Climate Change and Urban Health
Enduring Structures

We will examine closely an important "enduring structure" in the urban health framework - climate.

Remember, that enduring structures are social structures or conditions that change very slowly over time. Other examples of enduring structures include economic systems, religion, systems of government, culture and geography.

This short video gives an overview of the many impacts climate change is having on the health of populations.
Overview of the Potential Health Impacts of Climate Variability and Change

This module is modified from the United Nations Framework Convention for Climate Change training module.

7 potential health impacts of climate change

1. Extreme weather events
   - Temperature
   - Storms/floods
2. Drinking water supply
3. Air quality
4. Food production and security (drought/salinity)
5. Food and water borne disease
   - Diarrheal diseases
6. Vector-borne diseases
7. Other indirect impacts. (ex. ozone depletion)
In considering the impact of climate change on health there are 3 main impacts we need to consider.

Three kinds of health impacts have been identified:

1. Relatively direct impacts, usually caused by weather extremes
2. Consequences of environmental change and ecological disruption in response to climatic change
3. Consequences that occur when populations are demoralized and displaced by the following climate change induced factors:
   - Economic dislocation,
   - Environmental decline and conflict situations including traumatic, infectious, nutritional, psychological and other health consequences.
Impact on Climate Change on Human Health

- Injuries, fatalities, mental health impacts
- Asthma, cardiovascular disease
- Heat-related illness and death, cardiovascular failure
- Malaria, dengue, encephalitis, hantavirus, Rift Valley fever, Lyme disease, chikungunya, West Nile virus
- Forced migration, civil conflict, mental health impacts
- Respiration allergies, asthma
- Extreme heat
- Air pollution
- Changes in Vector Ecology
- Rising temperatures
- More extreme weather
- Sea levels
- Rising CO2 levels
- Environmental Degradation
- Increasing Allergens
- Water and Food Supply Impacts
- Water Quality Impacts
- Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms
- Malnutrition, diarrheal disease
- Increasing Water Quality
Climate change most often is associated with weather changes in terms of extreme temperatures. It also has the potential to impact the quality of the drinking water supply and the air we breathe. The following are key concepts in understanding climate change and health in these domains.

- Temperature
- Storms and Floods
- Drinking Water
- Air Quality
Direct Impacts to Health from Heat

- The human body maintains body temperature in ambient temperatures not exceeding 32 degrees C (90 degrees F)
- Above this temperature, heat is lost through the skin and sweating
- Heat-related illness occurs when the body is unable to adequately cool
- High humidity reduces effectiveness of sweating and increases the risk of heat-related illness at any given temperature.
1) Extreme Weather Events – Temperature

Relative Atmospheric Temperature (°C)

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<tr>
<th>Humidity(%) and Temperature</th>
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This chart shows that the apparent temperature felt by humans is a combination of temperature and humidity. As the relative atmospheric temperature increases – so does the severity of the health impact.

At 36 degrees Celsius (96.8 degrees Fahrenheit) with 80% humidity the relative atmospheric temperature is 61 degrees Celsius or 148 degrees Fahrenheit!

Direct impacts to human health:
- **Heat cramps** – muscular pains and spasms
- **Heat exhaustion** – body fluids are lost through heavy sweating
- **Heat stroke** – is life threatening

Indirect impacts:
- A range of ecosystems can potentially be affected with gradual and extreme temperature increases. This can disrupt water systems, food systems, disease-carrying vectors and/or directly impact lifestyles and community resilience.
1) Extreme Weather Events – Paris Heatwave: August 2003

Land surface temperatures, summer of 2003, vs. summers of 2000-04. NASA satellite spectrometry
1) Extreme Weather Events – Paris Heatwave: August 2003

Graph: Daily Mean Temps and Deaths

- Mean Daily Mortality 1999-2002
- Mean Daily Mortality 2003
- Mean Daily Summer Temperature 1999-2002
- Mean Daily Summer Temperature 2003

Van den Torren, 2004
1) Extreme Weather Events – Hurricane Mitch

**Storms and Floods**

On October 27, 1998 Hurricane Mitch struck Central America with Nicaragua and Honduras bearing the brunt of the storm which brought an estimated 75 inches of rainfall to certain areas. Damage and deaths were also seen in El Salvador, Guatemala, Belize, and Mexico.

Over 7,000 individuals died and damage was estimated to be greater than 2 billion dollars.

As a result of Hurricane Mitch there were new outbreaks of previously controlled diseases.

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**Disease Clusters**
- Malaria (>30,000 cases)
- Dengue fever (>1,000 cases)
- Acute Diarrhea
- Cholera (>30,000 cases)
- Respiratory track infections
1) Extreme Weather Events – Hurricane Katrina

Storms and Floods

On August 29, 2005 Hurricane Katrina struck the gulf coast of the United States. The impact of this flooding was extensive. This included failures of levees protecting New Orleans, breakdown of communication systems, extensive damage to roads and buildings and an estimated death toll of 1,500.

Thousands of houses in New Orleans were still under water well over a week after Hurricane Katrina barreled through Louisiana, Mississippi and Alabama.

Impacts:
- Poor access to clean drinking water
- Spoiled food
- Flooding also led to increased mold
- Outbreaks of West Nile Virus

Additional Impacts:
- Loss of power
- Water pumps and waste treatment plants malfunctioned or were rendered useless
- Structural damage to buildings resulting in increased homelessness
- Civil disturbances including looting and violence
Extreme Weather Events – Storms Floods

Storms and Floods

While Hurricane Mitch and Hurricane Katrina were noteworthy events in the Western Hemisphere, worldwide the greatest risk for flooding is concentrated in Asia (primarily Bangladesh and India) as seen in this graph.

This is due to several factors but geography is a main contributor. 75% of Bangladesh is less than 30 feet above sea-level and 80% of it is floodplain – (land adjacent to rivers and to the base of enclosing valley walls).

Monsoon floods in Pakistan during September killed more than 400 people and affected more than 4.5 million others.

During 2011, many Asian countries experienced flooding, including Bangladesh, China, India, Japan, Laos, North Korea, Pakistan, Thailand, the Philippines and Singapore.

Flooding in Asia

Most human exposure to floods occur in Asia. The top ten countries in absolute and relative terms - are in south and Southeast Asia.

Flooding in Pakistan

- Tens of thousands have been made homeless by heavy flooding in the provinces of Balochistan and Sindh – where 2.8 million were affected.
- Pakistan has suffered devastating floods in the past two years.
- The worst floods were in 2010, when almost 1,800 people were killed and 21 million were affected.
This table summarizes the direct health effects of flooding on population health.

<table>
<thead>
<tr>
<th>Causes</th>
<th>Health Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream flow velocity; topographic land features; absence of warning;</td>
<td>Drowning</td>
</tr>
<tr>
<td>rapid speed of flood onset; deep floodwaters; landslides; risk</td>
<td>Injuries</td>
</tr>
<tr>
<td>behaviour; fast flowing waters carrying boulders and fallen trees</td>
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<tr>
<td>Contact with water</td>
<td>Respiratory diseases; shock; hypothermia; cardiac arrest</td>
</tr>
<tr>
<td>Contact with polluted water</td>
<td>Wound infections; dermatitis; conjunctivitis; gastrointestinal illness; ear, nose and throat infections; possible serious waterborne diseases</td>
</tr>
<tr>
<td>Increase of physical and emotional stress</td>
<td>Increase of susceptibility to psychosocial disturbances and cardiovascular incidents</td>
</tr>
</tbody>
</table>
This table summarizes the indirect effects of flooding on population health.

<table>
<thead>
<tr>
<th>Causes</th>
<th>Health Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage to water supply systems; sewage and sewage disposal damage; insufficient supply of drinking water; insufficient water supply for washing</td>
<td>Possible waterborne infections (enterogenic <em>E. coli</em>, shigella, hepatitis A, Leptospirosis, giardiasis, campylobacter) dermatitis, and conjunctivitis</td>
</tr>
<tr>
<td>Disruption of transport systems</td>
<td>Food shortage; disruption of emergency response</td>
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<tr>
<td>Underground pipe disruption; dislodgement of storage tanks; overflow of toxic waste sites; release of chemicals; rupture of gasoline storage tanks may lead to fires</td>
<td>Potential acute or chronic effects of chemical pollution</td>
</tr>
<tr>
<td>Standing waters; heavy rainfalls; expanded range of vector habitats</td>
<td>Vector-borne diseases</td>
</tr>
<tr>
<td>Rodent and other pest migration</td>
<td>Possible diseases caused by rodents or other pests</td>
</tr>
<tr>
<td>Disruption of social networks; loss of property, jobs and family members and friends</td>
<td>Possible psychosocial disturbances</td>
</tr>
<tr>
<td>Clean-up activities following floods</td>
<td>Electrocutions; injuries; lacerations; skin punctures</td>
</tr>
<tr>
<td>Destruction of primary food products</td>
<td>Food shortage</td>
</tr>
<tr>
<td>Damage to health services; disruption of “normal” health service activities</td>
<td>Decrease of “normal” health care services, insufficient access to medical care</td>
</tr>
</tbody>
</table>
2) Drinking Water Supply

**Drying climate causes:**
Changes to land cover and run-off patterns (erosion)
- Increased bushfire risk
- Increased sediment, nutrient and debris.
- Reduction in flows to dams and groundwater aquifers
- Increased evaporation from surface water storages

**Flooding can also affect drinking water supplies:**
- Salt water intrusion into coastal aquifers
- Acidification of susceptible inland aquifers
- Increased risk from the:
  a) Concentration of nutrient and chemical contaminants
  b) Formation of toxic algal bloom
3) Air Quality

- Weather has a major role in the development, transport, dispersion and deposition of air pollutants
- Air pollution episodes are often associated with stationary or slowly moving air masses
- Air pollutants and fine particulate matter may change in response to climate change.

- Airflow on edges of a high-pressure system can transport ozone precursors (which are released in the burning of fossil fuels). Ozone levels are increasing in many areas. Exposure to ozone is linked to premature death, asthma, bronchitis, and heart attacks.

An increase in fire events will mean increased toxic gases and particulates

Changes in wind pattern may increase long-range transport of air pollutants

- Weather patterns can enhance urban “heat islands” which can lead to elevated pollution levels. A “heat island” is a city or metropolitan area that is significantly warmer than surrounding areas due to built structures and human activities which lead to the retention of heat
3) Air Quality

Potential health Impacts

• Particulate matter (PM) is microscopic solid or liquid matter suspended in the Earth's atmosphere and is known to affect morbidity and mortality. PM can be generated in a variety of ways including industrial processes.
• Toxic gases and PM from fires contribute to acute and chronic respiratory illness.
3) Air Quality

Most often air quality is impacted by chemical pollutants, however with climate change other factors (such as dust) can impact air quality.

Wind blown dust (respirable particles and trace elements) from desert regions can affect populations in remote areas.

This aerial photo from NASA gives an indication of the extent of dust storms.

Few studies have been conducted of the extent of illness and death occurring during dust storms. But there is evidence that mortality is increased in the days after a dust storm.
3) Air Quality

This image depicts dust from the Sahara desert in Africa impacting the Caribbean and Southern US.
Just as clean air and water are necessary for human survival, an adequate food system is vital. A food system includes all processes and infrastructure involved in feeding a population: growing, harvesting, processing, packaging, transporting, marketing, consumption and disposal of food and food-related items. The food system must provide enough food and of good quality to sustain populations.
4) Food Production, Security, and Illness

Land based agriculture is impacted by climate change:

Food production, loss of soil fertility, erosion and salinization can lead to:

a. Changes in crop yields and protein levels (+/-)
b. Effects on feed intakes and animal reproduction
c. Increased use of agrochemicals

Dietary and nutritional changes on a population level can result from changes in food production and availability.
4) Food Production, Security, and Illness

Oceanic and coastal Fisheries

A change in coastal circulation patterns can affect:

• Nutrient supply to water
• Lagoon flushing – introduction of freshwater
• Coastal erosion
• Ocean acidity and coral bleaching
• Decline in fish and shellfish productivity
5) Food and Water-borne Diseases

Food Safety

Food borne disease may cause food poisoning:

a. May increase the proliferation of bacterial pathogens including Salmonella, Campylobacter and Listeria spp.

b. May increase mycotoxins and aflatoxins in food.

- Mycotoxins are products of microfungi that are capable of causing disease and death in humans and other animals. Because of their pharmacological activity, some mycotoxins or mycotoxin derivatives have found use as antibiotics, growth promotants, and other kinds of drugs; still others have been implicated as chemical warfare agents and are very dangerous to humans.

- Aflatoxins are a family of toxins produced by certain fungi that are found on agricultural crops such as maize (corn), peanuts, cottonseed, and tree nuts. The main fungi that produce aflatoxins are abundant in warm and humid regions of the world. Aflatoxin-producing fungi can contaminate crops in the field, at harvest, and during storage.
5) Food and Water-born Diseases

Food Security


This graph demonstrates the increase risk of food poisoning with the bacteria salmonella in Australia with increasing temperatures.
Two important remaining impacts of climate change are related to vector borne illnesses and the depletion of the ozone layer. Vector-borne diseases are illnesses caused by pathogens and parasites in human populations. Every year there are more than 1 billion cases and over 1 million deaths from vector-borne disease.

The most common vector born disease is malaria – a mosquito-borne disease. This graph shows how malaria infections are impacted by seasonal weather patterns in Vanuatu.
Mosquito-borne-disease: Environmental Changes. These changes mainly affect the breeding grounds and conditions which affect vectors’ survival and reproduction.

Distribution of vectors will change arising from:
- Increasing temperature
- Changing rainfall:
  - Increase or decrease
  - Seasonality
- Cyclones, flooding
- Changes in animal host/reservoir populations
- Rising sea levels
- Extreme tides
- Loss of coastal margins
6) Vector-Borne Disease

Mosquito-borne-disease: Human Factors. Human factors can impact the distribution of vector-borne disease by a variety of means.

Location of a population:
Geographic location- example if the population is near bodies of water that attract certain vectors

Mobility of a population:
Arrival of infected people into previously unaffected areas. They may have migrated from within the country or immigrated from another country.

Living standards of a population:
- Availability of insect screens or mosquito nets, access to air conditioning can minimize external vectors entering home environment.
- Social/political breakdown leading to poor standards of living can be caused by economic challenges. These economic challenges, in turn impact other social determinants of health.
6) Vector-Borne Disease

Mosquito-borne-disease: Water Management. Breeding is also influenced by water management systems which can serve as breeding grounds for various vectors.

- Water hoarding/storage:
  a. Rainwater tanks
  b. Uncovered containers
- Dams
- Irrigation
- Groundwater recharge.
Estimated population at risk of dengue fever under “standard” climate change scenario: 1990, 2085
This image demonstrates the increased population (in red) who is expected to be at risk for dengue fever if global temperatures continue to rise, due to the expansion of breeding grounds for the mosquito carrying dengue.
6) Vector-Borne Disease

Climate change can also impact vectors other than mosquitoes. With increasing temperatures there is loss of species which feed on rodents which carry diseases.

For example, when raptors began to decrease in India, the population of rodents, which were a food staple for raptors, increased. This led to an increase in rodent-borne diseases such as the plague and hantaviruses.

With dramatic weather pattern changes a shift in vectors and the delicate system which keeps numbers in check can lead to an increase in disease such as was evidenced in India where the vulture population decreased and the feral dog population increased. These feral dogs are carriers of rabies.
7) Other Indirect Impacts – Ozone Depletion

This image demonstrates the ozone hole in blue over Antarctica. The ozone hole is not static and enlarges and shrinks overtime. However, the loss of the protective ozone layer has significant health effects due to increased solar radiation (ultraviolet radiation – UVR). Note: Ozone in the higher atmosphere is protective, but ozone in the lower atmosphere is dangerous to human health.

Click here to watch the Exploring Ozone video from NASA.
Many epidemiological studies have implicated solar radiation as a cause of skin cancer (melanoma and other types) in fair-skinned humans.

Assessments by the United Nations Environment Program project increases in skin cancer incidence and sunburn severity due to stratospheric ozone depletion for at least the first half of the twenty-first century (and subject to changes in individual behaviors such as sun bathing and skin tanning).

The groups most vulnerable to skin cancer are white Caucasians, especially those living in areas of high ambient UVR.

It is estimated that for the US population there will be a 10% increase in skin cancer incidence by around 2050.
This graph shows the age-adjusted melanoma incidence (per 100 000) in Australia, 1983-1999 (data from the National Cancer Statistics Clearing House at the Australian Institute of Health and Welfare).

Of concern, it is estimated that two in three Australians will be diagnosed with skin cancer by the time they are 70.
Over the past decades, the incidence of skin cancer has risen in Australia. From 1982 to 2010 melanoma diagnoses increased by around 60%.

Over 434,000 people are treated for one or more non-melanoma skin cancers in Australia each year.

In 2012, 2,036 people died from skin cancer in Australia.
The impact of climate change on urban populations can be severe as you have learned so far. The impact of disruptions caused by climate change can impact the social structure in important ways. These disruptions can have impacts on the well-being of urban dwellers.

It is important to understand which populations are particularly vulnerable to the health impacts of climate change so that public health professionals can work to avoid health disparities among vulnerable populations.

Once we understand how climate change can impact the health of urban dwellers we need to develop approaches to respond to climate change. This section will explore the role of mitigation, adaptation and resilience.
Social Impacts

Lifestyle and behavior have been predicted to be affected in the following ways:

- Increased body temperatures
- Increases in crime - particularly involving aggression
- Accidents - workplace and traffic
- Decline in physical health
- Hot nights may cause sleep deprivation
- Recreational opportunities - changes to exercise patterns
- Changes in alcohol consumption
- Stress
- Lack of cold water - reduced ability to cool down
Social Impacts

Mental Health can be impacted as follows:
- Anxiety and depression
- Post traumatic stress disorder
- Insecurity
- Grief
- Stress, self harm and possible suicide
- Drug and alcohol misuse
- Impacts on individuals, communities
- Loss of social cohesion
- Dislocation
- Specific impacts on children, women and elderly

Economic impacts may be as follows:
- Loss of income and/or assets
- Reduction of goods and services
- Higher costs of insurance, food, water and energy
- Financial strain for governments and others
- Impacts on provision of health services
Vulnerability is defined as the degree to which individuals and systems are susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes.

A result of integration of a number of factors:
Social Impacts

Many populations are vulnerable to the health impacts of climate change. These include:

- Elderly
- Children (immature immune response)
- Socio-economically disadvantaged (poor, socially isolated)
- Women, especially pregnant and breastfeeding women
- The obese
- Those who are not acclimatized, e.g. new arrivals to a geographic area
- Those who have underlying medical conditions or immune-compromised especially cardiovascular disease
- Athletes and other participants in outdoor recreational activities
- Manual laborers, outdoor workers
- Mentally ill, disabled and homeless
- Physically unfit – reduced vital capacity
## Urban Responses to Climate Change

### Local Changes Affecting Health

In order to determine public health responses to climate change, it is important to have a good understanding of local predicted changes in relation to:

**Biophysical environment:**
- Encompassing major impacts related to physical environment, including temperature, water quality, air quality and biodiversity

**Social environment:**
- Encompassing the wide range of social impacts, population displacement and mental health impacts

### Service and infrastructure:
- The range of impacts as it relates to services, infrastructure and economics, including resource availability and access to a range of health, emergency and other services

### Environmental diseases:
- Impacts related to production of food, vector-borne and food-borne disease and other environmental diseases.
Approaches to addressing climate change health impacts fall into 3 categories:

1. **Climate Change Mitigation**: actions to reduce emission of greenhouse gases.
2. **Climate Change Adaptation**: adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harms or exploits beneficial opportunities.
3. **Climate Change Resilience**: the capacity of cities to function, so that the people living and working in cities (particularly the poor and vulnerable) survive and thrive in the face of shocks and stresses related to climate change.
Responses – Climate Change Mitigation – Individual Responses
For more information on individual actions, please see this website.

Responses – Climate Change Mitigation – Global Responses
For more information on global response please see this website.
Urban Responses to Climate Change

Approaches to addressing climate change health impacts

• By reducing fossil fuel combustion:
  Less cardio-respiratory deaths/hospitalizations from local air pollution (esp. fine particulates).

• By decreasing emissions from urban (public) transport system:
  More physical activity (walking, cycling) $\rightarrow$ less over-weight, better lipid/endocrine profiles, more social contact and wellbeing.
  Road trauma should decline.

• By reducing red (ruminant) meat consumption (livestock sector is a major source of greenhouse gase emissions, esp. methane):
  Lower risk of some diseases: large bowel cancer, perhaps breast cancer; also heart disease (meat fat content).
Urban Responses to Climate Change

Responses to Climate Change

Climate Change Adaptation: adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harms or exploits beneficial opportunities.

Types of Adaptation

Adaptation responses may be of the form:

- Legislative or regulatory policy
- Public education or communication
- Surveillance and monitoring
- Ecosystem intervention
- Infrastructure development
- Technological/engineering
- Health intervention
- Research/ further information
Climate change resilience: the capacity of cities to function, so that the people living and working in cities (particularly the poor and vulnerable) survive and thrive in the face of shocks and stresses related to climate change. There are seven qualities of urban resilience to climate change.

1. Reflective – people and institutions systematically learn from experience and have a mechanism to continuously modify standards based on emerging evidence, rather than seeking permanent solutions based on an assessment of today’s shocks and stresses.

2. Robust – robust cities anticipate system failures and make provisions to maximize predictability and safety. They are designed and managed to withstand the impacts of extreme conditions and to avoid a catastrophic collapse of the city from the failure of a single element.

3. Redundant – capacity to accommodate for increasing demand or extreme pressures meaning that if one component of the system fails, other pathways or substitutable components can meet essential functional needs.

4. Flexible – involves a system that can change, evolve and adopt alternative strategies (either in the short or long term) in response to changing conditions.

5. Resourceful – people and institutions invest in the capacity to anticipate future urban conditions, set priorities and mobilize and coordinate the resource. This prepares a city to respond quickly to extreme events, modifying organizations or procedures as needed.

6. Inclusive – includes the consultation and engagement of communities, particularly those that are vulnerable.

7. Integrated – city systems, decision making and investments are mutually supportive of a common outcome. Requires ongoing feedback system for collection of information and response.