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

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

AIDS has Reduced Life Expectancy

- 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.

Source: 2007 AIDS Epidemic Update, UNAIDS/WHO

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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?

Source: 2007 AIDS Epidemic Update, UNAIDS/WHO

Pathophysiology of HIV/AIDS

Clinical Course of HIV/AIDS

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%

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%

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

2. Unintentional Injuries

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

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 2nd Law:
  - F = m a
  - a = dv/dt
  - a = initial velocity/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

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

2. Extending Time to Come to Rest:
- Crumple zones
- Seat belts
- 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

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


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

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

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

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- Developed World
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  3. Cancer
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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 (4th 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
- 2nd 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:
    - $Se = \text{probability of testing positive if you will commit suicide}$
  - Sensitivity of best questionnaires: 56% (low)

Screening and Prevention

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

  - PPV of best questionnaires: 3% (pathetic)

Summary of Lecture 3

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