Lesson /Week 8

Major Vectored and Non-vectored Diseases:

- ✓ Malaria
- ✓ Tuberculosis
- ✓ HIV/AIDS

- ✓ Humanity's response to the three major killers
  - ✓ Global Fund to Fight Malaria, Tuberculosis and AIDS
  - ✓ Roll Back Malaria partnership (RBM)
  - ✓ (US)President's Emergency Fund For AIDS Relief (PEPFAR)

Malaria

MALARIA

Simulation of agent life cycle

http://www.sumanasinc.com/scienceinfocus/sif_malaria.html

Disease Burden

http://www.rollbackmalaria.org/keyfacts.html

Annual cases of malaria (2010)

Globally: 247 million

Africa: 212 million

Asia: 21 million

Middle East: 8.1 million

Americas: 2.7 million

Annual deaths from malaria (2010)

Globally: 881,000

Africa: 801,000

Middle East: 38,000

Asia: 36,000

Americas: 3,000

Agent protozoa, vector aedes aegypti (a mosquito)

Simulation

Infection cycle http://www.sumanasinc.com/scienceinfocus/sif_malaria.html

Video

Mosquito life cycle http://www.youtube.com/watch?v=wFfO7f8Vr9c&NR=1

History

"Malaria is the most prevalent mosquito-transmitted disease in the world. The human race has had to contend with this ancient infirmity since we first began roaming the plains of Africa over 100,000 years ago. Since then, malaria has killed approximately 27 billion people (Fort et al., 2004, p. 131)". http://www.geog.umd.edu

Key facts

- In 2008, malaria caused nearly one million deaths, mostly among African children.
- Malaria is preventable and curable.
- Malaria can decrease gross domestic product by as much as 1.3% in countries with high disease rates.

Malaria is caused by five species of ***Plasmodium parasites***.

- *Plasmodium falciparum (global – below 1500 meters)*
- *Plasmodium vivax (Latin America, some parts of Africa)*
- *Plasmodium malariae ("benign" malaria) (global)*
- *Plasmodium ovale (Sub-Saharan Africa)*
- *P. knowlesi* - monkey malaria (found in southeast Asia).

- http://www.who.int/mediacentre/factsheets/fs094/en/index.htm

Triangle of human ecology (example):

"The farmers of Karuzi province were among Africa's poorest, but they had won at least one of nature's lotteries: for as long as anyone could remember their corner of Burundi had been free of malaria.
Geography and climate deterred malarial mosquitoes from the cool highlands, sparing the province a deadly disease which affects millions of Africans every year.

Looking back, it is easy to see how delicate was that blessing, how malaria's absence meant the population built up no immunity and were as vulnerable as the 19th century European explorers it felled.

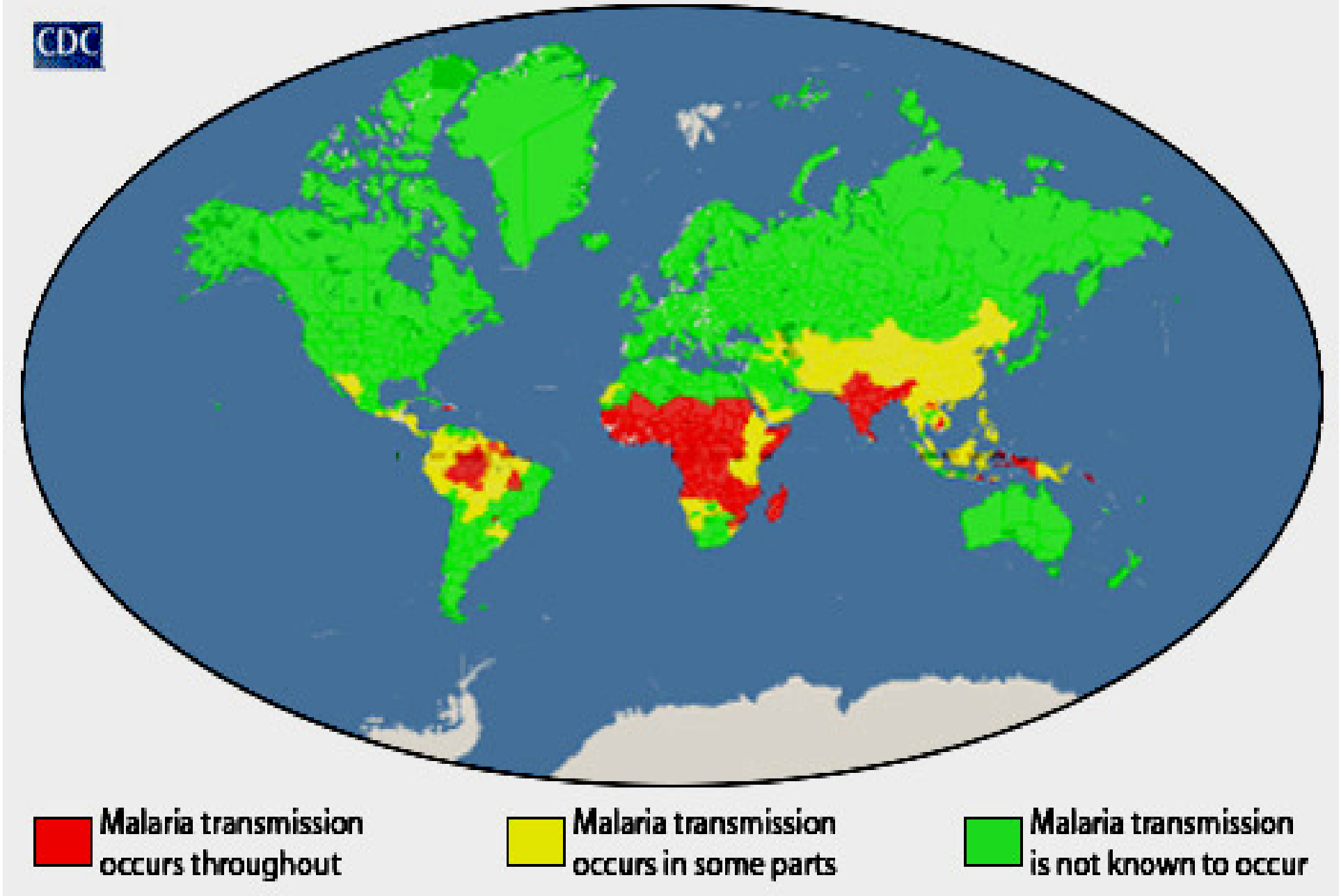
Two events ended Karuzi's luck. Some farmers cleared papyrus from the lower wetlands to cultivate rice, not realizing that by releasing an oil on the water's surface the papyrus had acted as a barrier against certain mosquitoes. Then a civil war in 1994 brought an influx of lowlanders with malaria to Karuzi.

The mosquitoes feasted on the newcomers' blood, thus becoming malaria carriers. Each subsequent rainy season left a slowly growing number of locals stricken with the classic symptoms of fever and nausea.

Then, in the course of several terrible weeks in October and November 2000, the trickle turned into a torrent. About half a million cases of malaria were recorded in a population of 350,000 as almost every man, woman and child was infected, many more than once".

Guardian news & Media 2008.Published: 12/18/2003

Global distribution www.CDC.Org



Transmission

✓• Malaria is transmitted exclusively through the bites of the female *Anopheles* mosquitoes.

✓• The intensity of transmission depends on factors related to the parasite, the vector, the human host, and the environment.

✓• About 20 different *Anopheles species are locally important around* the world.

✓• All of the important vector species bite at night.

✓• They breed in shallow collections of freshwater like puddles, ricefields, and hoofprints.

✓Transmission is more intense in places where the mosquito is relatively long-lived (so that the parasite has time to complete its development inside the mosquito) and where it prefers to bite humans rather than other animals.

Transmission contd….

✓For example, the long lifespan and strong human-biting habit of the African vector species is the underlying reason why more than 85% of the world's malaria deaths are in Africa.

✓• Human immunity is another important factor, especially among adults in areas of moderate or intense transmission conditions.

✓• Immunity is developed over years of exposure, and while it never gives complete protection, it does reduce the risk that malaria infection will cause severe disease.

✓• For this reason, most malaria deaths in Africa occur in young children, whereas in areas with less transmission and low immunity, all age groups are at risk.

✓• Transmission also depends on climatic conditions that may affect the abundance and survival of mosquitoes, such as rainfall patterns, temperature and humidity.

✓In many places, transmission is seasonal, with the peak during and just after the rainy season.

Medical geographical approaches:

Vector

Temperature requirements

Air temperatures to between 25°C and 27°C for optimum breeding, feeding, and cellular metabolism.

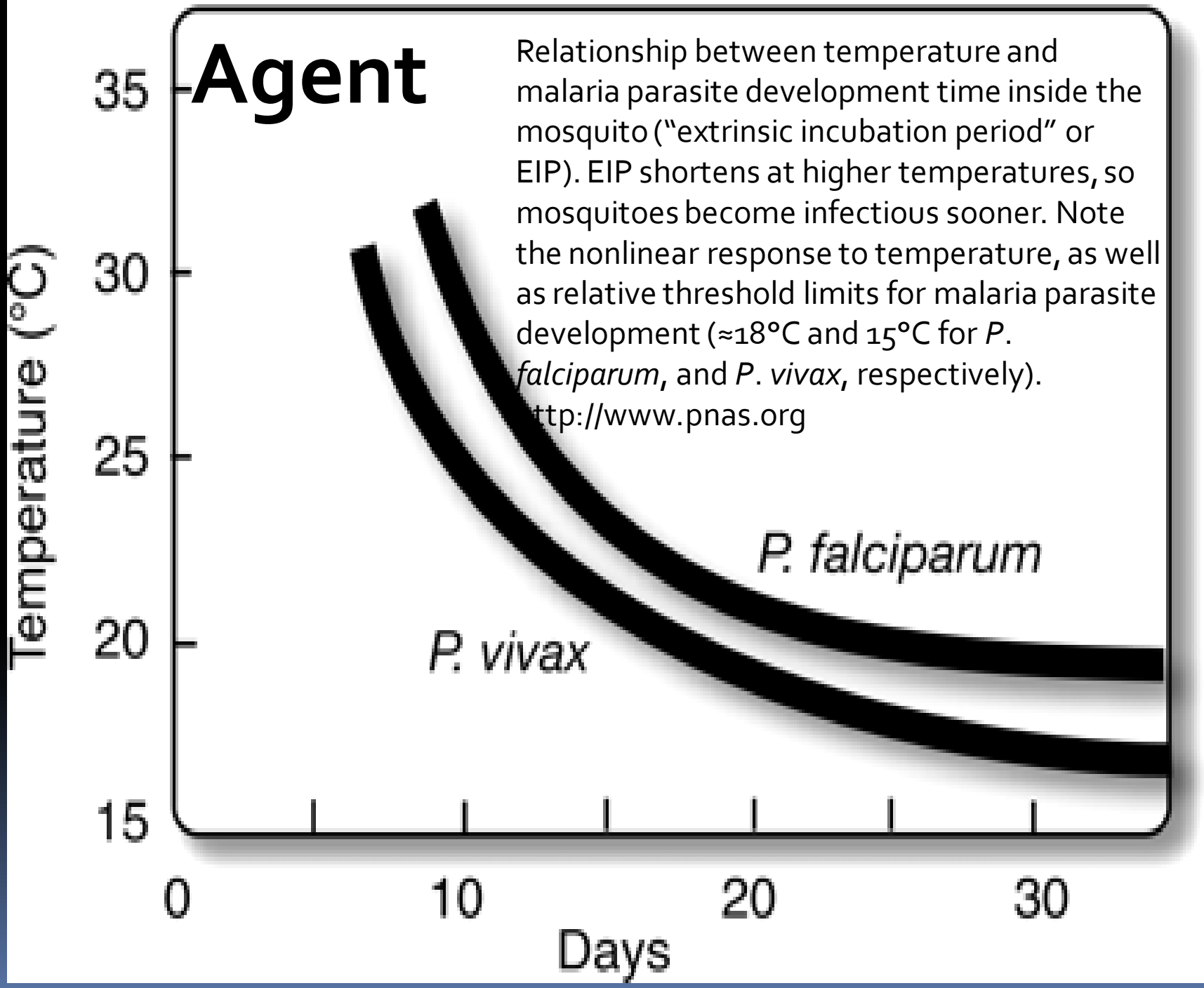
Warm air temperatures are also crucial for the development of the *Plasmodium parasite. In this case temperatures need to be* between 20°C and 30°C.

http://www.geog.umd.edu

Moisture requirements

- ✓Anopheles mosquitoes, like all mosquitoes, require water habitats in which to breed.
- ✓ Too much, or too little rainfall can adversely impact mosquito populations.
- ✓ Rainfall amount of 50mm - 80mm per month allows the creation of adequately-sized pools of standing water.
- ✓However, heavy rainfall is not always beneficial to mosquito and malaria production.
- ✓Sometimes heavy rains can reduce mosquito populations by washing away developing eggs and larvae, thus reducing the potential for a malaria outbreak.
- ✓Variability of rainfall is also important. Periods of heavy rainfall followed by a prolonged drought, lead to a potential for a malaria epidemic.

Agent



Relationship between temperature and malaria parasite development time inside the mosquito ("extrinsic incubation period" or EIP). EIP shortens at higher temperatures, so mosquitoes become infectious sooner. Note the nonlinear response to temperature, as well as relative threshold limits for malaria parasite development (≈18°C and 15°C for *P. falciparum*, and *P. vivax*, respectively).

ttp://www.pnas.org

HOST

Anthropogenic Determinants

✓Beyond the normal environmental determinants, anthropogenic determinants can influence the distribution of the disease by directly modifying the behavior and geographical distribution of the *Anopheles mosquitoes .*

✓*Over the past two* centuries anthropogenic factors such as deforestation, agriculture, irrigation, population increase, migration, and war have all influenced the spatial distribution pattern of malaria.

✓The eradication of both plant and animal species can have a profound impact on the survivability of malaria.

✓**Deforestation.** Deforestation can eliminate species (including frogs, certain bats, and numerous species of birds) which naturally prey on mosquitoes.

Deforestation cond….

Deforestation also has an enormous impact on local ecosystems. It alters microclimates by reducing shade, altering rainfall patterns, augmenting air movement, and changing humidity levels. It also increases surface water availability through the loss of topsoil and vegetation root systems that absorb rain water.

Agriculture: Example: The influence of African irrigation schemes has provided more favorable environments for malaria vectors.

✓The building of small dams and irrigation canals create prime breeding grounds for mosquitoes .

✓In Burundi, "malaria transmission rates are 70% higher near irrigated rice fields. Likewise, in the highlands of Kenya, irrigated cotton and vegetable farms experience nearly 55% higher incidents of malaria when compared to non-irrigated farms".

http://www.geog.umd.edu

Two types of vector control and prevention

ITNs (Insecticide-treated mosquito nets)

✓ITNs have been shown to avert around 50% of malaria cases, making protective efficacy significantly higher than that of untreated nets

✓5.5 lives could be saved per year for every 1000 children under 5 years of age protected.

Indoor spraying

Indoor residual spraying (IRS) with insecticides is the most powerful way to rapidly reduce malaria transmission. Its full potential is realized when at least 80% of houses in targeted areas are sprayed. Indoor spraying is effective for 3–6 months depending on the insecticide used and the type of surface on which it is sprayed.

Costs

✓**Direct health costs** of malaria include both personal and public expenditures on prevention and treatment.

✓In some heavy-burden countries, the disease accounts for:

- up to 40% of public health expenditures;
- 30% to 50% of inpatient hospital admissions;
- up to 60% of outpatient health clinic visits.

✓Malaria disproportionately affects poor people who cannot afford treatment or have limited access to health care, trapping families and communities in a downward spiral of poverty.

✓**Indirect costs** include reduced productivity and chronic malnutrition with its attendant effects on child health and mental development

Medical Geographical approaches

could include statistical analysis and Map making:

- ✓Favorable Temperature zones
- ✓Regions of optimum precipitation (amounts)
- ✓Precipitation (variability)
- ✓Deforestation (rate)
- ✓Deforestation (extent)
- ✓Agriculture (rain-fed)
- ✓Agriculture (irrigation)
- ✓Agriculture (cattle raring)
- ✓Vector control efforts by type (location and geographical distribution)
- ✓Treatment costs (geographical patterns)

Tuberculosis

Tuberculosis

Infection and transmission

http://www.who.int/mediacentre/factsheets/fs104/en/
http://www.cdc.gov/TB/topic/basics/default.htm

- "TB" is short for tuberculosis.
- TB disease is caused by a bacterium called *Mycobacterium tuberculosis.*
- The bacteria usually attack the lungs, but TB bacteria can attack any part of the body such as the kidney, spine, and brain. If not treated properly, TB disease can be fatal.

How TB Spreads

- TB is spread through the air from one person to another.
- The TB bacteria are put into the air when a person with active TB disease of the lungs or throat coughs, sneezes, speaks, or sings.
- People nearby may breathe in these bacteria and become infected.
- In most people who breathe in TB bacteria and become infected, the body is able to fight the bacteria to stop them from growing (Latent TB).
- People with latent TB infection do not feel sick and do not have any symptoms. The only sign of TB infection is a positive reaction to the tuberculin skin test or special TB blood test. People with latent TB infection are not infectious and cannot spread TB bacteria to others.
- However, if TB bacteria become active in the body and multiply, the person will get sick with TB disease (Active TB).

TB - Mycobacterium tuberculosis: bacteria
Malaria - Plasmodium: protozoa

What is the difference between bacteria and protozoa?

- ✓Bacteria are prokaryotes (they have no membrane-bounded nucleus or organelles) and are generally very small, and most importantly are all single-celled.
- ✓Protozoa (Proto- "before" and zoa- "animals") also known as Protists are eukaryotes (contain a nucleus and membrane-bound organelles) but are still single-celled like bacteria.

Therefore:

- ✓Protozoa are harder to kill
- ✓Antibiotics don't kill protozoa

TB contd.....

"The development of tuberculosis in humans is **a two-stage process** in which a susceptible person exposed to an infectious case first becomes infected and second, after an interval of years or decades, may later develop the disease, depending on a variety of factors."

"Since the acquisition of infection is often far removed from the development of disease and involves different physiologic mechanisms, **the risk factors for infection are quite different from the risk factors for development of disease following infection**. *This* has important implications for tuberculosis prevention and control".

American Journal of Epidemiology, Vol. 155, No. 11

Environmental risk factors:

✓ **TB is nearly as old as humanity itself; "fossilized evidence of this lethal infection has been found in a *Homo erectus* skeleton half a million years old".**

✓ **Historically, TB is a disease of the poor.**

✓ An estimated 1.7 million people died from TB in 2009. The highest number of deaths was in the Africa Region (WHO).

✓ **People who die of the disease live in the developing world or in poor, urban neighborhoods of wealthy nations.**

✓ **For centuries, TB has been linked anecdotally with environmental risk factors that go hand-in-hand with poverty: indoor air pollution, tobacco smoke, malnutrition, overcrowded living conditions, and excessive alcohol use. Now scientists are presenting convincing evidence to back these associations, leading to the conclusion that control programs must confront underlying risk factors to limit the spread of the disease.**

http://www.eoearth.org

The global picture:

✓Someone in the world is newly infected with TB bacilli every second.

✓• Overall, one-third of the world's population is currently infected with the TB bacillus.

✓WHO estimates that the largest number of new TB cases in 2008 occurred in the South-East Asia Region

✓• The region accounted for 34% of incident cases globally.

✓• However, the estimated incidence rate in sub-Saharan Africa is nearly twice that of the South-East Asia Region with over 350 cases per 100 000 population.

✓• The highest number of deaths was in the South-East Asia Region, while the highest mortality per capita was in the Africa Region.

TB Incidence (2008)

Incidence is the number of new cases arising during a defined period.

WHO region	Incidence[1] no. in thousands	% of global total	rate per 100 000 pop[3]
Africa	2 828	30%	351
The Americas	282	3%	31
Eastern Mediterranean	675	7%	115
Europe	425	5%	48
South-East Asia	3 213	34%	183
Western Pacific	1 946	21%	109
Global total	9 369	100%	139

http://www.who.int

TB prevalence and mortality rate (2008)

Prevalence is the number of cases (new and previously occurring) that exists at a given point in time.

http://www.who.int

	Prevalence [2]		Mortality	
	no. in thousands	rate per 100 000 pop	no. in thousands	rate per 100 000 pop
Africa	3 809	473	385	48
The Americas	221	24	29	3
Eastern Mediterranean	929	159	115	20
Europe	322	36	55	6
South-East Asia	3 805	216	477	27
Western Pacific	2 007	112	261	15
Global total	11 093	164	1 322	20

Risk factors/ environmental determinants

Crowding

"Crowding increases the risk of exposure by increasing the likelihood of contact between susceptible persons and infectious tuberculosis cases as well as the intimacy of exposure."

Urbanization and homelessness

"Urban centers have traditionally had higher rates of tuberculosis than rural areas…. Association between tuberculosis and urbanization is probably confounded by poverty and crowding, because residential crowding in low socioeconomic status groups brings more persons (especially children) into contact with infectious cases of tuberculosis in people living in the same household"

Epidemiol Rev Vol. 23, No. 2, 2001

Socioeconomic status

"Historically, tuberculosis has been linked with poverty ..... Poverty conditions during the industrial revolution in the 19th century in Europe were accompanied by disease and death due to tuberculosis ....."

Access to health care

"Delays in diagnosis and treatment increase morbidity and mortality from tuberculosis as well as the risk of transmission of tuberculosis in the community"

HIV infection

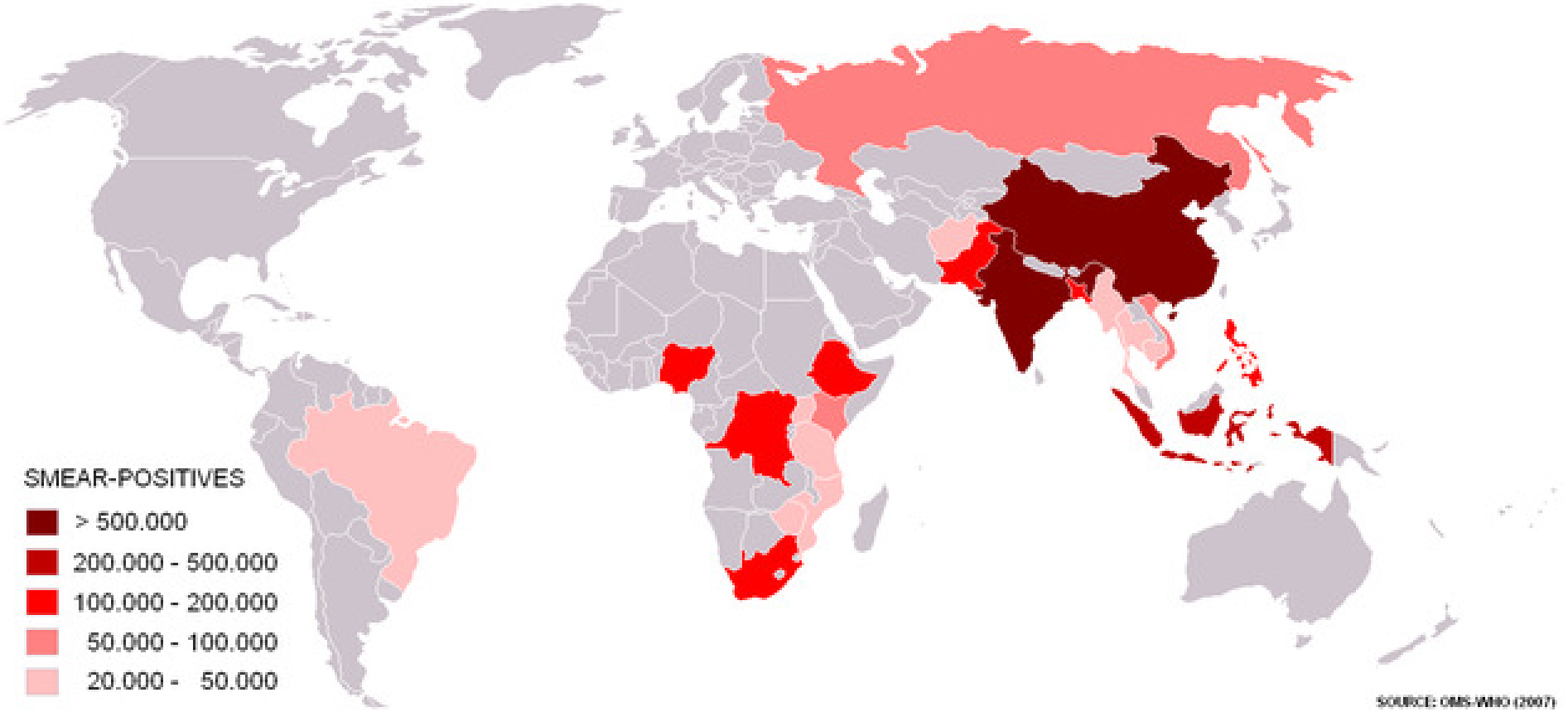
"HIV infection has emerged as the most important risk factor for development of tuberculosis in persons infected with *M. tuberculosis*.... The estimated risk of clinical disease in HIV-infected persons is between 6 and 26 times the risk in non-HIV-infected persons.... By mid-1992, an estimated 5.6 millions persons were dually infected with HIV and *M. tuberculosis worldwide, 3.8 million of them in sub*-Saharan Africa"

Migration.

Immigrants from countries with a high prevalence of tuberculosis have been reported to contribute to the increase in tuberculosis cases in the United States and the United Kingdom, and the risk of tuberculosis in ethnic minorities in the United States has been reported to be higher than in the general population

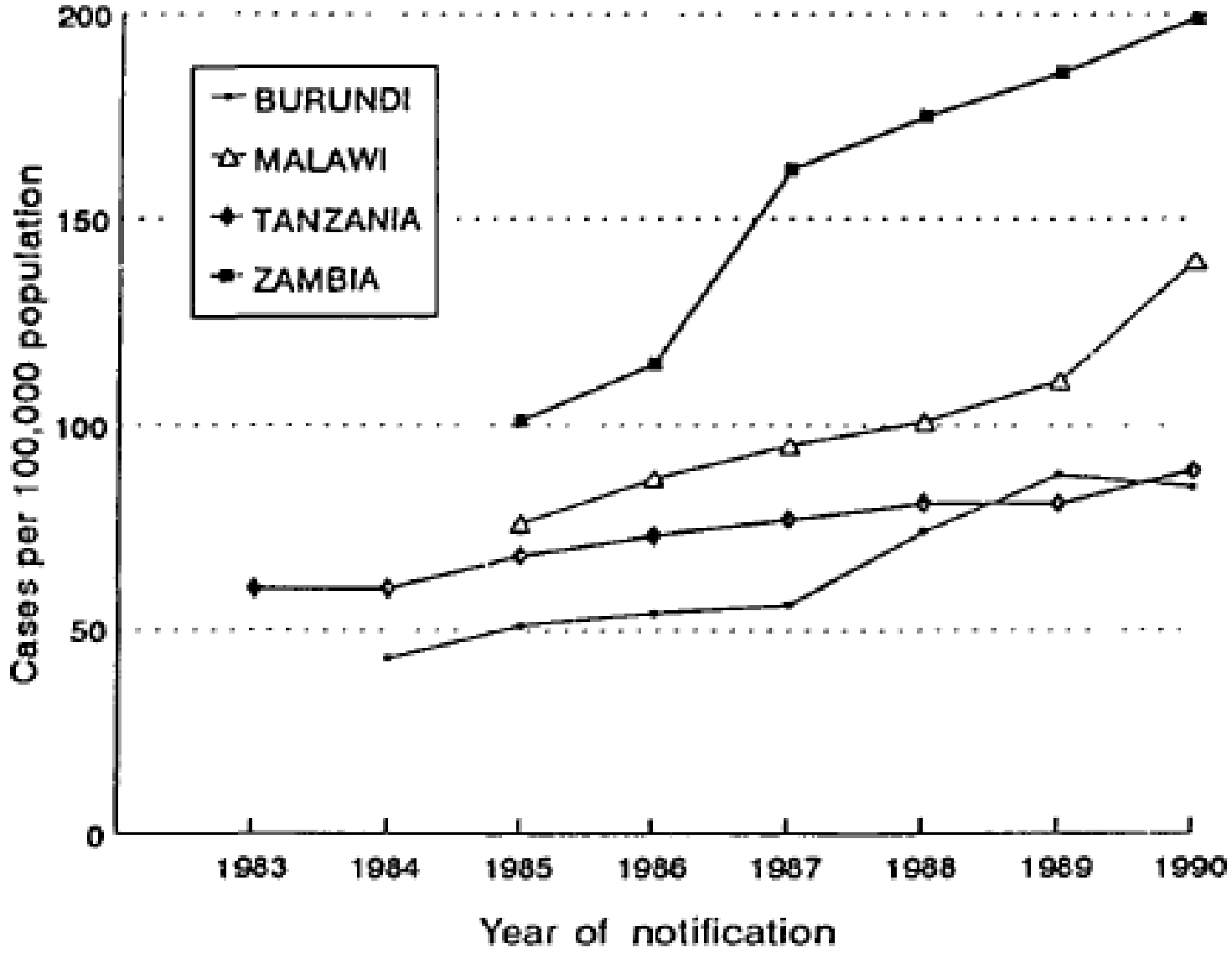
Epidemiol Rev Vol. 23, No. 2, 2001

Tuberculosis: Number of smear positive cases



http://www.eoearth.org/article/Tuberculosis_environment_linkage

The impact of HIV/AIDS on TB Incidence Rates in Four African Countries



Epidemiol Rev Vol. 23, No. 2, 2001

Drug-resistant TB

✓• Until 50 years ago, there were no medicines to cure TB.
✓• Now, strains that are resistant to a single drug are in every country.
✓Strains of TB resistant to all major anti-TB drugs have also emerged.
✓• Drug-resistant TB is caused by inconsistent or partial treatment, when patients do not take all of their medicines regularly for the required period because they start to feel better, or because doctors and health workers prescribe the wrong treatment regimens, or because the drug supply is unreliable.
✓• A particularly dangerous form of drug-resistant TB is multidrugresistant TB (MDR-TB), which is defined as the disease caused by TB bacilli resistant to at least isoniazid and rifampicin, the two most powerful anti-TB drugs.
✓In 2008, an estimated 62% of new smear-positive cases were treated under DOTS (Directly Observed Therapy Short-course).

HIV / AIDS

HIV/AIDS

Important facts

✓**33.3 million people are now living with HIV after nearly 30 years into a very complex epidemic.**

✓Approximately 1.8 million people died from AIDS-related illnesses in 2009

✓**Since 1999, the year in which it is thought that the epidemic peaked, globally, the number of new infections has fallen by 19%.**

✓**More than 5 million people are now receiving HIV treatment**

✓Expanding access to treatment has contributed to a 19% decline in deaths among people living with HIV between 2004 and 2009. However, 10 million people living with HIV who are eligible for treatment under the new WHO guidelines are still in need.

✓In 33 countries, HIV incidence has fallen by more than 25% between 2001 and 2009.

✓The biggest epidemics in sub-Saharan Africa—Ethiopia, Nigeria, South Africa, Zambia, and Zimbabwe—have either stabilized or are showing signs of decline. http://www.unaids.org

Facts....contd

✓However, several regions and countries do not fit the overall trend. In seven countries, five of them in Eastern Europe and Central Asia, HIV incidence increased by more than 25% between 2001 and 2009.

✓Mother-to-child transmission: In 2009, an estimated 370 000 children contracted HIV during the perinatal and breastfeeding period, down from 500 000 in 2001.

✓In 2009, UNAIDS called for the virtual elimination of mother-to-child transmission of HIV by 2015.

✓Slightly more than half of all people living with HIV are women and girls.

✓In sub-Saharan Africa, more women than men are living with HIV, and young women aged 15–24 years are as much as eight times more likely than males in the same age group to be HIV positive.

✓Protecting women and girls from HIV means protecting against gender-based violence and promoting economic independence from older men.

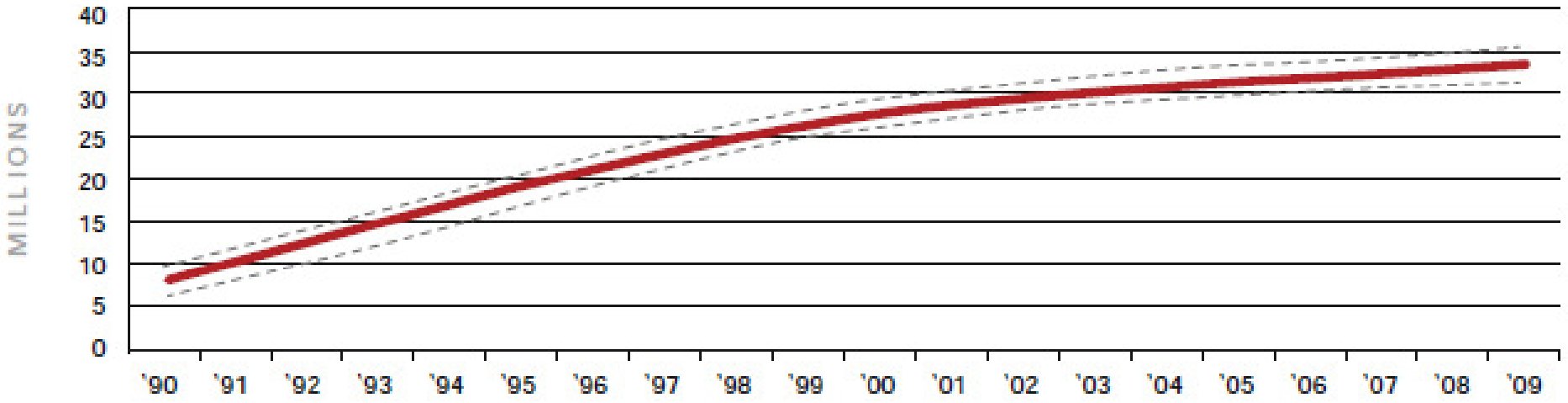
✓Knowledge of the epidemic and how to prevent HIV infection has increased among young people aged 15–24 years—people frequently at the highest risk for infection.

http://www.unaids.org

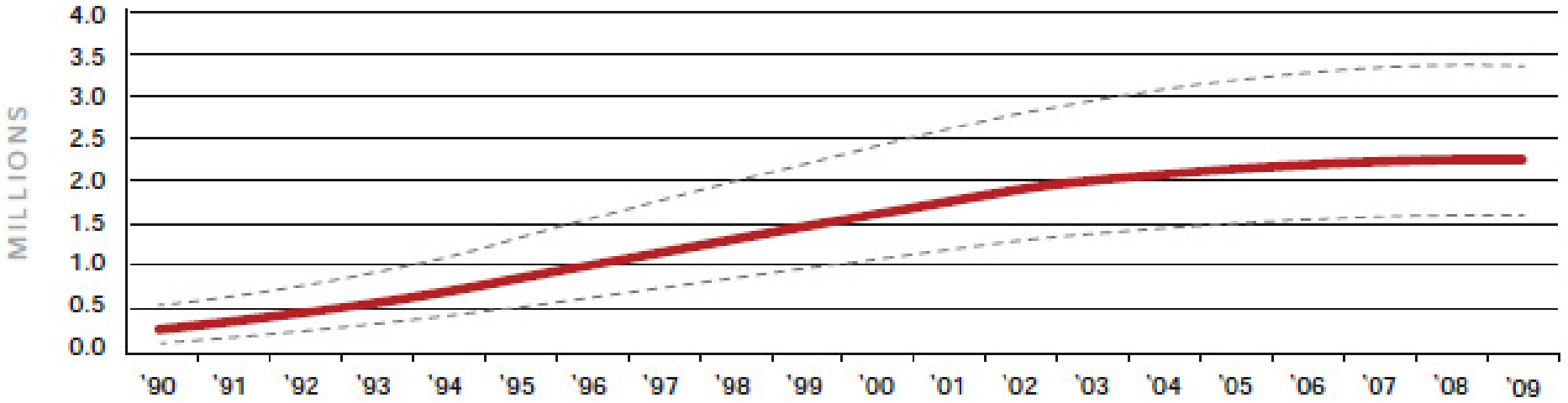
		Adults and children living with HIV	Adults and children newly infected with HIV	% Adult prevalence (15–49 years)	AIDS-related deaths among adults and children
SUB-SAHARAN AFRICA	2009	22.5 million [20.9–24.2 million]	1.8 million [1.6–2.0 million]	5.0 [4.7–5.2]	1.3 million [1.1–1.5 million]
	2001	20.3 million [18.9–21.7 million]	2.2 million [1.9–2.4 million]	5.9 [5.6–6.1]	1.4 million [1.2–1.6 million]
MIDDLE EAST AND NORTH AFRICA	2009	460 000 [400 000–530 000]	75 000 [61 000–92 000]	0.2 [0.2–0.3]	24 000 [20 000–27 000]
	2001	180 000 [150 000–210 000]	36 000 [32 000–42 000]	0.1 [0.1–0.1]	8300 [6300–11 000]
SOUTH AND SOUTH-EAST ASIA	2009	4.1 million [3.7–4.6 million]	270 000 [240 000–320 000]	0.3 [0.3–0.3]	260 000 [230 000–300 000]
	2001	3.8 million [3.5–4.2 million]	380 000 [350 000–430 000]	0.4 [0.3–0.4]	230 000 [210 000–280 000]
EAST ASIA	2009	770 000 [560 000–1.0 million]	82 000 [48 000–140 000]	0.1 [0.1–0.1]	36 000 [25 000–50 000]
	2001	350 000 [250 000–480 000]	64 000 [47 000–88 000]	<0.1 [<0.1–<0.1]	15 000 [9400–28 000]

http://www.unaids.org

Number of people living with HIV



Number of children living with HIV



CURRENT TRENDS: New HIV infections are declining

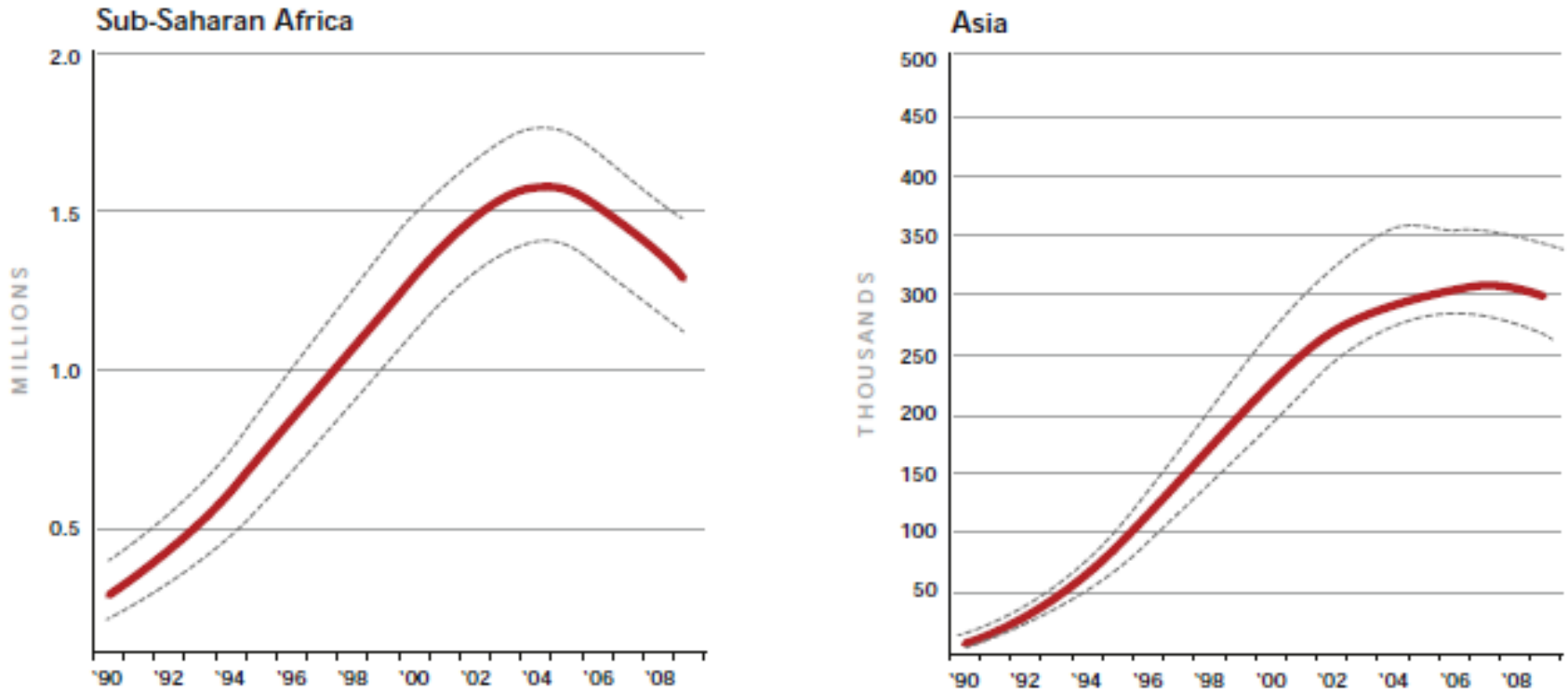
✓In 2009, there were an estimated 2.6 million people who became newly infected with HIV.
✓In sub-Saharan Africa, where the majority of new HIV infections continue to occur, an estimated 1.8 million people became infected in 2009; considerably lower than the estimated 2.2 million people in sub-Saharan Africa newly infected with HIV in 2001. An estimated 370 000 children were newly infected with HIV in 2009 (a drop of 24% from five years earlier).

AIDS-related deaths are decreasing

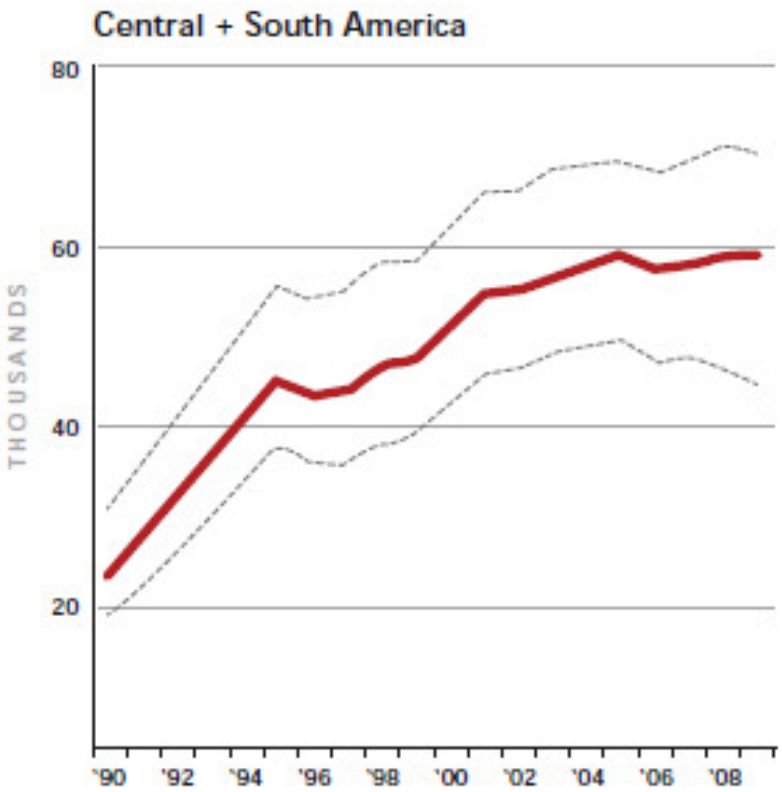
✓The number of annual AIDS-related deaths worldwide is steadily decreasing from the peak of 2.1 million in 2004 to an estimated 1.8 million in 2009 .
✓The decline reflects the increased availability of antiretroviral therapy, as well as care and support, to people living with HIV, particularly in middle- and low-income countries; it is also a result of decreasing incidence starting in the late 1990s.
http://www.unaids.org

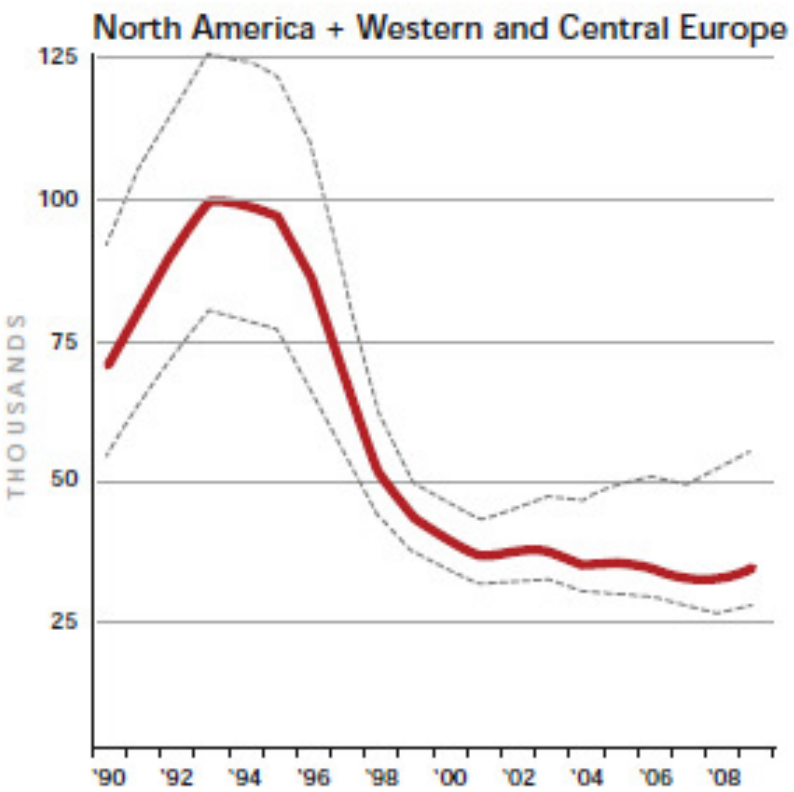
Annual AIDS-related deaths by region, 1990-2009

Source: UNAIDS.

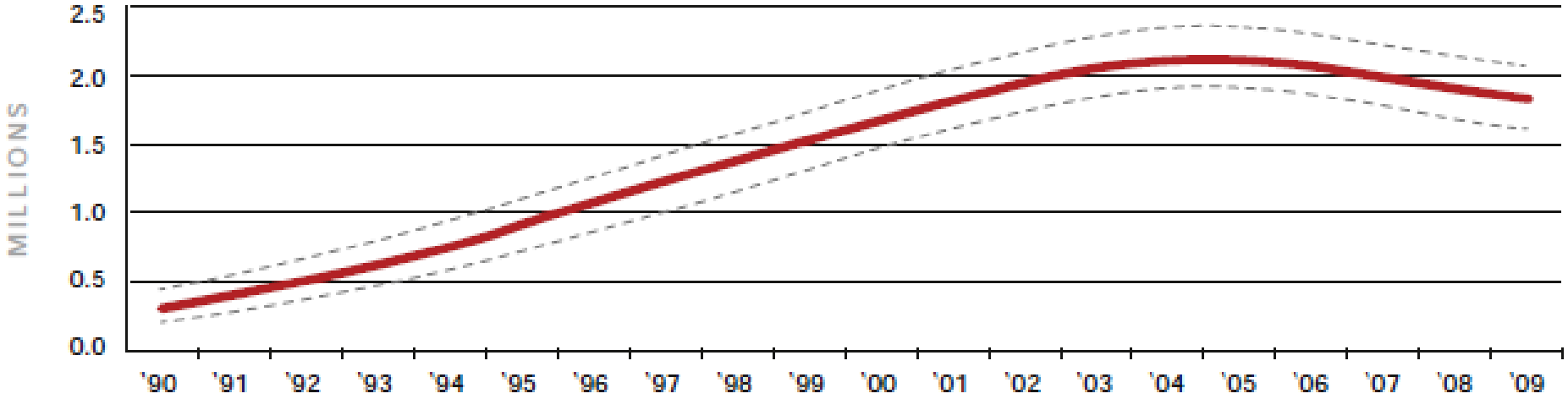


Aids-related deaths .....continued

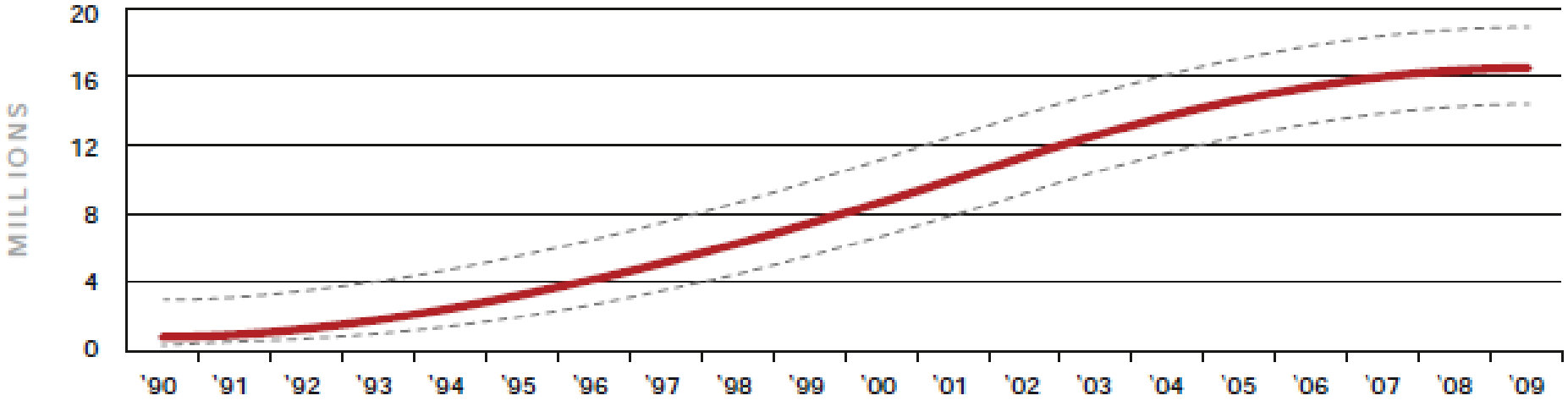




Adult and child deaths due to AIDS



Number of orphans due to AIDS



Humanity's response to the ongoing epidemics of malaria, tuberculosis and HIV/AIDS

I. The Global Fund to Fight AIDS, Tuberculosis and Malaria

The fund (founded in 2002) was created to dramatically increase resources to fight three of the world's most devastating diseases, and to direct those resources to areas of greatest need.

Watch video: http://www.theglobalfund.org/en/globalfundvideo/

Accomplishments so far

- ✓ **It is estimated that the programs supported by the Global Fund save at least 3,600 lives, prevent thousands of new infections everyday.**
- ✓ **US$ 10 billion spent (2002-2009) for HIV, tuberculosis (TB) and malaria control efforts.**
- ✓ ***Tuberculosis.*** ***Through 2009, programs funded by*** the **Global Fund have provided treatment to 6 million people who had active TB.**
- ✓ ***Malaria.*** ***By the end of 2009, Global Fund-supported*** **programs had distributed 104 million insecticide-treated nets (ITNs) to prevent malaria.**

Achievements….contd

- ✓**Malaria:** A reduction in malaria deaths of more than 50 percent.
- ✓**HIV/AIDS**. At the end of December 2009, programs financed by the Global Fund were providing antiretroviral therapy (ART) to 2.5 million people.
  - ✓1.8 billion male and female condoms and have provided
  - ✓790,000 HIV-positive pregnant women received treatment to prevent mother-to-child transmission
  - ✓4.5 million basic care and support services to orphans and other children made vulnerable by AIDS
  - ✓105 million HIV counseling and testing sessions

II. The Roll Back Malaria (RBM) partnership.

http://www.rollbackmalaria.org

"The Partnership is comprised of more than 500 partners, including malaria endemic countries, their bilateral and multilateral development partners, the private sector, nongovernmental and community-based organizations, foundations, and research and academic institutions."

RBM Targets

- **By 2010, through targeting universal coverage:**

– 80% of people at risk from malaria are using locally appropriate vector control methods such as long-lasting insecticidal nets (LLINs), indoor residual spraying (IRS) and, in some settings, other environmental and biological measures;

– 80% of malaria patients are diagnosed and treated with effective anti-malarial treatments;

– in areas of high transmission, 100% of pregnant women receive intermittent preventive treatment (IPTp); and

– the global malaria burden is reduced by 50% from 2000 levels to less than 175-250 million cases and 500,000 deaths annually from malaria.

III. (US) President's Emergency Fund for AIDS Relief (PEPFAR)

Started in 2003 (under Bush).

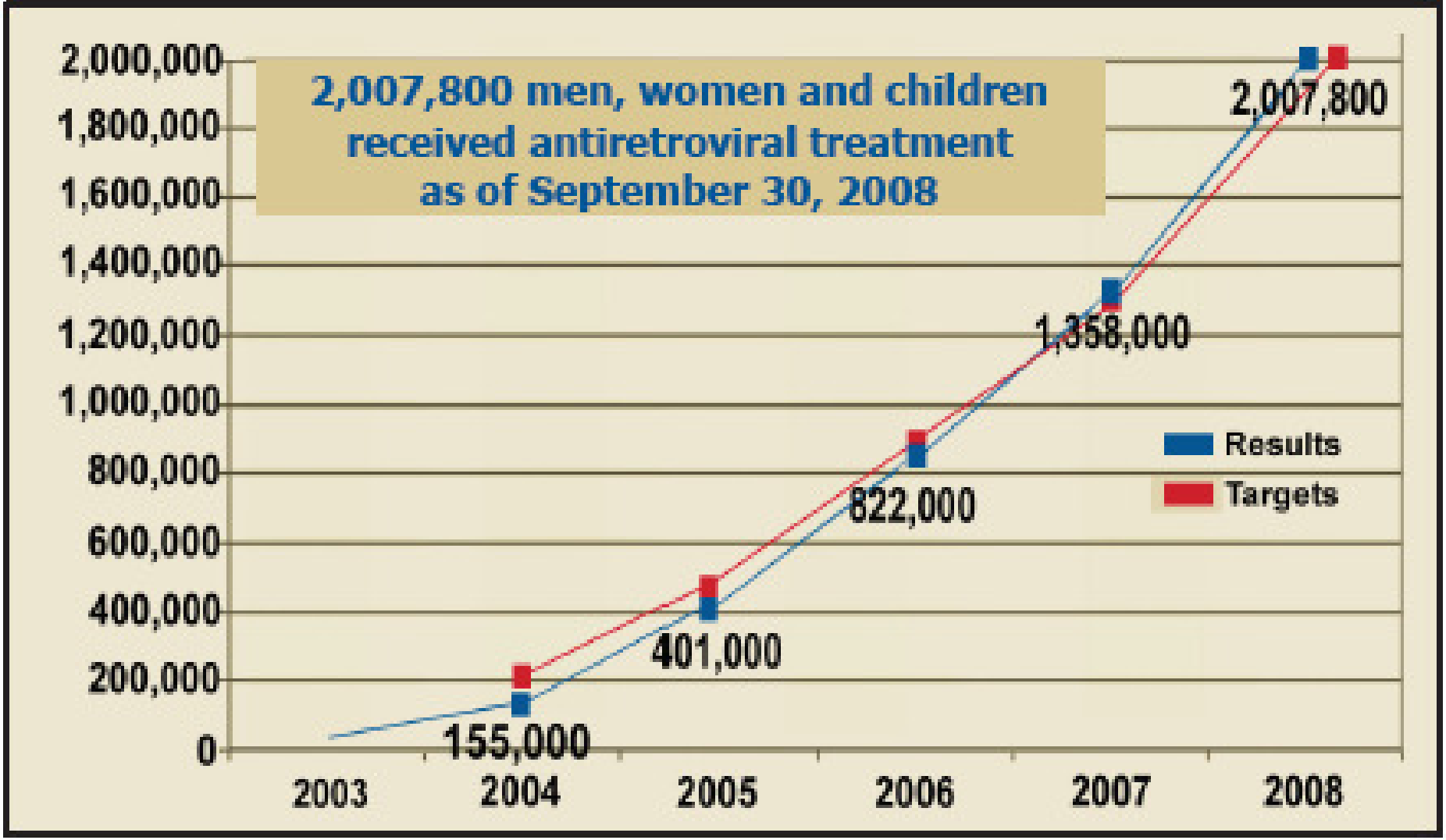
Progress so far:

✓Supported life-saving treatment for **more than 2.1 million men, women and children worldwide through September 30, 2008, including more than 2 million in 15 focus countries.**

✓Treatment support is estimated to save **nearly 3.28 million adult years of life through the end of September 2009.**

✓Increased the share of those receiving PEPFAR-supported treatment who are children from 3 percent in fiscal year (FY) 2004 to **8 percent in FY2008.** http://www.pepfar.gov/

Number of Individuals Receiving Antiretroviral Treatment in PEPFAR's 15 Focus Countries



http://www.pepfar.gov/documents/organization/115411.pdf