

# Climate Change and Health: What we know about it, and how we know it!

*Presented at the:*

The Air and Waste Management Association, New England Section Fall Conference-  
Climate Change: Risks, Rewards, Resiliency (R3 )  
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**HEALTH**

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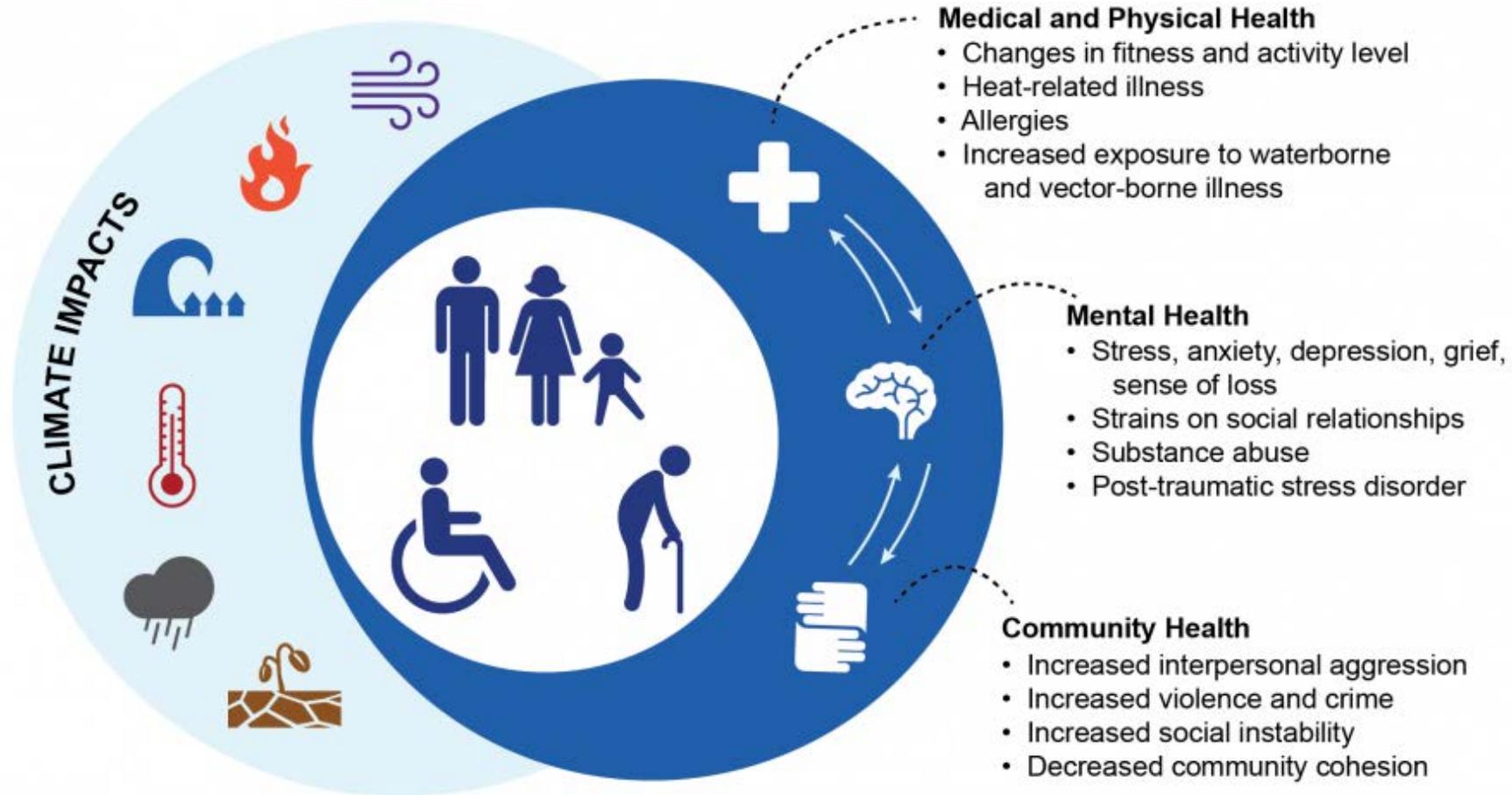
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*Thank you !*



Report slides are available at:  
<https://health2016.globalchange.gov/downloads>

# The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment.



# Flow of this talk

- Climate change- what do people generally think?
- Climate change and health- why is it a concern?
- How do we determine linkages?
- 40,000 foot summary and selected highlights of

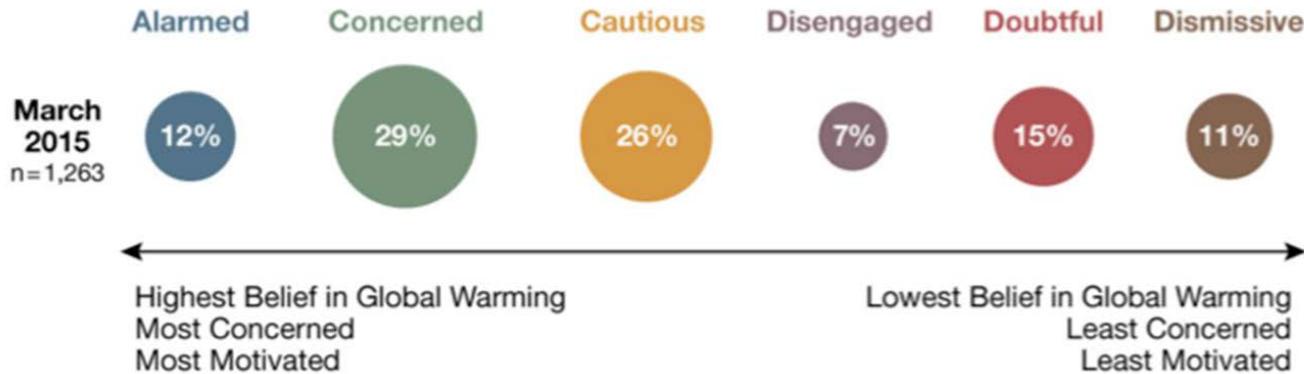
*The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC 2016*

*PLUS brief note from Lane et al. extreme events article*

- What can we do?

# Climate change and health- What do people generally think?

## Global Warming's "Six Americas"



Proportion represented by area

Source: Yale / George Mason University



# Climate Change

What does it mean?

- Science
- Consequences
- Equity
- Mitigation and adaptation
- Policy and environmental politics



*“We, the people, still believe that our obligations as Americans are not just to ourselves, but to all posterity. We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations. Some may still deny the overwhelming judgment of science, but none can avoid the devastating impact of raging fires and crippling drought and more powerful storms. “*

President Barack Obama

January 21, 2013

President Obama's Plan to Fight Climate Change

[www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf](http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf)



# United States Global Change Research Program

USGCRP

<http://www.globalchange.gov/>

- Presidential Initiative in 1989 and the Global Change Research Act of 1990 to “assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”
- Eight federal agencies (with leadership from the U.S. Environmental Protection Agency, the U.S. Department of Health and Human Services, and the National Oceanic and Atmospheric Administration)

# Climate change and health- why is it a concern?



- Majority of scientific community concerned –

from the 2014 The National Climate Assessment

“300 experts guided by a 60-member Federal Advisory Committee produced the report, which was extensively reviewed by the public and experts, including federal agencies and a panel of the National Academy of Sciences”

*“Global climate is changing and this change is apparent across a wide range of observations. The global warming of the past 50 years is primarily due to human activities. Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the Earth's climate is to those emissions.”*

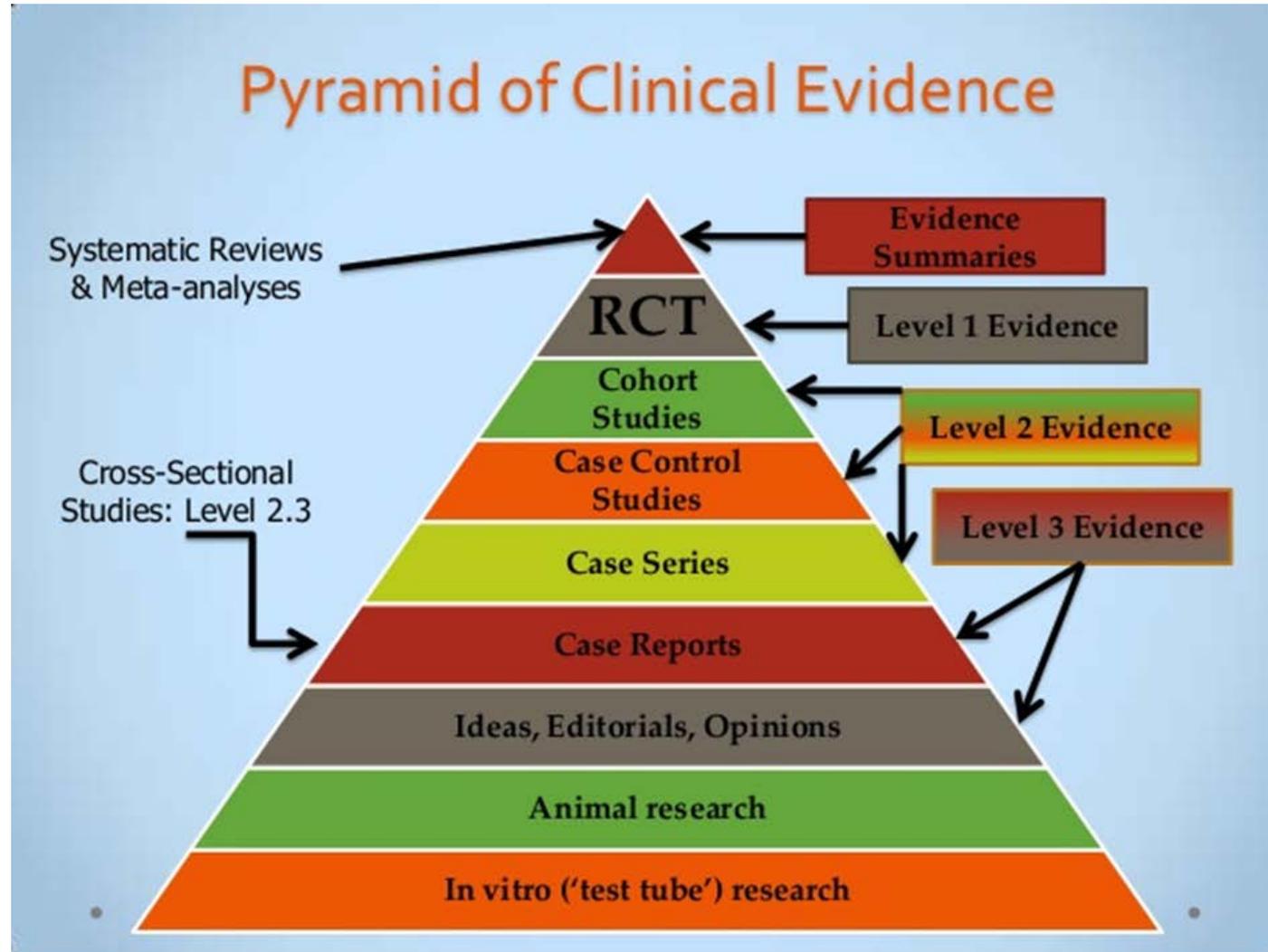
One chapter in the report summarized broad health impacts

<http://nca2014.globalchange.gov/>

# Climate change and health- why is it a concern?

- Public health challenges are HUGE- severe and widespread outcomes
  - Direct impacts-----
    - some obvious: heat, drought, severe weather and ----
    - some less obvious- spread of diseases, increased allergy, increased displacement, problems with healthcare delivery
  - Social and economic disparities made worse! Those least able to cope becoming more vulnerable
  - Global impacts require every level of government ( municipal, regional, state, country, international) for agreement, policy change, enforcement
- Hasn't played well politically –environment has overshadowed health

How do we determine linkages between environment and health?



Strategies to evaluate risks and health effects have *strengths and limitations*.

- Epidemiology/population studies (- cohort, case/control, cross sectional -)
- Toxicity studies (tissue and animal models, dose- response)
- Clinical reviews (cases series and reports)
- “Natural experiments”
- Tools
  - Risk factor questionnaires
  - Exposure assessment
  - Outcomes research and surveillance
  - Environmental public health tracking
  - Case series abstracts
  - Statistics

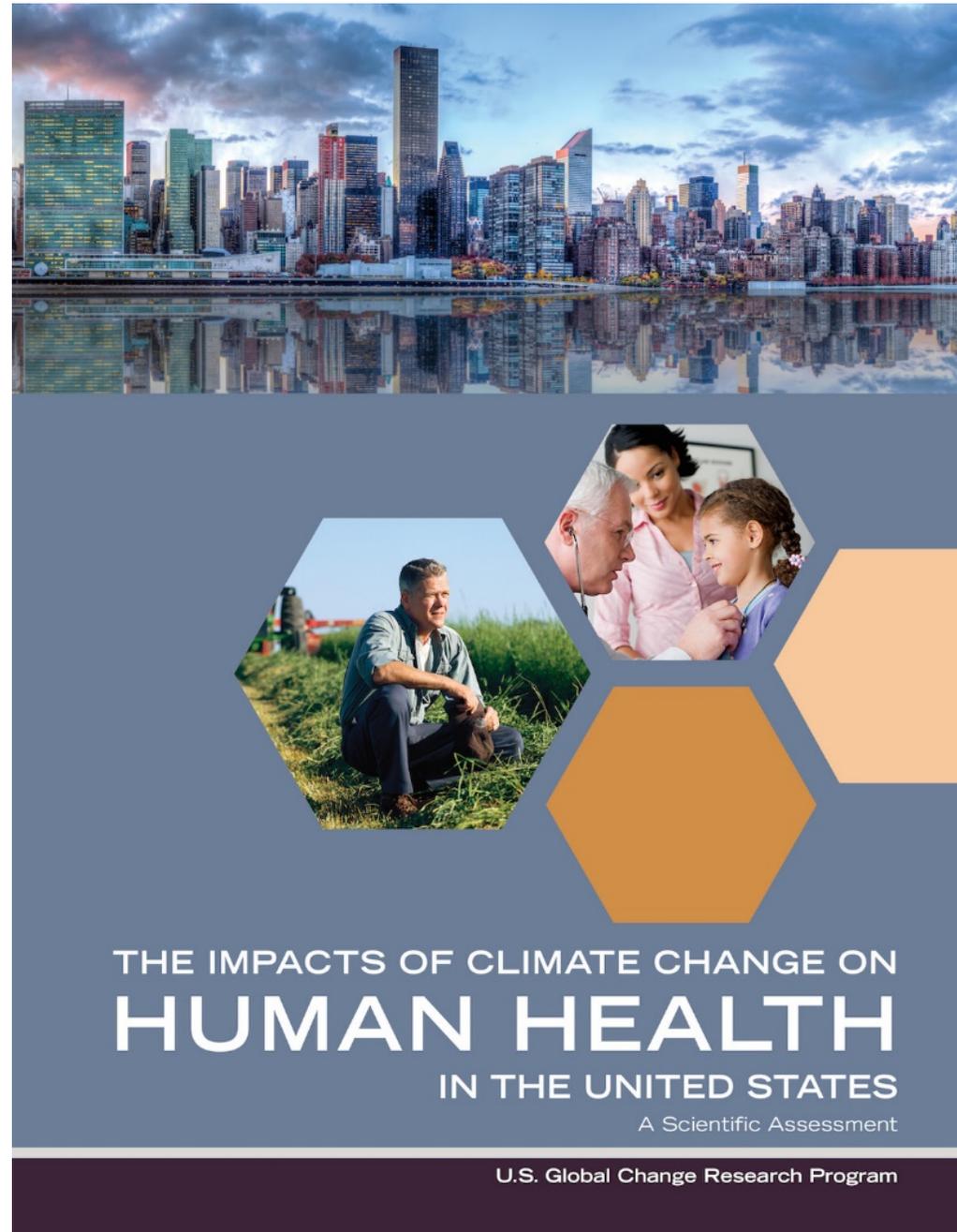
# Some reasons for limitations with health studies

- Co-factors
- Environmental characterization and exposure assessment
- Meteorology
- Epidemiological study design
- Exposure and outcome metrics are different
- Data quality...Is it available? Is it enough?

Purpose: to inform public health officials, urban and disaster response planners, decision makers, and other stakeholders within and outside of the government who are interested in better understanding the risks climate change presents to human health (*emphasis added*). The effort was overseen by the USGCRP-coordinated Interagency Crosscutting Working Group on Climate Change and Human Health, led by co-chairs from National Institutes for Environmental Health Sciences, National Oceanic and Atmospheric Administration, and the Centers for Disease Control and Prevention.

Lead author is from US Environmental Protection Agency.

Crimmins, A., J. Balbus, J. L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M. Hawkins, S.C. Herring, L. Jantarasami, D. M. Mills, S. Saha, M. C. Sarofim, J. Trtanj, and L. Ziska, 2016: Executive Summary. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 24 pp. <http://dx.doi.org/doi:10.7930/J00P0WXS>



# Background from the report-----

- Comprehensive, evidence-based
- Where possible quantitative estimation of observed and projected climate change related health impacts
- Geographic focus on the United States
- Compiled and assessed current research
- Summarized the science on key topics
- Observed and current impacts PLUS projected impacts for 2030, 2050 and 2100
- Health impacts including focus on population vulnerability to health impacts and how to address this vulnerability
- Relies on 2014 NCA report and other peer-reviewed scientific assessments

# From the report-----

- Sources: scientific, peer-reviewed research and other resources
- Reviewed by author teams
- Literature review process adhered to “Information Quality Act”
  - Utility
  - Transparency and traceability
  - Objectivity
  - Integrity and security

# Stated overarching perspective

- Global change context
- Complex linkages and role of non-climate stressors
- Cumulative, compounding or secondary impacts
- Societal choices and adaptive behavior
- International context



# Confidence/Likelihood Terminology

## Likelihood

<b>Very Likely</b> ≥9 in 10	<b>Likely</b> ≥2 in 3	<b>As Likely as Not</b> ≈ 1 in 2	<b>Unlikely</b> ≤ 1 in 3	<b>Very Unlikely</b> ≤1 in 10
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## Confidence Level

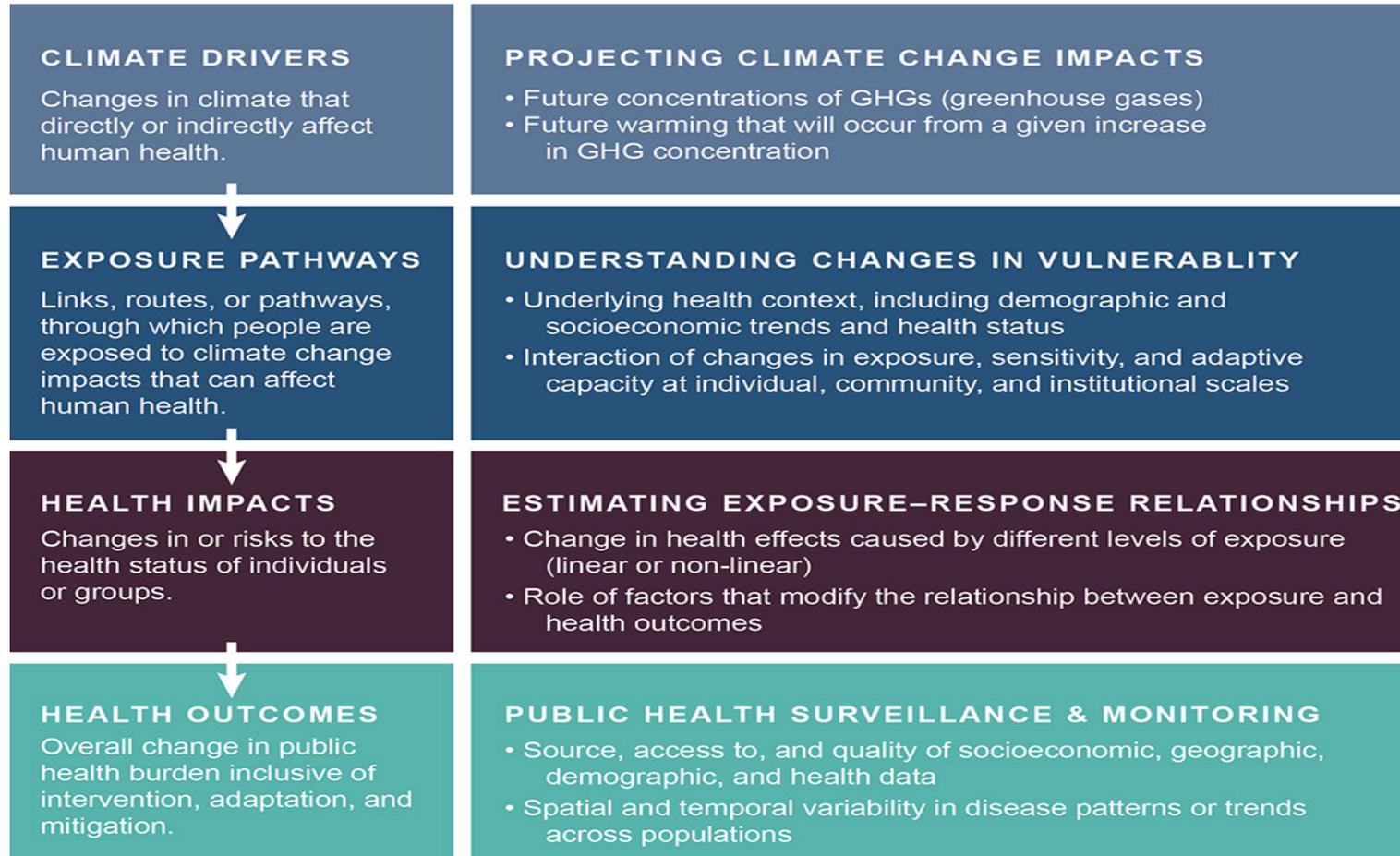
<b>Very High</b> Strong evidence (established theory, multiple sources, consistent results, well documented and accepted methods, etc.), high consensus	<b>High</b> Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.), medium consensus	<b>Medium</b> Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.), competing schools of thought	<b>Low</b> Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.), disagreement or lack of opinions among experts
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# 1

# Climate Change and Health

## Sources of Uncertainty





# 1

# Climate Change and Health

## Examples of Climate Impacts on Human Health

	Climate Driver	Exposure	Health Outcome	Impact
 <b>Extreme Heat</b>	More frequent, severe, prolonged heat events	Elevated temperatures	Heat-related death and illness	Rising temperatures will lead to an increase in heat-related deaths and illnesses.
 <b>Outdoor Air Quality</b>	Increasing temperatures and changing precipitation patterns	Worsened air quality (ozone, particulate matter, and higher pollen counts)	Premature death, acute and chronic cardiovascular and respiratory illnesses	Rising temperatures and wildfires and decreasing precipitation will lead to increases in ozone and particulate matter, elevating the risks of cardiovascular and respiratory illnesses and death.
 <b>Flooding</b>	Rising sea level and more frequent or intense extreme precipitation, hurricanes, and storm surge events	Contaminated water, debris, and disruptions to essential infrastructure	Drowning, injuries, mental health consequences, gastrointestinal and other illness	Increased coastal and inland flooding exposes populations to a range of negative health impacts before, during, and after events.
 <b>Vector-Borne Infection (Lyme Disease)</b>	Changes in temperature extremes and seasonal weather patterns	Earlier and geographically expanded tick activity	Lyme disease	Ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.
 <b>Water-Related Infection (<i>Vibrio vulnificus</i>)</b>	Rising sea surface temperature, changes in precipitation and runoff affecting coastal salinity	Recreational water or shellfish contaminated with <i>Vibrio vulnificus</i>	<i>Vibrio vulnificus</i> induced diarrhea & intestinal illness, wound and bloodstream infections, death	Increases in water temperatures will alter timing and location of <i>Vibrio vulnificus</i> growth, increasing exposure and risk of water-borne illness.
 <b>Food-Related Infection (<i>Salmonella</i>)</b>	Increases in temperature, humidity, and season length	Increased growth of pathogens, seasonal shifts in incidence of <i>Salmonella</i> exposure	<i>Salmonella</i> infection, gastrointestinal outbreaks	Rising temperatures increase <i>Salmonella</i> prevalence in food; longer seasons and warming winters increase risk of exposure and infection.
 <b>Mental Health and Well-Being</b>	Climate change impacts, especially extreme weather	Level of exposure to traumatic events, like disasters	Distress, grief, behavioral health disorders, social impacts, resilience	Changes in exposure to climate- or weather-related disasters cause or exacerbate stress and mental health consequences, with greater risk for certain populations.

The following slides with the report's key findings are taken from the report's slide deck. Additions and edits have been made by this presentation author to further summarize information.



## TEMPERATURE-RELATED DEATH AND ILLNESS

*Key Finding 1: Future Increases in Temperature-Related Deaths [Very Likely, High Confidence]*

*Key Finding 2: Even Small Differences from Seasonal Average Temperatures Result in Illness and Death [High Confidence].*

*Key Finding 3: Expected future increases in changing tolerance to extreme heat will reduce the projected increase in deaths from heat [Very Likely, Very High Confidence].*

*Key Finding 4: Older adults and children have a higher risk of dying or becoming ill due to extreme heat [Very High Confidence].*

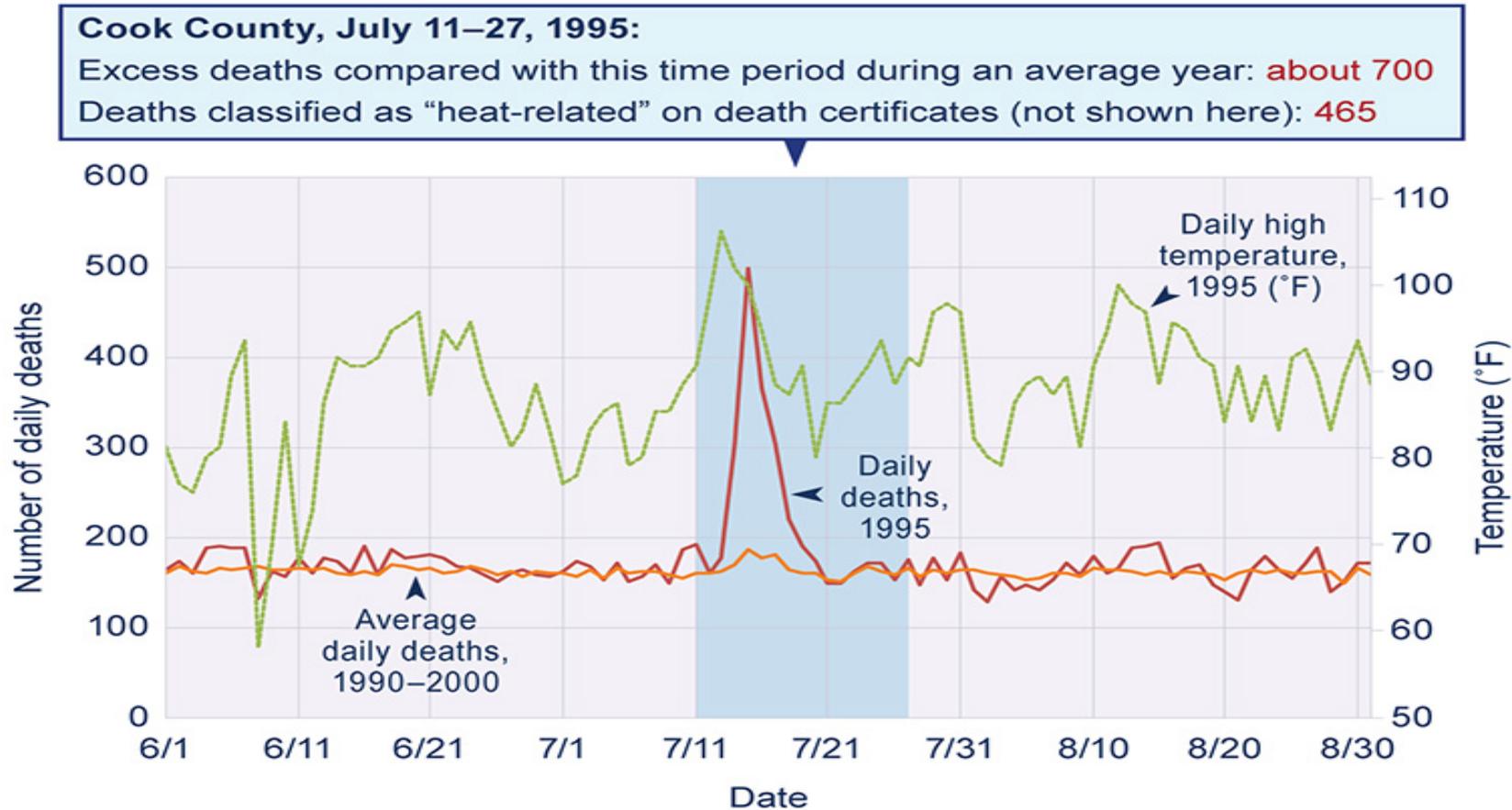




# 2

## TEMPERATURE-RELATED DEATH AND ILLNESS

### Heat-Related Deaths During the 1995 Chicago Heat Wave



# Air Quality





# 3

## AIR QUALITY IMPACTS

*Key Finding 1:* Climate-driven increases in ozone will cause premature deaths, hospital visits, lost school days, and acute respiratory symptoms [*Likely, High Confidence*].

*Key Finding 2:* Wildfires emit fine particles and ozone precursors that in turn increase the risk of premature death and adverse chronic and acute cardiovascular and respiratory health outcomes [*Likely, High Confidence*]. Climate change is projected to increase the number and severity of naturally occurring wildfires in parts of the United States [*Likely, High Confidence*].

*Key Finding 3:* Changes in climate, are expected to contribute to increases in the levels of some airborne allergens and associated increases in asthma episodes and other allergic illnesses [*High Confidence*].





# IMPACTS OF EXTREME EVENTS ON HUMAN HEALTH

*Key Finding 1:* ..exposure to extreme events (frequency and/or intensity of drought, wildfires, and flooding) include death, injury, or illness; exacerbation of underlying medical conditions; and adverse effects on mental health *[High Confidence]*.

*Key Finding 2:* *Disruption of Essential Infrastructure* that are essential to maintaining access to health care and emergency response services and safeguarding human health *[High Confidence]*.

*Key Finding 3:* Coastal populations with greater vulnerability to health impacts from coastal flooding include persons with disabilities or other access and functional needs, certain populations of color, older adults, pregnant women and children, low-income populations, and some occupational groups *[High Confidence]*.



# Catastrophic Weather - Superstorm Sandy



GOES View of Hurricane Sandy. acquired  
October 28, 2012 earthobservatory.nasa.gov

Massive area and strength, max winds in CT 79 mph-  
Groton, 90 mph on Long Island/LI near NYC

Bridgeport-Milford-New Haven hardest hit in CT-

Hits at high tide, storm surge in CT ~8 additional feet;

NJ storm surge ~9.5 feet

Record setting wave height off ISLIP LI ~32 feet, beat  
previous record by 6 feet

Means water /damage is higher up in buildings, building  
are affected farther from the coast (and materials  
carried by water traveling)



A street on the shoreline of Milford, Connecticut, floods  
at high tide as Hurricane Sandy approaches on Monday.  
October 29, 2012



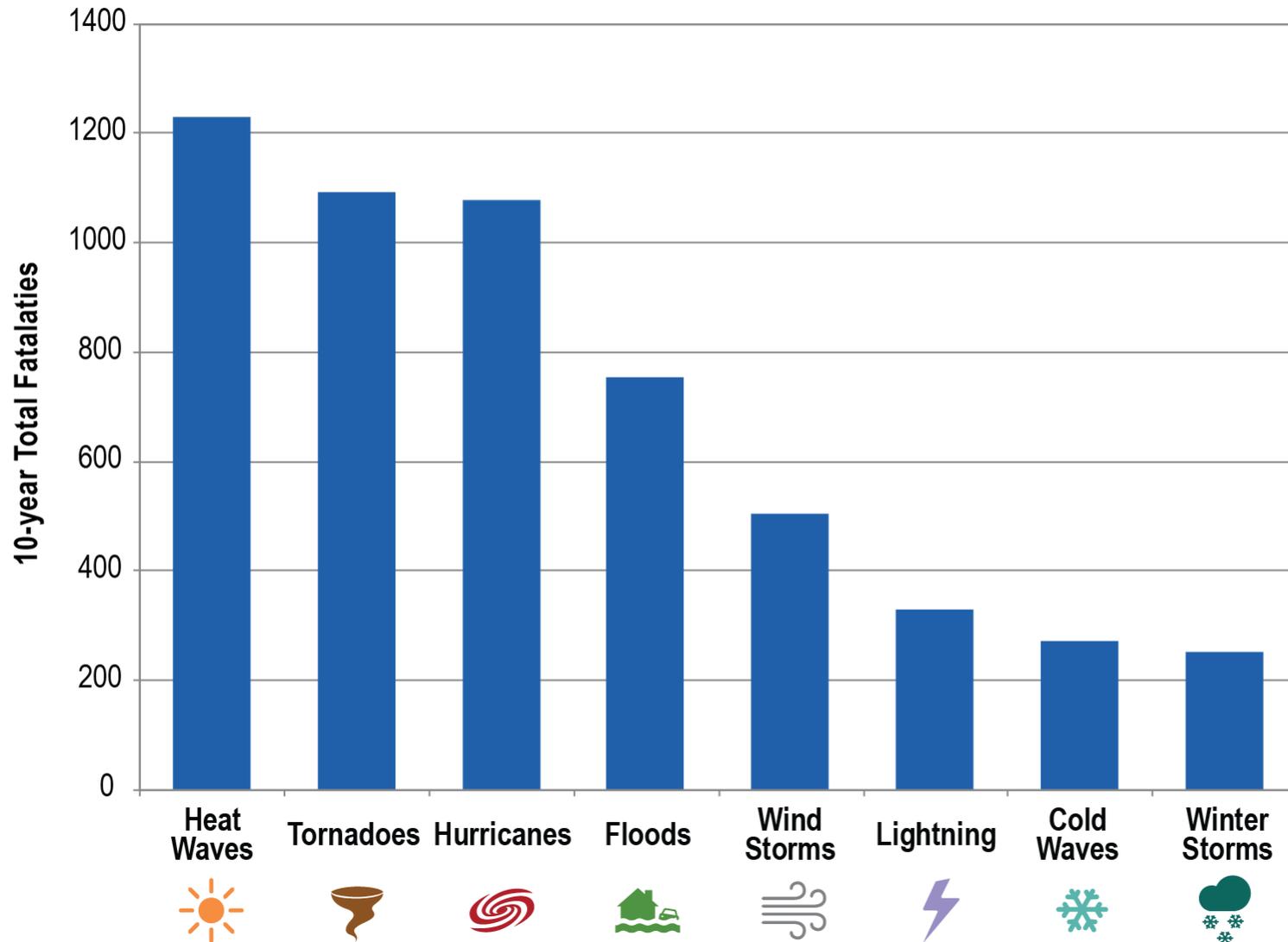
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4869/fema\\_606.pdf](http://www.fema.gov/media-library-data/20130726-1622-20490-4869/fema_606.pdf)

# Health Effects of Coastal Storms and Flooding in Urban Areas: A Review and Vulnerability Assessment- Lane et al. 2013

- Literature review to guide: Adaptation planning and identify population-level indicators of vulnerable populations
- Populations of concern:
  - Seniors
  - Black
  - Non-English speakers
  - Those in poor quality housing, unemployed, substance abusers, mental health history
  - Very young
  - Chronic illness
  - Weak social network
  - Workers

- Health outcomes from:
  - Exposure to storm-
    - death and injury from: drownings, electrocutions, physical trauma
  - Evacuation-
    - dehydration, depression, skin injury
  - Utility outages and sheltering in place-
    - CO poisoning, physical demands and increased exposure to pollution, health care access reduced exacerbated chronic conditions, injuries from fire risks, foodborne disease from spoiled food, safety concerns, mental health
  - Secondary hazards\_ contaminated drinking water, floodwaters, mold in housing-
    - Mold exposure and respiratory illness, exposure to untreated sewage- some from CSO- gastrointestinal , respiratory and skin infections, insects and vector-borne disease
    - High turbidity and disinfection difficulties
    - Toxic waste exposure
  - Displacement- population and services
    - Infectious disease spread
    - Limited access to health care- specialized treatment (ie dialysis) and medications
    - Injury
  - Mental health
    - Exacerbation of existing and new, other interpersonal issues
  - **Health and safety of clean up and recovery crews**
    - **Fatalities**
    - **Removing debris, indoor dust exposure- mold, fumes, strong cleaning products**

# Estimated Deaths and Billion Dollar Losses from Extreme Events in the U.S., 2004–2013



**Billion Dollar Losses from Disasters (2004-2013)**

-   
**\$392 Billion**  
Hurricanes
-   
**\$78 Billion**  
Heat Waves/Droughts
-   
**\$46 Billion**  
Tornadoes/Severe Storms
-   
**\$30 Billion**  
Flooding/Severe Storms



# VECTOR-BORNE DISEASES

*Key Finding 1:* Climate change is expected to alter the geographic and seasonal distributions of existing vectors and vector-borne diseases [*Likely, High Confidence*].

*Key Finding 2:* Ticks capable of carrying the bacteria that cause Lyme disease and other pathogens will show earlier seasonal activity and a generally northward expansion [*Likely, High Confidence*].

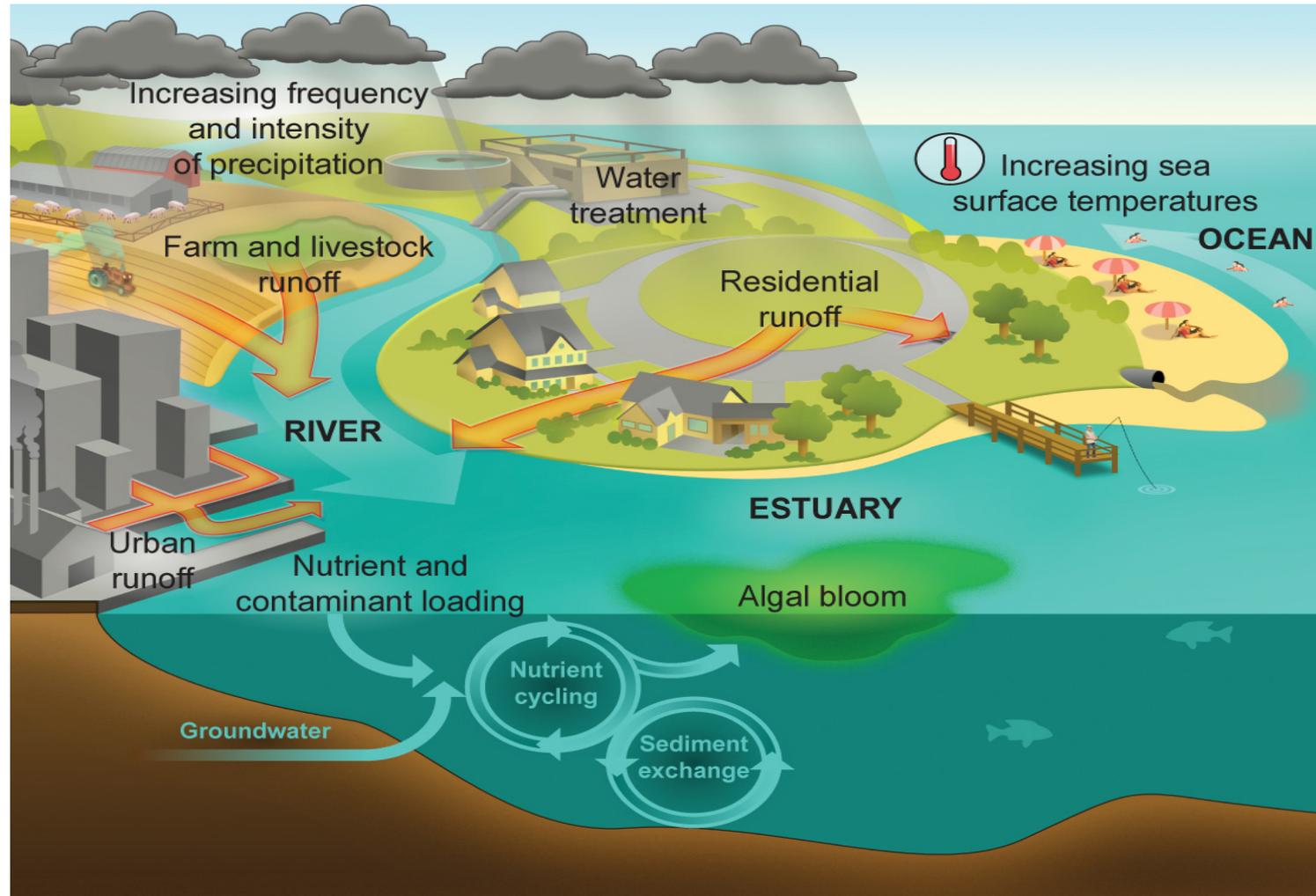
*Key Finding 3:* .. influence the distribution, abundance, and prevalence of infection in the mosquitoes that transmit West Nile virus and other pathogens by altering habitat availability and mosquito and viral reproduction rates [*Very Likely, High ..*Alterations in the distribution, abundance, and infection rate of mosquitoes will influence human exposure to bites from infected mosquitoes, which is expected to alter risk for human disease [*Very Likely, Medium Confidence*]. *Key Finding 4:* Vector-borne pathogens are expected to emerge or reemerge ..The impacts to human disease, however, will be limited by the adaptive capacity of human populations, such as vector control practices or personal protective measures [*Likely, High Confidence*].





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# CLIMATE IMPACTS ON WATER-RELATED ILLNESSES





# CLIMATE IMPACTS ON WATER-RELATED ILLNESSES

*Key Finding 1:* Increases in water temperatures .. will alter ..freshwater toxin-producing harmful algae [*Very Likely, High Confidence*], certain naturally occurring *Vibrio* bacteria [*Very Likely, Medium Confidence*], and marine toxin-producing harmful algae [*Likely, Medium Confidence*]. ‘ changes will increase the risk of exposure to waterborne pathogens and algal toxins that can cause a variety of illnesses [*Medium Confidence*].

*Key Finding 2:* Runoff events will increasingly compromise recreational waters, shellfish harvesting waters, and sources of drinking water through increased introduction of pathogens and prevalence of toxic algal blooms [*High Confidence*]. .., the risk of human exposure to agents of water-related illness will increase [*Medium Confidence*].

*Key Finding 3:*..Water Infrastructure Failure [*High Confidence*]. As a result, the risk of exposure to water-related pathogens, chemicals, and algal toxins will increase in recreational and shellfish harvesting waters, and in drinking water where treatment barriers break down [*Medium Confidence*].

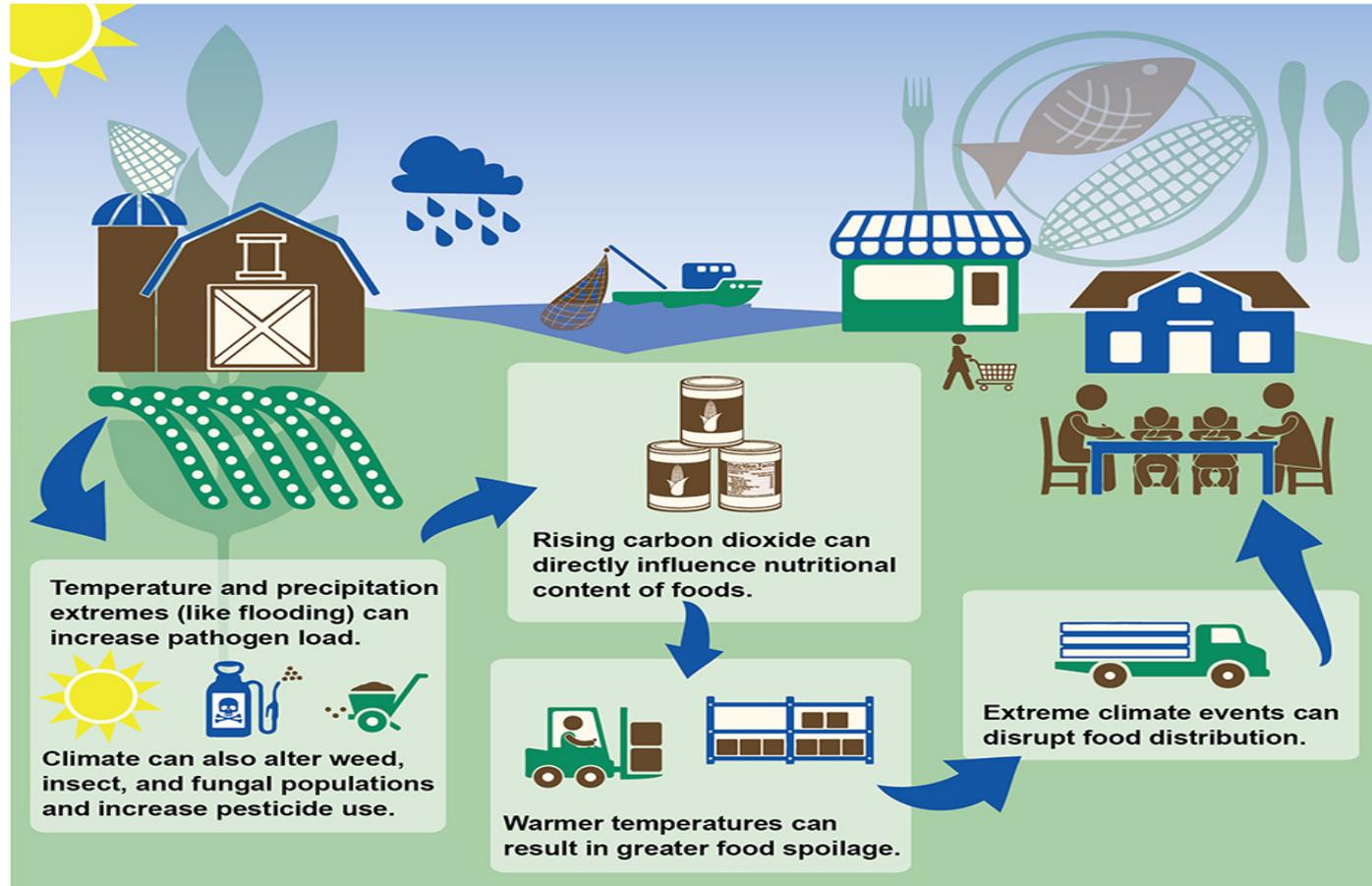




7

# FOOD SAFETY, NUTRITION, AND DISTRIBUTION

Farm to Table  
The Potential Interactions of Rising CO<sub>2</sub> and Climate Change  
on Food Safety and Nutrition





# FOOD SAFETY, NUTRITION, AND DISTRIBUTION

*Key Finding 1:* .., is expected to increase the exposure of food to certain pathogens and toxins [*Likely, High Confidence*]. .. Increased Risk of Foodborne Illness [*Likely, Medium Confidence*], but actual incidence of foodborne illness will depend on the efficacy of practices that safeguard food in the United States [*High Confidence*].

*Key Finding 2:* ..Elevated sea surface temperatures will lead to greater accumulation of mercury in seafood [*Likely, Medium Confidence*], . increases in extreme weather events will introduce contaminants into the food chain [*Likely, Medium Confidence*]. Rising carbon dioxide concentrations ..will alter incidence and distribution of pests, parasites, and microbes [*Very Likely, High Confidence*], leading to increases in the use of pesticides and veterinary drugs [*Likely, Medium Confidence*].

*Key Finding 3:* The nutritional value of agriculturally important food crops, such as wheat and rice, will decrease as rising levels of atmospheric carbon dioxide continue to reduce the concentrations of protein and essential minerals in most plant species [*Very Likely, High Confidence*]

*Key Finding 4:* ..disruptions of food distribution [*Likely, High Confidence*]. ..lead to increased risk for food damage, spoilage, or contamination [*Medium Confidence*].

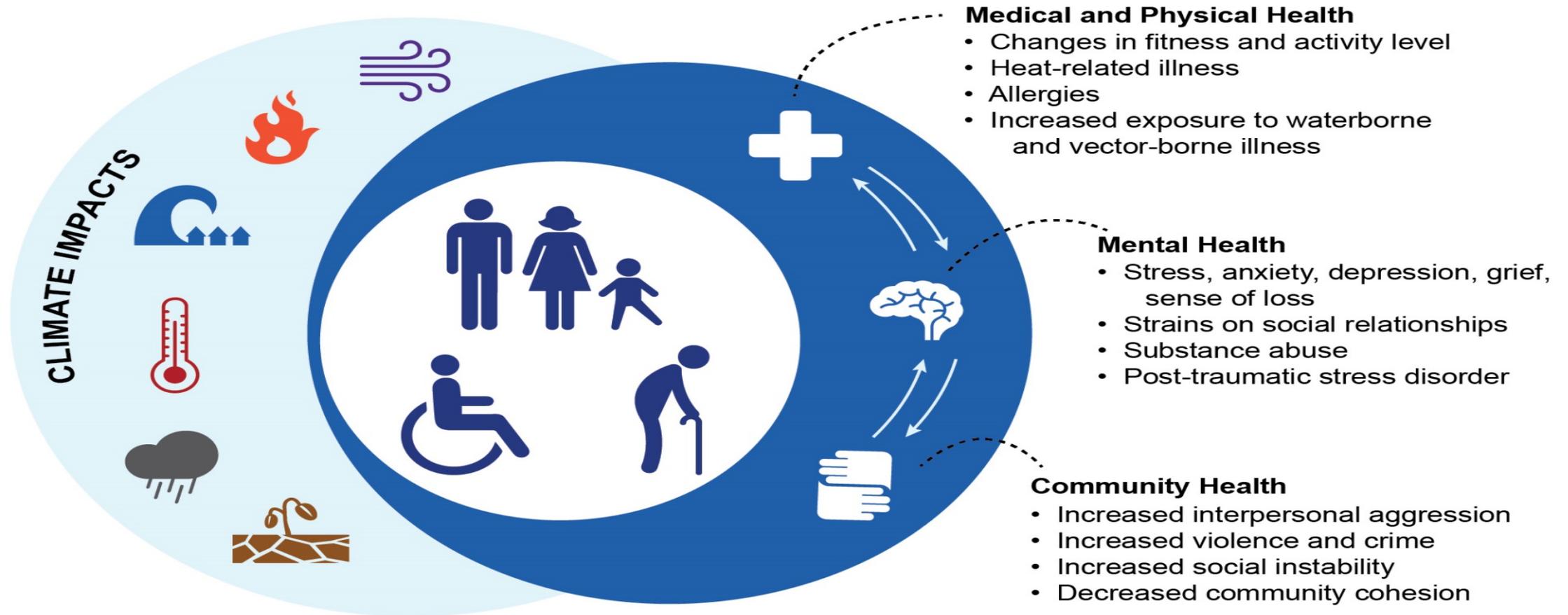




8

# MENTAL HEALTH AND WELL-BEING

## Impact of Climate Change on Physical, Mental, and Community Health





# MENTAL HEALTH AND WELL-BEING

*Key Finding 1:* .. stress and serious mental health consequences. ...e consequences include post-traumatic stress disorder (PTSD), depression, and general anxiety, which often occur at the same time *[Very High Confidence]*. The majority of affected people recover over time, although a significant proportion of exposed individuals develop chronic psychological dysfunction *[High Confidence]*.

*Key Finding 2:* ..at higher risk ..include children, the elderly, women (especially pregnant and post-partum women), people with preexisting mental illness, the economically disadvantaged, the homeless, and first responders *[High Confidence]*.

*Key Finding 3:* Many people will experience adverse mental health outcomes and social impacts from the threat of climate change, the perceived direct experience of climate change, and changes to one's local environment *[High Confidence]*. *Key Finding 4:* Increases in extreme heat will increase the risk of disease and death for people with mental illness, including elderly populations and those taking prescription medications that impair the body's ability to regulate temperature *[High Confidence]*.





# POPULATIONS OF CONCERN

*Key Finding 1:* Vulnerability to climate change varies across time and location, across communities, and among individuals within communities [*Very High Confidence*].

*Key Finding 2:* People experience different inherent sensitivities to the impacts of climate change at different ages and life stages [*High Confidence*]. For example, the very young and the very old are particularly sensitive to climate-related health impacts.

*Key Finding 3:* Social determinants of health, such as those related to socioeconomic factors and health disparities, may amplify, moderate, or otherwise influence climate-related health effects, particularly when these factors occur simultaneously or close in time or space [*High Confidence*].

*Key Finding 4:* The use of geographic data and tools allows for more sophisticated mapping of risk factors and social vulnerabilities to identify and protect specific locations and groups of people [*High Confidence*].



## Vulnerability to the Health Impacts of Climate Change at Different Life Stages



### *Mothers and babies*

Adverse pregnancy outcomes such as low birth weight and preterm birth have been linked to extreme heat events, airborne particulate matter, and floods.



### *Infants and toddlers*

Young children's biological sensitivity places them at greater risk from asthma, diarrheal illness, and heat-related illness.



### *School age and older children*

The behaviors and activities of older children increase their risk of exposure to heat-related illness, vector-borne and waterborne disease, and respiratory effects from air pollution and allergens.



# 9

# POPULATIONS OF CONCERN

## Intersection of Social Determinants of Health and Vulnerability

