Past and Present Pestilence: An Interdisciplinary Examination of the Impact of Zoonotic Diseases

ANTHSCI 178A/278A
Spring 2008
The world you live in

- Crowded
- Polluted
- Suffering from Fragmentation & Encroachment
- Poverty – Hunger and Drought
Leads to:

- Disease
- Fear/Terror
- Prejudice
- Actions
- Management
Crowded
The world’s population

- Earth’s population grew about 10-fold from 600 million people in 1700 to 6.3 billion in 2003
- It took from the beginning of time until about 1927 to put the first 2 billion people on the planet
- < 50 years to add the next 2 billion people (by 1974)
- Only 25 years to add the next 2 billion (by 1999).
- The population has doubled in the most recent 40 years.

Population growth since 1950

World Population: 1950-2050

Source: U.S. Census Bureau, International Data Base, July 2007 version.
Figure 18.
Age-Sex Structure of Global Population: 2002
The globe's population in 2002 was relatively young.

Source: U.S. Census Bureau, International Programs Center, International Data Base.
The world’s current and future population

- Currently 6.6 billion (US Census Bureau, 2007)

- In the 20th century, the world’s population increased by 1 billion

- In the next 50 years, world population expected to increase by 4 billion

- 10 billion people – where will they all live?
Crowded: the urban environment

The planet’s megacities (those with over 10 million inhabitants) are home to 16% of the entire world population – UNEP

By 2020 that is expected to rise to 30%.

Currently, 23 megacities worldwide.

By 2015, expected to grow to 36.
Crowded: the urban environment

Top 10 List

1. Tokyo, Japan 26.4 million
2. Mexico City, Mexico 18.4 million
3. Bombay, India 18.1 million
4. Sao Paulo, Brazil 17.8 million
5. Shanghai, China 17.0 million
6. New York City, USA 16.6 million
7. Lagos, Nigeria 13.4 million
8. Los Angeles, USA 13.1 million
9. Calcutta, India 12.9 million
10. Buenos Aires, Argentina 12.6 million

(2006 information)
Crowded: the urban environment

Megacities
2% of the earth’s land surface
75% of industrial wood use
60% human water use
80% human produced carbon emissions

5 A.D. Rome – first city in the world > 1 million
(total world population at the time was 170 million)

17 centuries later, Beijing passed 1 million in 1800, followed by New York, then London

Only 3% of world’s population was urban
Crowded: the rural environment

Google ‘rural crowding’ – see India for the first few hits, then about 7 hits down, you see *measles*.

Demographic statistics are complicated – what is ‘rural’?

FAO – Food and Agricultural Organization; anything not urban

Problem: more people = less land

e.g. Uganda – 85% rural, 56% under the age of 18
Map 2.2: Rural population density (persons per square kilometre), 2000

FGGD Module 2: Population

Persons per square kilometre

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<td>Urban areas</td>
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This map was printed from the DVD included in "Food Insecurity, Poverty and Environment Global GIS Database: DVD and Atlas for the Year 2000", Environmental and Natural Resources Working Paper No. 28. FAO, Rome 2006. The geographic representations employed on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, or of its authorities, or concerning the delimitation of its boundaries. Please, see the full FAO disclaimer in the above documents.

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• Almost the entire world’s population lives on only 10% of the Earth’s land
• Almost 90% live north of the Equator
• Why?
  • Temperate climates
  • Fertile soils
  • Coastal
Population growth seems pretty inevitable
Growth comes in many forms

Emigration as a form of population control is historically characteristic of empires

- Greece
- Roman

USA empire?

Not actually population regulation

Other options
- Genocide
- Family planning
Rwandan Hutu refugees who walked to Tanzania, and were turned away by soldiers, on their way to Kenya and Malawi
(Enforced) family planning: a good idea gone bad in practice

China banned child-control slogans: "One more baby means one more tomb," "Raise fewer babies and more piggies,"

“Two Is Enough”
Family Planning in Indonesia under the New Order 1968-1998

ABCs – Abstinence, Birth Control, Condoms
Helped Uganda reduce AIDS and curb population growth
U.S. supplies most of the money and prefers “A” only
Uganda’s AIDS levels are rising again.
### The 10 most polluted US cities in 2007

*American Lung Association*

<table>
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<td>Pittsburgh (PA)</td>
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<td>Visalia (CA)</td>
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<td>10</td>
<td>ST Louis (MO)</td>
</tr>
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"The Air We Breathe."
American Lung Association, [ca. 1980]
Polluted: Global

Citarum, the most polluted river in the world, near Jakarta
Polluted: Global

LEFT: the U.S. multinational Doe Run Company multi-metal processing plant at La Oroya, central Andes of Peru. (STR/AFP/Getty Images)
Suffering from Fragmentation & Encroachment:

• Fragmentation
  – The ‘chopping up’ of intact natural habitat
    • Logging
    • Agricultural conversion
    • Development – urban, suburban
  – Creates edge effects
  – Leaves small pockets that are not sustainable
  – Stripped land develops different properties
    • Hydrology
    • Albedo (sun reflectance)
    • Even local weather patterns can be altered
Suffering from Fragmentation & Encroachment:

- **Encroachment** – more vague
  - Living or occupying an area “beyond the appropriate limits”
    - Exploiting natural areas
    - Sprawl
  - Logging
  - Agricultural conversion
  - Living on the “edge”
    - Gives rise to disease transmissibility problems
Suffering from Fragmentation & Encroachment: Domestic USA

- Natureserve study “Endangered by Sprawl”
  - 2000: 35 fastest-growing metropolitan areas (> 1 million people)
    - 8% of land cover
    - 29% of ‘at risk’ species of wildlife
    - 13% found only in those metro areas

- 2025: these combined areas will convert 22,000 miles\(^2\) from natural areas to developments (size of West Virginia)
  - 18 counties will use up all their open space by 2025
  - 19 will use > 50%

- Closer to home: California
  - 8 of the top 10 counties are in CA
    - San Diego – home to 99 species
    - LA – 94 species
    - San Bernadino – 85 species
Fragmentation & Encroachment: Global - *How to measure it?*

Habitat loss?
Rural population density?
How to distinguish between
  Europe: all logged and converted ages ago
  and the developing world?

The Ozarks, IL ©TNC
Lovejoy’s famous Amazonian ‘experiment’, Manaus, Brazil
83% of the land's surface is influenced by one or more “footprint” factors:
- population density > 1 person /km²
- within 15 km of a road or major river
- occupied by urban or agricultural land uses
- within 2 km of a settlement or a railway,
- and/or producing enough light to be visible regularly to a satellite at night.
Poverty:

Half the world (~3 billion people) live on <$2/day

GDP (Gross Domestic Product) of the 41 Heavily Indebted Poor Countries (567 million people) < combined wealth of the world’s 7 richest people

27-28% of all children in developing countries are estimated to be underweight or stunted. The two regions that account for the bulk of the deficit are South Asia and sub-Saharan Africa.

Children suffer the most:
1 billion children live in poverty (1 in 2 children in the world). 640 million live without adequate shelter, 400 million have no access to safe water, 270 million have no access to health services.

10.6 million died in 2003 before they reached the age of 5 (or roughly 29,000 children per day).
Poverty

Hunger:
About 25,000 people die every day of hunger or hunger-related causes, according to the United Nations.

This is one person every three and a half seconds

Drought:
Literal lack of water due to climate anomalies, lack of agricultural planning
Lack of potable water access
Disease and poverty are inextricable

- Immune dysfunction, stress and overexposure to disease agents

- 40 million people are living with HIV/AIDS
  - 3 million deaths in 2004.

- Every year there are 350–500 million cases of malaria, with 1 million fatalities
  - 90% of malarial deaths are in Africa
  - > 80% worldwide are children


- Poverty.com lists the following as the problems of poverty, after Hunger:
  - AIDS
  - Pneumonia
  - Diarrhea
  - Tuberculosis
  - Malaria
  - Measles
What does it all add up to?

• Emerging and re-emerging infectious diseases (EIDs)

• Where and why?
Figure 1
Emerging or Reemerging Disease Threat Since 1990

*All of these diseases, except cholera, dengue, and diphtheria, are zoonotic; i.e., they result from the transmission of pathogens from animals to humans.*
Types of diseases* (named by source)

• Anthroponoses
  – Human to human spread
• Zoonoses
  – Animal to human spread
• Sapronoses
  – Environmental sources

*Hubalek reading
Where does zoonotic disease matter?

Jones et al., Nature, February 2008
“daisy of EIDs”

Daszak et al., 2000
Pigs and wild turkeys, Iowa. Turkeys are better vectors than waterfowl for avian flu.
Questions for the course

• Are these diseases public health issues?
• Wildlife issues?
• Management of population issues?
• Biological threats?
• WHO should be responsible for control and treatment?
• Can we identify the role of the disease in society to understand how management can be effective?
• Are zoonotics special?
Parade of Zoonotics

- Plague
- Measles
- Pox
- Influenza
- Tuberculosis
- HIV
- Malaria
- VHF
- Emergent grab-bag
Class Structure

• Each week, one disease or group of diseases

• I will lecture – basic facts and some history
  – the next lecture will be more like a seminar format
discuss readings, raise issues
  – Sometimes guest lecturers
    • Good opportunity for different perspectives
    • Good chance to ask them about their work

• Group research paper – more on this in a couple of slides
• One small exam (in class) – ‘midterm’
• One review/critique – book or movie
A few rules

• No cellphones. No newspapers. No pagers (unless you have a legal excuse).

• Do your reading. Check for reading updates. Be alert.

• If you are using your laptop, I will want to know that you are not checking Facebook or emailing people.

• Respect other people
  – This is potentially charged material – let people know gently (including me), if you are upset.
  – Let people talk – this goes both ways

• Come to class
  – Caveats: if you wake up drunk, please stay at home
Please don’t bring your colds to class!!!
Grading breakdown

• Class participation: 30%
  – Do your reading, participate, lead discussions

• One exam (in class): 10%
  – Very short, mostly multiple choice and matching

• Review/Critique: 10%
  – Write ~1000 words (3-5 pages), with references, if used, about a book relevant to the course, a movie, documentary or even a set of articles.
Grading breakdown, cont.

• Research Paper:
  – Outline: 10%
  – Draft: 10%
  – Final: 30%

Take one of the diseases we discuss, or another zoonotic of choice, and go into much greater depth
  – Absolutely not to exceed 10,000 words (plus refs)
  – Must have proper references
  – Must address multiple facets – this is why a group is good
  – Good experience for you.
Is Leprosy a zoonosis?
**HANSEN'S DISEASE (LEPROSY)**

A *Mycobacterium leprae*, related to tuberculosis, is the causative agent of leprosy.

Leprosy has affected humanity since at least 600 BC, and was well-recognized in the civilizations of ancient China, Egypt and India.

Although humans appear to be the primary source of *M. leprae*, naturally-acquired leprosy has been found in nine-banded armadillos and several species of nonhuman primates, chimpanzees, sooty mangabeys, cynmolgus macaques.

A leprosy zoonosis has the potential for perpetuating the infection in areas where leprosy in humans is no longer endemic.

Identified in 1873 by the Norwegian physician Gerhard Armauer Hansen
HANSEN'S DISEASE (LEPROSY), cont.

- *Mycobacterium leprae* has yet to be cultivated successfully in the laboratory.
  - *M. leprae* is an obligate intracellular parasite that lacks many necessary genes for independent survival.

- Transmission is likely naso-respiratory route
  - but insect vectors have not been ruled out

- The incubation period following exposure is usually 2 to 5 years
  - Ranges from a few months to 20 years
  - Epidemiological analyses of factors such as age, sex, race, climate, nutrition, social position, geography, genetic predisposition, and so on are inconclusive
  - Only about 5% of people who are exposed will actually then get Leprosy
• Two forms:
  – tuberculoid (paucibacillary Hansen's disease)
  – lepromatous (multibacillary Hansen's disease).

• Tuberculoid Hansen's disease
  – the milder form of leprosy in which bacteria live in a few small, symmetrical skin lesions.
  – Symptoms caused by the body's immune response to the bacteria. After exposure, it usually takes about four years for tuberculoid leprosy symptoms to appear.
HANSEN'S DISEASE (LEPROSY), cont.

• Lepromatous Hansen's
  – the severe form in which skin lesions are numerous and larger in size. There are more bacteria present in the lesions and the skin may become very thick.
  – As this type of leprosy advances, nodules may form on both sides of the body.
  – Thick skin folds form on the face and the entire nose may collapse.
  – With lepromatous leprosy, it may take as long as eight years for symptoms to appear after exposure.

• The infection leads to a loss of sensation in the affected areas.
  – This tends to leave the individual unaware of damaging the area
HANSEN'S DISEASE: Leprosy in society

- Since pre-Biblical times, the leprosy patient has been surrounded by myth, superstition, fear, apathy and rejection. In most instances the unfortunate individual was faced not only with a totally debilitating and deforming disease, but also with dire social and psychological consequences as well.

- He or she suffered social ostracism, inability to work, forced separation from family, and had virtually no hope of cure or return to normalcy.
  - As a result, many of them simply disappeared.
  - The victims, often believing they "were being punished for their sins" became despondent, apathetic and resigned to fate.
Lazarus the beggar
Leper Colonies

Leper colonies run by Christians were referred to historically as Lazar houses, after Lazarus the beggar. Maritime quarantine stations are known as Lazarettos.

Spinalonga Island, near Crete – Leper colony until 1957; featured in a recent romance best-seller “The Island” by Victoria Hislop.
Leper Colonies
Kalaupapa on Molokai, Hawaii
About 8,000 exiled since 1865
King Kamehameha V instituted "Act to Prevent the Spread of Leprosy,"
People with leprosy or anyone suspected of having the disease
In effect until 1969, when admissions to Kalaupapa ended.
Still have to be >16 years old to go there
Clean bill of health
Named a National Park in 1980 – after the last person leaves/dies, will be
turned over to NPS!
HANSEN'S DISEASE (LEPROSY), still here...

- Leprosy is generally considered to be a scourge of past centuries.
- ~ 6,000 known cases of leprosy in the United States today
  - Actual number is probably higher
- Estimated 2 - 3 million people with the disease globally
  - ~ 600,000 new cases being detected annually.
  - In 2002, WHO listed Brazil, Madagascar, Mozambique, Tanzania, and Nepal as having 90% of cases.
- Regarded as primarily a disease of the tropics and sub-tropics
- It was endemic in northern Japan, Korea, Australia, some areas of Europe, and the Soviet Union in the past.
- Persists today in developing regions many of which are in tropical areas of the world.
• Unanswered questions remain as to why Mycobacterium leprae produces the tuberculoid type (mild) of disease in some people, and the lepromatous type (serious) in others.

• *M. tuberculosis* seems to generate cross-immunity
  – Could explain the reduction in leprosy with a rise in TB
  – BCG (Bacille Calmette-Guérin – BTB ‘lite’) can help

• 1940s dapsone was developed
  – Weak antibacterial, treatment indefinite
  – Evolution of resistant *M. leprae*

• 1960s, 1970s, rifampin and clofazimine added
  – MDT (multi-drug treatment) WHO 1981
  – No drug alone allowed in case of resistance
  – 1995, WHO and Nippon Foundation – treatment packs to everyone, takes 24 months + 6 months
  – Adherence?
Is Leprosy a zoonosis? What does that mean for management and treatment?
For next week…
who’d like to lead?

• Readings:
  – Desowitz: Introduction, Ch.1, Ch.2
  – Daszak et al, 2000
  – Hubalek, 2003
  – Cleaveland, 2001
  – Scott et al., 1988

*Optional:*
  – Quammen, 2007
  – Jones et al., 2008

• Posted online at: www.stanford.edu/~sjryan/PPP

• Books available in the bookstore
  – listed as ANSI 170A/270A