FUNDAMENTALS OF GLOBAL HEALTH

Introduction to Infectious Disease (ID):
ID GBD
Epidemiology
The Unholy Trinity
Plebeians & Stealth Bombs

28 September 2015
Last Unit in Review

- Concepts & Metrics
- Determinants & Data
- Systems, Actors, Actions
ID GBD: A Global Picture*

TOTAL RECALL: Aggregated data can obfuscate vulnerability! ID comprises 7% of DALYs in Latin America, but 35% of DALYs for indigenous Maya.

*Totally speaking, ID will comprise ~2/3 of Category I DALYs in any region.

Source: IHME, accessed 2015
ID GLOBAL DALYs: The Top 5*

1. Lower Respiratory Infections
2. Diarrhea
3. HIV/AIDS
4. Malaria
5. Tuberculosis

*Mortality ranking varies slightly: LRI, HIV, Diarrhea, TB, Malaria
*In the Global North only LRI appears in TOP 20 causes of all DALYs!

Source: IHME, accessed 2015
Unsafe water, food, sanitation, hygiene

Housing & working conditions

Unsafe sex

Gender, age, genetics, nutritional status

Cultural practices

Microbial adaptation, change, resistance

Ecosystems & demographics

Economic & political vicissitudes

Poverty, vulnerability, inequity

War, famine, disasters

Drug & vaccine development, access

Travel & international commerce

DETERMINANTS and the SDGs

Goal 1: End poverty
Goal 2: End hunger
Goal 3: Well-being
Goal 4: Quality education
Goal 5: Gender equality
Goal 6: Water and sanitation for all
Goal 7: Affordable and sustainable energy
Goal 8: Decent work for all
Goal 9: Technology to benefit all
Goal 10: Reduce inequality
Goal 11: Safe cities and communities
Goal 12: Responsible consumption by all
Goal 13: Stop climate change
Goal 14: Protect the ocean
Goal 15: Take care of the Earth
Goal 16: Live in peace
Goal 17: Mechanisms and partnerships to reach the goals
In FOCUS: ID & SDG3 Healthy Lives & Wellbeing

9 MAIN TARGETS

3.1 Reduce maternal mortality ratio
3.2 End preventable neonatal & child mortality
3.3 End AIDS, TB, malaria, NTDs, and other ID’s
3.4 Reduce NCDs, inc. mental health and wellbeing
3.5 Prevention & treatment of substance abuse
3.6 Halve deaths & injuries from road traffic accidents
3.7 Universal access to sexual & reproductive health ed. & care
3.8 Universal health coverage/access to services, vaccines, medicines
3.9 Reduce morbidity & mortality from chemicals & environmental pollution

4 OTHER TARGETS

3a. Strengthen implementation of WHO Framework Convention on Tobacco Control
3b. Support research, development, access to vaccines & medicines for LMIC
3c. Increase health financing and health work force in LMIC, esp. least developed
3d. Strengthen early warning, risk reduction, management of national & global health risks.
Political/ethnic conflict, rumors of vaccine use to sterilize Muslims, employment of a health-care provider as gatherer of military intelligence have all slowed down eradication of polio (virus, oral-fecal route, paralysis).

2010 Haiti earthquake: UN peacekeepers brought aid and cholera (bacteria, oral-fecal route, causes severe diarrhea & death via dehydration). Faulty sewage control at UN camp contaminated major water source. 600,000 cases & 8500 deaths to date.

Funeral practices, bush meat and bat consumption, weak health systems, traditional healers, regional political denial, and WHO overreach fueled Ebola (virus, via body fluids, hemorrhagic fever).

Spread of HIV in AFRO accelerated by increased regional commerce, migrant workers, and reuse of syringes in early days of mass vaccinations.

Consider Impacts & Consequences—Unintended Or Not

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TODAY'S LECTURE

- ID GDB
- Epidemiology (or ID Epi101)
- The Unholy Trinity
- Plebeians & THE STEALTH BOMBS
**THE EPIDEMIOLOGIC TRIAD**

- **Host**
- **Agent**
- **Environment**

**INFECTIOUS DISEASE 101**

- An **agent** infects a **host** in a conducive environment
- Agents survive in **reservoirs** (human, animal, environmental)
- **Modes of transmission:** food, water, sex, body fluids and feces, **vectors**, inhalation, (non)traumatic contact
- IDs can be **endemic**, **epidemic**, or **pandemic**
- Many ID’s are **communicable**
- **Infectivity**, **virulence**, **pathogenicity** vary
- The number of new infections generated by a current infection is the **Reproduction Number**, or $R_0$ (pronounced ‘R nought’)

*viruses, bacteria, fungi, parasites (protozoa & helminths), prions
Combatting ID: Global Health Goals & Strategies*

**GOALS**

- **CONTROL** an ID (through appropriate strategies)
- **ELIMINATION** (strategies must continue)
- **ERADICATION** from existence (no more strategies necessary). Smallpox achieved! Next, Guinea Worm Next!

**STRATEGIES:**

- Surveillance, reporting, contact tracing (inc. concentric ring strategies)
- Vaccination for individual & herd immunity
- Medication, including mass chemotherapy
- Vector and environmental modification, inc. improved water, sanitation, hygiene
- Case management-reduce case fatality rate
- Education and behavioral change
- DIQ: detection, isolation and quarantine
- Building and maintaining surge capacity

*Goal selection depends on cost/benefit analysis, opportunity costs, specific nature of ID. Strategy selection targets at least one element of epidemiologic triad
ID GDB

Epidemiology

The Unholy Trinity: Malaria, TB, HIV

Plebeians & THE STEALTH BOMBS
MALARIA (Parasite--Protozoa)

• The Current Numbers:
  • 200 million cases annually
  • 500,000 deaths annually

• The Heat:
  • Hot Spots: AFRO (80% of cases)
    SEARO (#2)
  • Hot Pops: anyone in endemic zone, particularly infants, children, pregnant women

• The Impact:
  • 1 bout = 2% of adult’s income (4-5 bouts/year is common)
  • Increased child hospital admissions
  • Loss of child school days
  • Impact on high-burden countries equals 1.3% of their GDP

**Basics:** human-human, via vector (female anopheles mosquito); parasite travels from bloodstream to liver to red blood cells, which burst: fever/chills, lassitude, anemia, death, LBW babies

**Risks:** mosquito exposure, environment, immune status

**Diagnosis:** blood smear, symptoms

**Prevention:** (insecticide-treated) bed nets, indoor residual spraying, larvacides, environmental modification

**Treatment:** antimalarial drugs (including prophylaxis during pregnancy)
Tuberculosis (Bacterium)

• The Current Numbers:
  • 1/3 of humans infected
  • 10-14 million active cases (only ¾ get treated)
  • Annually 9 million new cases & 1-2 million deaths

• The Heat:
  • Hot Spots: 60% cases in SEARO & WPRO (China & India = 40%!)  
  • Hot Pops: the poor, the immunocompromised; prisoners & miners

• The Impact:
  • Several months loss of wages annually for families
  • Stigma, shunning, and rejection
  • TB rate and macroeconomic growth inversely correlated

Basics: primarily human-human, spread via air; primarily affects lungs; cough, lassitude, fever, night sweats, wasting; 50% mortality for untreated active cases (90-95% of infections latent)

Risks: exposure/crowding, undernutrition, smoking, lowered immunity (especially HIV co-infection), air pollution. $R_0$: An active TB case can infect 10-15 others/year

Diagnosis: sputum-smear, chest x-ray

Prevention: detection, diagnosis, treatment, improved social determinants, BCG vaccine for LMIC children

Treatment: 6 month drug combo via DOTS (directly observed therapy, short course)
HIV/AIDS (Virus)

- **The Current Numbers:**
  - ~35 million people infected
  - Annually, 2 million new infections and 1.8 million deaths
  - ~13 million being treated

- **The Heat:**
  - Hot Spots: AFRO: 69% of all infections and 72% of deaths; SEARO is #2
  - Hot Pops: girls & young women, sex workers, MSM particularly in homophobic environments

- **The Impact:**
  - Where to begin... economic development? social and familial cohesion? trade, business, agriculture? Education? public services and governance?

**Basics:** via body fluids; ravages immune system, increases vulnerability to opportunistic infections. Diagnosed as AIDS when CD4 < 200

**Risks:** Unprotected sex, blood, birth/breastfeeding, IV drug use, ↓ immunity; social vulnerabilities, e.g. gender inequality, poverty-induced transactional sex (food, schoolbooks, etc),

**Diagnosis:** blood, saliva

**Prevention:** safe sex/condoms; male circumcision; education and screening (esp. targeting most at-risk populations--MARPs); improve social, educational, and gender norms/opportunities, reduce stigma & discrimination; prophylaxis to pregnant and lactating women (to prevent mother-child transmission--PMTCT); prophylaxis to MARPs and serodiscordant couples;

**Treatment:** antiretrovirals (ARVs) when CD4 < 500 (prioritize <350), prevent/control opportunistic diseases and co-infections
Great Strides, Yet Grand Challenges

**THE STRIDES (since 2000):**
- **Malaria:** incidence ↓37%; mortality ↓58%
- **TB:** mortality & (active) prevalence ↓> 40%
- **HIV/AIDS:** incidence ↓40%

**THE CHALLENGES:**
- **Malaria:** increase in fake drugs; global warming & deforestation expand risk areas
- **TB:** Multi-drug resistant TB (MDR-TB) is burgeoning--5-6% of new cases in China, 15-30% of new cases in former USSR countries
- **HIV/AIDS:** Need expanded prevention, early detection, and treatment with once a day, single pill, ARVs as soon as diagnosed
- **PLUS,** all demonstrate increased resistance to current meds

**Co-infection ≥2:** morbidity & mortality!
**TB in AFRO:** A top killer of HIV+ adults!
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- Plebeians & THE STEALTH BOMBS
# The Plebeians

<table>
<thead>
<tr>
<th>LRI</th>
<th>Diarrhea</th>
<th>Neglected Tropical Diseases (NTDs)</th>
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<tbody>
<tr>
<td><strong>Pneumonia</strong> (primarily bacterial) &amp; influenza virus</td>
<td>3 or more liquid stools/day (or &gt; norm) causing dehydration. Bacterial (e.g., <em>e-coli</em>, <em>cholera</em>) or viral (e.g., <em>rotavirus</em>)</td>
<td>17 diseases, one or more commonly infecting the “bottom billion, varying by region and climate</td>
</tr>
<tr>
<td>A Top ID killer of children (SOUTH) &amp; elderly (SOUTH and NORTH)</td>
<td>Dehydration from diarrhea kills more children than AIDS &amp; malaria combined!</td>
<td>Collectively, the DALYs from NTDs rival that of malaria!</td>
</tr>
<tr>
<td>Risks: low immunity, low birth weight, undernutrition, housing condition, pollution</td>
<td>Risks: low immunity, disasters, undernutrition, living conditions, poor sanitation and hygiene</td>
<td>Risk: conditions of poverty, Global North apathy (and, frankly, squeamishness)</td>
</tr>
<tr>
<td>Keys to success: flu vaccine, pneumococcal vaccine (esp. LMIC children), limiting exposure</td>
<td>Keys to success: vaccines (rotavirus, cholera), improved water/sanitation/hygiene, ORT, zinc supplementation, access to med tx, breastfeeding</td>
<td>Keys to success: first let’s learn some common NTDs . . .</td>
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</tbody>
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**Diarrhea**: 3 or more liquid stools/day (or > norm) causing dehydration. Bacterial (e.g., *e-coli*, *cholera*) or viral (e.g., *rotavirus*).

**Dehydration from diarrhea** kills more children than AIDS & malaria combined!

**Risks**: low immunity, disasters, undernutrition, living conditions, poor sanitation and hygiene.

**Keys to success**: vaccines (rotavirus, cholera), improved water/sanitation/hygiene, ORT, zinc supplementation, access to med tx, breastfeeding.
Some Common NTDs in Humans

THE TOP SEVEN:

**Roundworms, whipworms, hookworms** (collectively, *geohelmenths*): parasites cause undernutrition, anemia, low birth weight, discomfort, developmental disorders, stunting, poor school performance.

**Schistosomiasis**: infected snails in water release the helminths; first penetrate human skin, then to intestines or urinary tract: blood vessel & organ damage, bloody urine/feces, bladder CA, genital lesions (↑HIV risk)

Mosquitoes transmit *lymphatic filariasis* parasites, nest & multiply in lymphatic system: disfiguring lymphadema, fever, pain, stigma

Type of Chlamydia bacteria get in eyes (via fingers or flies) produces *trachoma*: entropion, inflammation, blindness

Blackfly bite transmits parasitic *onchocerciasis* larva, which mature into worms lodging in nodules, mature females release larvae that migrate to skin (severe itching) and eyes (blindness).

TWO OTHERS:

**Leishmaniasis**: protozoa from female sandfly’s bite: skin (& sometimes visceral) lesions/damage

Kissing bugs with *T. Cruzi* protozoa defecate as they feed on humans; infected feces enters the bite, producing **Chagas**: cardiac, digestive, nervous system damage in 20% of chronic infections
NTD’s: Keys to Success

- Improved sanitation, hygiene, education, vector and parasite control

- Mass Drug Administration (MDA) strategies, including a) rapid impact package of 4 pills to treat top 7 NTDs and b) children in schools/communities

- SAFE (Surgery, Antibiotics, Face-washing, Environmental Modification) trachoma

The End7 Campaign:
http://www.globalnetwork.org/sites/default/files/End7FactSheet.pdf
New ID’s-- or “old friends” that resurface (possibly in more highly virulent and pathenogenic forms)

**Dengue fever** —mosquito-transmitted virus to 50-100 million people annually worldwide. Severe pain and body aches (and hemorrhagic fever possible with Dengue) Re-emerged in AMRO in after reduced vector control in late 70’s. Now in most of Latin America and cases in South East US.

**Chikungunya**--another mosquito-born virus causing severe pain, is following dengue’s global path.

**Avian Influenzas** such as H5N1 and H7N9 constantly emerge as viruses circulate among pigs, birds, and humans and go through minor (drift) or major (shift) changes.

This is the way humanity will end, not with a bang but a cough.

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A new concern: MERS (Middle-Eastern Respiratory Virus). Bats likely origin, with camels possibly intermediate hosts. Case fatality rate 20-40%.

*The majority of newly identified human pathogens are zoonoses (from animals); hence the “One Health” Initiative*
Genetic changes in viruses, bacteria, and parasites can make them resistant to current medicines.

Changes can result from natural mutations, from improper use of medications, or both.

The inappropriate use of antibiotics in livestock ain’t helping!

There are too few new antibiotics in the development pipeline.

Many malaria drugs no longer work—now evidence of artemisinin resistance.

MDR-TB is increasing globally, requiring more costly, extended drug tx.

C. difficile is not responding to antibiotics, resulting in need for fecal implants.

Drug-Resistant Gonorrhea emerges, 2011.

Non-adherence to HIV med schedule creates resistant “superbugs”

The CDC: the situation is “alarming”!

A STEALTH BOMB: DRUG RESISTANCE
LET’S WRAP IT UP!

ID Epidemiology

ID GBD

The Unholy Trinity

Plebeians & THE STEALTH BOMBS
NEXT UP:

• W/F Discussion Sections: ID Case Studies
  • Review Slidesets & Notes
  • Read Case Studies Carefully (& complete worksheets):
    – Controlling Tuberculosis in China
    – Preventing Diarrheal Deaths in Egypt
    – Review Smallpox and Malaria Cases from Unit I

• Monday 5 October: NCD’s