quad h_1 \quad h_2
\]

\[
\sigma_1 \quad \sigma
\]

\[
S_1 \quad S_2
\]

---

\[
h \quad h_1
\]

\[
\sigma_1 \quad \sigma
\]

\[
D_1 \quad D_2 \quad D_3
\]
Why are transmission rates different?

- Greater incidence of STDs
  - Greatly increase transmission
  - Evidence not so clear
- Lower rates of circumcision in Africa
  - Observational studies show 44% lower rate of transmission for males circumcised
  - Benefits much greater among men w/ STD
- RACT in three countries (SA, Kenya, Uganda)
  - 55-76% reduction in FTM transmission rate for circumcised males
AIDS and growth

- Literature in development suggesting persistent health problems have thwarted economic growth in Africa
  - Sachs is primary proponent
  - Malaria, hook worms, diarrhea, etc.
- Pooled TS/CS work on this subject
- Nice paper by Bleakly, looks at hookworm eradication in US south, shows increased educational attainment

- Similar concerns about AIDS and growth
  - Mainly impacts young people in prime working years
  - David Bloom, Harvard School of public health
- Other concern that lower life expectancy will further reduce HC accumulation
  - Expected returns to HC have been lowered by reduced working years
  - Should discourage investment
- Work to date is limited
Fortson

- Pooled Time Series/Cross Section model.
- People 15-49 in survey year 2002/2003
- Cohorts born 1951-1989
- Some completed schooling before AIDS hit, some did not
- Younger cohorts are therefore ‘treated’ with AIDS threat
- Also variation across countries in extent of disease

First AIDS case identified in 1980
- Cross section data in 2003 on regional incidence of HIV
- Assume areas have smooth trends
- Results: 10% HIV rate reduces education by 1.2 years
- Some areas have 30% incidence rate, reduce education by more

Simple model of education

- Suppose education is discrete: Everyone goes E1 years, some can choose to go E2 years
- Cost of additional schooling:
  - Direct cost (tuition, supplies, etc)
  - Indirect costs (foregone earnings)
- More education increases earnings
- Earnings increase with age