Today’s EH Nexus Webinar will be available to view on demand a few days after this webinar. You can find the video recording of today’s webinar at the CDC EH Nexus webpage at

[cdc.gov/nceh/ehsp/ehnexus]
Webinar Logistics

All attendees are muted. To adjust your audio settings in the webinar, click on Audio Options.

Please use the Q&A window to ask questions of the panelist.
Opening Remarks

Patrick Breysse, Ph.D., CIH
Director, National Center for Environmental Health
Agency for Toxic Substances and Disease Registry
Centers for Disease Control and Prevention

Suma Nair, Ph.D., M.S., RD
Director, Office of Quality Improvement
Health Resources and Services Administration
Bureau of Primary Health Care
Today’s Presenters

Arie Ponce Manangan, M.A.
Health Scientist

Elizabeth (Beth) Gillespie, M.D., FACP
Guest Researcher

Climate and Health Program
Division of Environmental Health Science and Practice
National Center for Environmental Health
Centers for Disease Control and Prevention
Climate Change and Health
The Risks to Community Health and Health Care Utilization

Arie Manangan, M.A. (Health Scientist)
Climate and Health Program, Division of Environmental Health Science and Practice, (DEHSP), National Center for Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC)

Elizabeth Gillespie, M.D., FACP (Academic Hospitalist)
Denver Health and Hospital Authority, University of Colorado School of Medicine
Climate and Health Program, Division of Environmental Health Science and Practice, (DEHSP), National Center for Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC)
Learning Objectives

- Building Climate Resilience with the CDC’s Climate and Health Program
- Climate-Related Hazards and Potential Health Effects
- Disproportionately Affected Populations and Under-Resourced Communities
- Utilizing Electronic Health Records to Characterize Individual and Community Health Risk
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
- Extreme weather
- Changes in vector ecology
- Increasing allergens
- Water and food supply impacts
- Water quality impacts
- Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms
- Malnutrition, diarrheal disease
- Increasing CO2 levels
- Rising sea levels
- Rising temperatures
- More extreme weather
CDC’s Climate and Health Program

- Funded by Congress in 2009
- **Serve as a resource** for federal, state, local, territory, and Tribal health agencies
- **Prepare public health practitioners** to address the health effects of climate change
- **Provide tools, guides, and processes** to help assess vulnerability to possible health effects
- **Serve as a leader** in planning for public health effects of climate change
Climate Ready States and Cities Initiative

- 9 states and 2 cities currently funded
- 5 step framework: Building Resilience Against Climate Effects (BRACE)
- New notice of funding opportunity awarded September 2021
  - Builds on previous work
  - Emphasizes adaptation actions and evaluation
  - Health equity is a centerpiece
Current Climate and Health Grantees

State or Territorial Grantees
- CA
- OR
- AZ

City or Tribal Grantees
- Santa Clara
- San Francisco

Commonwealth of the Northern Mariana Islands
- Guam
- U.S. Virgin Islands
- Puerto Rico
- Federated States of Micronesia
Previous Climate and Health Grantees

State or Territorial Grantees

City or Tribal Grantees
AFFECTING HEALTH DIRECTLY

AIR POLLUTION

Increased wildfires, smog, pollen, and mold can lead to:

Asthma and Allergy attacks

People who are at higher risk: People with heart and respiratory conditions such as heart disease, asthma, or chronic lung disease
Mortality Burden Associated with Wildfire Smoke Exposure in the Western United States
Wildfires and Air Quality

Historical (1988–2016) PM$_{2.5}$ Trends

Source: L McClure CD and Jaffe DA. PNAS 115 (31): 7901–7906, 2018

Increase in PM$_{2.5}$ annual concentration attributed to an increase in wildfire emissions
Smoke Exposure Summary

**Distribution of Smoke-Days, by Month**

- Histogram showing the percent of smoke-days by month.

**Percent of Smoke-Days, by State (May–Nov.)**

- Bar chart displaying the percent of smoke-days by state.

**Population-level Exposure**

- Map showing the number of person-days of smoke exposure by state, with color coding indicating different ranges.
DISRUPTING WELL-BEING

MENTAL HEALTH PROBLEMS

Increased frequency and severity of extreme weather events can lead to

Stress, depression, anxiety, PTSD, and suicidal thoughts

People who are at higher risk: Children, older adults, pregnant and postpartum women, people with mental illnesses, people with lower incomes, people experiencing homelessness, first responders, and people who rely on the environment for their livelihood
SPREADING DISEASE

INSECTS, TICKS, AND RODENTS

Higher temperatures, changes in rain patterns, and disrupted ecosystems help spread

Diseases carried by insects, ticks, and rodents

People who are at higher risk: People who spend more time outdoors in places where these insects and other disease-carriers live
AFFECTING HEALTH DIRECTLY

EXTREME WEATHER

Increased frequency and severity of heavy downpours, floods, droughts, and major storms can lead to

Injury, Illness, Displacement, and Death

People who are at higher risk: People who lack access to evacuation routes and people who cannot use stairs when elevators are out of service, people in wheelchairs, older adults, people with lower incomes, and people with disabilities, particularly if they are unable to access elevators and evacuation routes
SPREADING DISEASE

CONTAMINATED WATER

Higher water temperatures, heavier downpours, rising sea levels, and more flooding help spread gastrointestinal illness, Diseases from toxins in swimming areas and drinking water.

People who are at higher risk: Children, the elderly, people with weakened immune systems, people in remote or under-resourced communities with inadequate water systems, and people in communities that are dependent on fish and shellfish.
Climate Change is Expected to Make Hurricanes More Powerful due to warming ocean temperatures
More Damaging due to sea-level rise

Image Credit: NASA Earth Observatory images by Joshua Stevens and Jesse Allen, using VIIRS day-night band data from National Polar-orbiting Partnership and Terra MODIS data from the Land Atmosphere Near real-time Capability for EOS (LANCE)
Flooding and Healthcare Infrastructure
A national assessment of flooding risk to medical infrastructure: hospitals, nursing homes, pharmacies, dialysis clinics

Source: HHS
Source: HHS; The Cedar Rapids Gazette
Flood Hazard Data: FEMA National Flood Hazard Layer (NFHL) and EPA EnviroAtlas

- FEMA NFHL - current effective flood hazard data
  - 100-year and 500-year floodplains
  - Partial coverage
  - AK, HI, PR

- Supplement NFHL with EPA EnviroAtlas Floodplain Data
  - Full CONUS coverage
  - 100-year floodplain

Sources
FEMA NFHL: [https://www.fema.gov/national-flood-hazard-layer](https://www.fema.gov/national-flood-hazard-layer)
EPA: [https://www.epa.gov/enviroatlas](https://www.epa.gov/enviroatlas)
Medical Infrastructure Data

Hospitals: American Hospital Association

CMS: Nursing homes

Pharmacies: OpenRX

CMS: Dialysis clinics
Medical Infrastructure Within Flood Hazard Zones (Savannah, Georgia)

Data Source: FEMA NFHL (2019), Definitive Health Care
Flooding Risk to Medical Infrastructure: Hospitals
## Facilities Within Flood Hazard Area (NFHL or EPA)

<table>
<thead>
<tr>
<th>High or Moderate to Low Flood Risk (100-year or 500-year floodplain)</th>
<th>Hospitals</th>
<th>Nursing Homes</th>
<th>Dialysis Clinics</th>
<th>Pharmacies</th>
</tr>
</thead>
<tbody>
<tr>
<td>643</td>
<td>1,546</td>
<td>770</td>
<td>7605</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent of Total</th>
<th>9.3%</th>
<th>10.2%</th>
<th>10.9%</th>
<th>12.1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>6881</td>
<td>15133</td>
<td>7047</td>
<td>62516</td>
</tr>
</tbody>
</table>

Results: HRSA Facilities Within Flood Hazard Areas

HRSA Facilities
- Within 100 Year Flood Zone
- Within 500 Year Flood Zone
- Not Within Flood Zone
Results: HRSA Facilities Within Flood Hazard Areas

HRSA Facilities
- ● 100 year
- ○ 500 year
- • Not within flood hazard

- Clearwater
- Tampa
- St. Petersburg
- FLORIDA
## Results: HRSA Facilities Within Flood Hazard Areas

<table>
<thead>
<tr>
<th>HRSA</th>
<th>100 year</th>
<th>500 year</th>
<th>No Floodplain</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities</td>
<td>695</td>
<td>692</td>
<td>12,368</td>
<td>13,755</td>
</tr>
<tr>
<td>% Facilities</td>
<td>5.05%</td>
<td>5.03%</td>
<td>89.92%</td>
<td>-</td>
</tr>
</tbody>
</table>
Example Adaptation Strategies For Flooding

- Relocation of mission-critical and essential services
- Evacuation planning
- Medical staff training and education
- Backup power generation
- Site Modification (e.g., flood walls)

Lourdes Hospital from 2011 flood (FEMA)
AFFECTING HEALTH DIRECTLY

EXTREME HEAT

Higher heat, increased humidity, longer and more frequent heat waves can lead to

Dehydration and Heatstroke

People who are at higher risk: Outdoor workers, student athletes, people in cities, people without air conditioning, people with chronic diseases, pregnant women, older adults, and young children
Heat: A Climate and Health Priority

Heat has significant impacts on public health in the US

- During 2004–2018, an average of 702 heat-related deaths occurred each year.¹
- During 2007–2017, an average of 67,512 emergency room visits due to heat occurred each year.²

Extreme heat events are becoming more frequent and intense

- Annual average temperature in the U.S. has increased by 1.2°F from 1986–2016.
- Increases of 2.5°F are projected for the period 2021–2050.

² Based on recent results from a forthcoming MMWR
Extreme Summer Heat is Increasing

Extreme heat events will be more frequent and intense in coming decades.
“The mean daily number of heat-related illness ED visits...was more than seven times higher than that in June 2019, and during June 25–30, 2021 was 69 times higher than that during the same days in 2019...”
AFFECTING HEALTH DIRECTLY

EXTREME HEAT

Pacific Northwest: June 2021
Focus on Health Equity and Vulnerability Assessment

Assessing Health Vulnerability to Climate Change: A Guide for Health Departments

Guidance for health departments to identify communities that will be disproportionately affected by climate change
Heat Vulnerability to Climate-Related Health Effects
CDC's Heat & Health Tracker

What is it?
A publicly-available, online tool that provides heat and health data and information at the local level to help communities better prepare for and respond to extreme heat events.

https://ephtracking.cdc.gov/Applications/heatTracker/
Number of days above 90 degrees
Total population
Social Vulnerability Index
% pop with limited English-speaking ability
% of pop over 65 years and living alone
% land used for development
% impervious surfaces

Daycare centers
Emergency medical service stations
Fire stations
Hospitals
Nursing homes
Parks
Public Schools
What Communities Can Do

**Extreme Heat**
- Develop Heat Response Plan
- Cooling Centers

**Mental Health Problems**
- Behavioral Health Plans
- Access to mental health services and counseling

**Air Pollution**
- Active and Mass Transportation
- Reduce Energy Waste

**Storms & Flooding**
- Prepare Infrastructure
- Sanitation & Water Management
Measuring Community Level-Healthcare Utilization During Extreme Heat

Using Electronic Health Records to Characterize Individual and Community Health Risk

Beth Gillespie, M.D., FACP
Academic Hospitalist, Denver Health and Hospital Authority, Assistant Professor, University of Colorado School of Medicine
Fellow, University of Colorado Climate Science Policy Fellowship
Climate and Health Program, Division of Environmental Health Science and Practice, (DEHSP), National Center for Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC)
Heat exposure in Denver County

Heat & Health Tracker

Denver County, CO

Heat Vulnerability Data Explorer

Image source: CDC Heat and Health Tracker

Image source: climatecentral.org
“Climate change... because all this adjusting to weather is not good and cause a person to get sick”

“work environment is not clean and is very hot”

“Anxiety caused by climate lunacy (the world will end in 12 years unless we act NOW? Our species will go extinct unless we act NOW....Stop the constant barrage of idiotic opinions passing as knowledge”
Social Determinants of Health, High Temperatures, and Health Outcomes

- **Design:** Retrospective, Cross Sectional, Cohort
- **Population:** Denver County residents ages \( \geq 4 \) years receiving health care at Denver Health hospital and clinics
- **Study Time period:** April 1, 2016, through Dec 31, 2020
- **High temperature period:** May 1–Sept 31, 2016–2020
- **Team:** Art Davidson\(^1\), Josh Durfee\(^1\), Abbie Steiner\(^1\), Ken Scott\(^1\)
- **Funding:** Denver Health Office of Research Pilot Grant

\(^1\)Denver Public Health

Image source: denverhealth.org
Health network relative heat vulnerability

Mean Denver Health patient heat vulnerability score compared to that of remaining Denver County residents

1.4

Image source: Heat Vulnerability (denvergov.org)
Study Aim

- **Aim:** Compare rates of healthcare utilization among DH patients in chronic disease groups, depending on exposure to heat (Tmax > 90°F)
  
  Building “the model”—odds ratio for high heat utilization versus non-high heat utilization
  
  Model to be adjusted for:
  
  - age,
  - gender,
  - race/ethnicity, and
  - residential heat vulnerability.

- **Hypothesis 1:** Denver Health patients living in higher heat vulnerability areas have increased heat-exposed acute utilization

- **Hypothesis 2:** Patients with heat-sensitive conditions have higher heat-sensitive acute utilization
## Data sources

- **CHORDS (Colorado Health Observation Regional Data Service)**

<table>
<thead>
<tr>
<th>Data table</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENSUS LOCATION</td>
<td>Stores patients’ geocoded address. Every person ID in other tables has a record here</td>
</tr>
<tr>
<td>DEMOGRAPHICS</td>
<td>Includes basic descriptive data (DOB, gender, race, ethnicity)</td>
</tr>
<tr>
<td>ENCOUNTERS</td>
<td>Includes records from encounters between patients and medical personnel, indexed by encounter ID and person ID</td>
</tr>
<tr>
<td>DIAGNOSIS</td>
<td>Lists final diagnoses from encounters table (does not include chief complaint/ problem list)</td>
</tr>
</tbody>
</table>

- **Daily temperature data (NOAA, EPA stations)**
- **Denver County heat vulnerability indices**
  - Built environment, demographics, human health
- **American Community Survey (2016-2020)** –
  - 5-year estimates for Denver County

Image source: [Heat Vulnerability (denvergov.org)](http://www.denvergov.org)
Consort Diagram

Population Denver County*  
N=673,042

*based on 2016 ACS average

Non-Denver Health (DH) population  
N=449,932

DH population (>=1 encounter 2016)  
N=223,110

DH population with >=1 encounter in DH network  
N=230,895

Insufficient encounters and/or time in study  
N=148,296

DH population with >/= 2 DH encounters, in study >365.25 days, age >=4  
N=82,599

Insufficient encounters and/or time in study  
N=148,296
Results

Clinical Characteristics of eligible DH patients

Footnote

CHF = congestive heart failure  
PeriphVas = Peripheral vascular disease  
ChrPulmDz = Chronic Pulmonary Disease  
DM = Diabetes  
RenalDz = Renal disease  
LiverDz = Liver disease
Next Steps

- Develop final model testing Hypotheses 1 and 2:
  - **Hypothesis 1**: Denver Health patients living in higher heat vulnerability areas have increased heat-exposed utilization
  - **Hypothesis 2**: Patients with heat-sensitive conditions have higher heat-sensitive utilization

- Identify disease groups most associated with heat-sensitive acute care utilization

- **Potential next steps:**
  - Evaluate utilization patterns of patients with specific ICD-10 codes
  - Community outreach to representatives of higher risk disease groups
  - Evaluate best practices for targeted education, targeted social services

Conclusion

- Building Climate Resilience with the CDC’s Climate and Health Program
- Climate-Related Hazards and Potential Health Effects
- Disproportionately Affected Populations and Under-Resourced Communities
- Utilizing Electronic Health Records to Characterize Individual and Community Health Risk
The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official view of the Centers for Disease Control and Prevention.
All attendees are muted. To adjust your audio settings in the webinar, click on Audio Options.

Please use the Q&A window to ask questions of the panelist.
Today’s Presenters

Arie Ponce Manangan, M.A.
Health Scientist

Elizabeth (Beth) Gillespie, M.D., FACP
Guest Researcher

Climate and Health Program
Division of Environmental Health Science and Practice
National Center for Environmental Health
Centers for Disease Control and Prevention
Closing Remarks

Patrick Breysse, Ph.D., CIH
Director, National Center for Environmental Health Agency for Toxic Substances and Disease Registry Centers for Disease Control and Prevention

Suma Nair, Ph.D., M.S., RD
Director, Office of Quality Improvement Health Resources and Services Administration Bureau of Primary Health Care
Thank you for joining us today!

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official view of the Centers for Disease Control and Prevention.

EHNexus@cdc.gov
Impact of Climate Change on Human Health
A graphic describing the climate-related exposures (e.g. air pollution, extreme heat, poor water quality, changes in disease vectors) and their associated health effects (e.g. Respiratory allergies, heat-related illness, cholera, Malaria). The CDC is focused on climate change because the impacts to human health are very broad, from increasing the risk of vector borne diseases such as West Nile Virus and Lyme disease, to bringing more intense heatwaves and a greater frequency of severe weather events that can cause flooding. These changes in climate-related exposures translate into increasing health risks, as seen in the outer circle of this diagram.

Figure. Current Climate and Health Grantees
A map of the currently funded climate and health grantees, which includes the state health departments: Arizona Department of Health Services, California Department of Public Health, Connecticut Department of Public Health, Wisconsin Department of Health Services, Maine Department of Health and Human Services, North Carolina Department of Health & Human Services, New York State Department of Health/Health Research, Inc., Oregon Health Authority Public Health Division, Vermont Agency of Human Services.

There are currently two city health departments that are funded by the CDC Climate and Health program: County of Santa Clara, Department of Public Health, San Francisco Department of Public Health.

Figure. Previous Climate and Health Grantees
A map of previously funded climate and health grantees, which additionally includes the state health departments of: Minnesota, Wisconsin, Illinois, Florida, and New Hampshire. Additionally, the Climate and Health program has previously funded cities, tribes, and US territories. This is addition to the previously funded states of: Arizona Department of Health Services, California Department of Public Health, Connecticut Department of Public Health, Wisconsin Department of Health Services, Maine Department of Health and Human Services, North Carolina Department of Health & Human Services, New York State Department of Health/Health Research, Inc., Oregon Health Authority Public Health Division, Vermont Agency of Human Services.

There are currently two city health departments that are funded by the CDC Climate and Health program: County of Santa Clara, Department of Public Health, San Francisco Department of Public Health.

Map of Wildfires and Air Quality in the U.S.
A map showing Wildfires and Air Quality in the U.S. Previous studies have shown that wildfires are increasing, and the associated air quality has been worsening, as reflected in this map of data published in 2018 showing that PM2.5 concentrations have increased over a 28-year period, particularly in the northwestern U.S.

Graph of the Distribution of Smoke-Days by Month
A graph showing the month with the highest percentage of smoke-days. The later summer month of July, August, and September had the high distribution of smoke days per month. August had the highest percentage of smoke days.
Graph of the Distribution of Smoke-Days per State
The states with the highest percentage of smoke days are Montana, Idaho, California, and Wyoming. Generally, the states with the highest percentage of smoke days were located in the Northwestern US and California.

Map of the Population-Level Smoke Exposure in the Western U.S.
The largest populations exposed to smoke are in Southern California, Southern Arizona, and Central Washington State.

Extreme Summer Heat is Increasing
A map showing this increase in heat events. This map of U.S. counties represents the change in the number of heat waves days per year.

Counties in dark red exhibited the greatest increase in the number of heat wave days, as compared to counties in light red. Counties in gray did not exhibit a statistically significant change in the number of heat wave days.

Heat-Related Emergency Department Visits During the Northwestern Heat Wave
The figure, four line graphs, shows emergency department visit numbers for heat-related illness in U.S. Department of Health and Human Services Region 10 and nationwide, May 1–June 30, 2019 and 2021. The mean daily number of heat-related illness emergency department visits was more than seven times higher than that in June 2019, and during June 25–30, 2021 was 69 times higher than that during the same days in 2019.

Heat Vulnerability to Climate-Related Health Effects
An example of a climate and health vulnerability assessment, which utilizes not only data on the social determinants of health, but also measures of environmental determinant, and measures of health response capacity.

Colorado Heat and Health Tracker and Future Temperature Days Above 100 degrees
This graph shows projections by Climate Central. Based on 1997-2016 averages, there were no days above 100. We already broke 100 XX times last year, and number of high temperature days are projected to increase to over 20 by 2050 and over 35 by 2100, with even more occurring without emission cuts.

Clinical Characteristics of Eligible Denver Health Patients
This bar graph represents the number of patients in each health category of interest. All categories were chosen based on known risk factors for heat-related illness, based on previous scientific literature. Categories include asthma, congestive heart failure.