

# Biomedical Engineering for Global Health

Lecture Three:

Leading Causes of Mortality, Ages 15-44

# Review of Lecture Two: Leading Causes of Mortality, Birth-Age 4

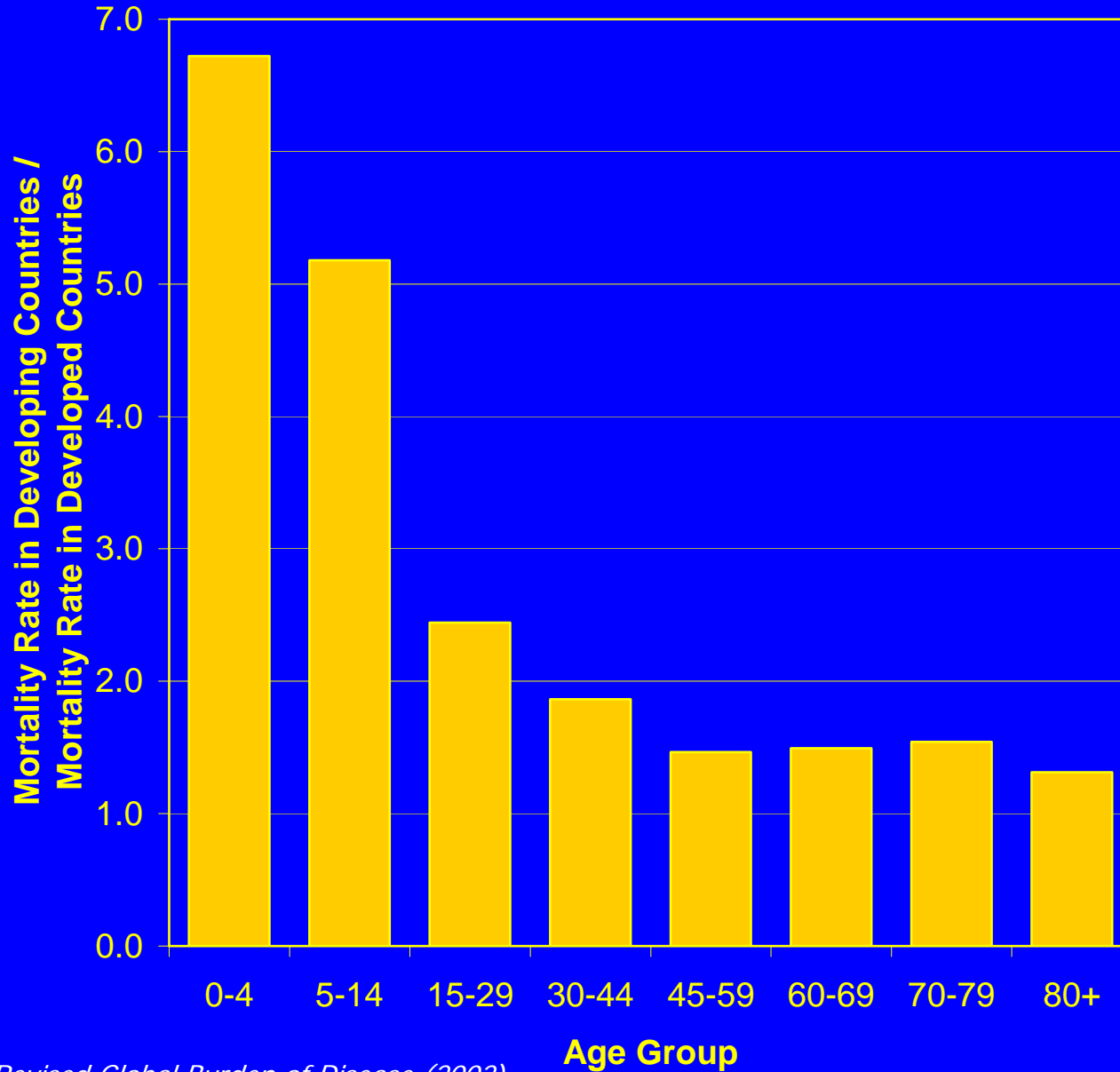
## ■ Developing world

1. Perinatal conditions
2. Lower respiratory infections
3. Diarrheal diseases
4. Malaria

## ■ Developed world

1. Perinatal conditions
2. Congenital anomalies
3. Lower respiratory infections
4. Unintentional injuries

# Ratio of Mortality Rate



# 1. Perinatal Conditions

- Question: What is the #1 way to prevent septicemia in a newborn in the developing world?

## 2. Lower Respiratory Infections

- Question: How can a busy health worker (or a parent) *quickly* screen for pneumonia in a child?

## 3. Diarrheal Diseases

- Question: What is the #1 way to prevent diarrheal illness in a newborn?

## 4. Malaria

- Question: How was malaria eradicated from the southern U.S.? What are the challenges with implementing this technology in less developed countries?

# Leading Causes of Mortality Ages 15-44

## ■ Developing World

1. HIV/AIDS
2. Unintentional injuries
3. Cardiovascular diseases
4. Tuberculosis

## ■ Developed World

1. Unintentional injuries
2. Cardiovascular diseases
3. Cancer
4. Self-inflicted injuries

# 1. HIV/AIDS

- Burden of HIV/AIDS
- Pathophysiology of HIV
- Clinical course of HIV/AIDS
- Highly Active Antiretroviral Therapy
- Prevention of Mother to Child Transmission (PMTCT)

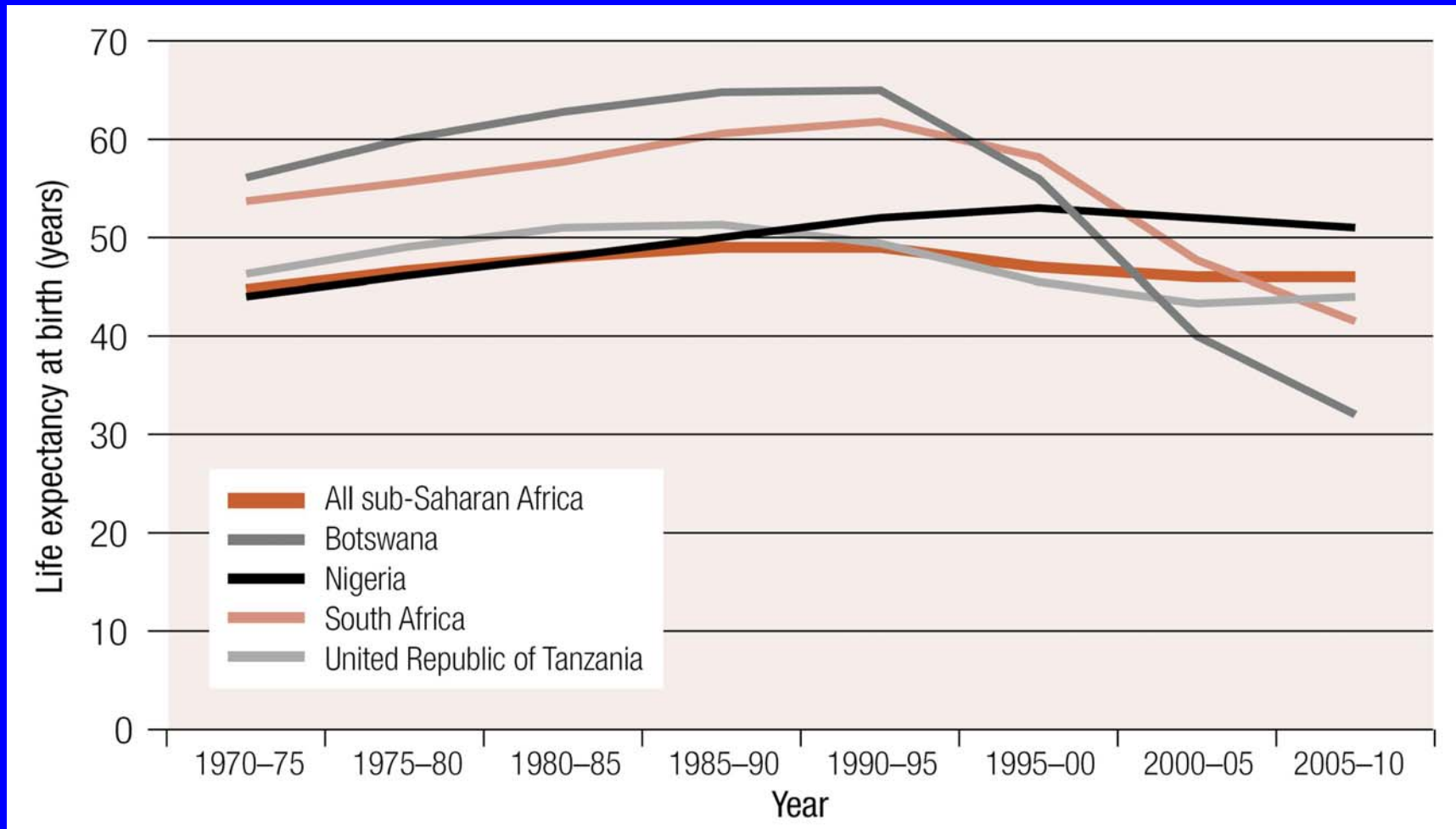
# Burden of HIV/AIDS

## ■ Worldwide

- 33.2 million people are living with HIV/AIDS
- 20 million people have been killed by the disease
- 2007:
  - 2.1 million deaths
  - 2.5 million new HIV infections
  - 17% of new infections occurred in children (<15 yrs)
- 2/3 of those with AIDS and 3/4 of all AIDS deaths are in sub-Saharan Africa
- 6800 new infections per day
  - 96% in low- and middle-income countries
  - 1200 children

Source: 2007 AIDS Epidemic Update, UNAIDS/WHO

# AIDS has Reduced Life Expectancy



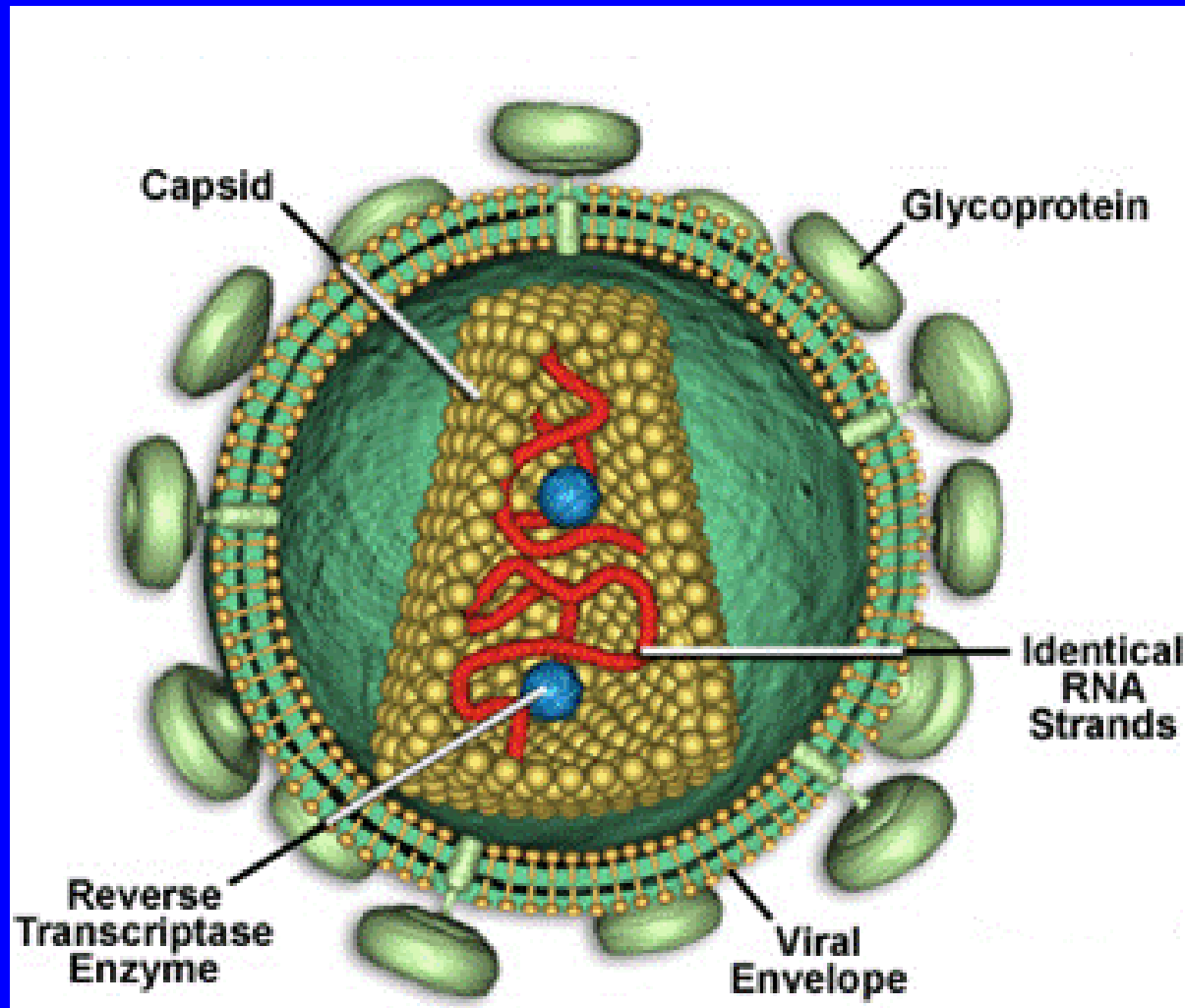
# Burden of HIV/AIDS in the U.S.

- 1.2 million people have HIV/AIDS (prevalence)
- 30,000-40,000 new infections per year (incidence)
- Only 7 countries in the world have more people living with HIV than the U.S.
- Routes of transmission:
  - Unsafe sex between men (53%)
  - Unprotected heterosexual intercourse (32%)
  - Non-sterile drug injection equipment (18%)

# Burden of HIV/AIDS in the U.S.

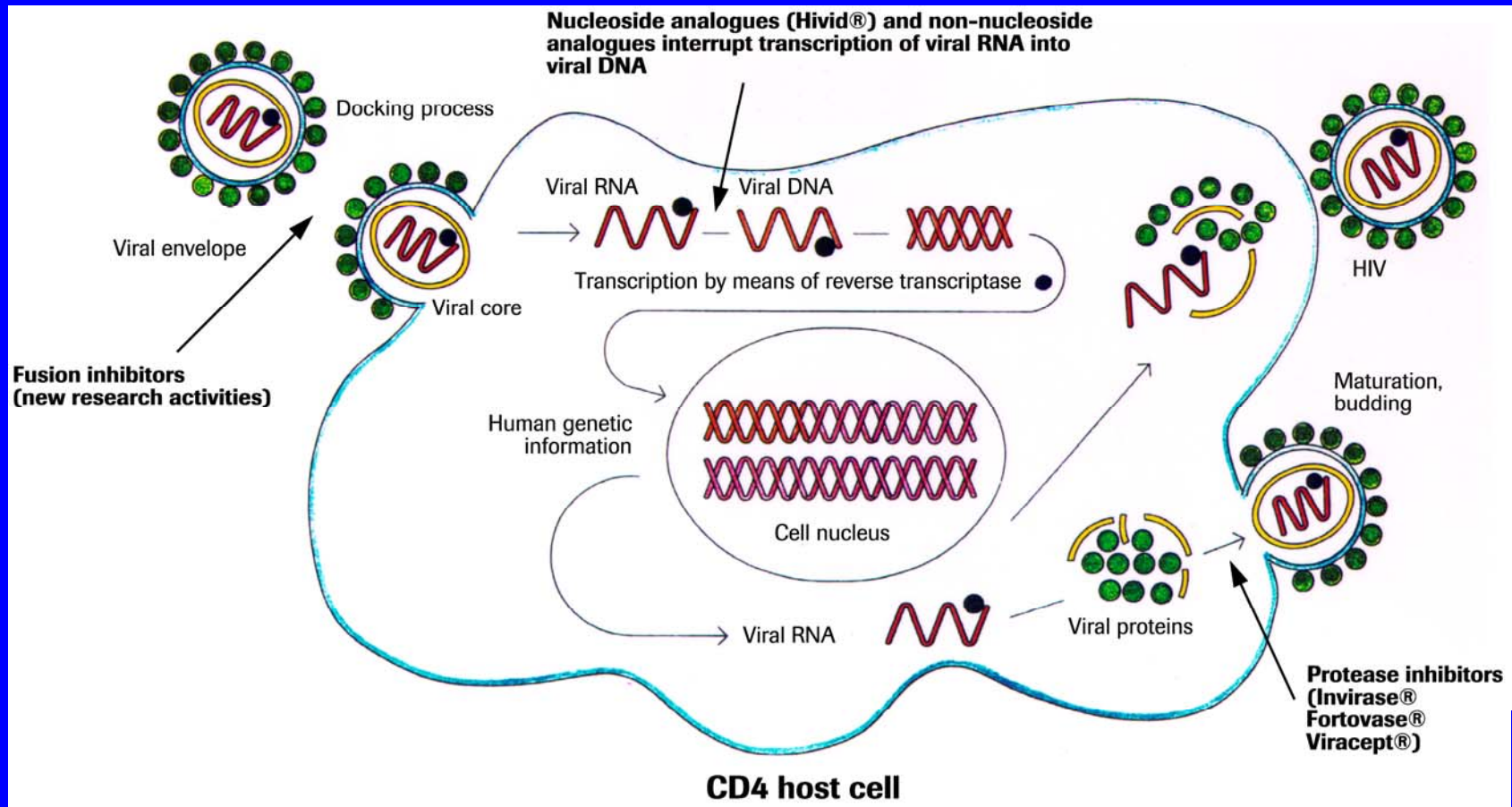
- **Racial and ethnic minorities are disproportionately affected:**
  - 48% of AIDS diagnoses are African-Americans (15% pop)
  - The rate of new HIV diagnoses was 21x higher in African-American women than in Caucasian women
- **Women are increasingly affected:**
  - The proportion of women among new HIV/AIDS diagnoses have risen from 15% to 26% in 10 years
- **Question: Why is the prevalence of HIV in the U.S. continuing to increase?**

# Pathophysiology of HIV/AIDS

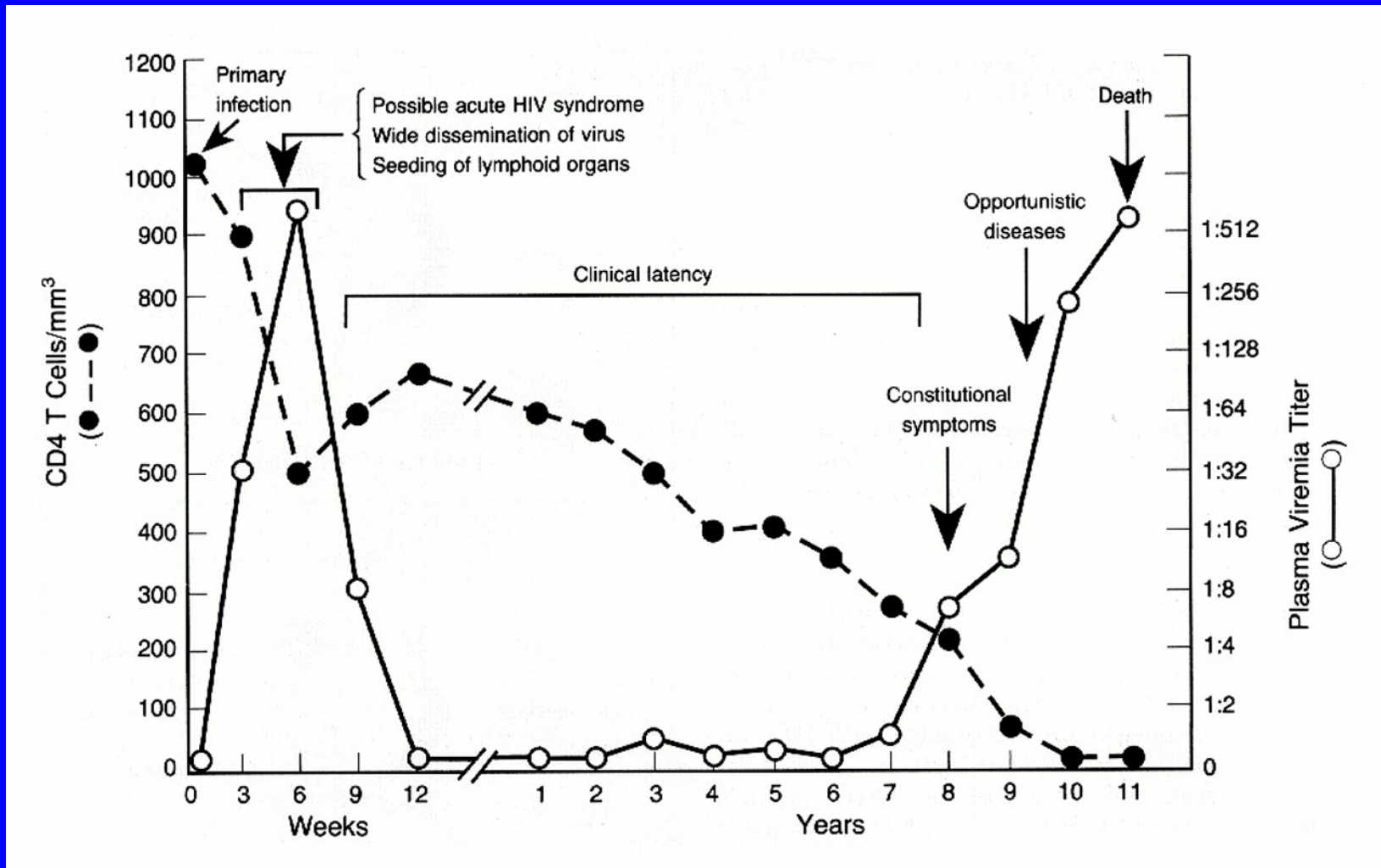


Michael W. Davidson at Florida State University

# Pathophysiology of HIV/AIDS



# Clinical Course of HIV/AIDS



Pantaleo, G., Graziosi, C., Fauci, A. (1993) *The Immunopathogenesis of Human Immunodeficiency Virus Infection. Mechanisms of Disease*. 328 (S): 327-335. c. 1993. Massachusetts Medical Society. All rights reserved.

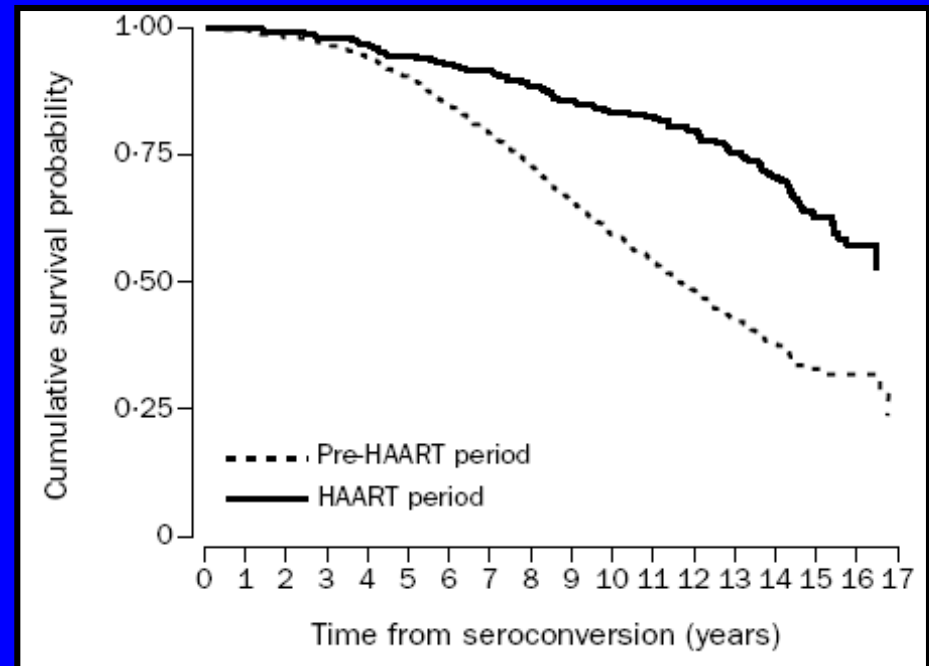
# HIV/AIDS Therapy

- **Reverse Transcriptase Inhibitors (1987)**
  - Enzyme is specific to HIV
  - Combinations of RTIs appear effective
- **HIV Protease Inhibitors (1995)**
  - HIV proteases are distinct from mammalian proteases
  - Most significant advance in HIV therapy yet
- **Highly Active Antiretroviral Therapy (HAART)**
  - Combination of three or more drugs
- **Fusion inhibitor (2003)**
- **Integrase inhibitor (2007)**



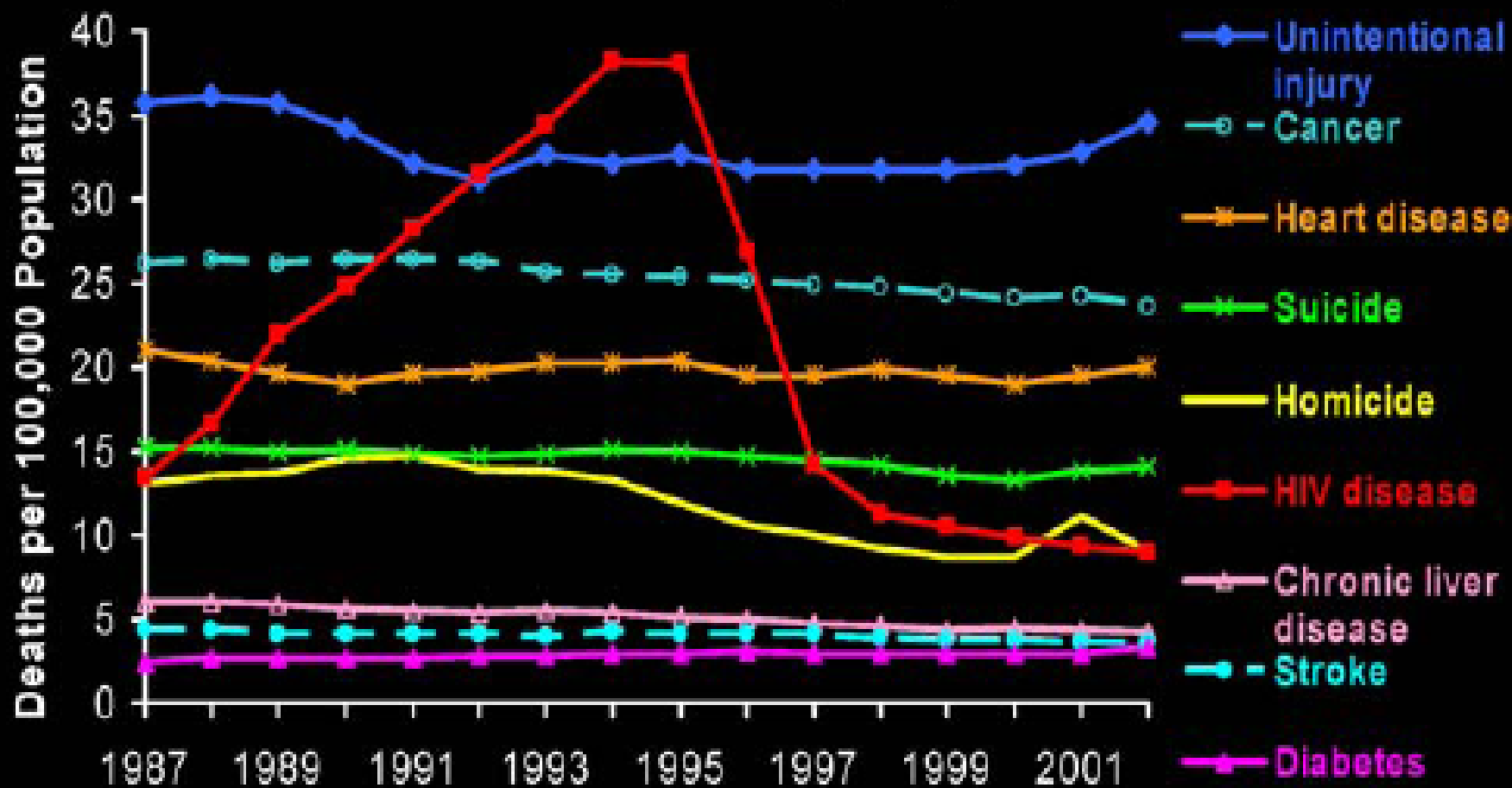
# HIV/AIDS Therapy

- HIV can rapidly mutate to quickly develop resistance to a single drug
- Resistance develops much more slowly to drug combinations
- Goal of HAART:
  - Reduce viral levels to undetectable levels
  - Has reduced death rate in US and Europe by 80%



The Lancet, Vol. 355, The CASCADE Collaboration, Survival after introduction of HAART in people with known duration of HIV-1 infection, page 1, 2000, with permission from Elsevier.

## Trends in Annual Rates of Death due to the 9 Leading Causes among Persons 25–44 Years Old, USA, 1987–2002

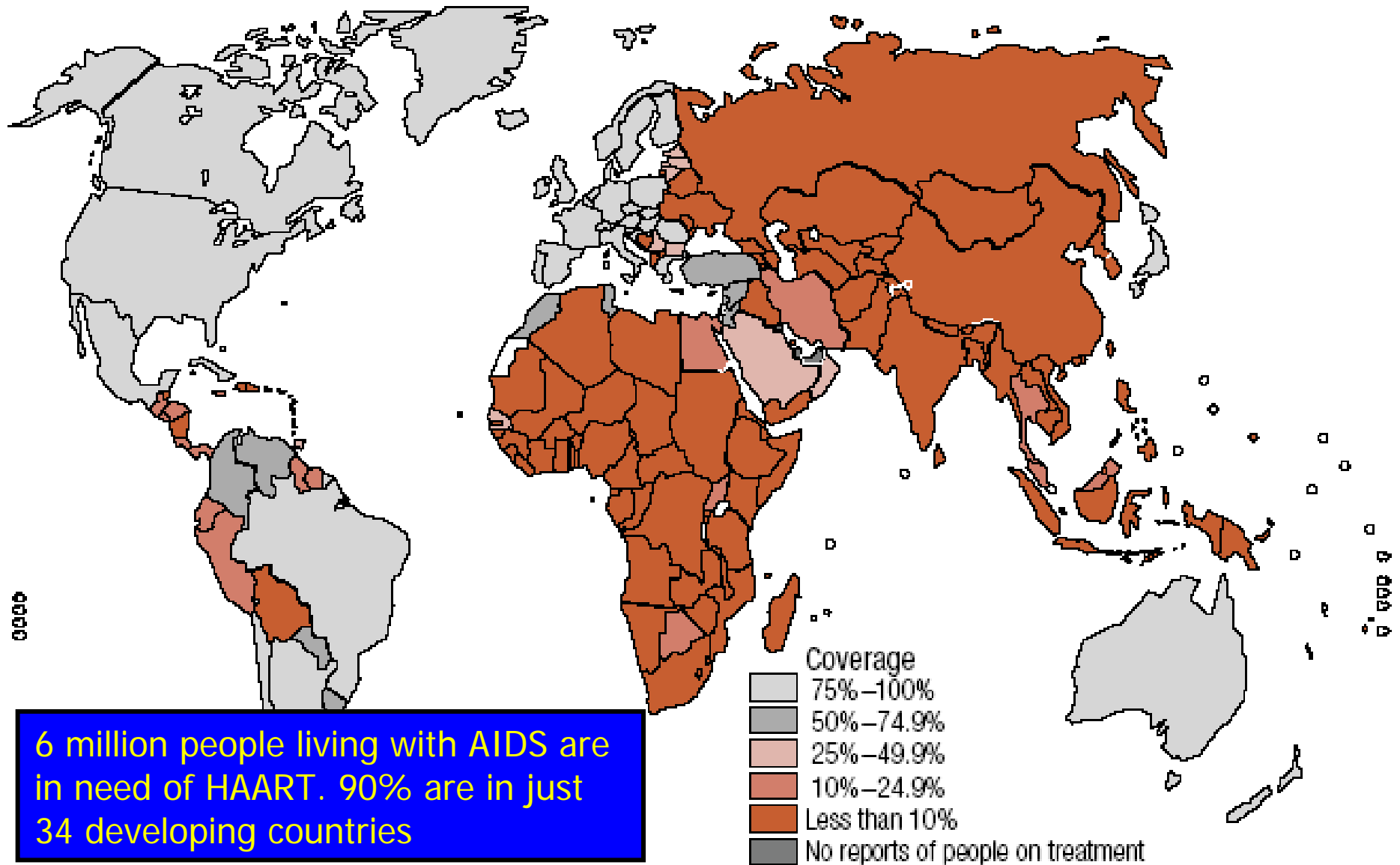


Note: For comparison with data for 1999 and later years, data for 1987–1998 were modified to account for ICD-10 rules instead of ICD-9 rules.



## HIV/AIDS: THE TREATMENT GAP

Estimated worldwide coverage with antiretroviral treatment, end 2003



# Prevention of Mother to Child Transmission (PMTCT)

- 3 routes of transmission:
  - Parentally (during pregnancy)
  - Perinatally (during delivery)
  - Breast feeding (through milk)
- 4 Core interventions:
  - HIV testing and counseling
  - ARV prophylaxis (ZDV, NVP)
  - Safer delivery practices
  - Safer infant-feeding practices
- Reduces transmission from 30-40% to 4-6%

## 2. Unintentional Injuries

- Burden of Unintentional Injuries
- Accident Physics
- Slowed Driver Reaction Time
- Prevention of Road Accidents

# Burden of Unintentional Injuries

- More than 1.25 million people ages 15-44 die from unintentional injuries each year
- 1 million deaths in developing countries, 1/4 million in developed countries
- 40x this number are injured
- Major cause of disability
- Leading cause is *road accidents*:
  - 500,000 deaths per year in this age group
  - 90% of these deaths occur in developing countries

# Burden of Unintentional Injuries

- Road Accidents in the U.S.
  - Rates declining steadily
  - A leading cause of potential years of life lost
  - 2006:
    - 42,642 Americans killed
    - 2,699,000 Americans injured
    - Fatal accident rates 3X higher for males than for females
    - Motorcycles: 40X higher death rate per mile traveled
  - 39% of fatalities related to alcohol use

# Accident Physics

- **Newton's 2<sup>nd</sup> Law:**

- $F = m a$

- $a = dv/dt$

- $a = \text{initial velocity}/\text{time to come to rest}$

- **In a crash:**

- Velocity slows to zero in a very short time

- Generates large forces

- **How can we reduce these forces?**

1. Reduce initial velocity of impact

2. Extend time that it takes passengers to come to rest

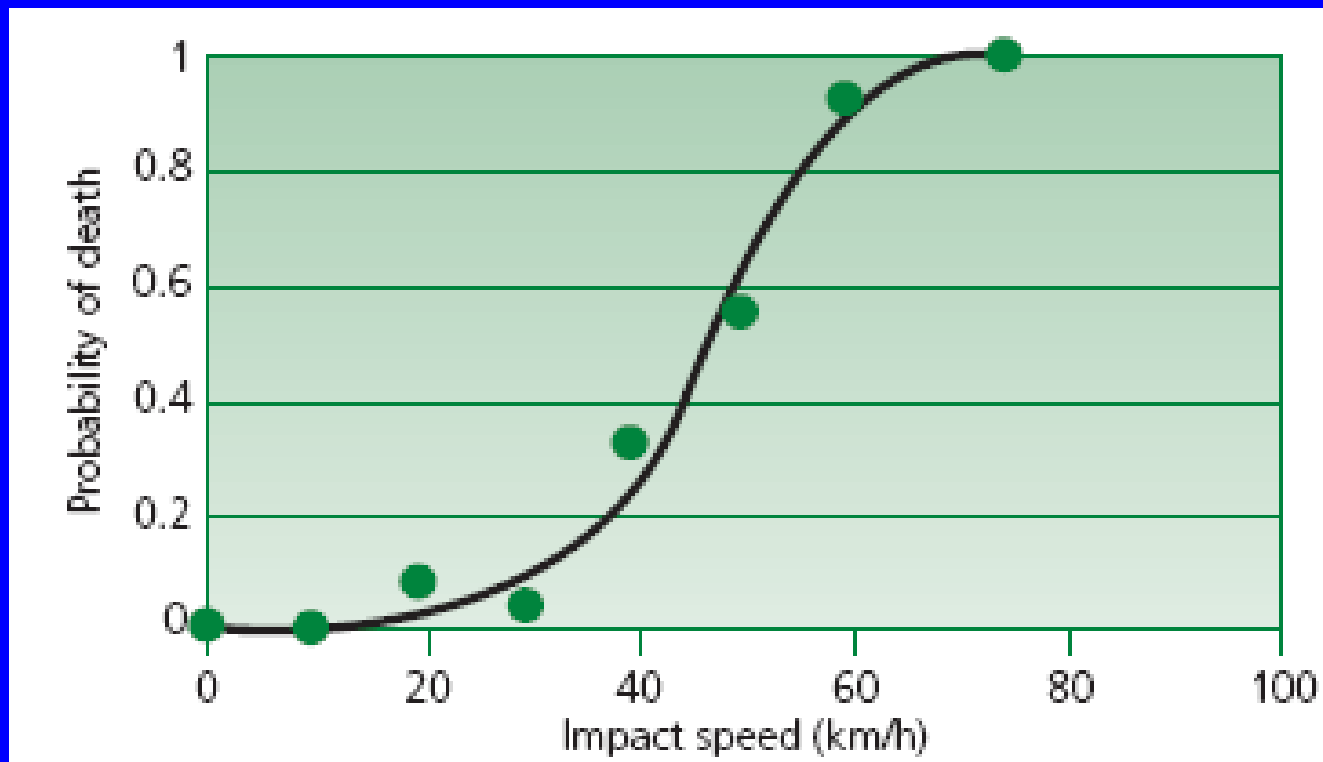


*CDC/Gwinnett County Police Department.*

# Accident Physics

## 1. Reduce initial velocity of impact

- Excessive speed contributes to:
  - 30% of deaths in developed countries
  - 50% of deaths in developing countries

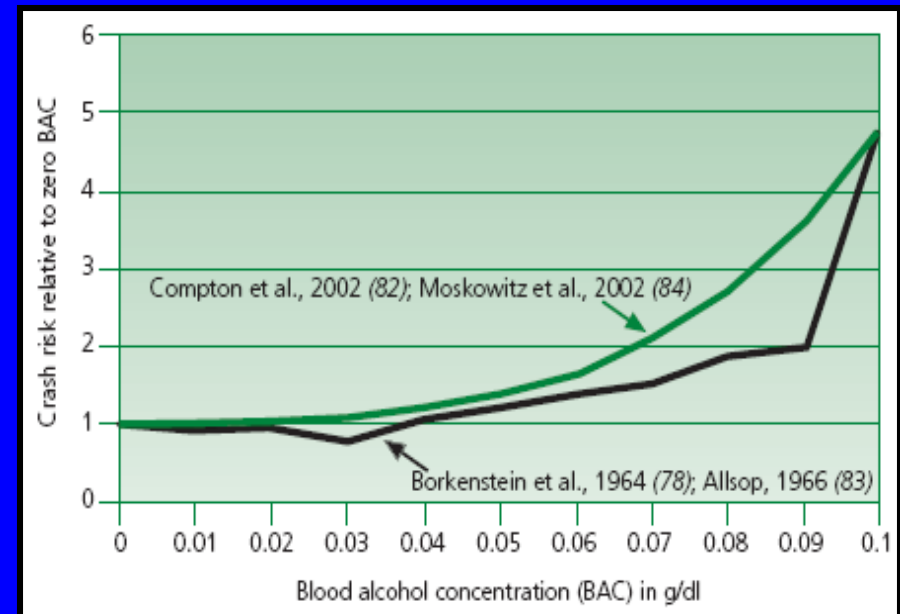


# Slowed Driver Reaction Time

- When drivers anticipate a crash, they have time to brake and reduce initial velocity
- Factors which slow driver reaction time:
  - Alcohol use
  - Mobile phone use
  - Poor visibility
  - Driver inexperience

# Slowed Driver Reaction Time

- Alcohol impaired drivers have 17X increased risk of being in fatal crash
- Alcohol use increases risk more in younger drivers
- 1 in 5 Americans will be involved in an alcohol-related crash at some time in their lives
- TX BAC limit:
  - 0.08+ g/dl is illegal
  - Approx 3 drinks in a 140 lb individual
  - Significant driving impairment at just 0.04 BAC!



# Slowed Driver Reaction Time

- Mobile phone use:
  - At any given daylight moment in US:
    - 10% of drivers are using a cell phone
  - Increases driver reaction time by 0.5-1.5 seconds
  - Risk of crash is 4X higher when using a mobile phone
  - Same as driving with a BAC of 0.09 g/ dl
- 4 states and D.C. have banned use of hand held phones while driving (NY, NJ, CT, CA)
  - Partial bans in AR, AZ, FL, GA, IL, ME, MA, MN, NH, NM, OH, PA, TN, VA, WA

# Prevention of Road Accidents

## 2. Extending Time to Come to Rest:

- Crumple zones
  - Allow passengers additional time to decelerate
- Seat belts
  - Keep occupants in the passenger compartment
  - Stretch during impact
  - Reduce risk of death in crash by 40-60%
- Air bags
  - When combined with seat belts, reduce risk of serious and fatal injuries by 40-65%
- Child restraints:
  - Reduce risk of infant death by 71% and toddler death by 54%

# Prevention of Road Accidents

## ■ Legislation:

- Speed
- Seat belts, Car seats, Air Bags
- Alcohol use
- Motorcycle helmets

## ■ Engineering:

- Restraints
- Safety standards

## ■ Education:

- Seat belts, Car seats, Air Bags
- Alcohol use

## 3. Cardiovascular Diseases

- 768,000 people ages 15-44 die as a result of cardiovascular disease every year
- Most common causes:
  - Ischemic heart disease (286,000 deaths)
  - Cerebrovascular disease (159,000 deaths)
- Will be covered in depth in *Lecture 4*

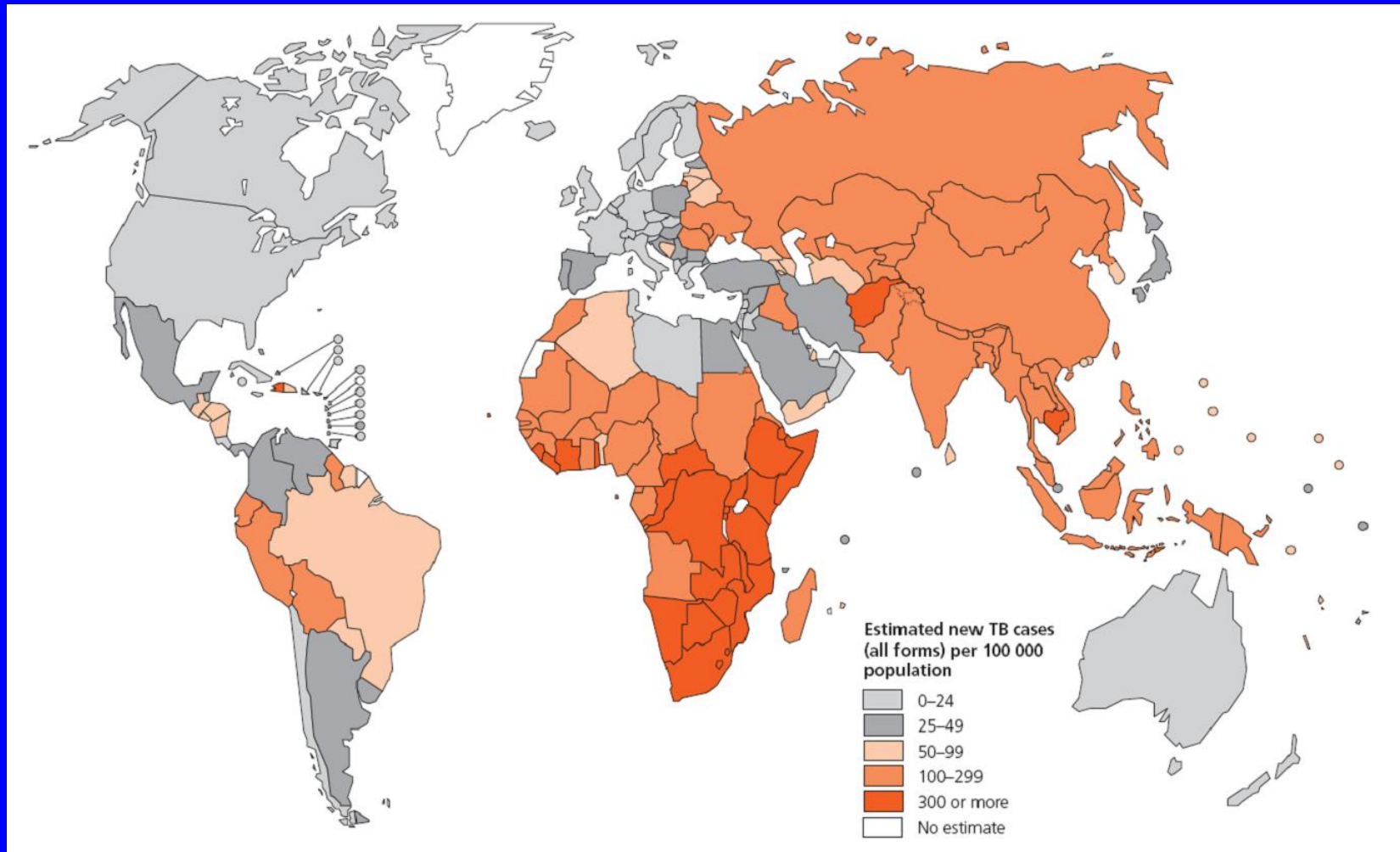
# 4. Tuberculosis

- Burden of Tuberculosis
- TB Pathophysiology
- Diagnosis of Tuberculosis
- Directly Observed Therapy

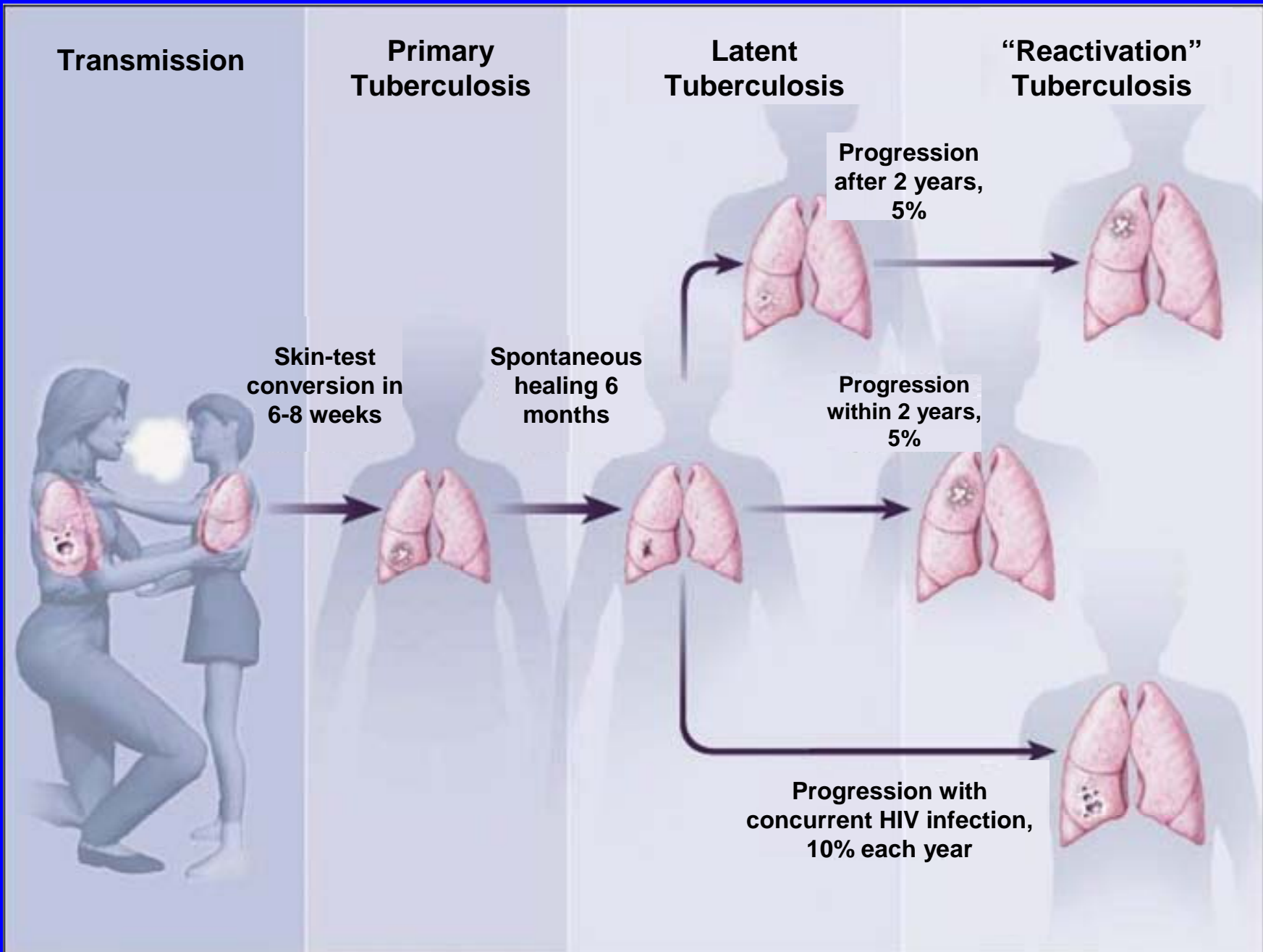
# Burden of Tuberculosis

- Bacterial infection of the lungs caused by *Mycobacterium tuberculosis*
- Bacterium infects 1 in 3 people on the planet
- Drugs that cure TB were discovered in 1940s
- Results in death in 5 years in half of cases if untreated
- Kills 600,000 people ages 15-44 each year
- Estimated that TB will kill 35 million people in next 20 years if situation does not change
- 2005:
  - 8.8 million new cases (incidence)
  - Growing 1%/year
  - 1.6 million deaths
  - 98% of deaths occur in developing world

## Estimated New Tuberculosis Cases in 2004



*Courtesy of WHO Report 2006: Global Tuberculosis Control – Surveillance, Planning, Financing*



# TB Pathophysiology

- Primary TB
- Latent TB
- Secondary, or reactivation, TB

# TB Pathophysiology

## ■ Active TB:

### ■ Symptoms

- Fever
- Night sweats
- Weight loss
- Weakness
- Coughs (productive with bloody sputum)

### ■ Airborne transmission

- Left untreated, one person with active TB can cough millions of infectious droplets into the air



Andrew Dandhazy, Rochester Institute of Technology.

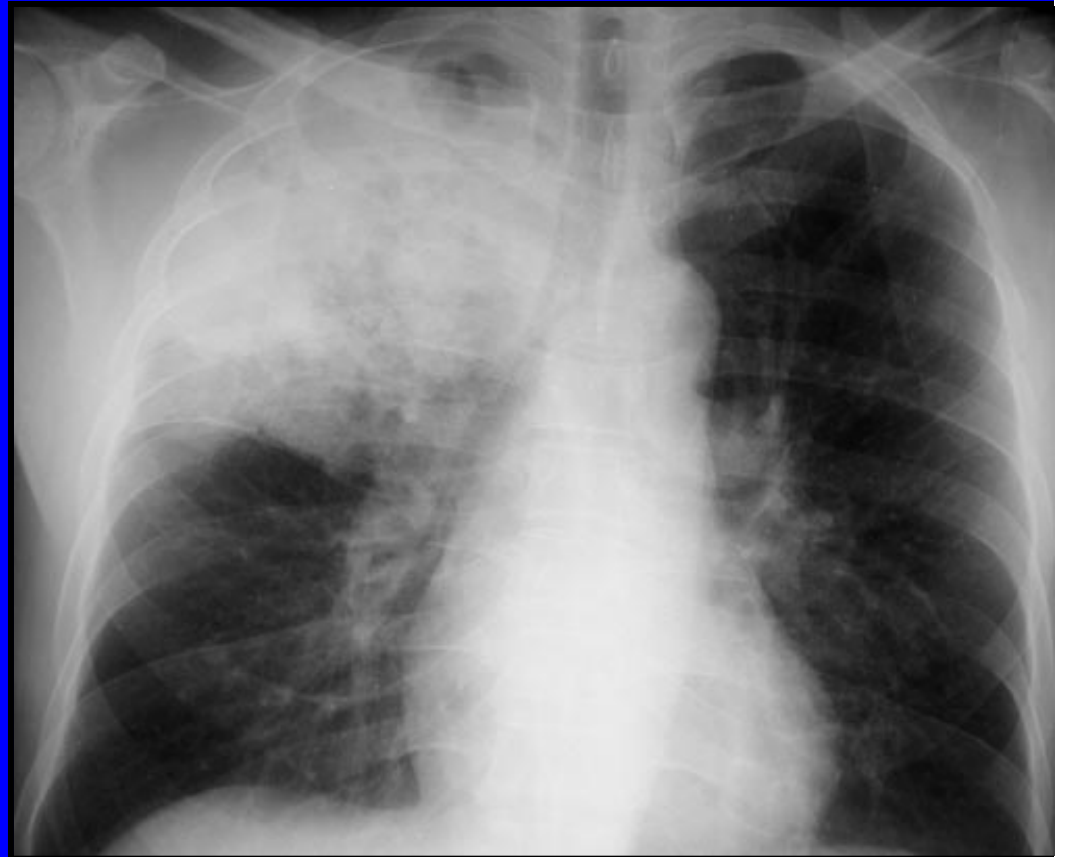
# TB Pathophysiology

## ■ TB and AIDS

- People with AIDS are 10x more likely to develop active TB once infected
- TB is the leading cause of death among HIV positive individuals, accounting for 13% of AIDS deaths worldwide

# Diagnosis of Tuberculosis

- Skin test (PPD)
- Serum test
- Chest X-ray
  - Shows nodules in active TB
- Sputum
  - Acid-fast bacilli



# Directly Observed Therapy (DOT)

- A health care worker watches and helps as the patient swallows anti-TB medicines in his/her presence.
- DOT shifts responsibility for cure from patient to health care system
- Requires political commitment, accurate diagnosis, quality drugs, observation, follow up
- DOT works well in many developing countries

# Directly Observed Therapy (DOT)

- 6 month supply is \$10
- Cure rates of up to 95% even in poorest countries
- 17 million patients worldwide have been treated with DOT since 1995
- 25% of world's population does not have access to DOT.

# Leading Causes of Mortality Ages 15-44

## ■ Developing World

1. HIV/AIDS
2. Unintentional injuries
3. Cardiovascular diseases
4. Tuberculosis

## ■ Developed World

1. Unintentional injuries
2. Cardiovascular diseases
3. Cancer
4. Self-inflicted injuries

# 3. Cancer

- 580,000 people ages 15-44 die as a result of cancer every year
- Most common causes:
  - Liver Cancer (68,000 deaths per year)
  - Leukemias (65,000)
  - Stomach Cancer (58,000)
  - Breast Cancer (57,000)
- Will be covered in depth in *Lecture 4*

# 4. Self-Inflicted Injuries

- Burden of Self-Inflicted Injuries
- Risk Factors Associated with Suicide
- Methods of Suicide
- Screening and Prevention

# Burden of Self-Inflicted Injuries

- 480,000 people ages 15-44 take their own lives each year (4<sup>th</sup> leading cause of death)
- Unipolar depressive disorder ranks #1 for DALYs in this age group in developed countries
  - Second to HIV/AIDS in developing countries
- Highest rate of completed suicides
  - Men >65 years old
- Highest rate of attempted suicides
  - Men and women ages 20-24

# Risk Factors Associated with Suicide

## ■ Psychiatric illness

- Affective, substance abuse, personality, other mental disorders

## ■ Other risk factors

- Social adjustment problems
- Serious medical illness
- Living alone
- Recent bereavement
- Personal history of suicide attempt or completion
- Divorce or separation
- Unemployment

# Methods of Suicide

- Most common:
  - Firearms are used in 60% of suicides
- 2<sup>nd</sup> leading cause:
  - Men: Hanging
  - Women: Drug overdose or poison
- Alcohol is involved in 25-40% of suicides
- Women attempt suicide more often; men are more often successful

# Screening and Prevention

- 50-66% of all suicide victims visit physician <1 month before event
- 10-40% in the preceding week
- Hard to identify who is at risk
  - Direct questioning has low yield
  - General questions about sleep disturbance, depressed mood, guilt and hopelessness
  - Survey instruments aren't good at predicting what will happen

# Screening and Prevention

- How do we quantify the efficacy of such questionnaires?
  - Goal of screening:
    - Catch as many positives as possible, even at the risk of some false positives
  - Sensitivity:
    - $Se$  = probability of testing positive if you will commit suicide

$$Se = \frac{\text{\# who test positive}}{\text{\# who commit suicide}}$$

- Sensitivity of best questionnaires: 56% (low)

# Screening and Prevention

- How many false positives result?
  - Positive predictive value:
    - PPV=probability of committing suicide if you test positive

$$PPV = \frac{\# \text{ who test positive and commit suicide}}{\# \text{ who test positive}}$$

- PPV of best questionnaires: 3% (pathetic)

# Summary of Lecture 3

## ■ Developing World

1. HIV/AIDS
2. Unintentional injuries
3. Cardiovascular diseases
4. Tuberculosis

## ■ Developed World

1. Unintentional injuries
2. Cardiovascular diseases
3. Cancer
4. Self-inflicted injuries