



Emerging Infectious Diseases and Global Health

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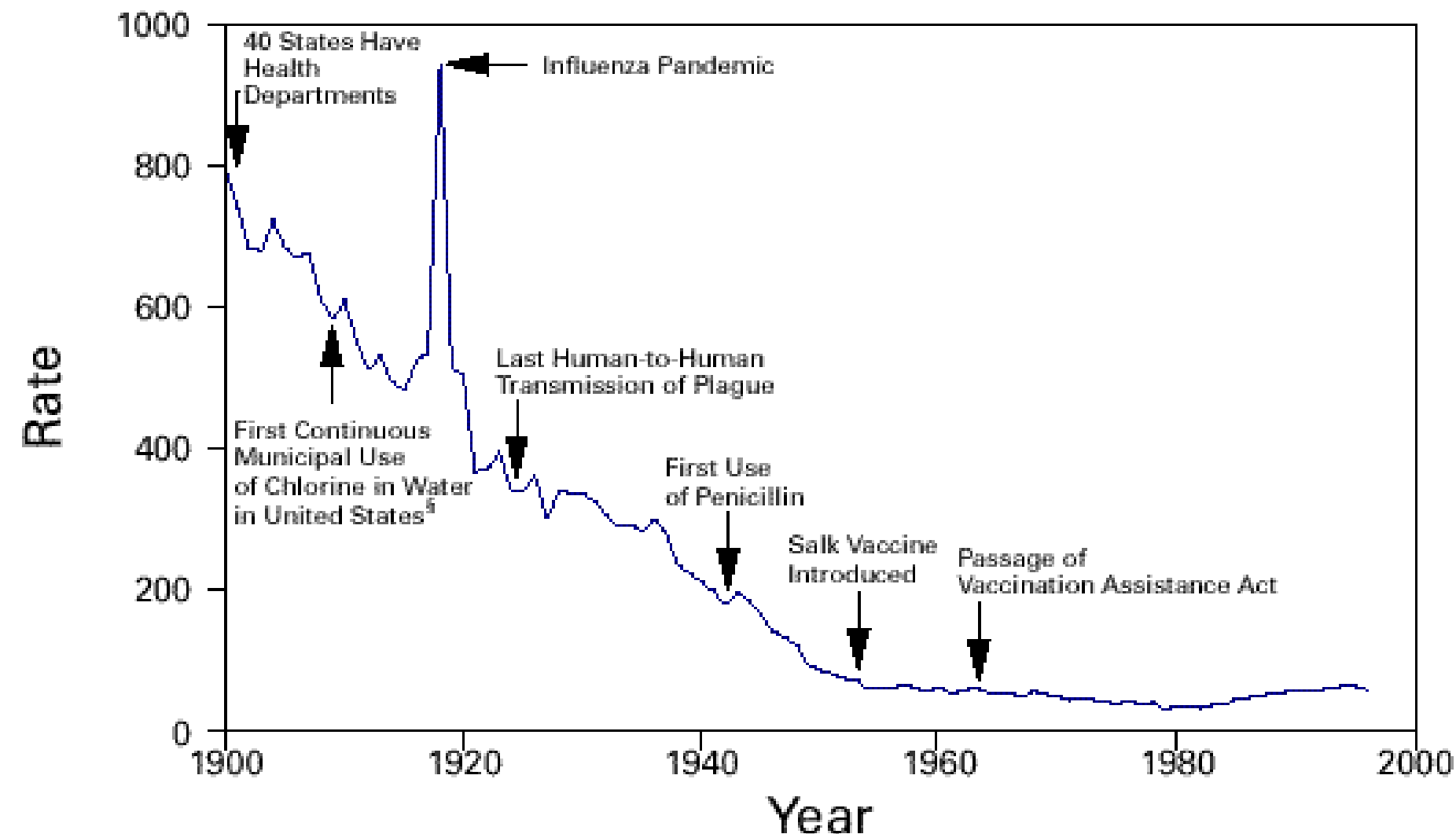
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Improving health and reducing disease worldwide

Outline

- Global burden of infectious diseases
- Meta-trends underlying emerging and re-emerging infectious diseases
- Some examples
 - HIV
 - Tuberculosis
 - Chikungunya virus infection
- Lessons of history

FIGURE 1. Crude death rate* for infectious diseases — United States, 1900–1996†



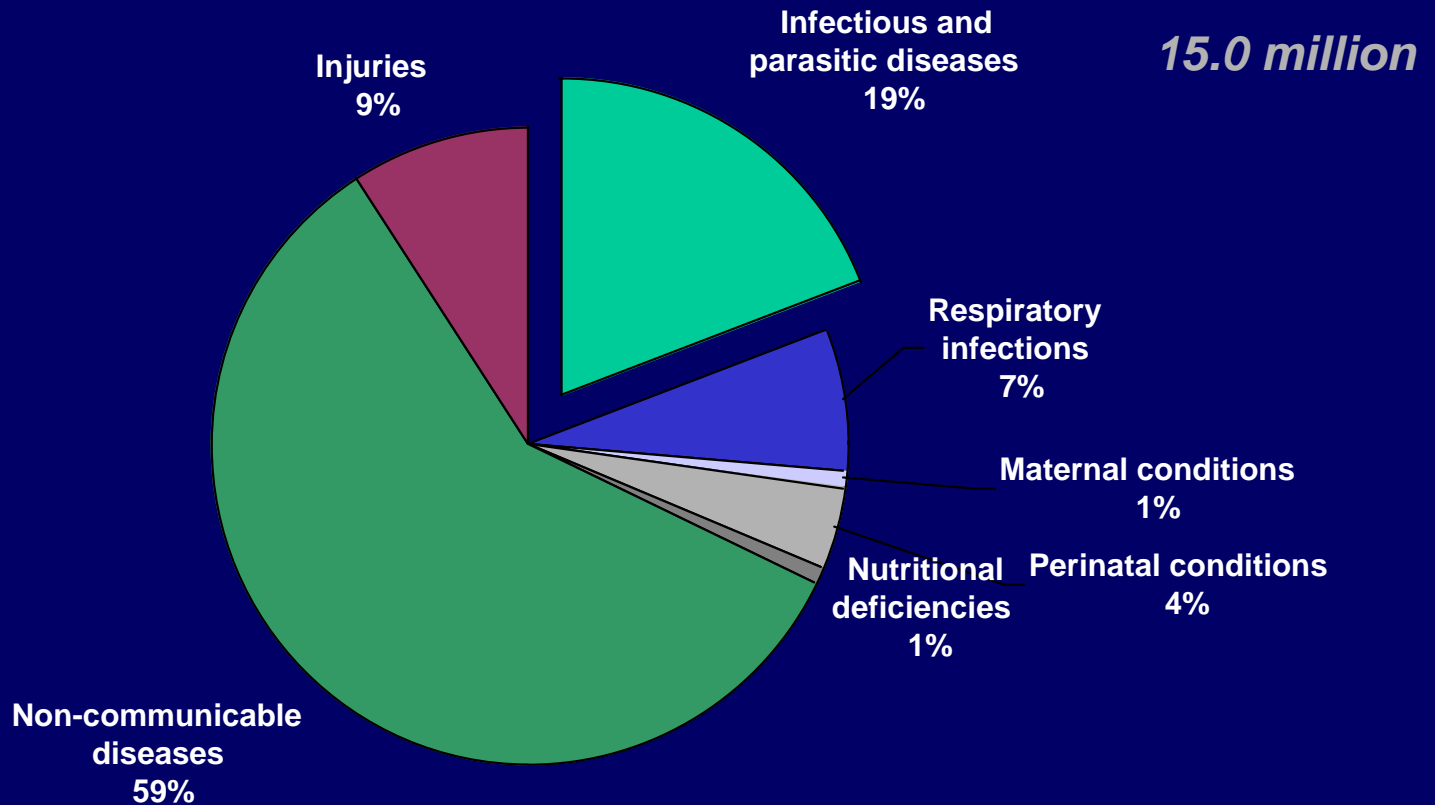
*Per 100,000 population per year.

†Adapted from Armstrong GL, Conn LA, Pinner RW. Trends in infectious disease mortality in the United States during the 20th century. *JAMA* 1999;281:61–6.

§American Water Works Association. Water chlorination principles and practices: AWWA manual M20. Denver, Colorado: American Water Works Association, 1973.

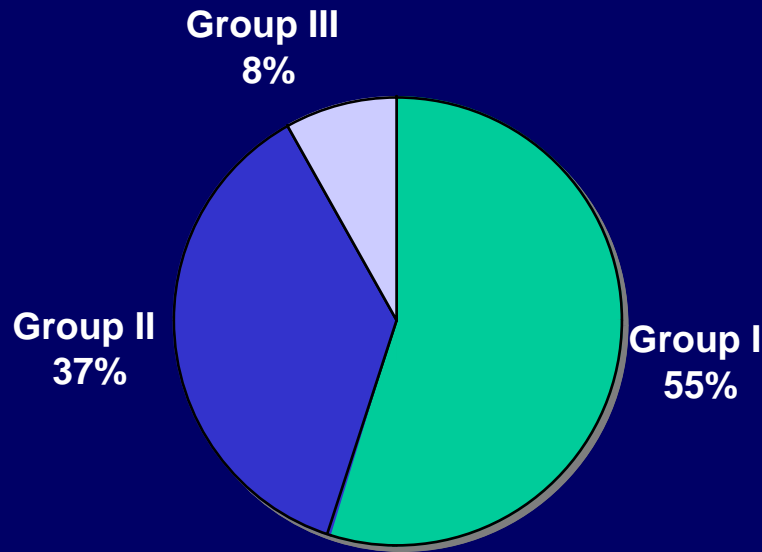
Leading causes of death worldwide

57.1 million deaths from all causes worldwide in 2002

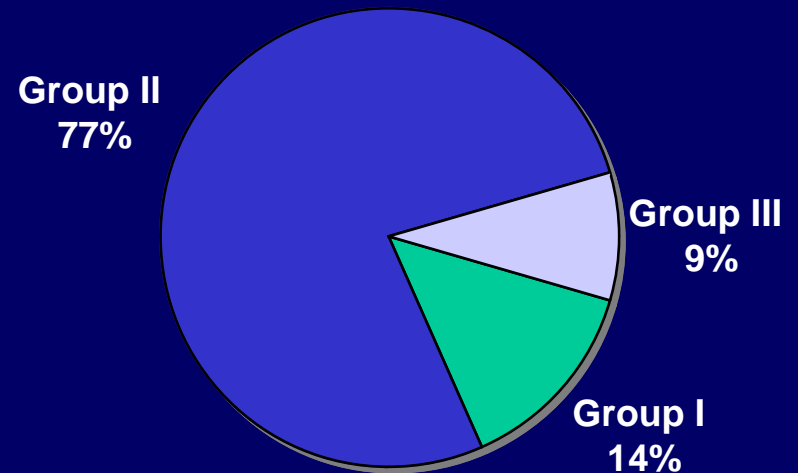


In low-income countries, 45% of all deaths are from infectious diseases

Deaths by country income category and disease group, 2004



Low- and middle-income countries



High-income countries

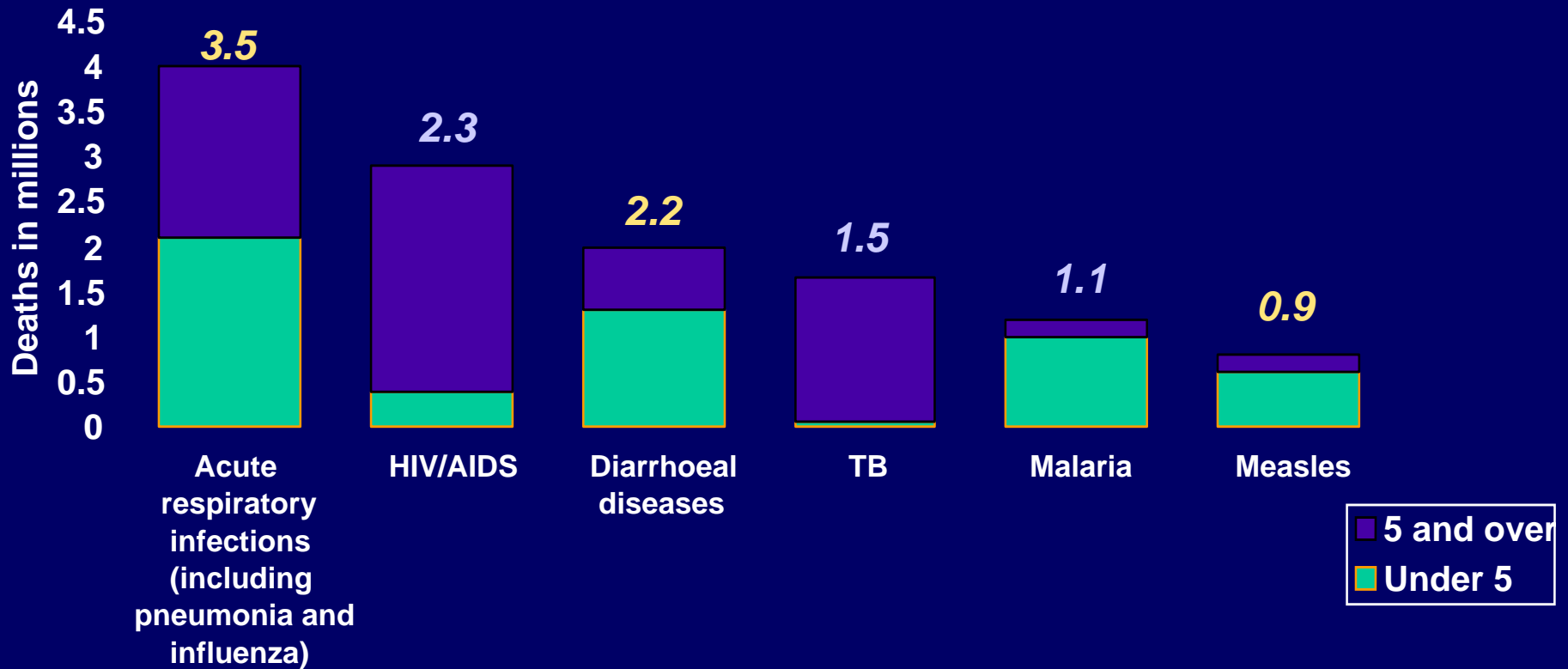
Group I: infectious and parasitic diseases, respiratory infections, maternal conditions, perinatal conditions and nutritional deficiencies; Group II: non-communicable diseases (including psychiatric diseases); Group III: injuries

Leading causes infectious disease deaths worldwide

14,989,900 deaths worldwide in 2002

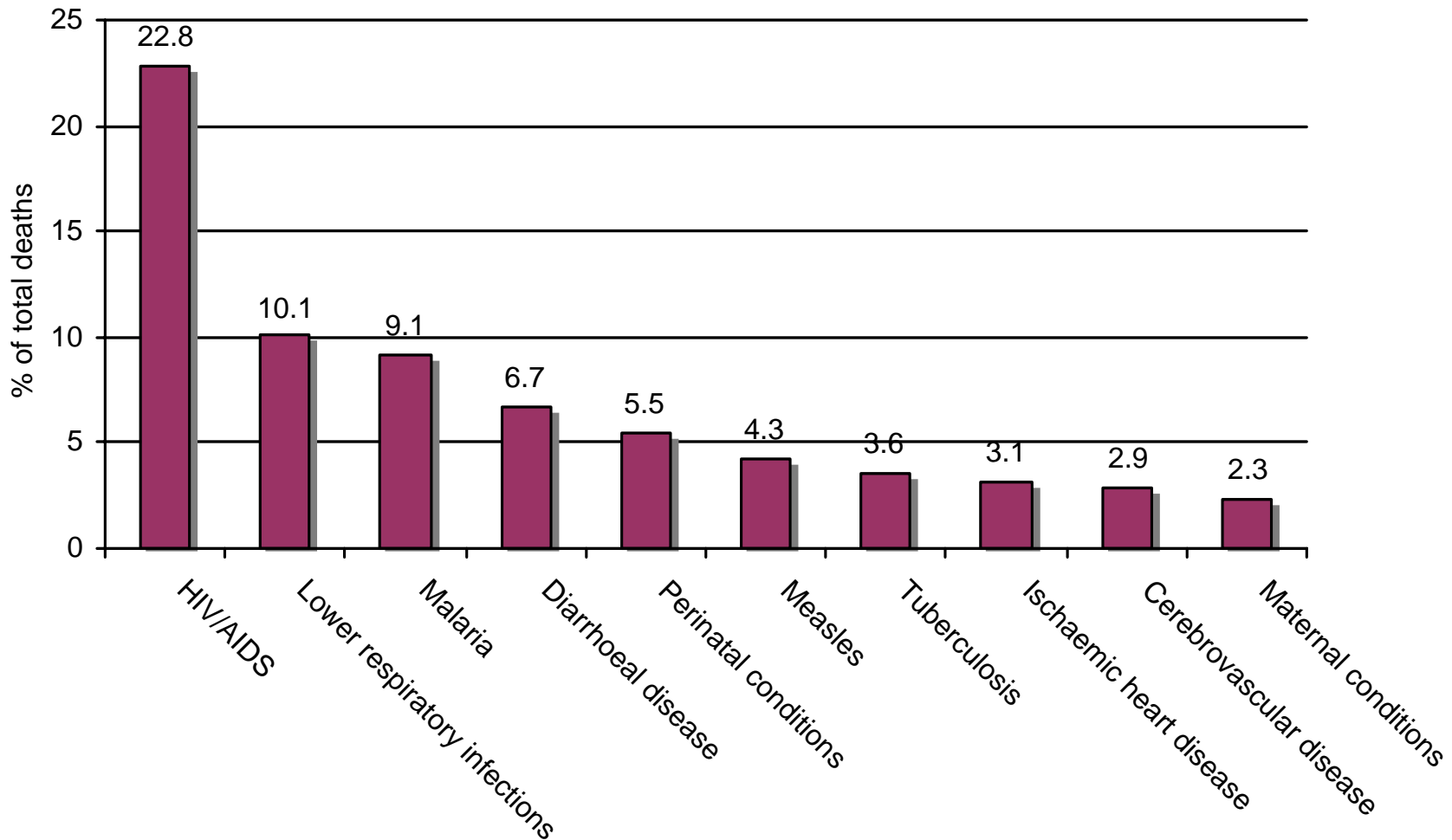
<i>Disease group</i>	<i>Death (thousands)</i>	<i>Percentage</i>
Lower respiratory tract infections	3,939.1	26%
HIV/AIDS	2,917.1	20%
Diarrhoeal disease	1,868.3	13%
Tuberculosis	1,564.8	10%
Childhood cluster diseases	1,120.3	8%
Malaria	910.7	6%
STDs excluding HIV	179.5	1%
Meningitis	172.8	1%
Tropical cluster diseases	157.8	1%
Hepatitis B and C	156.4	1%
Other	2,003.1	13%

Leading causes of infectious disease deaths by age group, 2001



These six diseases cause 86% of infectious disease mortality in the World

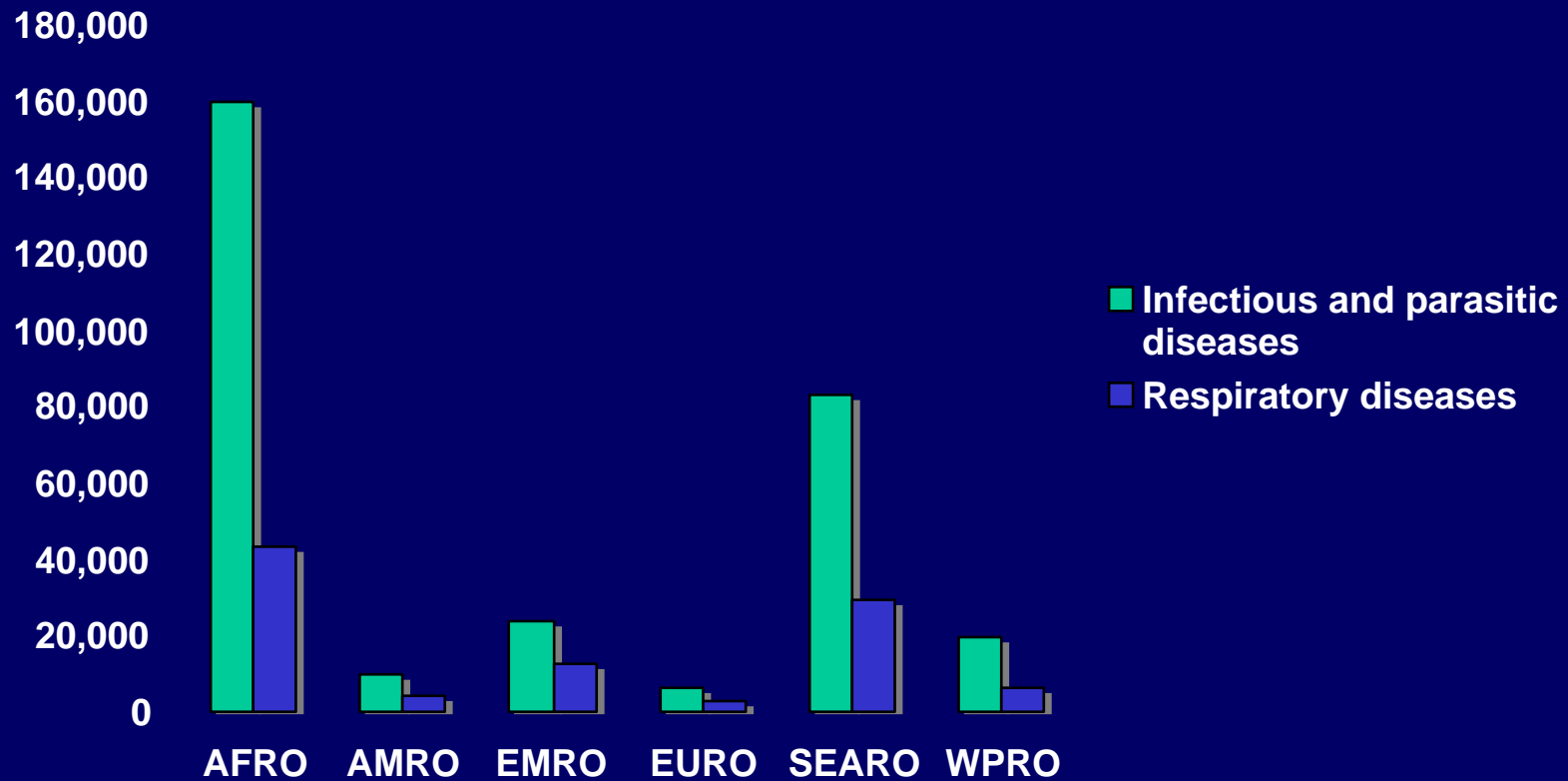
Leading causes of death in Africa, 2000



10 leading causes of global burden of disease, DALYs in millions, 2004

Rank	Cause	DALYs in millions	% of total DALYs
1	Perinatal conditions	126.4	8.3%
2	<i>Lower respiratory tract infections</i>	94.5	6.2%
3	<i>Diarrheal diseases</i>	72.3	4.8%
4	Unipolar depressive illness	65.5	4.3%
5	Ischemic heart disease	62.6	4.1%
6	<i>HIV/AIDS</i>	58.5	3.8%
7	Cerebrovascular disease	46.6	3.1%
8	Road traffic accidents	41.2	2.7%
9	<i>Tuberculosis</i>	34.2	2.2%
10	<i>Malaria</i>	34.0	2.2%

Infectious and parasitic disease and respiratory infection DALYs by region, 2002



What are the infectious diseases of global public health significance

- HIV
- Malaria
- Tuberculosis
- Acute respiratory infections (also called lower respiratory tract infections)
- Diarrhoeal diseases
- Vaccine-preventable diseases
- Neglected tropical diseases
- Epidemic-prone diseases

Infectious diseases of global public health significance

- Acute respiratory infections
 - *S. pneumoniae*
 - *Haemophilus influenzae b*
 - Influenza virus
 - Measles
 - Parainfluenza virus
 - RSV
 - SARS
- Diarrhoeal diseases
 - Coronavirus
 - Rotavirus
 - Parvovirus
 - Shigellosis
 - Cholera
 - Typhoid

Infectious diseases of global public health significance: Vaccine-preventable diseases

- *BCG*
- *Diphtheria*
- Hepatitis A
- *Hepatitis B*
- Hib
- HPV
- Influenza
- Japanese encephalitis
- *Measles*
- *Neisseria meningitidis*
- Mumps
- *Pertussis*
- *Poliovirus*
- Rabies
- Rotavirus
- Rubella
- *S. pneumoniae*
- *Tetanus*
- Typhoid
- Varicella
- *Yellow fever*

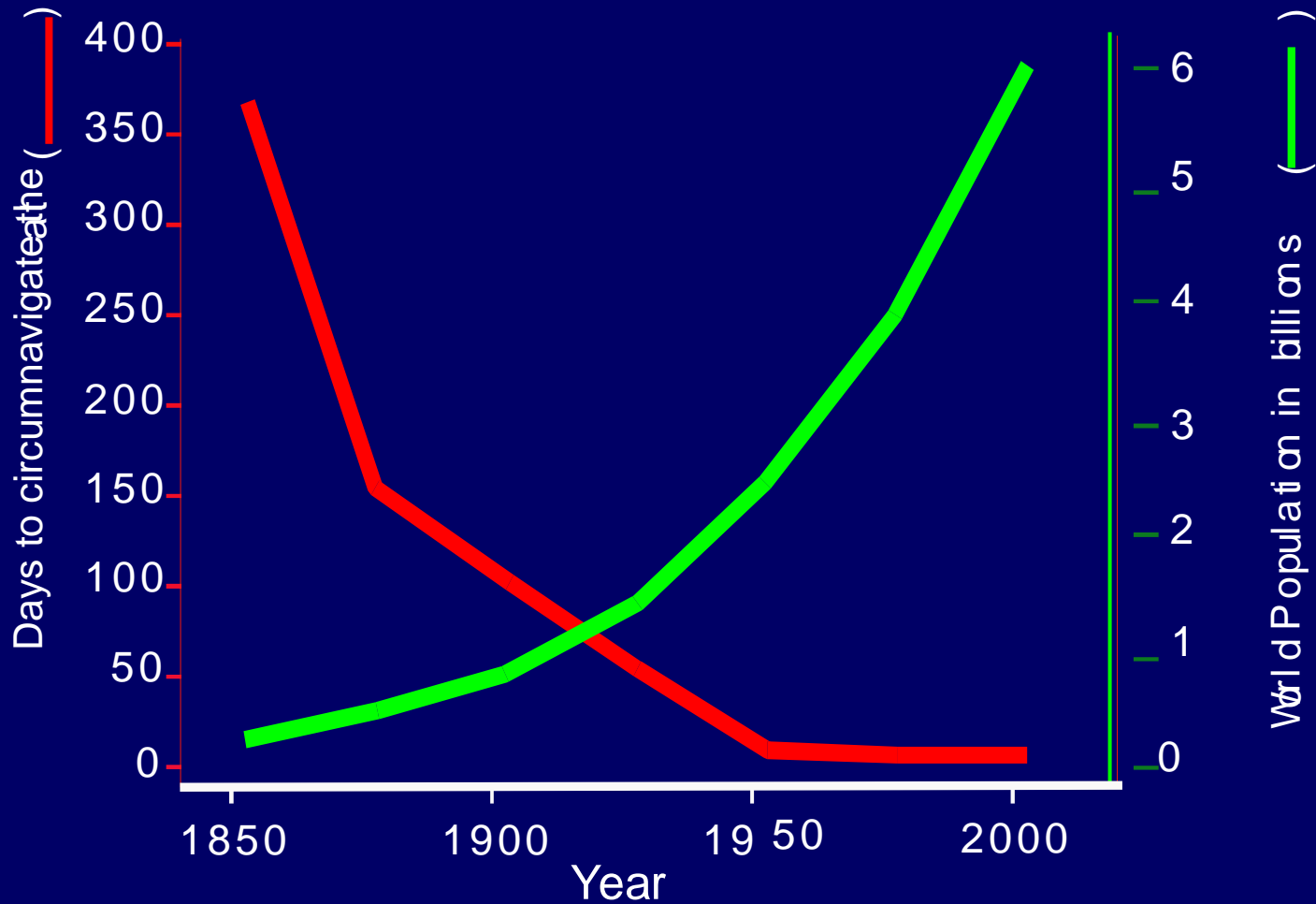
Infectious diseases of global public health significance: Neglected tropical diseases

- Buruli ulcer
- Chaga's disease
- Cholera/epidemic diarrhoea
- Dengue/dengue haemorrhagic fever
- Dracunculiasis
- Endemic trepanematoses
- African trypanosomiasis
- Leishmaniasis
- Leprosy
- Lymphatic filariasis
- Onchocerciasis
- Schistosomiasis
- Soil-transmitted helminths
- Trachoma

Why do epidemics emerge?

- Global travel
- Globalization of food supply and central processing of food
- Population growth and increased urbanization and crowding
 - Increased crowding with domestic animals
- Population movements due to civil wars, famines, and other man-made or natural disasters
- Irrigation, deforestation, and reforestation projects that alter the habitats of disease-carrying insects and animals

Speed of global travel in relation to world population growth



From: Murphy and Nathanson Sems. Virol. 5, 87, 1994

Why do epidemics emerge?

- Human behaviors, such as intravenous drug use and risky sexual behavior
- Increased use of antimicrobial agents and pesticides, hastening the development of resistance
- Increased human contact with tropical rain forests and other wilderness habitats that are reservoirs for insects and animals that harbor unknown infectious agents

But what is really going on?

- Poverty, poverty, poverty
- Human population growth
 - Growth of mega-cities and mega-slums
- Global warming
 - Competition for natural resources (water)
 - Severe weather and natural disasters
- Global economic instability
 - Brain drain
 - Migration
 - War

Millennium developments goals

6. *Combat HIV/AIDS, malaria and other diseases*

Target 7: Have halted by 2015 and begun to reverse the spread of HIV/AIDS

Target 8: Have halted by 2014 and begun to reverse the incidence of malaria and other major diseases

Global summary of the AIDS epidemic, December 2007

Number of people living with HIV in 2007

Total	33 million [30 – 36 million]
Adults	30.8 million [28.2 – 34.0 million]
Women	15.5 million [14.2 – 16.9 million]
Children under 15 years	2.0 million [1.9 – 2.3 million]

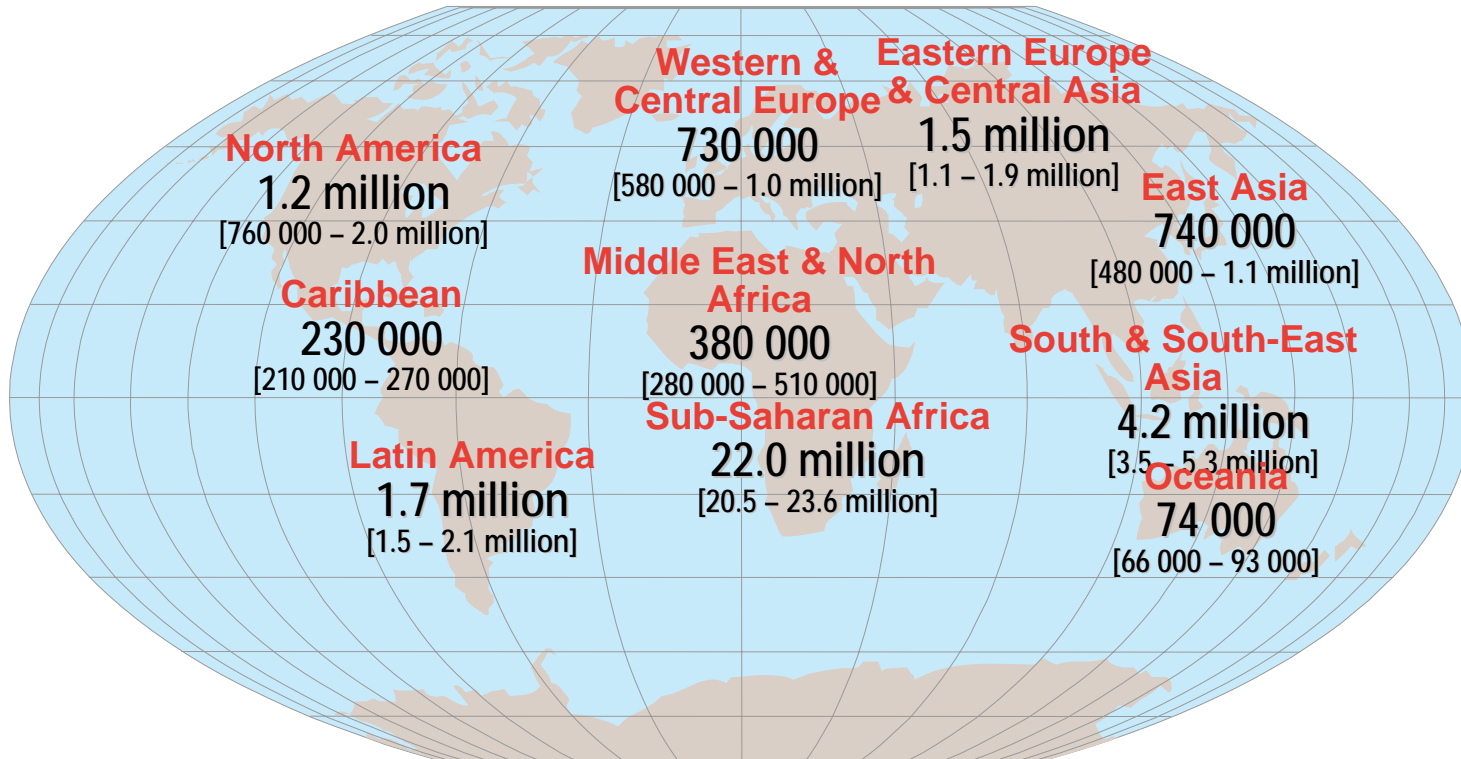
People newly infected with HIV in 2007

Total	2.7 million [2.2 – 3.2 million]
Adults	2.3 million [1.9 – 2.8 million]
Children under 15 years	370 000 [330 000 – 410 000]

AIDS deaths in 2007

Total	2.0 million [1.8 – 2.3 million]
Adults	1.8 million [1.6 – 2.1 million]
Children under 15 years	270 000 [250 000 – 290 000]

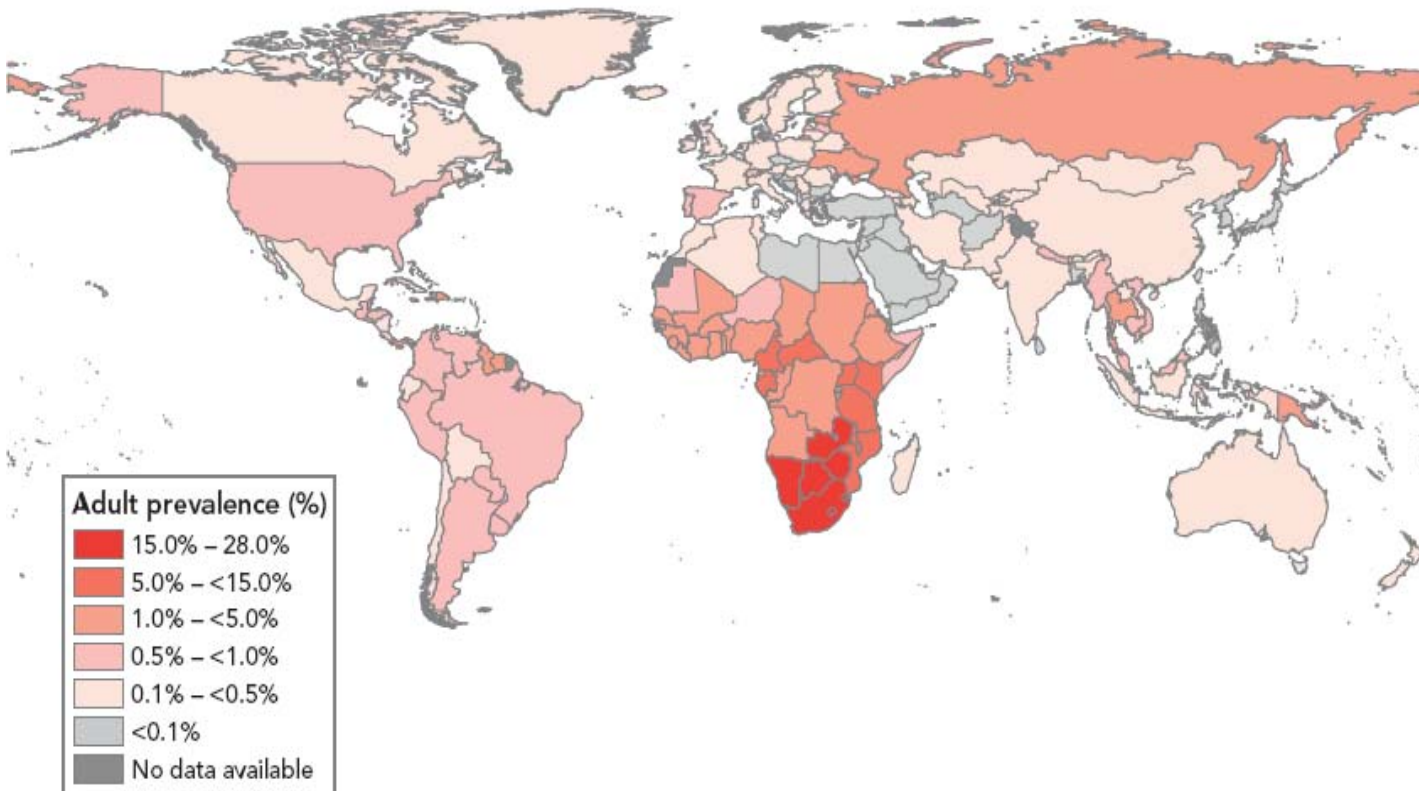
Adults and children estimated to be living with HIV, 2007



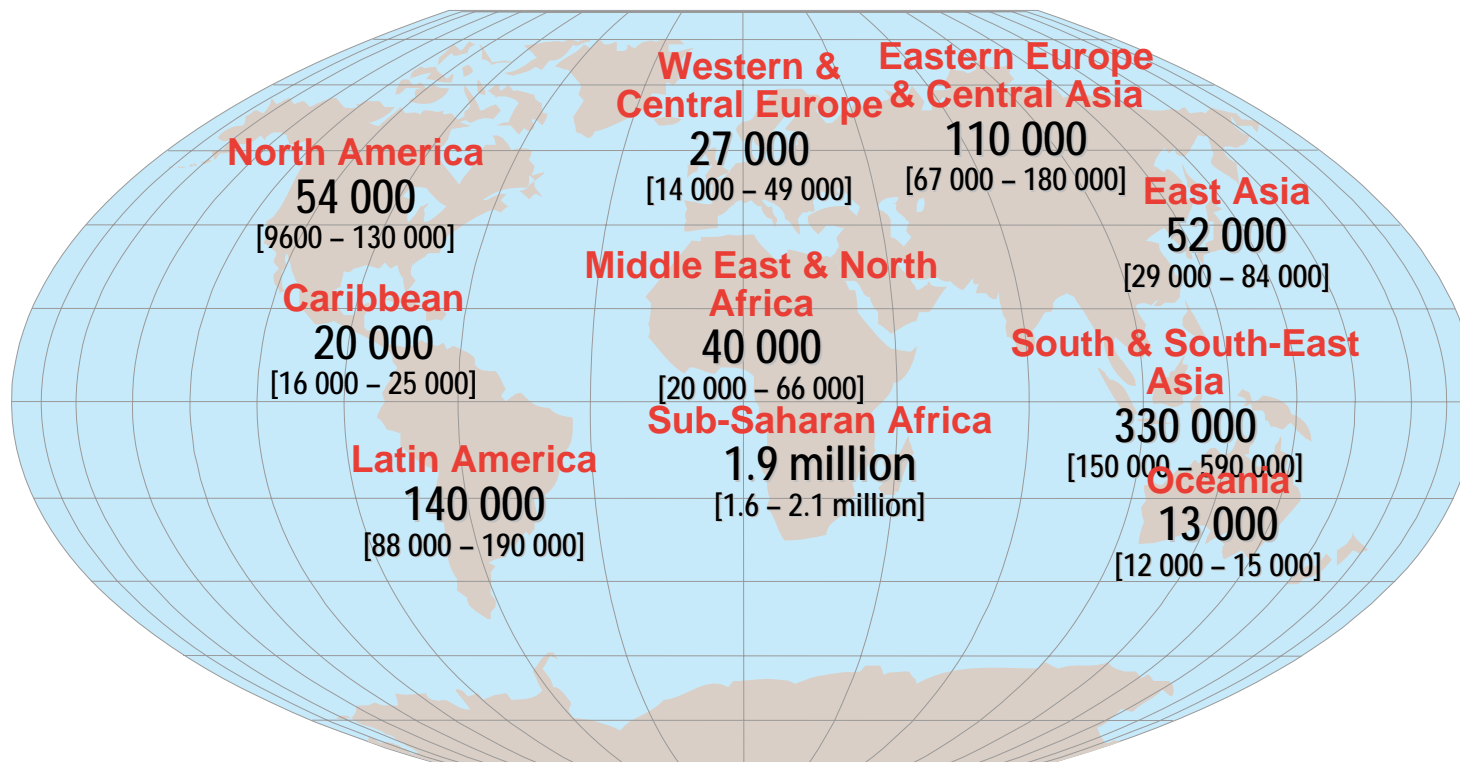
Total: 33 million (30 – 36 million)

A global view of HIV infection

33 million people [30–36 million] living with HIV, 2007



Estimated number of adults and children newly infected with HIV, 2007

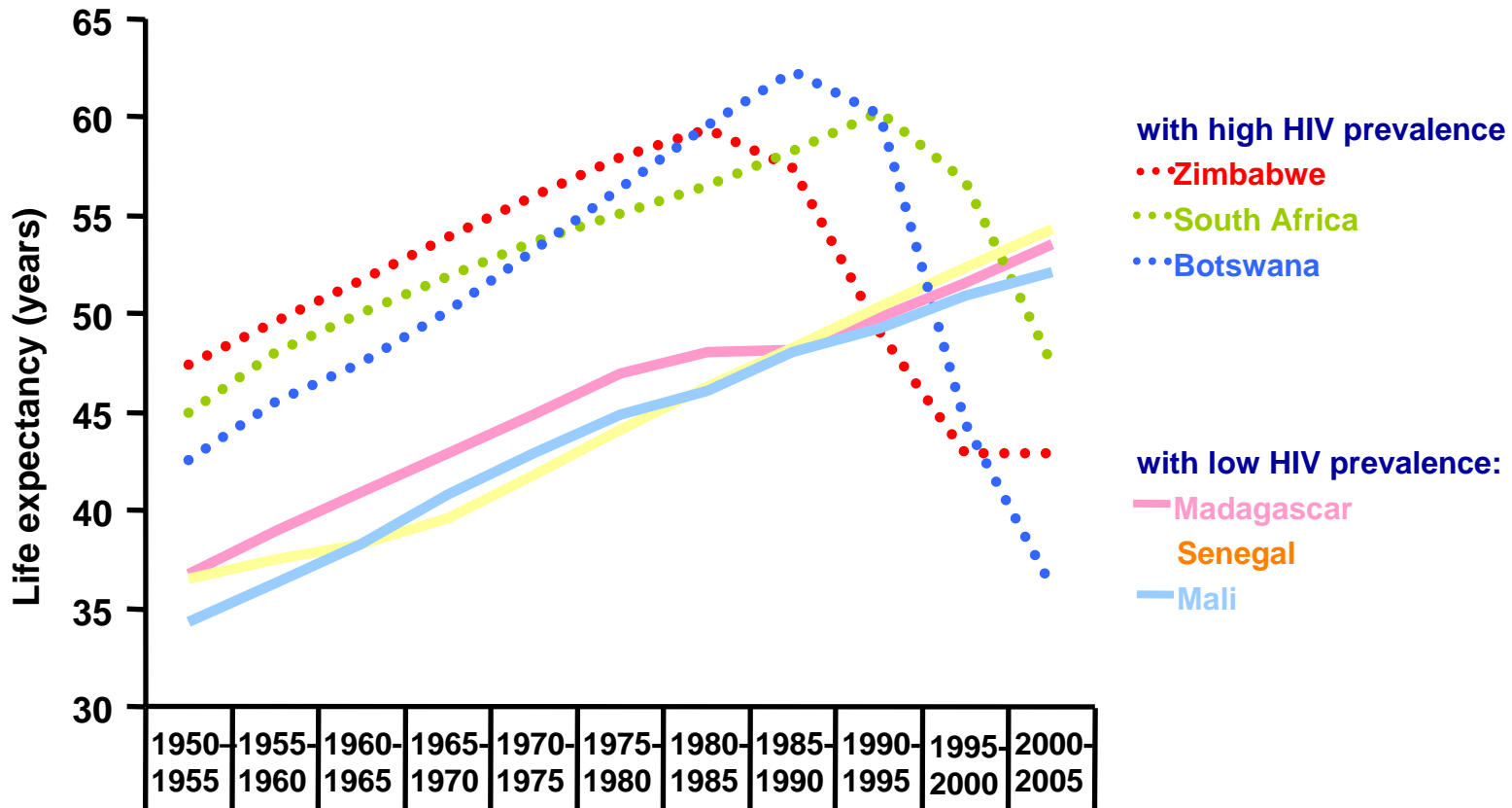


Total: 2.7 million (2.2 – 3.2 million)

Over 7400 new HIV infections a day in 2007

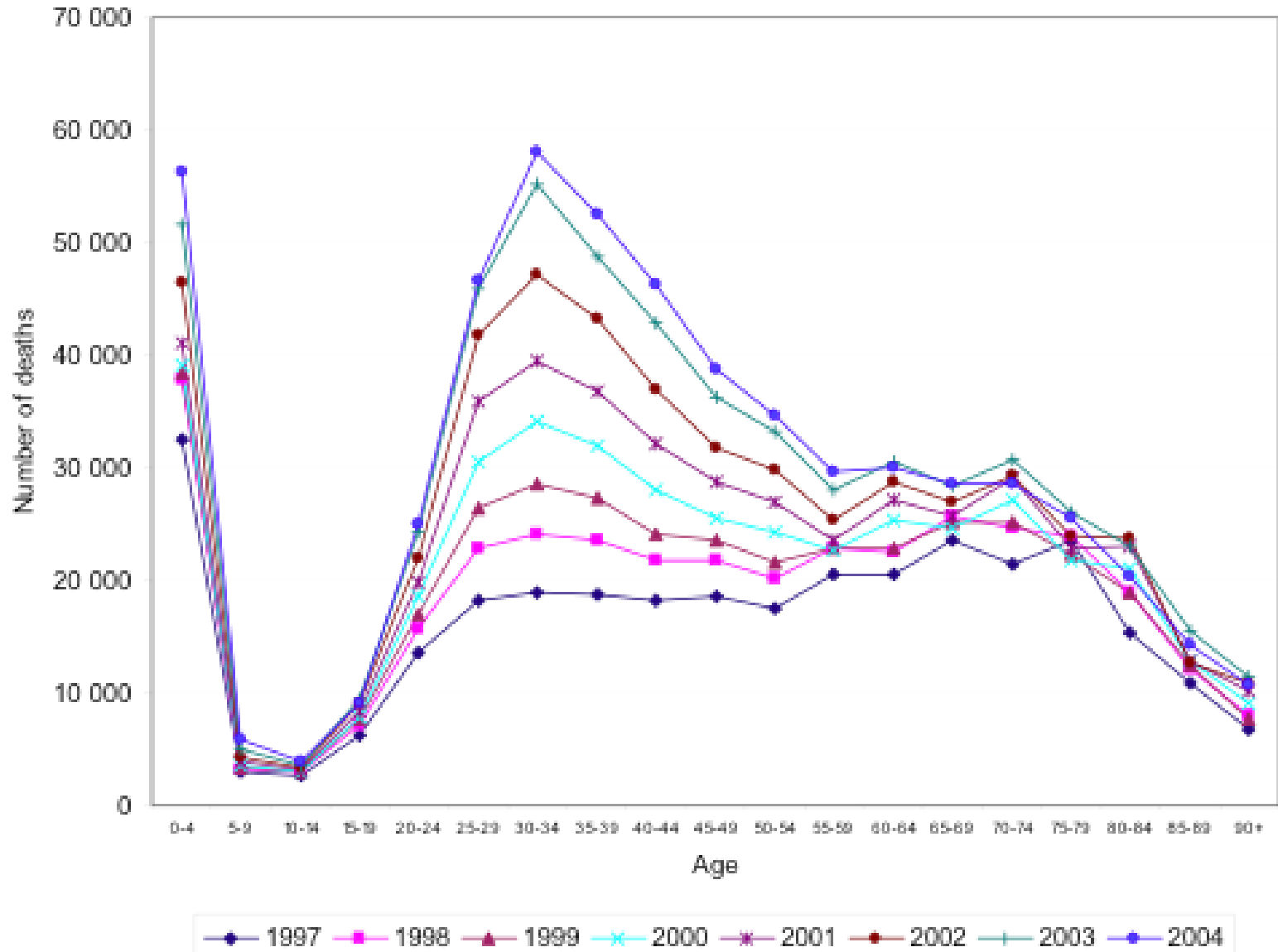
- **More than 96% are in low and middle income countries**
- **About 1000 are in children under 15 years of age**
- **About 6300 are in adults aged 15 years and older of whom:**
 - **almost 50% are among women**
 - **about 45% are among young people (15-24)**

Changes in life expectancy in selected African countries with high and low HIV prevalence: 1950 - 2005

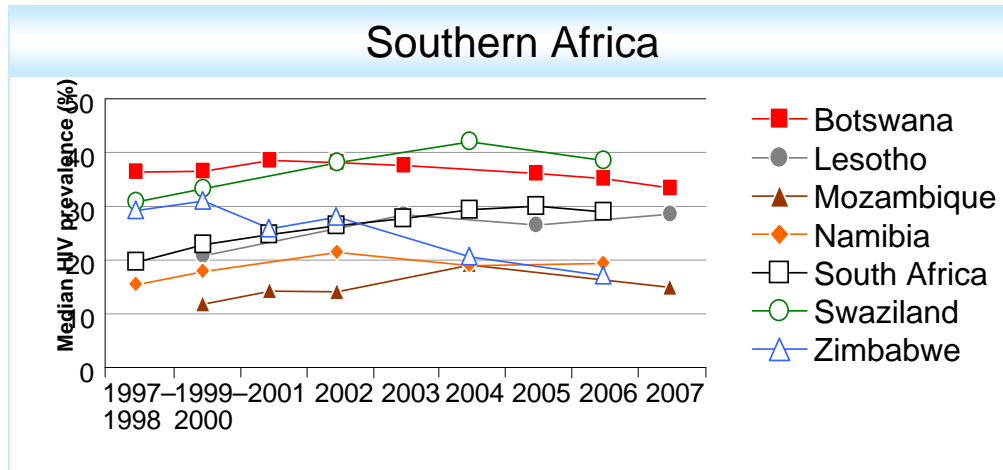


Source: UN Department of Economic and Social Affairs (2001) *World Population Prospects, the 2000 Revision*.

Numbers of deaths by age group and year, South Africa, 1997-2004



HIV prevalence (%) among pregnant women attending antenatal clinics in sub-Saharan Africa, 1997–2007



NOTE: Analysis restricted to consistent surveillance sites for all countries except South Africa (by province) and Swaziland (by region).

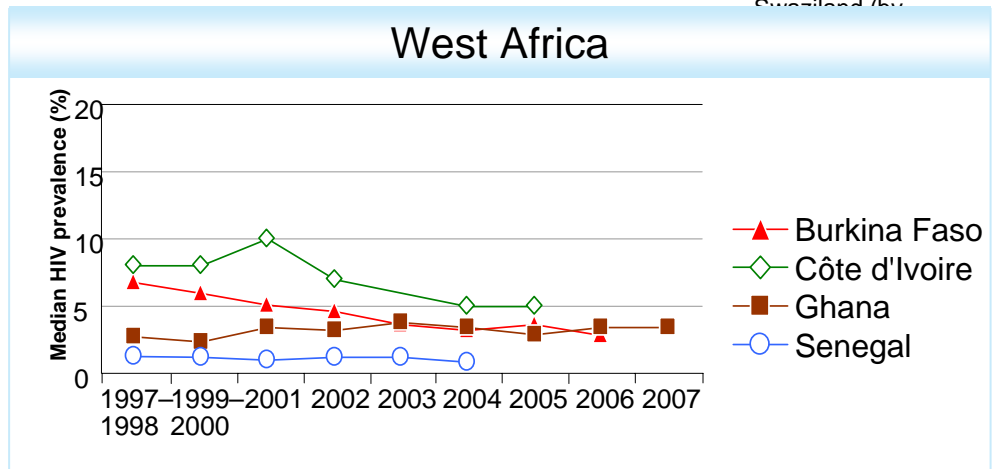
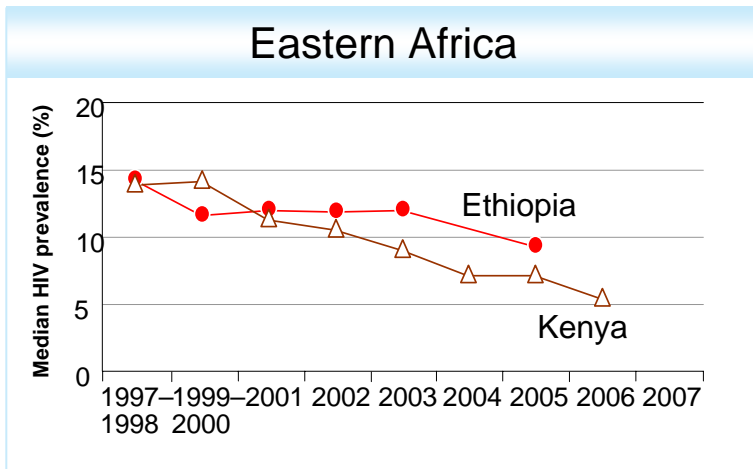


Figure 2.9

Source: National surveillance reports and UNAIDS/WHO/UNICEF, Epidemiological Fact Sheets on HIV and AIDS. July 2008.

Scale up of antiretroviral coverage over time select group of generalized and concentrated epidemic countries, 2004 to 2007

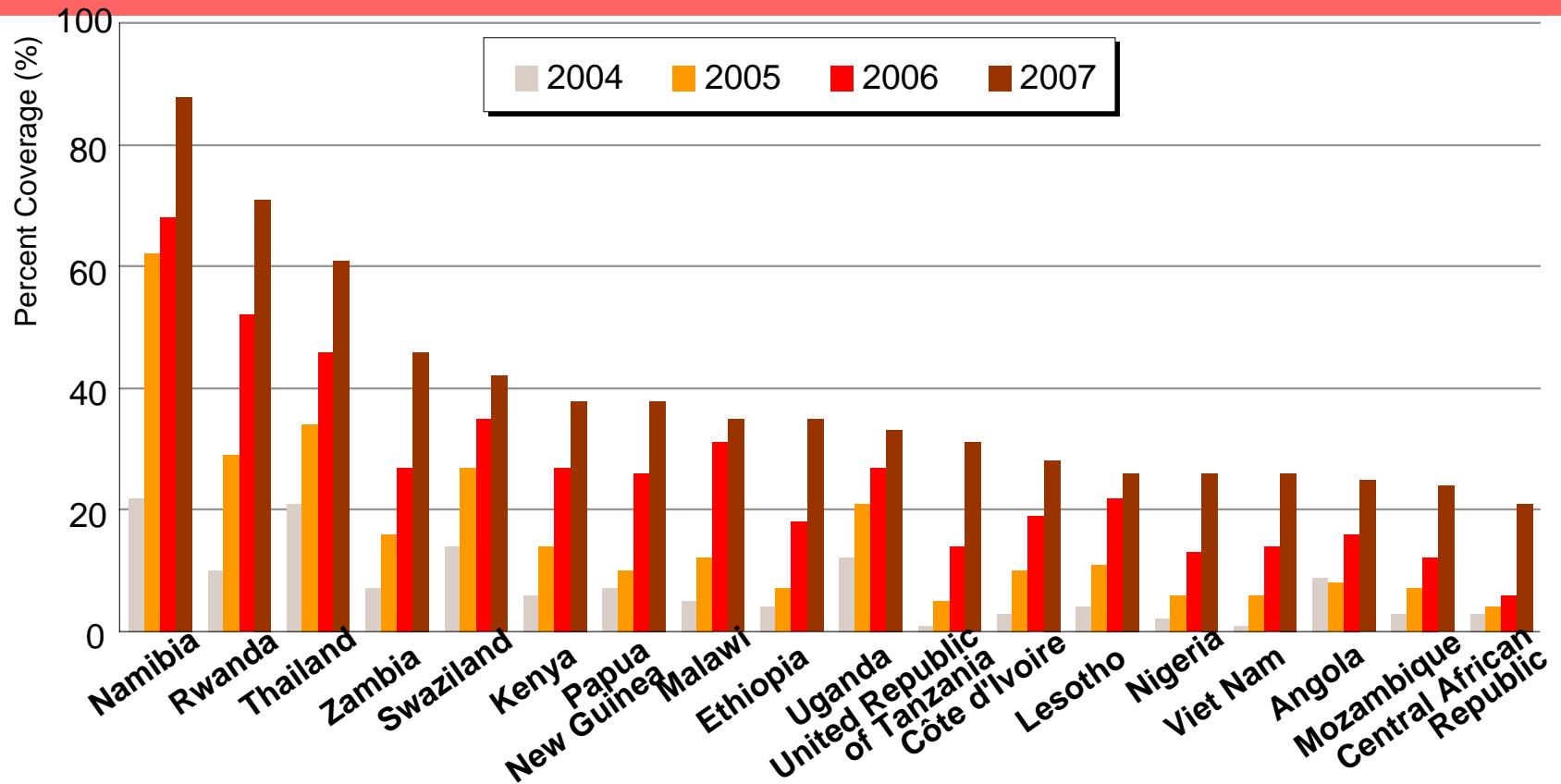
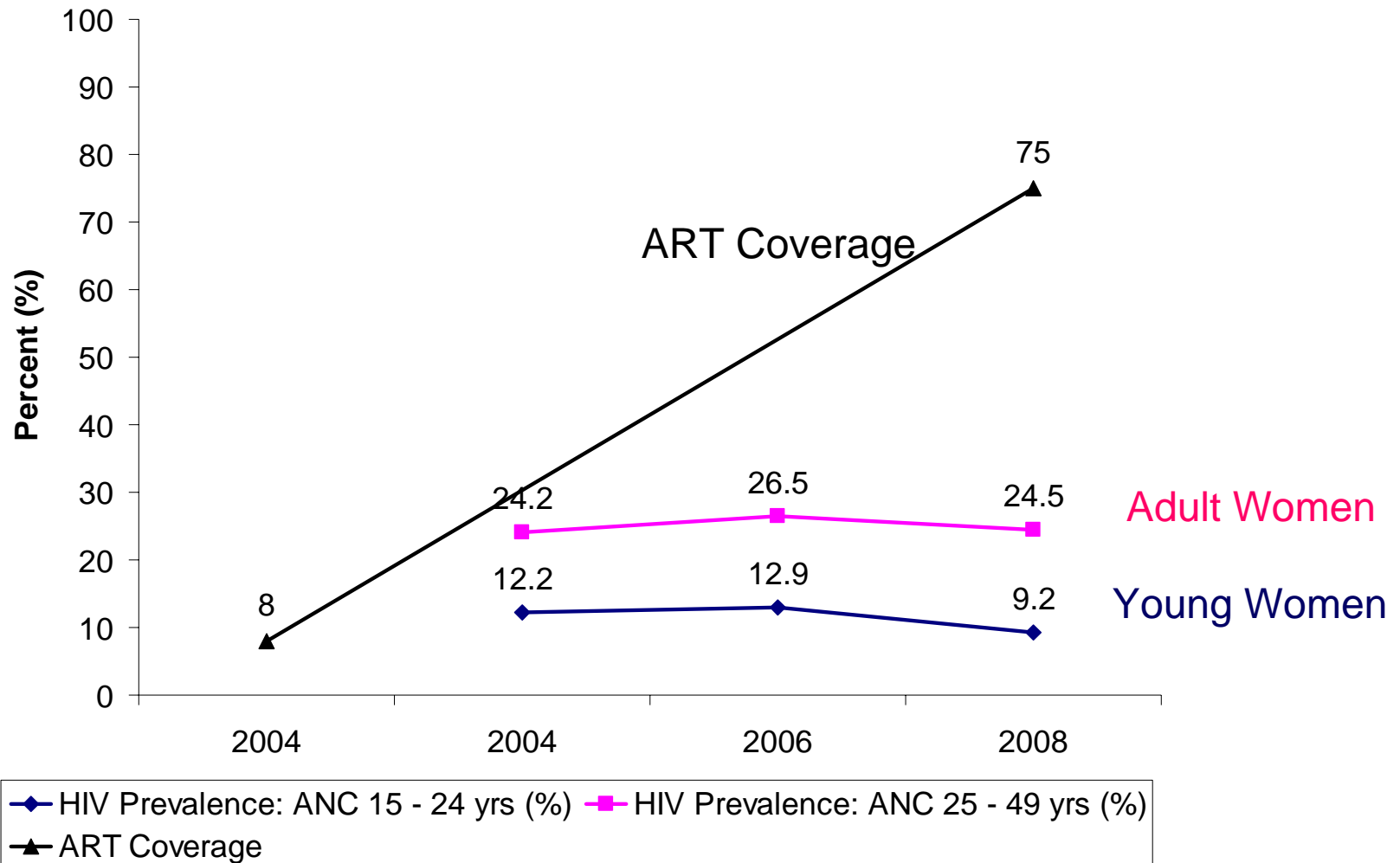


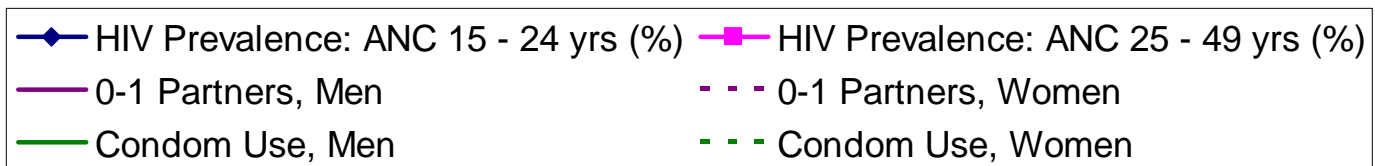
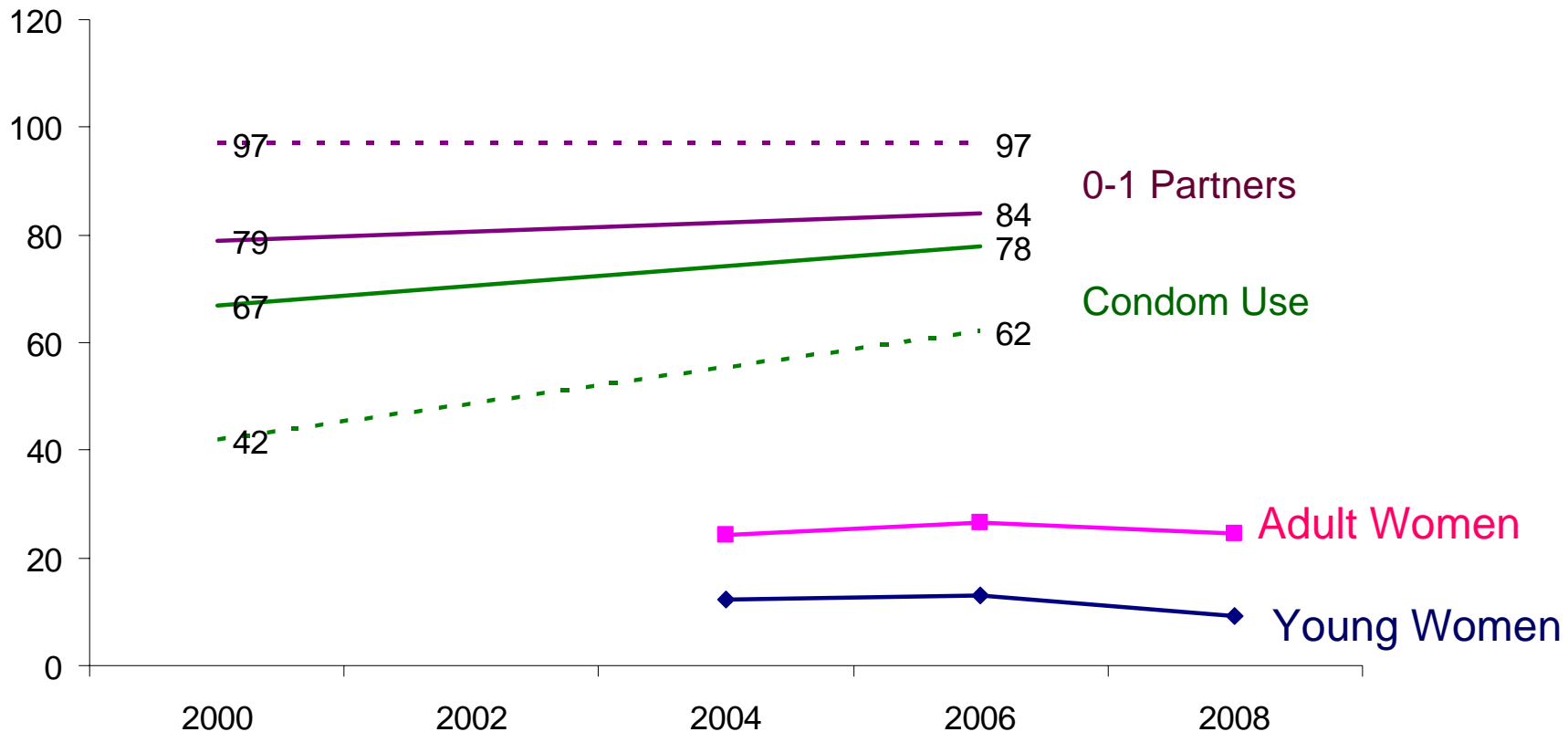
Figure 5.4

Source: UNGASS Country Progress Reports 2008.

Hypothesis 1: Increase in ART coverage between 2004 to 2008 is associated with decline in HIV prevalence among ANC attendees 15-24 years old, Namibia



Hypothesis 2: Increase in condom use and reduction in multiple partners with decline in HIV prevalence among ANC attendees 15-24 years old, Namibia

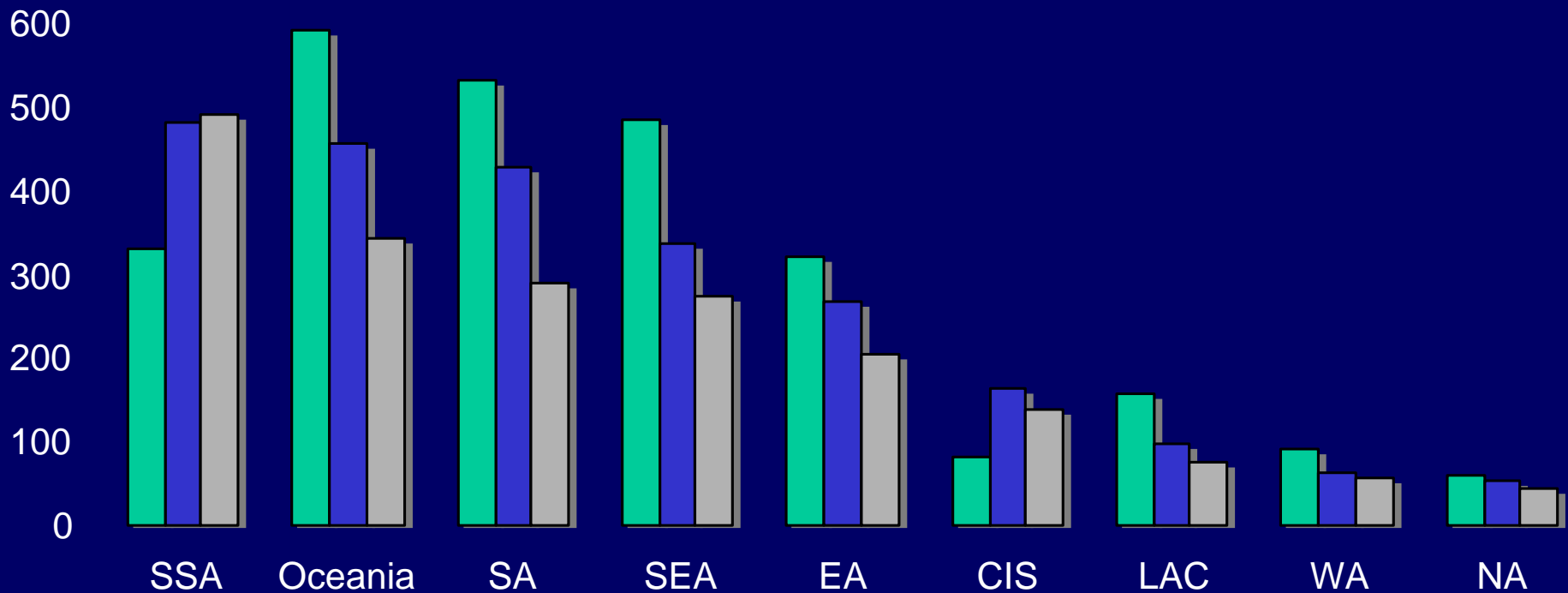


Five clear treatment priorities

- Prevention, prevention, prevention - we can't treat our way out of the epidemic
- Nonetheless, need to:
 - Scale up HIV testing
 - Ensure minimum package of care that includes tuberculosis screening and treatment or preventive therapy, co-trimoxazole prophylaxis and other simple interventions
 - Ensure all patients with WHO stage III or IV disease receive ART as early as possible
 - Strengthen laboratory capacity for CD4+ testing, allowing earlier initiation of therapy based on immunologic criteria
 - Define HIV/AIDS treatment as a global public good requiring the abolition of user fees at point of care

Progress to target 8 by region, 1990-2005

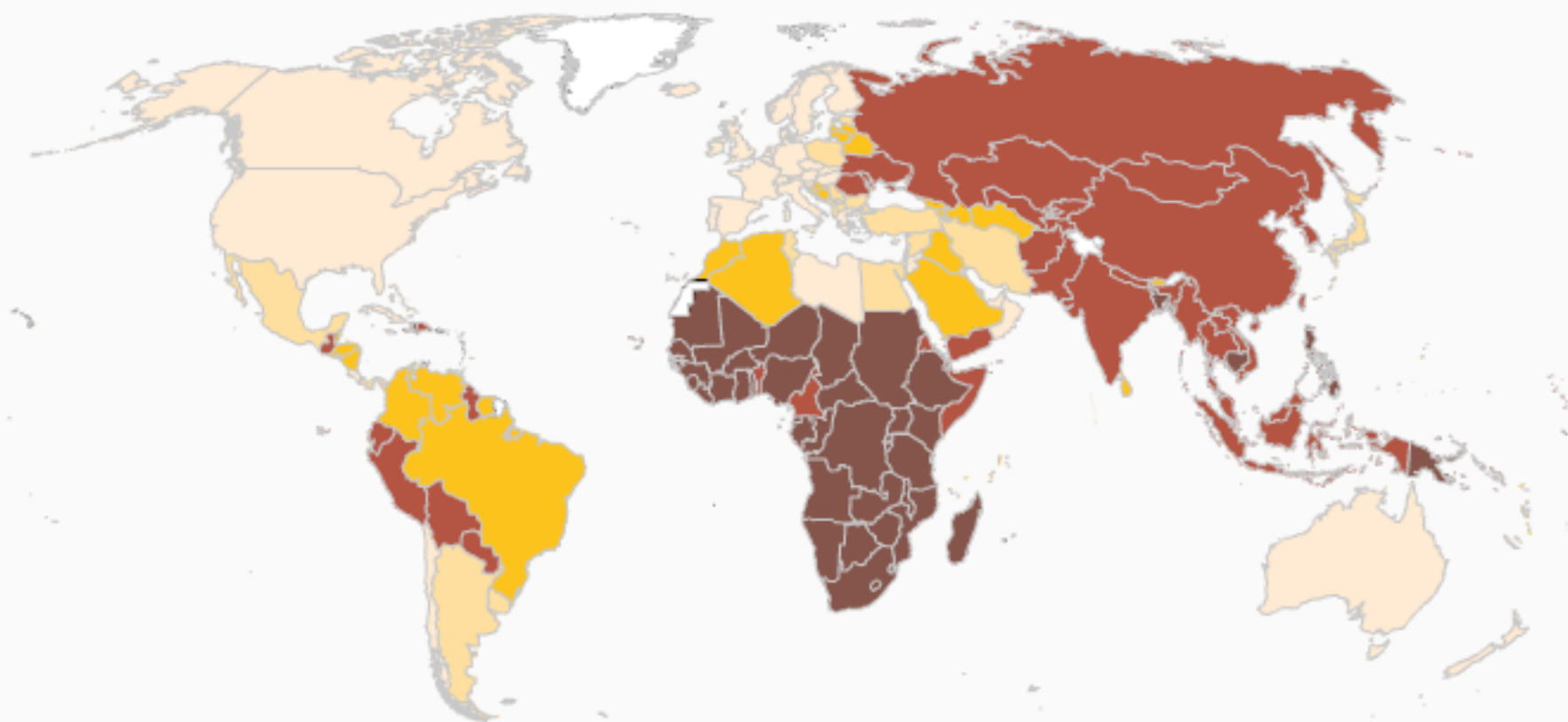
Tuberculosis cases per 100,000 population (excluding HIV/AIDS patients), 1990-2005



SSA, sub-Saharan Africa; SA, South Asia; EA, East Asia; LAC, Latin America and the Caribbean; SEA, Southeast Asia; WA, Western Asia; NA, North Africa; CIS, former Soviet republics

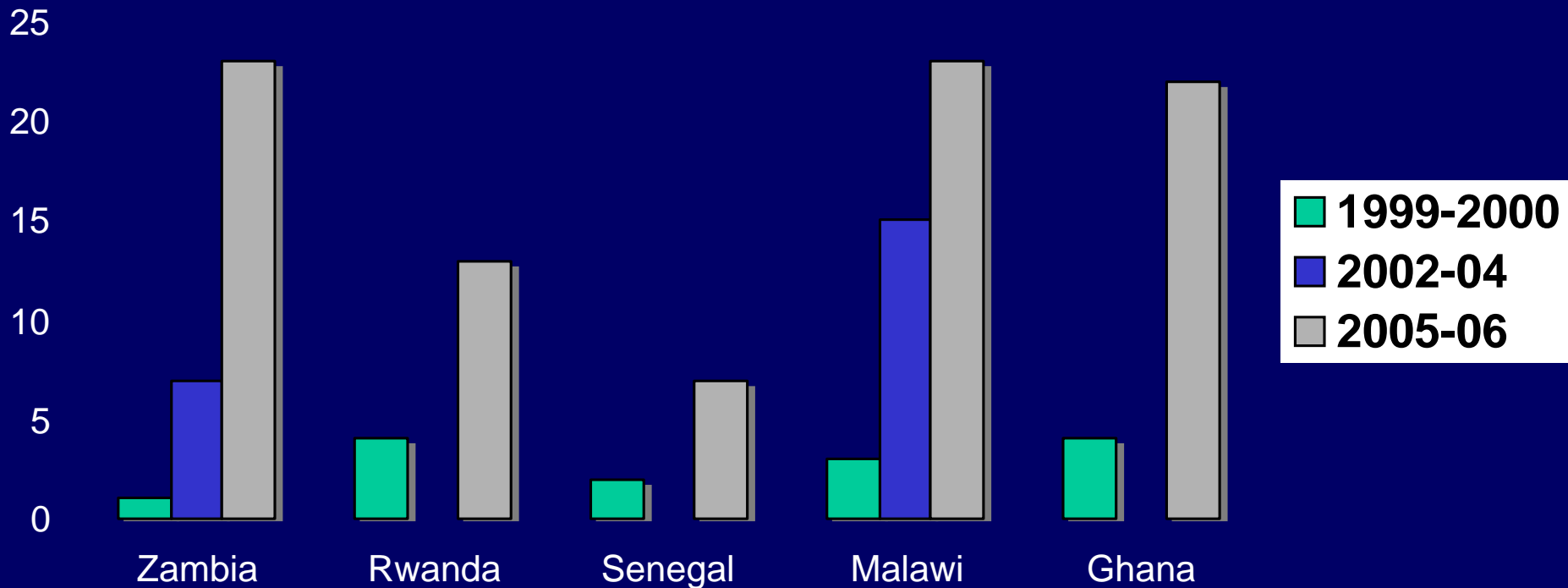
Targets 8 by country, 2006

LEGEND Tuberculosis prevalence rate per 100,000 population



Progress to target 9 by region, 1999-2006

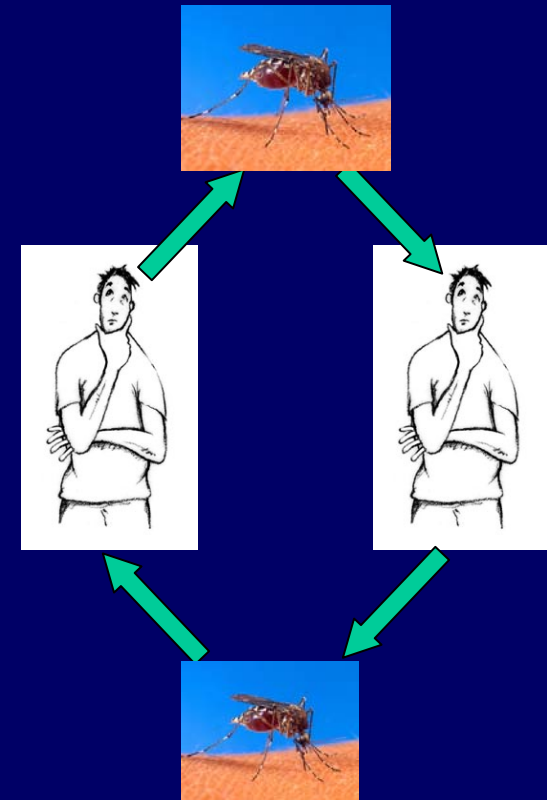
Proportion of children sleeping under insecticide-treated bed nets in selected countries, 1999-2006



Chikungunya virus

- Family: *Togaviridae*, genus: *Alphavirus* (*Semliki Forest virus Complex*), first isolated in Tanganyika in 1953
- Sylvatic cycle - rainy season
 - *Aedes spp.*, maintenance in wild primates
- Urban cycle - rainy season
 - *Ae. aegypti* and *Ae. albopictus*
- Chikungunya (Makonde): contorted
 - High fever (103-104 F)
 - Maculopapular rash
 - Hemorrhagic, neurologic and cardiac complications rare
 - Severe incapacitating arthritis/arthritis
 - Generalized myalgia and arthralgia
 - Usually acute (12% chronic)
 - Symmetrical and peripheral arthritis
 - Rarely if ever fatal (dengue?)
 - High titer viremia with 1:3 to 1:50 symptomatic:asymptomatic

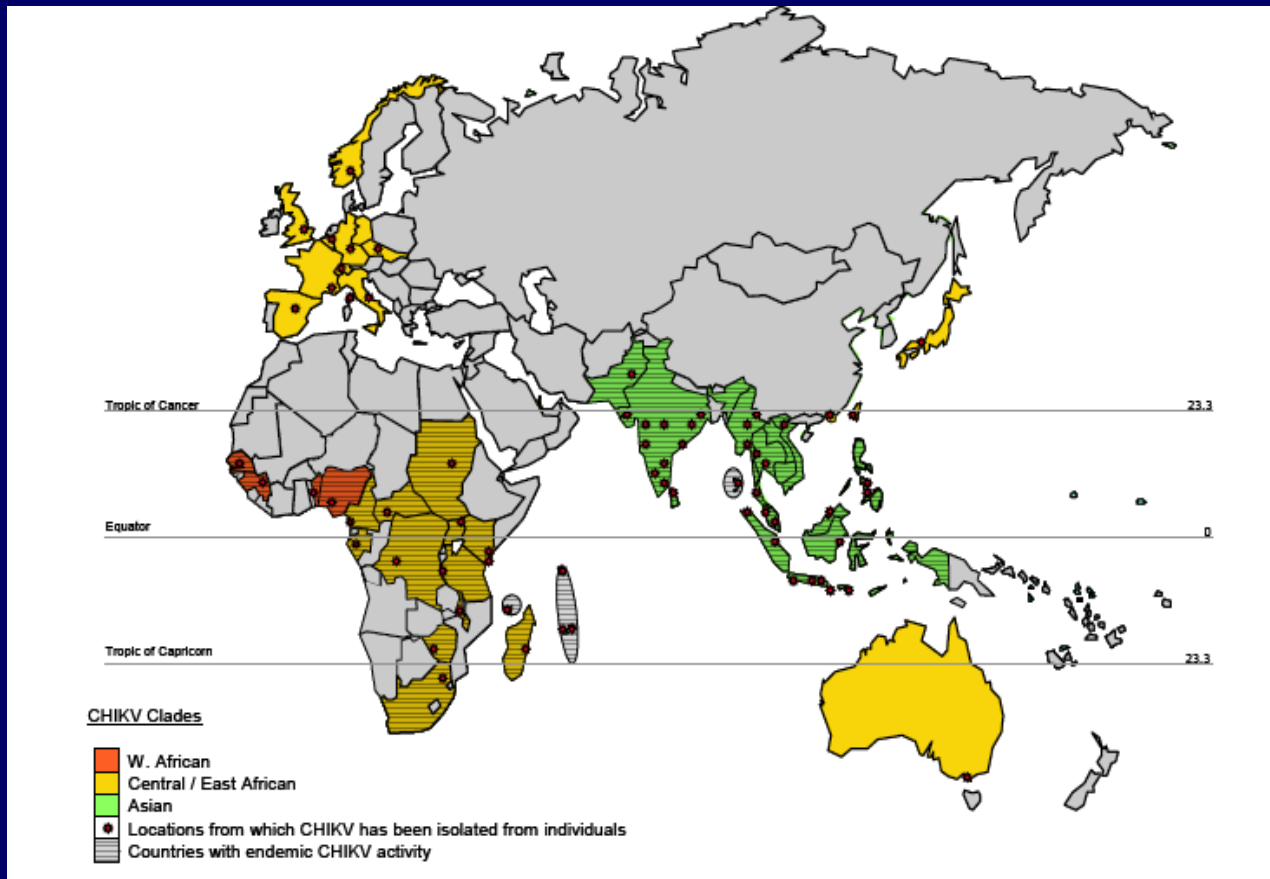
Ae. aegypti, *Ae. albopictus*



Ae. aegypti, *Ae. albopictus*

Urban cycle

Chikungunya geographical distribution



Three distinct CHIKV clades:

- West Africa
- East/Central African
- Asian

In Africa: sylvatic cycle with epizootics every 3-4 years in primates, multiple forest-dwelling insect vectors

In Asia, no known non-human vertebrate hosts, primarily transmitted by *Ae. aegypti*

Chikungunya treatment and prevention

- Supportive care only
- Nursing under mosquito netting or on screened ward to prevent further transmission
- Screening blood and organ donors?
- Prevention:
 - Personal protection by avoiding biting (note Aedes are daytime feeders)
 - Public health protection by vector control -- primarily elimination of habitat
 - Surveillance

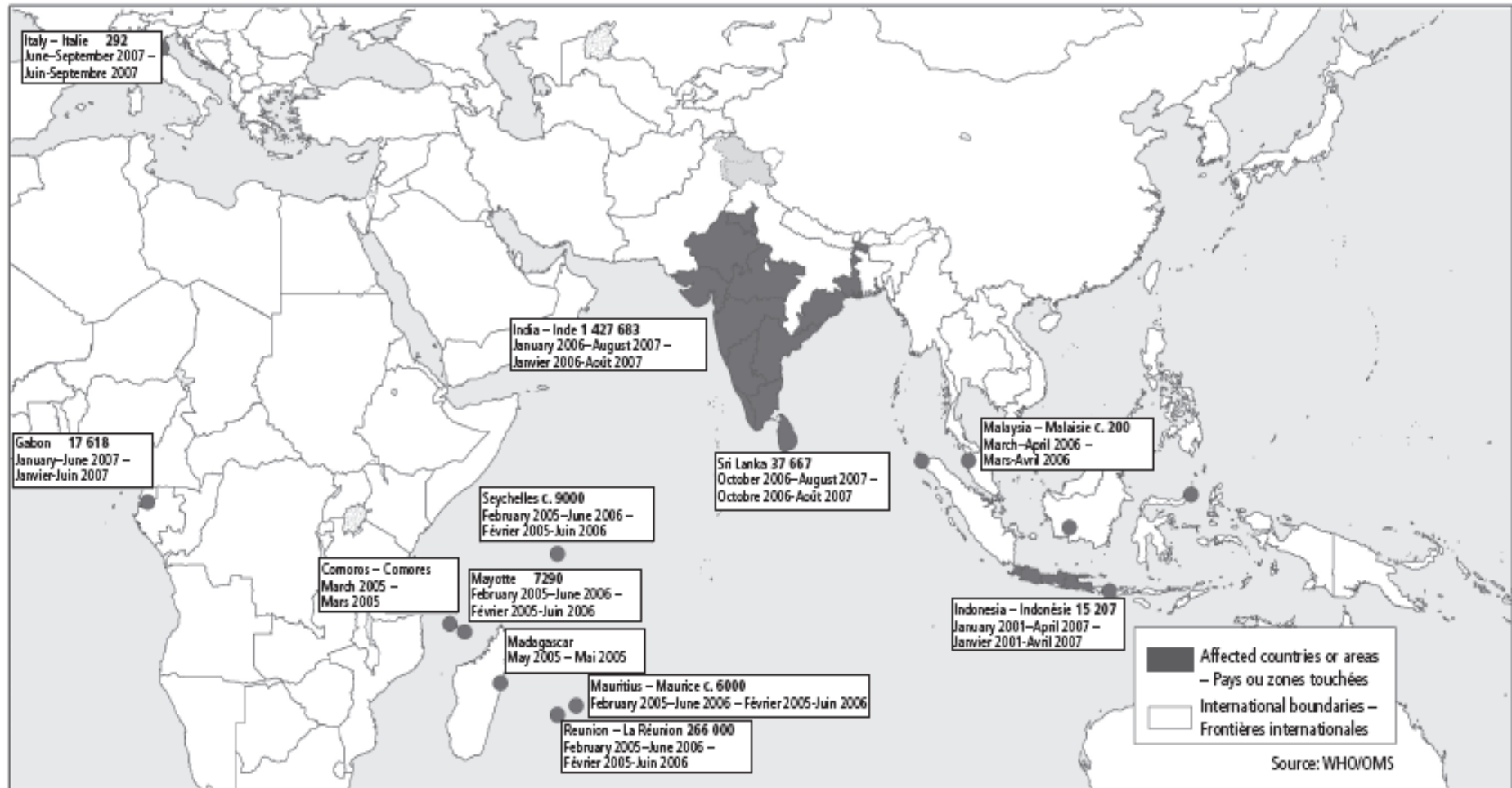


Chikungunya outbreaks, 2005-2008

- Outbreak started February 2005 in western Indian Ocean
- Central/East African clade
- Numerous imported cases in Europe (808 in France from April 2005-August 2006)
- 37 imported cases in US and 9 in Caribbean in 2006
- 2006 large outbreak (1.4 million) in India with same strain in 16 states
- 2007 outbreak in Gabon (17,000 cases)
- 2007 outbreak in Emilia-Romagna region of Italy (292 cases, *Ae. albopictus*)

Map 1 Geographical distribution of chikungunya cases 2001-2007 (data are presented as reporting period followed by the estimated number of cases, where data are available).

Carte 1 Répartition géographique des cas de chikungunya 2001-2007 (les données sont présentées pour la période de notification, suivie par le nombre estimé de cas, lorsque les données sont disponibles)



Chikungunya virus outbreaks, Indian Ocean, 2006

	La Réunion	Mayotte	Mauritius
Population	760,000	180,000	1,200,000
Estimated cases	218,000	3,754	8,800
Attack rate	29%	2%	2%
Hospital rate	3%	3%	1%
Deaths(?)	155	None	None

Threat of CHIKV introduction

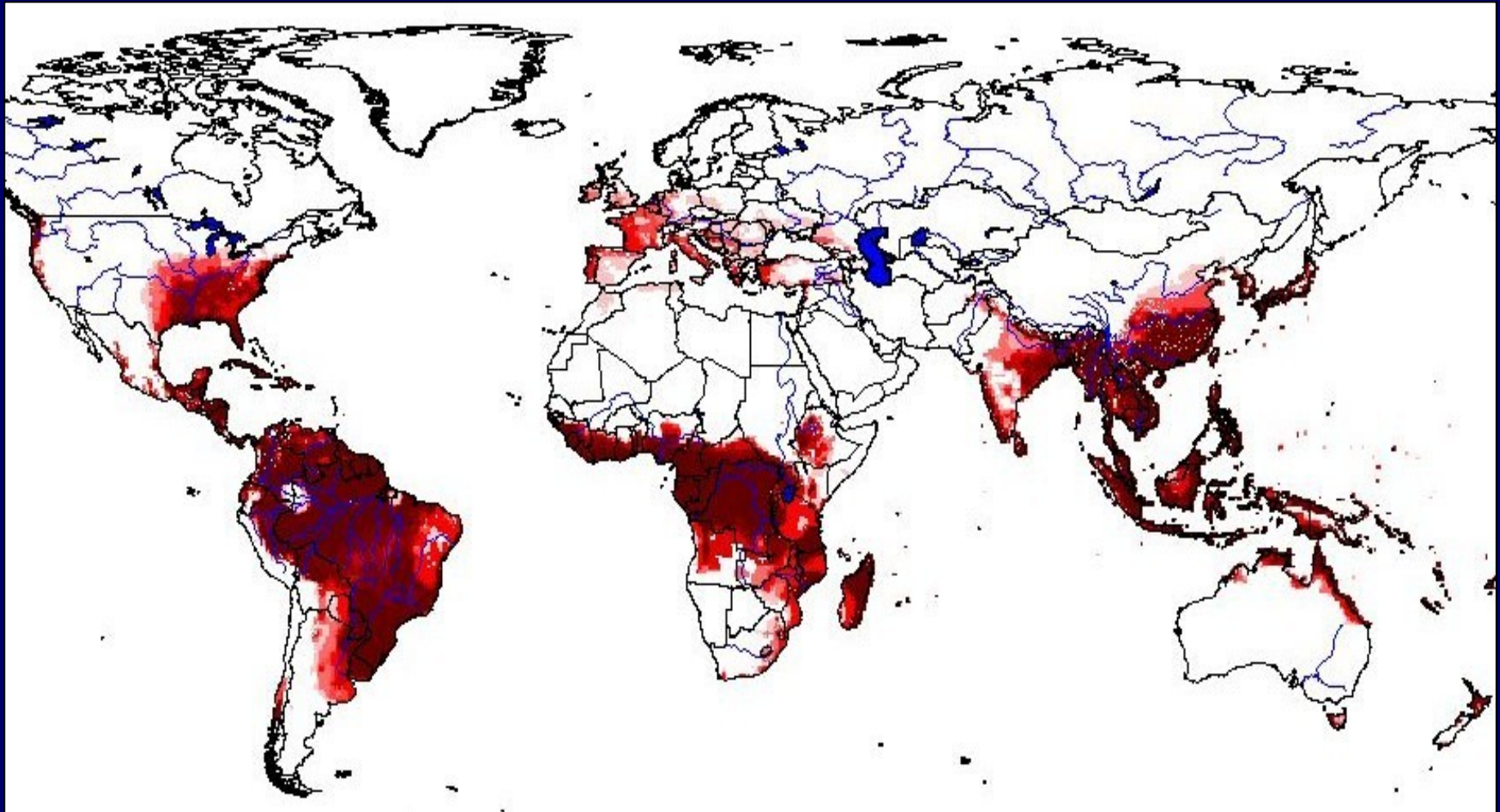
- Sporadic outbreaks
 - Returning travelers
 - Potential for localized spread (as in Italy)
- Large-scale epidemic?
 - Risk in areas with competent mosquito vectors (*Ae. Albopictus*)
 - Dengue and WNV as examples

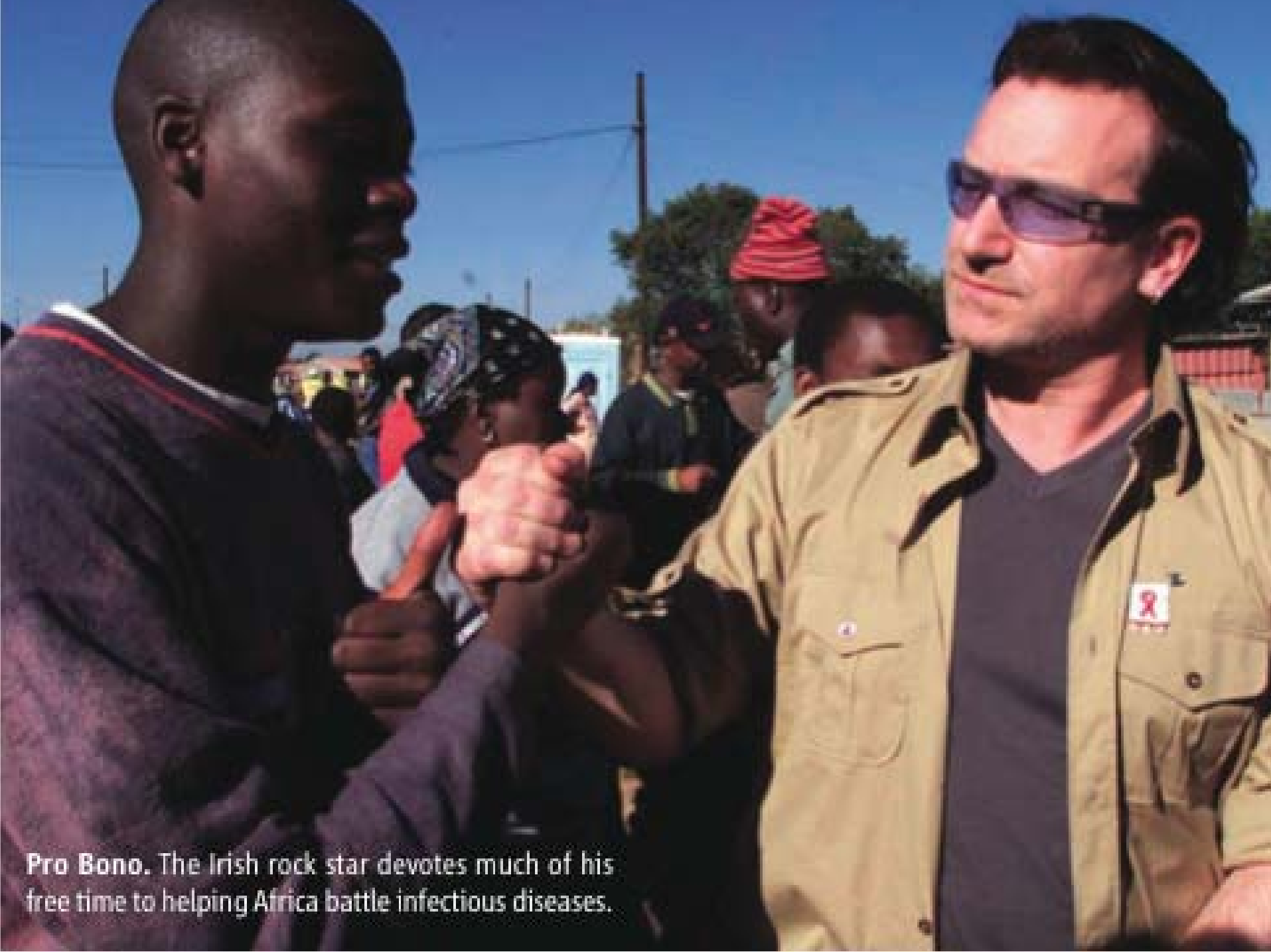
Aedes albopictus



- Asian Tiger Mosquito
- Invader; drought-resistant eggs; fastest spreading mosquito in the world, primarily through import/export of used tires
- Aggressive daytime biter and pest
- Known to transmit Chikungunya, Dengue, La Crosse, St. Louis, Eastern Equine, Ross River, Rift Valley, and West Nile Viruses

Aedes albopictus: world risk-map





Pro Bono. The Irish rock star devotes much of his free time to helping Africa battle infectious diseases.

Hands on. Bill Gates drops the polio vaccine into the mouth of a boy in New Delhi.



Dead duck. Disney icon Donald Duck is the first victim of avian influenza in California

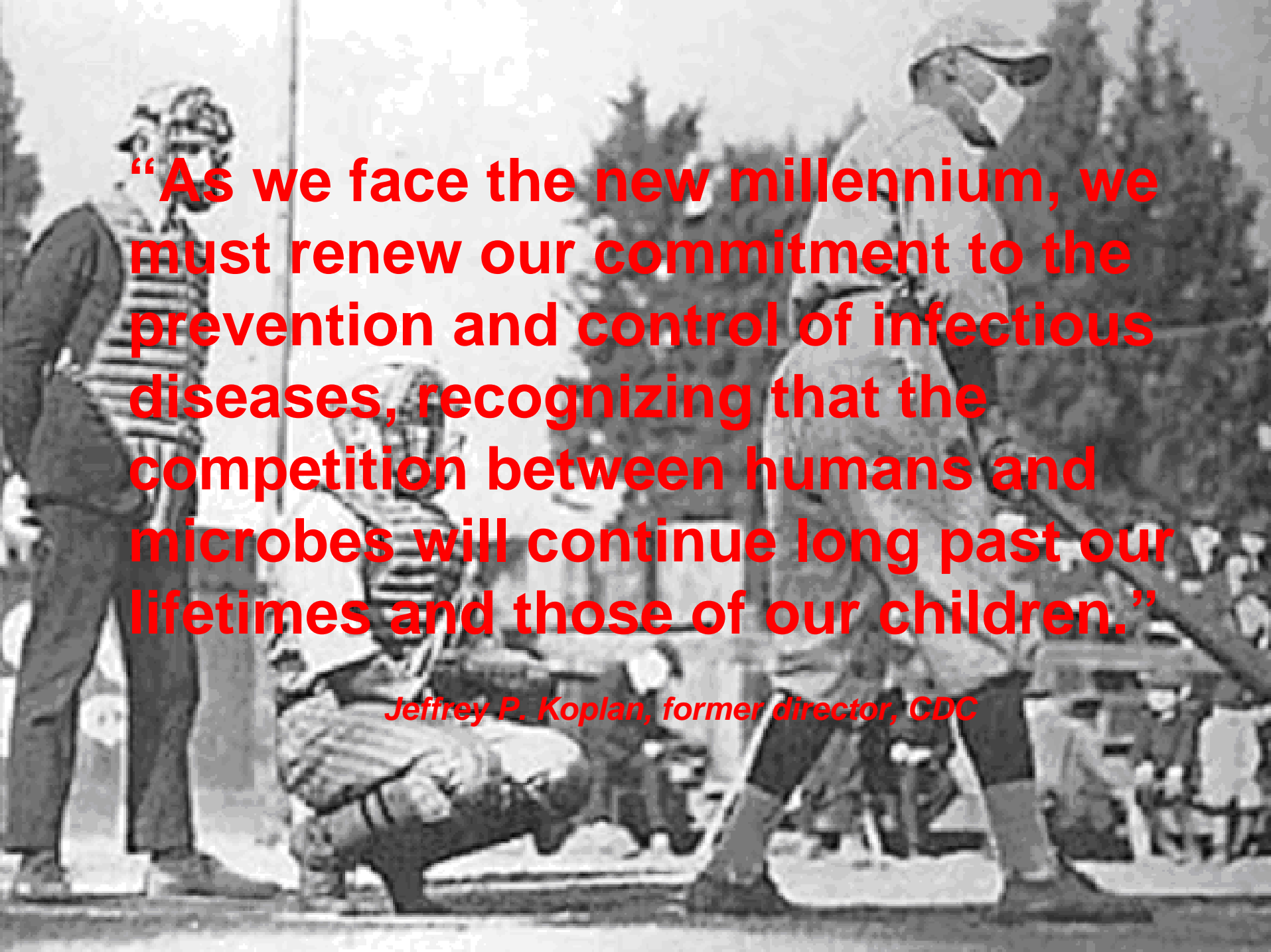


Fatal attraction. The entertainment world was shocked by the first celebrity fatality from swine flu. We all know where he got it.



Lessons from history

- “Those who cannot remember the past are condemned to repeat it”
George Santayana, 1905
- “We learn from history that men never learn anything from history”
George Bernard Shaw, 1948
- “It’s like déjà vu all over again.”
Yogi Berra, 1961



“As we face the new millennium, we must renew our commitment to the prevention and control of infectious diseases, recognizing that the competition between humans and microbes will continue long past our lifetimes and those of our children.”

Jeffrey P. Koplan, former director, CDC