ICM: Trade-offs in the fight against HIV/AIDS

As the HIV/AIDS pandemic enters its 25th year, both the number of infections and number of deaths due to the disease continue to rise. Despite an enormous amount of effort, our global society remains uncertain on how to most effectively allocate resources to fight this epidemic.

You are a team of analysts advising the United Nations (UN) on how to manage the available resources for addressing HIV/AIDS. Your job is to model several scenarios of interest and to use your models to recommend the allocation of financial resources. The narrative below provides some background information, and outlines specific tasks.

Task #1: For each of the continents (Africa, Asia, Europe, North America, Australia, and South America), choose the country you believe to be most critical in terms of HIV/AIDS. Build a model to approximate the expected rate of change in the number of HIV/AIDS infections for these countries from 2006 to 2050, in the absence of any additional interventions. Fully explain your model and the assumptions that underlie your model. In addition, explain how you selected the countries to model.

Use as a list of countries for inclusion in your analysis the countries included in the attached spreadsheet, which include all member states of the World Health Organization (WHO) as of 2003.

Data: "**list_WHO_member_states.xls"**

Reliable data on HIV prevalence rates by county are generally difficult to obtain. The attached spreadsheet includes several worksheets of data which you may use in your analysis.

Data: "**hiv_aids_data.xls"**

a. **"Global HIV- AIDS cases, 1999":** These data come from UNAIDS (the Joint United Nations Programme on HIV/AIDS) and report the estimated number of HIV positive 0 to 49 year olds by country at the end of 1999.
b. **"HIV- AIDS in Africa over time":** These data come from the US government and give some piecemeal time series data on measured HIV prevalence rates among women of childbearing age, in urban areas, over time for some African countries.
c. **"HIV- AIDS subtypes":** These data come from UNAIDS and give the geographic distribution of HIV-1 subtypes by country.

Also attached, for your use, are some basic population and demographic data.

Data:

(1) **"fertility_data.xls":** These data come from the UN and give age-specific fertility rates by major area, region, and country, 1995-2050 (births per thousand women)
   a. Estimates for 1995-2005
   b. Projections (under the assumption of medium fertility levels) for 2005-2050
(2) **"population_data.xls":** These data come from the UN and give total population (both sexes combined) by major area, region, and country, annually for 1950-2050 (thousands).
   a. Estimates for 1950-2005
   b. Projections (under the assumption of medium fertility levels) for 2006-2050
(3) **"age_data.xls":** These data come from the UN and give population (for both sexes, and by gender) by five-year age groups, major area, region, and country, 1950-2050 (thousands).
   a. Estimates, 1950-2005
   b. Projections (under the assumption of medium fertility levels) for 2010-2050
(4) **"birth_rate_data.xls":** These data come from the UN and give crude birth rates by major area, region, and country, 1950-2050 (births per thousand population).
   a. Estimates, 1950-2005
   b. Projections (under the assumption of medium fertility levels) for 2005-2050
(5) **"life_expectancy_0_data.xls":** These data come from the UN and give life expectancy at birth (by sex and both sexes combined) by major area, region, and country, 1950-2050 (years).
   a. Estimates, 1950-2005
   b. Projections (under the assumption of medium fertility levels) for 2005-2050

There are a number of interventions that HIV/AIDS funding could be directed towards -- including prevention interventions (voluntary counseling and testing, condom social marketing, school-based AIDS education, medicines to prevent mother-to-child transmission, *etc*.) and care interventions (treating other untreated sexually transmitted diseases, treating opportunistic infections, *etc*.). You should focus on only two potential interventions: provision of antiretroviral (ARV) drug therapies, and provision of a hypothetical HIV/AIDS preventative vaccine.

Task #2: First, estimate the level of financial resources from foreign aid donors that you realistically expect to be available to address HIV/AIDS, by year, from 2006 to 2050, for the countries you selected in Task #1. Then use the model you developed in Task #1 and these estimates of financial resources to estimate the expected rate of change in the number of HIV/AIDS infections for your selected countries from 2006 to 2050 under realistic assumptions for the following three scenarios:

(1) Antiretroviral (ARV) drug therapy
(2) A preventative HIV/AIDS vaccine
(3) Both ARV provision and a preventative HIV/AIDS vaccine

Assume in these scenarios that there is <u>no risk</u> of emergence of drug-resistant strains of HIV (you will examine this issue in Task #3).

Be sure to carefully describe the assumptions that underlie your model.

You can choose whether these scenarios should be implemented for all of the countries you selected in Task #1, or for certain subsets of countries based on income cut-offs, disease burden, etc. Available for use if you wish is a spreadsheet of country-level income data.

Data: **"income_data.xls"**: These data are from the World Bank (2002) and give per-capita gross national product (GNP) data as well as broad income classifications that you are free to use in your analysis if you wish.

ARV drug therapies can have tremendous benefits in terms of prolonging the lives of individuals infected with HIV/AIDS. ARVs are keeping a high proportion of HIV/AIDS-infected individuals in rich countries alive, and policy makers and international institutions are facing tremendous political pressure to increase access to ARVs for individuals in poor countries. Health budgets in low-income countries are very limited, and it seems unlikely that poor countries will be able to successfully expand these programs to the majority of their populations using their own resources. Appendix 1 presents country-specific data from UNAIDS on current access to ARVs for a number of countries.

The efficacy of ARVs depends in large part on adherence to the treatment regimen and to proper monitoring. The most favorable conditions for ARVs are structured programs with extensive counseling and physician care, as well as regular testing to monitor for disease progression and the onset of opportunistic infections. Non-adherence or inadequate treatment carries with it two very serious consequences. First, the treatment may not be effective for the individual undergoing treatment. Second, partial or inadequate treatments are thought to directly lead to the emergence of drug-resistant strains of HIV.

The price of the drugs initially used to treat patients has come down to several hundred dollars a year per patient, but delivering them and providing the necessary accompanying medical care and further treatment is the key administrative and financial challenge. It is estimated that purchasing and delivering antiretrovirals using the clinically-recommended approach (DOTS, or directly observed short course treatments) which is intended to minimize the emergence of drug-resistant strains would cost less than $1,100 per person per year. (Adams, Gregor et al. [2001]. "Consensus Statement on Antiretroviral Treatment for AIDS in Poor Countries,"
http://www.hsph.harvard.edu/bioethics/pdf/consensus_aids_therapy.pdf)

For a preventative HIV vaccine, make assumptions you feel are reasonable about the following (in addition to other factors you may choose to include in your model):

(1) The year in which an HIV/AIDS preventative vaccine might be available
(2) How quickly vaccination rates might reach the following steady-state levels of vaccination:
    a. If you wish to immunize new cohorts (infants), assume the steady-state level for new cohorts of the country-by-country immunization rates for the third dose of the diphtheria-pertussis-tetanus vaccine (DTP3), as reported by the WHO (2002)
        i. *Data*: **"vaccination_rate_data.xls"**

b. If you wish to immunize adults (any group over age 5), assume the steady-state level for older cohorts is the second dose of the tetanus toxoid (TT2) rate, as reported by the WHO (2002)
    i. *Data*: **"vaccination_rate_data.xls"**

(3) The efficacy and duration of protection of the vaccine
(4) Whether there would be epidemiological externalities from vaccination
(5) Assume the vaccine is a three-dose vaccine, and can be added to the standard package of vaccines delivered under the WHO's Expanded Programme on Immunization (EPI) at an incremental cost of addition of $0.75

Task #3: Re-formulate the three models developed in Task #2, taking into consideration the following assumptions about the development of ARV-resistant disease strains.

Current estimates suggest that patients falling below 90-95 percent adherence to ARV treatment are at a "substantial risk" of producing drug resistant strains. Use as an assumption for your analysis that a person receiving ARV treatment with adherence below 90 percent has a 5 percent chance of producing a strain of HIV/AIDS which is resistant to standard first-line drug treatments.

Second- and third-line ARV drug therapies are available, but assume for your analysis that these drugs are prohibitively expensive to implement in countries outside of Europe, Japan, and the United States.

Task #4: Write a white paper to the United Nations providing your team's recommendations on the following:

(1) Your recommendations for allocation of the resources available for HIV/AIDS among ARV provision and a preventative HIV vaccine
(2) Your argument for how to weigh the importance of HIV/AIDS as an international concern relative to other foreign policy priorities
(3) Your recommendations for how to coordinate donor involvement for HIV/AIDS

For (1): assume that between now and 2010 the available financial resources could be allocated so as the speed the development of a preventative HIV vaccine – through directly-financing vaccine research and development (R&D), or through other mechanisms. Any gains from such spending would move the date of development you assumed in Task #2 to some earlier date.

Appendix 1.

Percentage of adults with advanced HIV infection receiving antiretroviral treatment

Country	% of adults with advanced HIV infection receiving ARVs	Source of information
Sub-Saharan Africa		
Angola	< 1	WHO 2002
Benin	2.5	AAI 2002
Botswana	7.9 (2780)	UNGASS CR 2003
Burkina Faso	1.4 (675)	UNGASS CR 2003
Burundi	1.9	AAI 2002
Cameroon	1.5	National Target 2002
Central African Rep	< 1	National Target 2002
Côte d'Ivoire	2.7	UNGASS CR 2003
Democratic Rep. of Congo	0	AAI 2002
Equatorial Guinea	6.8	WHO 2002
Eritrea	< 1	WHO 2002
Ethiopia	< 1	WHO 2002
Gambia	6.3	WHO 2002
Ghana	1.8	WHO 2002
Lesotho	< 1	WHO 2002
Malawi	1.8	UNGASS CR 2003
Mali	2.5	WHO 2003
Mauritius*	100	UNGASS CR 2003
Mozambique	0	WHO 2002
Namibia	0	WHO 2002
Nigeria	1.5 (8,100)	UNGASS CR 2003
Kenya	3	UNGASS CR 2003
Rwanda	< 1 (1,500)	UNGASS CR 2003
Senegal	< 1	AAI 2002
Seychelles*	68.2	UNGASS CR 2003
Sierra Leone	0	WHO 2002
South Africa	0	WHO 2002
Swaziland	1.7 (450)	UNGASS CR 2003
Uganda	6.3 (10,000)	UNGASS CR 2003
United Republic of Tanzania	< 1	UNGASS CR 2003
Zambia	0	WHO 2002
Zimbabwe	0	WHO 2002
South & South-East Asia		
Afghanistan*	0	WHO country office
Bangladesh*	0	WHO 2002
Cambodia	3	NCHADS 2002
India	2	UNGASS CR 2003
Indonesia*	2.7	WHO 2002
Iran*	100	WHO 2002
Myanmar*	< 1	UNGASS CR 2003
Pakistan*	2.2	WHO 2002
Philippines*	3.5	WHO 2002
Sri Lanka*	2	National Target 2002
Singapore*	0	MoH
Thailand	4	NACP 2003
Viet Nam*	1	UNGASS CR 2003
East Asia & Pacific		
China*	5	National Target 2002
Hong Kong*	100	WHO 2002
Papa New Guinea*	0	WHO 2002
Samoa*	100	MoH 2002
Tonga*	0	NACP 2003
Caribbean & Latin America		
Argentina*	91.2 (23253)	UNGASS CR 2003
Bahamas*	< 1	WHO 2002
Belize	7.7 (29)	UNGASS CR 2003
Bolivia*	< 1	WHO 2002
Brazil*	100 (119,500)	UNGASS CR 2003

Dominican Republic	0	National Target 2002
Guatemala	46	UNGASS CR 2003
Guyana	0	WHO 2002
Honduras	< 1	WHO 2002
Jamaica	< 1	AAI 2002
Mexico*	92	UNGASS CR 2003
Nicaragua*	0	WHO 2002
Paraguay*	50 (300)	UNGASS CR 2003
Peru*	19.2	NACP 2002
Trinidad & Tobago	< 1	AAI 2002
Uruguay*	50.5	NACP 2002
Eastern Europe & Central Asia		
Albania*	0	WHO EURO Survey of ARV access 2003
Armenia*	0	WHO EURO Survey of ARV access 2003
Azerbaijan*	0	WHO EURO Survey of ARV access 2003
Belarus*	< 1	UNGASS CR 2003
Bosnia & Herzegovina*	10	WHO EURO Survey of ARV access 2003
Bulgaria*	44.5	WHO EURO Survey of ARV access 2003
Croatia*	98.7	WHO EURO Survey of ARV access 2003
Cyprus*	100	Dept Medical and Health Services
Estonia*	32	WHO EURO Survey of ARV access 2003
Georgia*	8	WHO EURO Survey of ARV access 2003
Hungary*	97	WHO EURO Survey of ARV access 2003
Kazakhstan*	1	UNGASS CR 2003
Kyrgyzstan*	0	EURO survey 2002
Latvia*	51	WHO EURO Survey of ARV access 2003
Lithuania*	55	WHO EURO Survey of ARV access 2003
Macedonia*	20	WHO EURO Survey of ARV access 2003
Moldova Republic*	8.3	WHO 2002
Poland*	92.9	WHO EURO Survey of ARV access 2003
Romania*	64.4	WHO EURO Survey of ARV access 2003
Russian Federation*	83.3	WHO 2002
Serbia & Montenegro*	26.4	WHO EURO Survey of ARV access 2003
Slovakia*	95	WHO EURO Survey of ARV access 2003
Slovenia*	96.3	WHO EURO Survey of ARV access 2003
Tajikistan*	0	UNGASS CR 2003
Ukraine	< 1	MoH and WHO 2002
Uzbekistan*	0	WHO EURO Survey of ARV access 2003
North Africa & Middle East		
Djibouti*	1.8	MoH, WHO 2002
Jordan*	21.3	UNGASS CR 2003
Lebanon*	100	NACP 2003
Morocco*	20.7	UNGASS CR 2003
Qatar*	64.9	HIV registry 2002
Sudan	< 1	WHO 2002
High-income OECD		
Australia*	53.2	Annual Surveillance Report
Austria*	92.6	WHO EURO Survey of ARV access 2003
Belgium*	93.8	WHO EURO Survey of ARV access 2003
Denmark*	90.9	WHO EURO Survey of ARV access 2003
Finland*	94.6	WHO EURO Survey of ARV access 2003
Germany*	94.7	WHO EURO Survey of ARV access 2003
Iceland*	87.5	WHO EURO Survey of ARV access 2003
Italy*	72.7	WHO EURO Survey of ARV access 2003
Luxembourg*	96.9	WHO EURO Survey of ARV access 2003
Malta*	94.3	WHO EURO Survey of ARV access 2003
Netherlands*	96	WHO EURO Survey of ARV access 2003
Norway*	89.6	WHO EURO Survey of ARV access 2003
Spain*	92.3	WHO EURO Survey of ARV access 2003
Sweden*	95	WHO EURO Survey of ARV access 2003
Switzerland*	95	WHO EURO Survey of ARV access 2003
United Kingdom*	92.1	WHO EURO Survey of ARV access 2003

Notes: * := Countries with low prevalence/concentrated epidemics; AAI := Accelerated Access Initiative; UNGASS CR 2003 := program monitoring data from UNGASS (United Nations General Assembly Special Session) country reports 2003; WHO 2002 := 2002 program monitoring data through WHO (World Health Organization) country offices; MoH := Ministry of Health; NACP := National AIDS Control Programme; NCHADS := National Centre for HIV/AIDS, Dermatology and STIs (sexually transmitted infections).