Nitin S. Damle MD MS FACP
President
American College of Physicians
Clinical Associate Professor of Medicine
Alpert Medical School of Brown University
Senior Partner
South County Internal Medicine Inc.
Nitin S. Damle MD MS FACP

Has no relationships with any entity producing, marketing, re-selling, or distributing health care goods or services consumed by, or used by patients in this presentation.

There are no other conflict of interests.
Climate Change and Health:
The Greatest Global Health Opportunity of the 21st Century
Major Idea/Context

Reason to Care

Benefits and Worth Sharing
To my mind there is no better demonstration of the folly of human conceits than this distant image of our tiny world. To me it underscores our responsibility to deal more kindly and compassionately with one another and to preserve and cherish that pale blue dot, the only home we’ve even known. –Carl Sagan, 1994
Global Climate Change (GCC)

The United Nations Intergovernmental Panel on Climate Change:
“Is the Greatest Global Threat of our Time”

Lancet, 11/09:
“Climate Change is the biggest global health threat of the 21st century...The impacts will be felt all around the world---and not just in some distant future but in our lifetimes and those of our children”
Four Principles of GCC

- The climate is changing at a pace and in pattern that is not explainable under natural phenomena.
- Build up of CO2 and other gases (methane and nitrous oxide) from the burning of fossil fuels is the main driver of this phenomena.
- The harm to humans and the ecosystem has begun.
- There is a chance to stem the changes if aggressive action is taken now.
Organizations with Statements on Human Activity and GCC

- American Association for the Advancement of Science
- National Academy of Sciences
- American Chemical Society
- American Meteorological Society
- The Vatican and Pope Francis
- American Medical Association
- American Academy of Pediatrics
- American College of Physicians
The Greenhouse Effect

1. Solar radiation passes through the clear atmosphere.
   - Incoming solar radiation: 343 Watt per m²

2. Some solar radiation is reflected by the atmosphere and earth’s surface.
   - Outgoing solar radiation: 103 Watt per m²

3. Some of the infrared radiation passes through the atmosphere and is lost in space.
   - Net outgoing infrared radiation: 240 Watt per m²

4. Solar energy is absorbed by the earth’s surface and warms it...
   - 168 Watt per m²

5. Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules. The direct effect is the warming of the earth’s surface and the troposphere.

6. Surface gains more heat and infrared radiation is emitted again.

... and is converted into heat causing the emission of longwave (infrared) radiation back to the atmosphere.
The largest producers of CO2 emissions worldwide in 2015, based on their share of global CO2 emissions

- China: 28.03%
- U.S.: 15.9%
- India: 5.81%
- Russian Federation: 4.79%
- Japan: 3.84%
- Germany: 2.23%
- Korea: 1.78%
- Canada: 1.67%
- Iran: 1.63%
- Brazil: 1.41%
- Indonesia: 1.32%
Global anthropogenic GHG emissions

Source: 2010 Intergovernmental Panel on Climate Change (AR4 Synthesis Report)
Indicators of Global Climate Change
(GCC)

- Global Temperature Rise
- Sea Level Rise
- Ocean Acidification
- Ice Melt and Loss of Glacier Mass
Global Temperature Rise
Figure 1.1. Variations in Earth's average surface temperature, over the past 20,000 years.
Global climate temperature
Separating Human and Natural Influences on Climate

Global Temperature Change (°F)

- Observations
- Natural and Human Factors
- Natural Factors Only

Year

1900 1920 1940 1960 1980 2000

-1.0 0.0 0.5 1.0 1.5 2.0
Ice Melt and Glaciers
The 1979-2010 average Arctic sea ice minimum (outlined in orange) compared with the August 2012 sea ice (shown in bluish white).

Photo credit: SVS/NASA.
Projected Arctic Sea Ice Decline

Sea Ice Extent (million km²)

Year

Essentially Ice Free

RCP 8.5
RCP 6.0
RCP 4.5
RCP 2.6
Historical
Observed
Mendenhall Glacier, Alaska 1894 and 2015.
Sea Level Rise
Global mean sea level rise
(relative to 1986–2005)

Year

0 0.2 0.4 0.6 0.8 1
2000 2050 2100

Mean over 2081–2100

RCP2.6
RCP4.5
RCP6.0
RCP8.5

21
As Oceans Absorb CO₂, They Become More Acidic

- Mauna Loa Atmospheric CO₂ (ppm)
- Aloha Ocean pCO₂ insitu (μatm)
- Aloha Ocean pH (in situ)
Shells Dissolve in Acidified Ocean Water
50% Extinction of Plants and Animals by 2100 and Mass Migration at 18 feet/day to the poles
Forest Fires
Drought
Floods
Heat Waves
Extreme Weather
Globally, over 1 billion people lack access to safe drinking water

2.5 billion lack access to adequate sanitation

Estimated that 5 million people globally, primarily kids, die from water-related diseases annually
GCC and Human Health
“The biggest health threat of the 21st Century”
Impact of 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
- Respiratory allergies, asthma
- Extreme Heat
- More Extreme Weather
- Severe Weather
- Air Pollution
- Changes in Vector Ecology
- Increasing Allergens
- Rises in CO2 Levels
- Rising Sea Levels
- Water and Food Supply Impacts
- Water Quality Impacts
- Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms
- Malnutrition, diarrheal disease
- Environmental Degradation
Heat Related Effects/ Clinical Presentations

- **Mild symptoms** (rash, fatigue)
- **Heat Exhaustion**
  - Thirst/Weakness/Dizzy
  - Cramps/Headache
  - Nausea/Vomiting
  - Profuse diaphoresis/tachycardia
- **Heat Stroke**:
  - Confusion/Syncope/Coma
  - Dry skin or moist
  - Core temperature > 104 F
Groups at Increased Risk

- Elderly
  - sweat less, less thirst drive/non-ambulatory/
    Cardiopulmonary and renal conditions
  - Multiple medications
  - Thermoregulation
- Children (0-4) and older kids – thermoregulatory
  issues and activities
- Sports Enthusiasts – may overdo
- Laborers – may be placed at greater risk
- Homeless – may not recognize the danger or have
  resources to cope
Heat Waves

HISTORY
- 7400 annual deaths: 1999-2010 in USA
- 15000 deaths in France 2003
- 70000 excess deaths, Europe 2009
- 15000 deaths Russia 2010

FUTURE
- By 2081 Chicago 2000 deaths per year
- In 200 US cities 11000 deaths by 2030
- 21000 deaths in US by 2100
Prevention of Heat Morbidity/Mortality

- Communication by clinical teams: reach vulnerable populations
- Public Health warning systems of impending heat waves
- Temporary housing for vulnerable population
- Timely education about the risk of heat illness
- Community outreach teams organized by local public health authorities
Respiratory Effects

American tourists wearing masks to filter out smoke from forest fires surrounding Moscow, Russia. Summer 2010.

Respiratory Effects
Particulate matter and ozone

- Source: Autos, power plants and forest fires
- 43 million in US and 92% of the world live in areas in excess of WHO limit of 10 micrometers/mm3.
- In 2012 7 million deaths attributable to air pollution (WHO)
- Ozone will increase to 60 ppb by 2030/irritable to alveoli/air trapping/more vulnerable to particulates
Pathogenesis: Ozone irritates the lungs and makes people more vulnerable to the effects of small particles and allergens.*

Allergies and Asthma
Allergies and Asthma

- 55% of US and European population tests positive for allergens and 34 million people with asthma
- Increased length of pollen season in North America and Europe
- Increased CO2 production leads to increase growth of allergen producing weeds, grasses, trees and fungus.
- Rain and floods leads to increase mold and fungal growth
Allergies and Asthma

- **Allergies**: 11 million office visits per year
- $11.2 billion per year to treat
- **Asthma/COPD**: 2 million ED visits/.5 million hospitalization/3600 deaths
- 56 billion dollars per year
Infectious Disease
Deaths from vector-borne disease

VBD Deaths/million

- 0 - 1
- 1 - 20
- 20 - 50
- 50 - 200
- 200 - 500
- 500 - 1900
- No Data


The boundaries shown on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Coloured lines on maps represent approximate border lines for which there may not yet be full agreement.

© WHO 2000. All rights reserved.
Figure 3. Approximate Ranges of *A. aegypti* and *A. albopictus* in the United States (as of March 2016).

These mosquitoes may not be present in all areas, and vector density may vary considerably within these ranges.
WHO Vector Borne Diseases in North American/European Region

- **Mosquito:**
  - Dengue
  - Chikungunya
  - Malaria
  - West Nile Fever
  - Zika

- **Sandfly borne:**
  - Leishmaniasis

- **Tick borne:**
  - Lyme/Anaplasma/Babesia
RISK OF MALARIA TRANSMISSION will have risen in many parts of the world by 2020 (relative to the average risk in the years 1961 to 1990), according to projections assuming a temperature increase of about two degrees Fahrenheit. The analysis was based solely on temperature threshold and did not assess other factors that could influence malaria’s spread.
Waterborne Diseases
Heavy Downpours are Increasing Exposure to Disease

- Storm Drain
- Wastewater
- Stormwater

Streams and rivers rise, which contributes to flooding of homes, businesses, and critical infrastructure like sewer and storm water systems.

Climate change increases heavy downpours.

Sewage overflow from treatment plants, septic fields, and municipal lines can back up into people's homes.

Floodwaters can become contaminated with agricultural waste, chemicals, raw sewage, and other pollutants.

Flooded materials in homes, schools, and businesses can cause molds to grow and be inhaled.

Floodwaters can contain disease-causing bacteria, viruses, and parasites.
Association between precipitation and waterborne disease outbreaks/Toxigenic E. Coli

Amy Greer, PhD et al. CMAJ 2008;178:715-722
- **Toxigenic E. Coli (O157:H7)** from contaminated food and water
- Bloody diarrhea, vomiting-may lead to kidney failure and even death
- **Campylobacter**-common cause of food poisoning from meats/unpasteurized dairy products/contaminated water.
- **Salmonella**-common cause of food poisoning
- **Leptospira**-spread through the urine of infected animals, rodents, through the soil and water, and during flooding. Infections in urban kids increasing.
- Higher temperatures are associated with higher rates of production and disease.
Bacteria: Vibrio Species & Legionella

- **Vibrio** is strongly influenced by climate—both fresh and marine waters.
- **V. Cholera** causes estimated 3-5 million cases and 100,000-120,000 deaths yearly world-wide. Young children in endemic areas most affected.
- Virulent *V. parahaemolyticus* strain found in Maryland shellfish & Alaskan oysters in Price William Sound (furthest north) - big public health concern.
- Climate warming can increase pathogen development and survival rates, disease transmission and host vulnerability.
- **Legionella** (Legionnaire’s Disease)-respiratory illness transmitted solely by water. Warm water and perhaps other factors, like association with amoebas, influence the potential to colonize water systems.
Parasitic Disease

- **Cryptosporidium**: 2,000-3,000 cases annually in the U.S. through livestock waste & contaminated water.
- Cryptosporidium oocysts detected in 65% to 97% of surface waters tested in the U.S.
- Common disinfectants, like chlorination, are ineffective.
- 1993 outbreak in Milwaukee was the largest outbreak ever documented in the U.S. with 400,000 cases and 100 deaths.
- In 1997, 2,566 cases were reported from 45 states.

- **Giardia lamblia**: Second most common parasite in the U.S.
- Cyst found in raw surface water from animal and human feces.
- 39% of filtered drinking water found Giardia (17%) and Crypto (27%).

- **Cyclospora**: Often associated with fresh produce from contaminated water. Big outbreak in 2013 from salad bar/cilantro in TX, NE, and IA.
Viruses

- **Viruses** are heat resistant and likely to survive sewer treatment processes. Viruses found in shellfish contaminated with wastewater and fecal sources.
  - Hepatitis A
  - Norovirus
  - Norwalk virus
Food Security
Food Security

Temperature and precipitation extremes (like flooding) can increase pathogen load.

Climate can also alter weed, insect, and fungal populations and increase pesticide use.

Rising carbon dioxide can directly influence nutritional content of foods.

Warmer temperatures can result in greater food spoilage.

Extreme climate events can disrupt food distribution.
Protein Content in Wheat Flour

Observed 2014 CO₂ concentration: 399 ppm

Atmospheric CO₂ Concentration (ppm)

Concentration of Essential Minerals at CO₂ Concentration of 689 ppm

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Change in Mean Concentrations (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>8</td>
</tr>
<tr>
<td>P</td>
<td>-8</td>
</tr>
<tr>
<td>K</td>
<td>-8</td>
</tr>
<tr>
<td>Ca</td>
<td>-8</td>
</tr>
<tr>
<td>S</td>
<td>-8</td>
</tr>
<tr>
<td>Mg</td>
<td>-8</td>
</tr>
<tr>
<td>Fe</td>
<td>-8</td>
</tr>
<tr>
<td>Zn</td>
<td>-8</td>
</tr>
<tr>
<td>Cu</td>
<td>-8</td>
</tr>
<tr>
<td>Mn</td>
<td>-8</td>
</tr>
<tr>
<td>ionome</td>
<td>-8</td>
</tr>
<tr>
<td>Protein</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>-12</td>
</tr>
<tr>
<td>Rice</td>
<td>-12</td>
</tr>
<tr>
<td>Wheat</td>
<td>-12</td>
</tr>
<tr>
<td>Soybean</td>
<td>-12</td>
</tr>
<tr>
<td>Potato</td>
<td>-12</td>
</tr>
</tbody>
</table>
Compromised Food and Water security

- Increased crop losses from diseases such as fungi, bacteria and viruses
- Decreased nutrient content in iron, zinc and protein.
- Global climate change will decrease food production by 2% per year in the face of a 14% per year increase in demand.
- Reduced water supply from droughts with 100 million people in areas of water shortage.
Mental and Emotional Effects
Medical and Physical Health
- Changes in fitness and activity level
- Heat-related illness
- Allergies
- Increased exposure to waterborne and vector-borne illness

Mental Health
- Stress, anxiety, depression, grief, sense of loss
- Strains on social relationships
- Substance abuse
- Post-traumatic stress disorder

Community Health
- Increased interpersonal aggression
- Increased violence and crime
- Increased social instability
- Decreased community cohesion
E.g., effects of Hurricane Katrina

49% developed an anxiety or mood disorder
1 in 6 developed posttraumatic stress disorder
Mass Migration
In 2012, extreme weather drove more than 32 million people from their homes.

98% of climate refugees were from developing countries.
The Global Risks of Highest Concern, 2016

Percent of participants mentioning the respective risk to be of high concern for the time frame of 18 months or 10 years, respectively. Participants could name up to five risks in each time frame. In each category, the risks are sorted by the total sum of mentions.

For the next 18 months

<table>
<thead>
<tr>
<th>Risk</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large-scale involuntary migration</td>
<td>52.0%</td>
</tr>
<tr>
<td>State collapse or crisis</td>
<td>27.9%</td>
</tr>
<tr>
<td>Interstate conflict</td>
<td>26.3%</td>
</tr>
<tr>
<td>Unemployment or underemployment</td>
<td>26.0%</td>
</tr>
<tr>
<td>Failure of national governance</td>
<td>25.2%</td>
</tr>
</tbody>
</table>

For the next 10 years

<table>
<thead>
<tr>
<th>Risk</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water crises</td>
<td>39.8%</td>
</tr>
<tr>
<td>Failure of climate-change mitigation and adaptation</td>
<td>36.7%</td>
</tr>
<tr>
<td>Extreme weather events</td>
<td>26.5%</td>
</tr>
<tr>
<td>Food crises</td>
<td>25.2%</td>
</tr>
<tr>
<td>Profound social instability</td>
<td>23.3%</td>
</tr>
</tbody>
</table>

Read more: wef.ch/risks2016    #risks2016
Elements of Vulnerability to Climate Change

Aging Population in the U.S.


U.S. Chronic Respiratory Disease Deaths (1980-2010)

U.S. Obesity Rates in Children and Adolescents (1971-2010)

Diagnosed Diabetes in the U.S. (1958-2010)


Note: only 4 years of data available in 1980s
WHO predicts
250,000 deaths per year by 2030

- Malaria
- Dengue
- Diarrheal disease
- Heat stress
- Under nutrition

Heaviest Burden:
- Children, women, older people, the poor, individuals of color, disabilities
The Biggest Health Opportunity of the 21st Century
Solutions
GCC Agreement

- United Nations Framework Convention on Climate Change in 2015 adopted the Paris Agreement of the Conference of Parties.
- Keep global temperature rise to less than two degrees and preferably 1.5 degrees Celsius.
- The agreement states: “parties should promote their obligations on the right to health when addressing global climate change”
- WHO agreement includes reporting to WHO/UNFCCC on sustainable development goals
Mitigation
Three Principles

- Global effort to reduce anthropogenic greenhouse gas emissions
- The developed countries need to take a leading role in developing/implementing and monitoring the success of mitigation measures.
- Health co-benefits are an integral part of global climate change discussions
Mitigation Strategies

- Expanded use of low carbon or carbon neutral energy
- Improve carbon sinks by decreasing deforestation and increasing reforestation
- Increase fuel efficiency standards
- Energy efficiency standards for buildings
- Financial incentives for proper land management
Personal Initiatives

- Commuting
- Electric Cars
- Walking/Biking
- Healthy foods
- Limiting air travel
- No water bottles
Greenhouse gas emissions from food, in CO2e/kg

- lamb
- beef
- cheese
- pork
- turkey
- chicken
- tuna
- eggs
- potatoes
- rice
- nuts
- beans/tofu
- vegetables
- milk
- fruit
- lentils
There is hope and there is movement!
The health care sector is ranked second in energy use after the food industry
- It spends about $9 billion annually on energy costs
- Hospitals in the United States produce a massive amount of garbage/waste (>2.3 million tons per year)
Health Care Sector Efforts

- Energy efficient lighting
- Recycle and purchase recycled products
- Electric car charge station
- Clean energy sources (wind and solar)
- Environmentally sustainable building materials and construction.
- Reduce fleet emissions
- Waste conservation and disposal
- Green Building (LEED or Energy Star Programs)
Case Study: Boston Green Ribbon Commission
Health Care Working Group

• 22 Boston-area hospitals participate.
Commission’s goal is 25% drop in GHG emissions by 2020, 80% by 2050
• Member hospitals achieved cuts in electricity, natural gas use, GHG reductions for all fuels.
• Sector energy use dropped by 6% from 2011-2013, “equal to eliminating GHG impact of an average care traveling over 85 million miles.”
• Mass General cut GHG emissions by 35% in 2014, Boston Medical on track for a 45% cut in 2020, Brigham & Women’s will reach 35% in 2020.
• “Cost savings are conservatively estimated at $11.9 million, enough to pay for healthcare for 1055 Massachusetts Medicare enrollees.” (1)
Case Study: Group Health Puyallup Medical Center

- Washington State facility first in nation to receive LEED for Healthcare Gold certification. (1)
- Facility includes ground-level vegetation and green roof
- Designed for water use reduction – Special sensors activate cold water for cooling sanitized medical equipment only when necessary
- Uses a more efficient steam generator boiler
- Used local and/or recycled construction materials
- Car charging stations and bike racks on site.
Global renewable energy consumption

Excluding hydropower. In million tons of oil equivalent.

- North America
- South America
- Europe
- Middle East
- Africa
- Asia Pacific

Wind Cost Per Kwh (US)

55¢ / kwh

22x Price Decline

2.5¢ / kwh
How Cheap Can Solar Get?

This is a future model of solar prices. Assumes 16% cost reduction of new solar electricity per doubling of scale. Solar costs unsubsidized. Natural gas prices do not include carbon pollution externalities.

When solar reaches 2% of 2015 global electricity demand

New Natural Gas Electricity Price

Average Solar - Medium Sunlight Locations

Lowest Cost Solar - Sunniest Locations

Graph by Ramez Naam rameznaam.com/tag/solar/

2015: Solar is 1% of global electricity

2020?

2028?

2035?

5 Doublings, from 200GW in 2015 to 6,400 GW at a future point. 20 years? Difficult to Estimate.
DIVEST  

INVEST
Public/Private Partnerships in Green Economy

- United Nations report estimates 90 trillion dollars needed over 15 years.
- World GDP is 73 trillion in 2015.
- Principles and Guidelines on investments/credibility/disclosure and transparency
- Bonds and Incentive Programs
- CO2 emissions taxes and trades
- China has green bonds/40% of global market
- Multinational Trust Funds for Solar Energy
Repeal of Paris Agreement/Clean Power Plan

- Economic forces may dictate movement to clean energy with tax incentives for wind and solar.
- Renewable tax credits have been extended through 2021.
- Improved battery, wind and solar technology
- Social investing/69% of Fortune 500 companies requesting low carbon products.
Greatest Public Health Opportunity of the 21<sup>st</sup> Century

- Health care system can be a leader in transformation
- Reduce global emissions of climate pollutants to gain health co-benefits.
- Fundamental and coherent approach to aligning economic development, environmental protection and health and human well being.
- Your trusted voice and strength can be a powerful force in meeting this opportunity!
Physician Advocacy/Education

- Physicians at the individual level have the trust and authority to make an impact.
- Town and County Councils and mayors (especially in low lying areas)
- Community Centers
- Schools
- Civic Organizations/Businesses
- State Health officials/Legislators/Governor
- Representatives/Senators
- ACP Chapters/International meetings
- Medical School Curriculum/Physician CME
Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has.

Margaret Mead
Which World Would You Like?
Global Climate Change and Health is Health Imperative an Economic Imperative a Political Imperative a Moral Imperative
Thank you
Questions?

Climate Change and Health: A Position Paper of the American College of Physicians
http://annals.org/article.aspx?articleid=2513976
nsdamle@scim.necoxmail.com