Infectious Diseases

Human diseases are categorized as **chronic** or **infectious**

chronic diseases: non infectious, usually long lasting; eg cancer, heart disease, diabetes, etc

infectious diseases: caused by some pathogen (virus, bacteria, fungus, etc)
eg. malaria, TB, HIV, pneumonia, etc

bacteria and viruses cause the majority of human infectious diseases (and some protists and fungi)

some of these infectious diseases are transmitted directly from person to person:

in air (cough)
foods and drinks
direct contact
infected wounds
insect bites

some involve two or more species as **hosts, vectors, carriers, reservoirs**

<u>History of Infectious Disease Control</u>

before the 1800's disease was just a fact of life

→ could not be predicted or controlled or effectively treated

→ thought due to moral failings

it wasn't until early 1800's that people began associating clean running water, sewers and clean streets with good health

→ but only because disease was associate with the "foul air" that came with the stagnant water and raw sewage in the streets

even in the mid 1800's the idea of disease control was a foreign concept for medical care

as recently as the 1870's:

hospitals were dirty, dingy buildings

patients were on mats on floor or in crowded beds

the dead and dying were often crowded together in the same bed

1870's typical physician making his rounds in 1st rate hospital of the time:

1. washed his hands only after his rounds or if they were heavily soiled with blood or pus
2. wore a black coat so when he wiped his bloody hands on it, it didn't show as much
3. kept a scalpel in his breast pocket in case he needed to lance a boil or cut out an infection
4. if it needed to be sharpened he used the sole of his shoe
5. had some linen thread wound around one of his

buttons in case he needed to suture a cut or wound

6. there were no anesthetics in common use other than a stiff drink

it wasn't until 1880's that scientists began to accept the "germ theory" of disease

eg. Pasteur

in past 140 years or so we have made dramatic strides in understanding and controlling infectious diseases

1929, Fleming discovered Penicillin

after that the control of infectious diseases, especially in industrialized countries made tremendous strides

40's and 50's enormous progress in developing arsenals of antibiotics

eg. penecillin, tetracycine, ampicillin

vaccines were developed to dramatically control the outbreak & spread of diseases

in 1979 smallpox was the first infectious disease to be completely eliminated from the planet

Smallpox → a severe acute infectious disease known since ancient times

1966 WHO began an immunization campaign
→ 250M were vaccinated

Oct, 1977, last naturally occurring case was found in Somalia

Dec, 1979, certified that smallpox had been completely eradicated from the earth

the frozen virus still exists in 5 labs around the world

Why Smallpox
humans are only host
no animal reservoirs
easily diagnosed
highly effective vaccine

in 2010 the second infectious disease was eliminated:

a viral disease found only in cattle called "rinderpest"

it plagued Europe from the days of the Roman Empire until the 1920's

it arrived in Africa in 1887 and killed 80% of the livestock there

an effective vaccine was developed in the 1960's

last outbreak was in Kenya in 2001

2 more viral diseases have nearly been eliminated:

measles → nearly gone from the industrialized world

polio → has been eliminated from 145 countries

in last 100 years has been a 90% drop in infectious diseases in developed countries

eg. 1902 top causes of death in US
→ pneumonia, TB, diarrheal diseases

2005 top causes of death in US
→heart disease, pulmonary diseases, cancer, strokes

chronic disease became a much more important causes of mortality in developed countries

these reductions in world deaths has been hailed as the most significant public health achievement of the 20th century

But Today:

1. despite improvements in medicine, sanitation, personal hygiene, diet and health education

   infectious diseases are still the #1 killer worldwide

   today, worldwide, infectious diseases kill ~10-12 M/yr

   →~1/3rd of all global mortalities

   →most of these deaths occur in developing countries.

90% of deaths from infections diseases are caused by only 5 diseases:

1. Respiratory infections (2008; 4.2 M/yr) [viral]
2. HIV/AIDS (2008; 2.0 M/yr) [viral]
3. diarrheal diseases (2001; 2.2 M/yr) [bacterial]
4. tuberculosis (2008; 1.5 M/yr [bacterial]
5. malaria 2M/yr (2008; 1.0 M/yr) [protozoan]

also, 100's of millions/yr are disabled by infectious diseases

2. today, some diseases that have easily controlled in the past are now are reemerging in drug resistant forms

   eg. TB, meningitis, some staphylococcus, enterococcus

   → all but some respiratory infections and measles (viral) have developed antibiotic resistant strains

   and the incidence of many of these diseases are actually on the increase

   eg. Cholera epidemic in Peru, l991 was 1st appearance of the disease in 75 years

   eg. *Cryptosporidium* in Milwaukee water supply, 1993
   → 400,000 sick

   eg. 100,000 in 40 states made ill by *Salmonella* in ice cream

   eg. TB: new strains are emerging that are drug resistant

their potential for spread is greater than ever before

3. New diseases that have never been seen before in humans are emerging

   eg. Ebola --. 1st appeared in Zaire, 1976

   eg. Lassa Fever → 1st reported in Nigeria, 1969

   eg. HIV → earliest case in Central Africa, 1959 (probably emerged in 1940's)

   eg. hantavirus appeared in 1993 in SW desert since has been found in 21 states

→we are experiencing an epidemic of epidemics

→ increasing risks to 100's of Millions of people

Causes of the Crisis

With all our progress in treatment and control, why are infectious diseases still the worlds leading causes of death?

some causes have been with us our entire history others are new pressures that favor the spread of infectious diseases

1. **Contaminated Water**
2. **Counterproductive Human Behaviors**
3. **Altered Ecosystems**
4. **Transportation**
5. **Complacency & Underfunding**
6. **Abuse of Antibiotics & Disinfectants**
7. **Access to Vaccines**

1. Contaminated Water

contaminated water is strongly linked to incidence and spread of infectious diseases

→ 99% of infectious illnesses worldwide are at least partly related to contaminated water

→water borne disease cost $9.7 Bil/yr

→ access to a toilet adds 20 years to the average lifespan

poor sanitation is *directly* responsible for 90% of the worlds infectious diseases

2.6 Billion people in the world to not have access to toilets

these are generally the same people who do not have access to purified water

eg. worldwide, diarrheal diseases kill 3M kids <5yrs old/yr

→cholera does not spread easily in developed countries due to sanitation

→ even in US, 1/3rd of all cases of diarrhea in N Am were associated with inadequately treated drinking water

eg *Cryptosporidium*, *Giardia*

2. Counterproductive Human Behaviors

our own behavior can cause or exacerbate the effects of pathogens

eg. though diarrheal diseases kill 5M children/yr

it is very easily treated by oral rehydration therapy (water, sugar, salt) education

1993 this education saved >1M children's lives

in subSarahan African, deaths from diarrhea due to cholera and dysentery were reduced b up to 80%

eg. polio in Nigeria

political and religious leaders claimed vaccinations made girls infertile and banned them

→ incidence of polio is now increasing in that country

eg. 2/3rd 's of the worlds cases of HIV are in Africa and Asia

→ education has changed the dynamics of the disease in the west as most susceptible groups have learned how to reduce susceptibility to the disease

3. Altered Ecosystems

deaths by infectious diseases also tend to corrolate to our alterations of the natural environment

eg. agriculture and economic development are frequently identified as causes for the emergence or resurgence of infectious diseases

when you clear the land for agriculture you change the environment in ways that suddenly allow vectors (rodents, mosquitoes) access to new hosts

eg. "man made" malaria flares up near dams, irrigation projects, construction sites

the disease is normally common only during certain seasons but spreads thru canals and now occurs year around

eg. domestic animals can be reservoirs from which parasite jumps to hosts

eg. influenza → originated n China's ducks, pigs, and chicken farms

each year new strains jump to cause human pandemics

eg. displacing wild populations and disrupting habitats

deprives microbes of usual host
→ jumps to new human host

eg. 1975 new subdivision in Old Lyme, Connecticut
predators were driven out
native deer population increased
human interactions increased
→ lyme disease spread to humans

eg. climate change
can affect survival of pathogens
especially outside their hosts

eg. humidity
hantavirus outbreaks occurred after very wet season

eg. vectors for many diseases are moving into new areas

especially true for seasonal pathogens

eg. influenza

eg. ecological disruptions
during disruptions such as fire, flood, deforestation, earthquakes etc

the balance between people and microbes is skewed in favor of the microbes

→ a damaged environment makes us more vulnerable to pathogens
→ host physiology is disrupted

eg. rainforest destruction
→ malaria cases have increased dramatically

eg. release of HIV with road construction in central Africa
→ rapid increase in human populations promotes epidemics

4. Transportation

today >1M people/day cross international borders by air

→an infectious agent can easily travel the world in 24hrs

the movement of people across borders provides easy access of pathogens to new hosts

some of the greatest plagues in history were caused by "border crossings":

eg. Columbus to "New World"
population of Mexico <1492 → 20M
+50 yrs → 3M
+100 yrs → 1.5 M

most of these deaths were not from war but from successive epidemics of smallpox, measles and typhoid

5. Complacency & Underfunding

a. the very success of modern medicine has lead to complacency today

→ the leading causes of death in industrial countries are NOT infectious diseases

in US: we did such a good job in 60's with antibiotics and vaccines that may abandoned the field

→ thought there was nothing left to be done

1967, US Surgeon General declared it was time for scientific community to close the book on infectious diseases and turn its attention to fighting chronic problems like heart disease and cancer

→many **fewer specialists** are around today, especially in industrial countries where chronic diseases are more important

b. in developed countries much more research and funding is given to chronic diseases

we are dangerously insolated from the ravages of infectious diseases

have a false sense of immunity

c. **disease prevention** is not as profitable to

pharmaceutical companies or medical industry as treatment

→ most money in US healthcare is used *after* people get sick, not for prevention

→inadequate money for drug research

d. need to have good surveillance system around world to detect and monitor outbreaks

eg. Collapse of communism in Russia also resulted in collapse of its health system

→ TB, diptheria, measles, mumps, etc increased
eg. diptheria
1989 603 cases
1994 40,000 cases

e. if its bad in industrial countries its even worse in poor countries where little or no infrastructure exists at all

these are the same areas of the world with greatest biodiversity:

→lots of diseases, lots of hosts

→ primed for emergence of new strains and least able to deal with them

f. Poor infrastructure can lead to inaccurate reporting

and misdiagnoses

→ this can affect world efforts to control outbreaks

5. Abuse of Antibiotics & Disinfectants

bacterial diseases are usually treated using antibiotics

Antibiotics were developed from **mycotoxins** treatment for bacterial diseases

bacteria have very high rates of **mutation** and trade genes easily

bacteria:
→ are opportunists
→ have high rates of reproduction and mutation
→ can adapt quickly to changing environments and new opportunities

for many years science kept up with this trend by developing new antibiotics able to kill new bacteria

Doctors and patients have been eager to use newly developed drugs

but pathogens have also been continuously exposed and develop resistance to many

microorganisms are becoming increasingly resistant to standard drugs of treatment:

today almost all bacterial diseases show some signs of resistance to antibiotics used to control them

drug resistance is an inevitable natural evolutionary change

→ prime example of the power of evolution

eg. in 1980, 99% of streptococcal bacteria that cause pneumonia were susceptible to penicillin

in 1997 up to 29% of such infections are resistant to penicillin

in US today we pay over $4 Bil in drug-resistant related medical costs

eg. Staphylococcus → originally treated with penicillin
became resistant

then treated with methicillin
became resistant

then treated with vancomycin (most powerful antibiotic yet)
is last resort against most resistant bacteria

some are developing resistance to it

eg. TB → new multidrug resistant strains

eg. dysentery → in some countries, up to 90% of all cases are resistant to the 2 main drugs formerly used to treat it

Humans are contributing to this problem of drug resistance:

a. many of these antibiotics are **overprescribed** by doctors and misused by patients

eg. JAMA, 1992, survey of 29,000 patients of 1500 physicians found that doctors encourage the spread of drug resistant "supergerms"

>1/2 of patients with "cold" or upper respiratory infection and 61% of those with bronchitis received antibiotic prescriptions

but, the great majority of such infections are viral, not bacterial; ANTIBIOTICS DON'T AFFECT VIRAL INFECTIONS

ie. 1 in 5 prescriptions were issued for conditions that they don't even help

Why do doctors overprescribe?

→ patients *expect* and even *demand* drugs when they are sick

→ physicians feel too rushed to take the time to explain why the drugs won't do any good

→ doctors don't know if its viral or bacterial so they prescribe "just in case"

b. patients often stop taking them when they start to "feel better"

→ stronger strains are the ones that survive

often to cause a much more serious relapse and

spread into the environment as a much more dangerous pathogen

c. Also, people are brainwashed by commercials to use massive quantities of antibacterials and disinfectants

eg. 2000, AMA urged govt to step up regulation of antibacterial soaps, lotions and other household products

→ residues can give rise to more resistant bacteria

→ may cause misdevelopment of children's immune systems

d. animal antibiotics

only ~ half of all antibiotics prescribed are slated for direct human treatment

→ the other half are used to
→treat sick animals
→ as growth promotors in livestock
→ to rid food of various microorganisms

this results in promoting resistant strains in livestock

some of these strains could "jump" between species

7. Access to Vaccines

there are very few treatments for viral infections once they have become established in the body

the best treatment for viruses is to vaccinate before you are exposed to them

effective vaccines also offer the possibility of actually **eliminating** diseases from the world

for 200 years vaccines have provided critical 1st line of defense against mainly viral pathogens

during 60's and 70's UNICEF significantly reduced the incidence of many infectious diseases by providing worldwide, widespread immunizations

in 1980 25% of the world's children were immunized

by 1990, 80% of world's children received immunizations for various lethal diseases including:

diptheria
pertussis
tetanus
typhoid
polio

6 diseases that were once the leading causes of death among infants and children have been brought under control worldwide due to vaccines:

diptheria

whooping cough
tetanus
measles
polio
TB

vaccines are also **very cost effective**
→ they pay back $7 for every dollar spent

But:

a. they have spotty availability
b. most need refrigeration; often unavailable where they are needed most
c. the neediest countries cant afford them

new vaccines against 60 different diseases could save up to 8M lives a year

but new vaccines are getting more expensive to develop they are more complex and more difficult to develop
→ R&D for 1 vaccine could cost $20-100 M

while governments are willing to pay large sums of money for hospitalization and antibiotics they balk at having to pay comparable sums to PREVENT them in the 1st place

d. successful immunization programs require parents to take their children to doctor for **booster shots**, many don't

eg. CDC:
<55% of US children received required boosters in 1992
eg. Bronx → 38%
eg. Houston → 11%

yet, >80% of children in developing countries ***were*** getting their vaccinations under WHO programs

f. some viruses mutate too quickly to develop an effective vaccine

viruses:

→ are a million times more likely to mutate than are human cells

eg. HIV mutates rapidly even after it invades the body
→ makes it impossible for human immune system to recognize, attack and kill the virus

eg. influenza mutates rapidly
→ need new vaccines every year

vaccines are under development and in clinical testing for:

HIV/AIDS

Pneumonia
vaccines available are not effective against children <2 yrs old (the highest risk group)

Malaria (Protozoan)
many vaccines are under development
companies spending $50M over next few years

work is also progressing on the development of a vaccine given at birth for a variety of infectious diseases

babies are vulnerable during the first few weeks of life since their immune system is immature

most vaccines do not produce lasting immunity in newborn babies

→infants usually have to wait several months before being vaccinated

new research has found a way to "activate" the newborns immune systems so that vaccines are effective