Climate Change and Infectious Diseases

Naomi Hauser MD MPH
Assistant Clinical Professor, Infectious Disease
Dept. of Internal Medicine, UC Davis Health
Climate Adaptation Research Center, UC Davis

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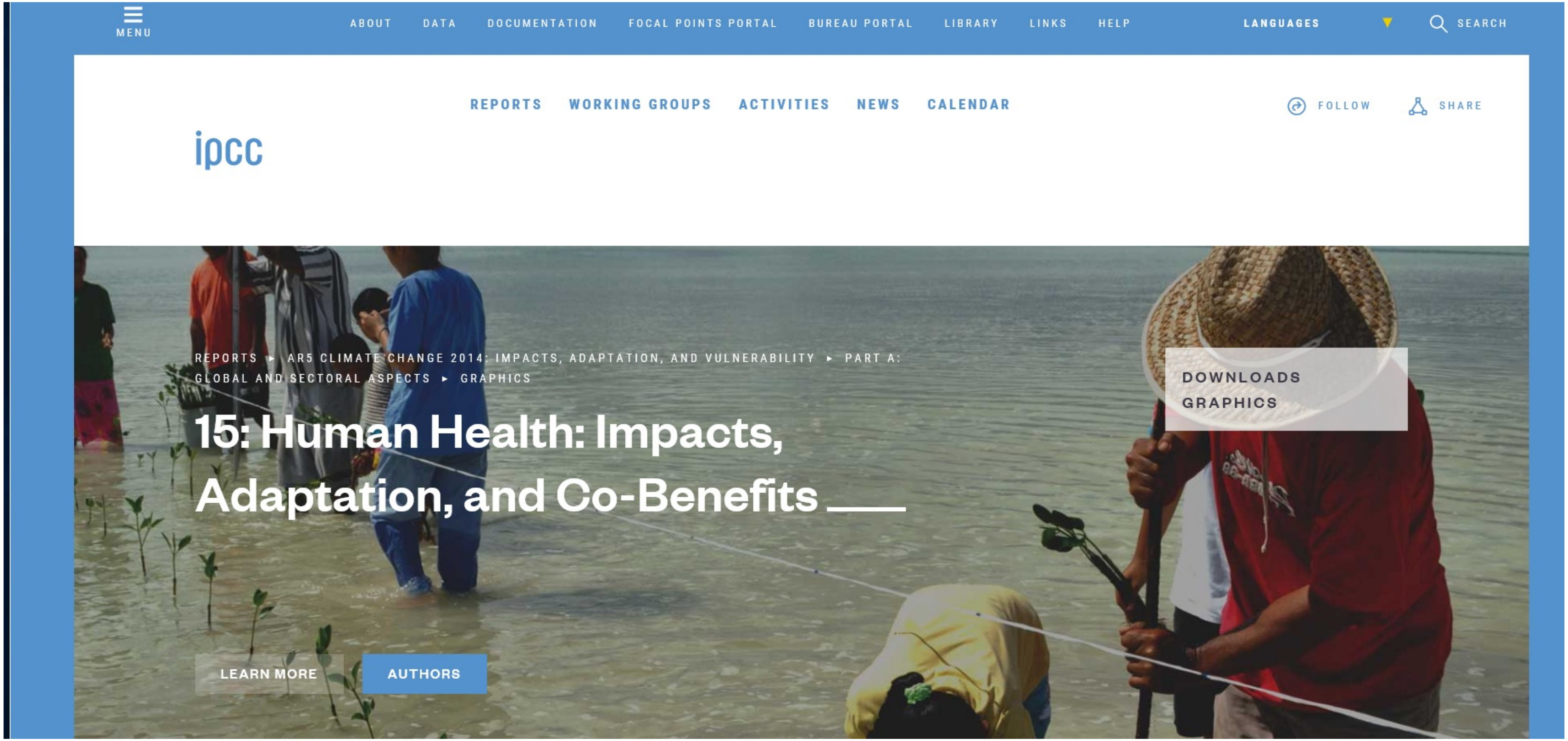
- *The Planning Committee and Faculty have no relevant financial relationships with commercial interests to disclose.*

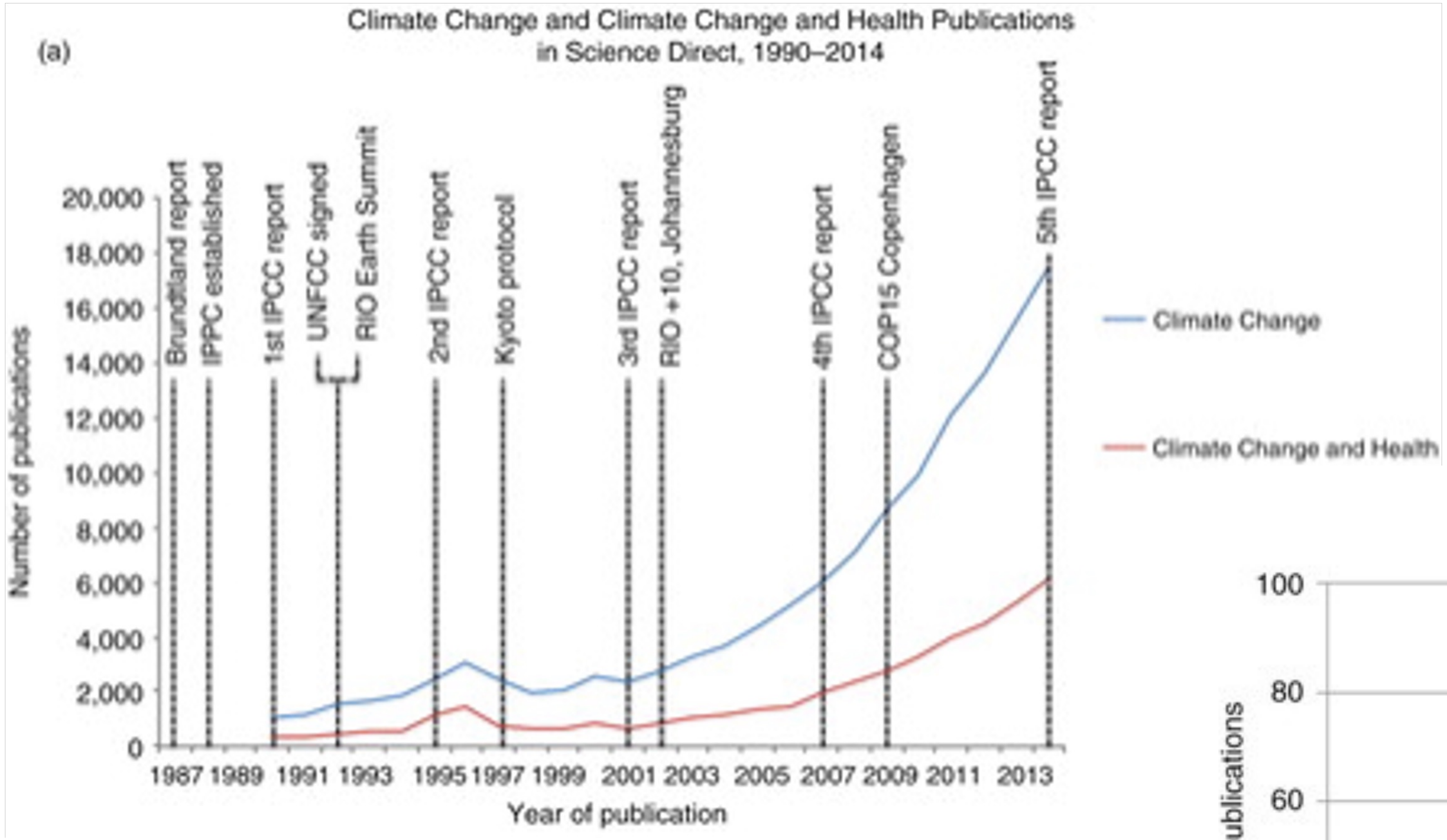
Objectives

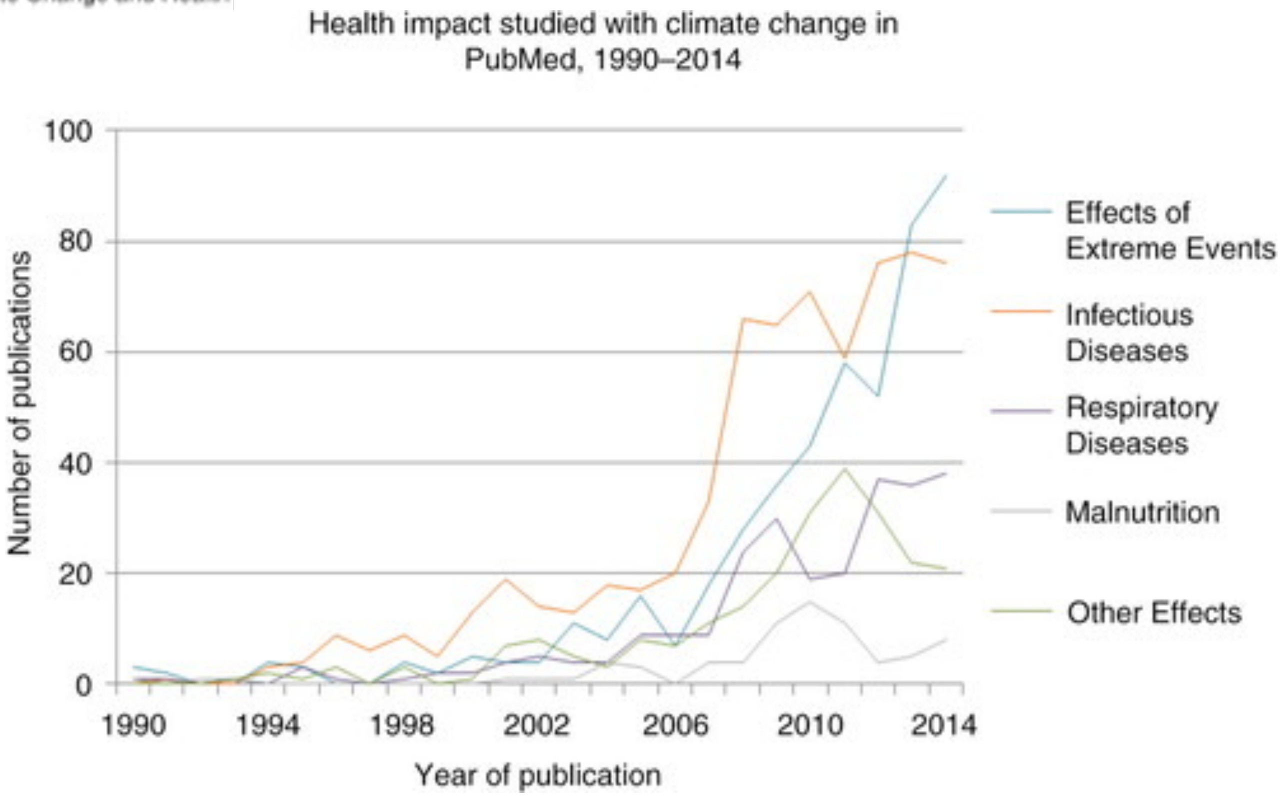
- Recall the relationship between climate change-induced extreme weather events and infectious diseases
- List several modes of infectious disease transmission that are affected by climate change
- Examine the healthcare industry's role in contributing to and treating climate change-related infectious diseases

Climate Change and Human Health



KR Smith et al. 2014: Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change





G. Verner et al. 2016. Health in climate change research from 1990 to 2014: positive trend, but still underperforming, Global Health Action, 9:1, DOI: [10.3402/gha.v9.30723]

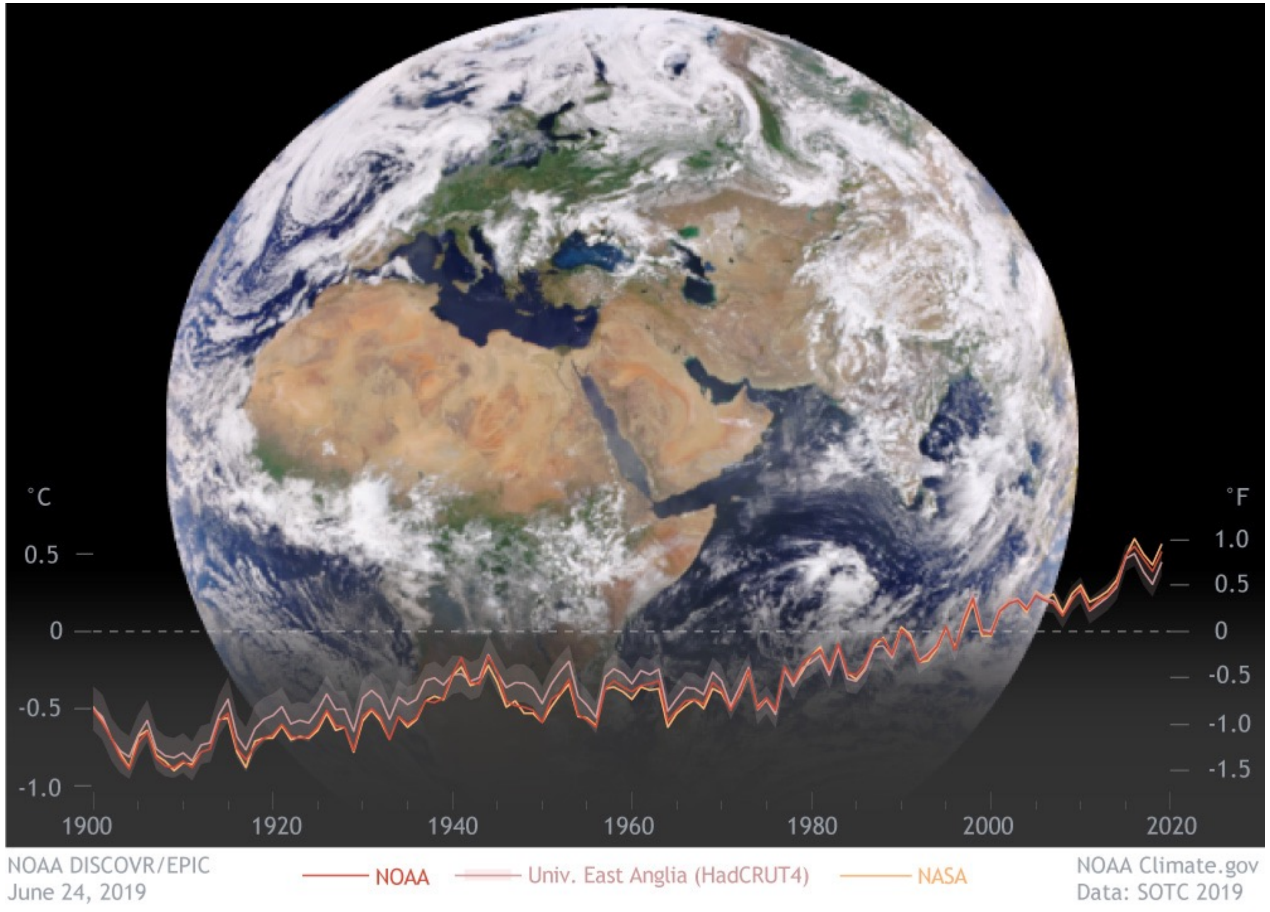
Extreme weather events

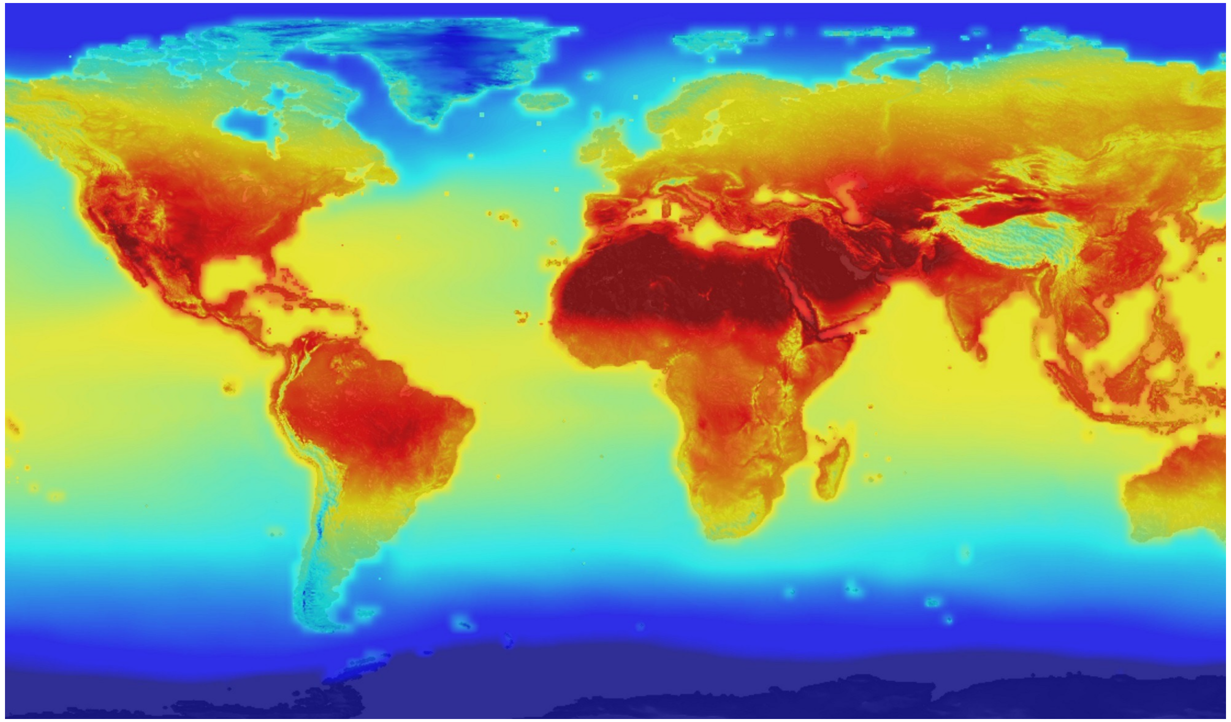
NASA, Global Climate Change: Vital signs of the planet

Health impacts

- Allergies
- Pregnancy and newborn complications
- Heart and lung disease
- Risks for children
- Dehydration
- Kidney disease
- Heat stroke
- Skin disease
- Digestive illnesses
- Mental health conditions
- Neurologic disease
- Nutrition
- Trauma
- **Infectious diseases**

Climate change primer





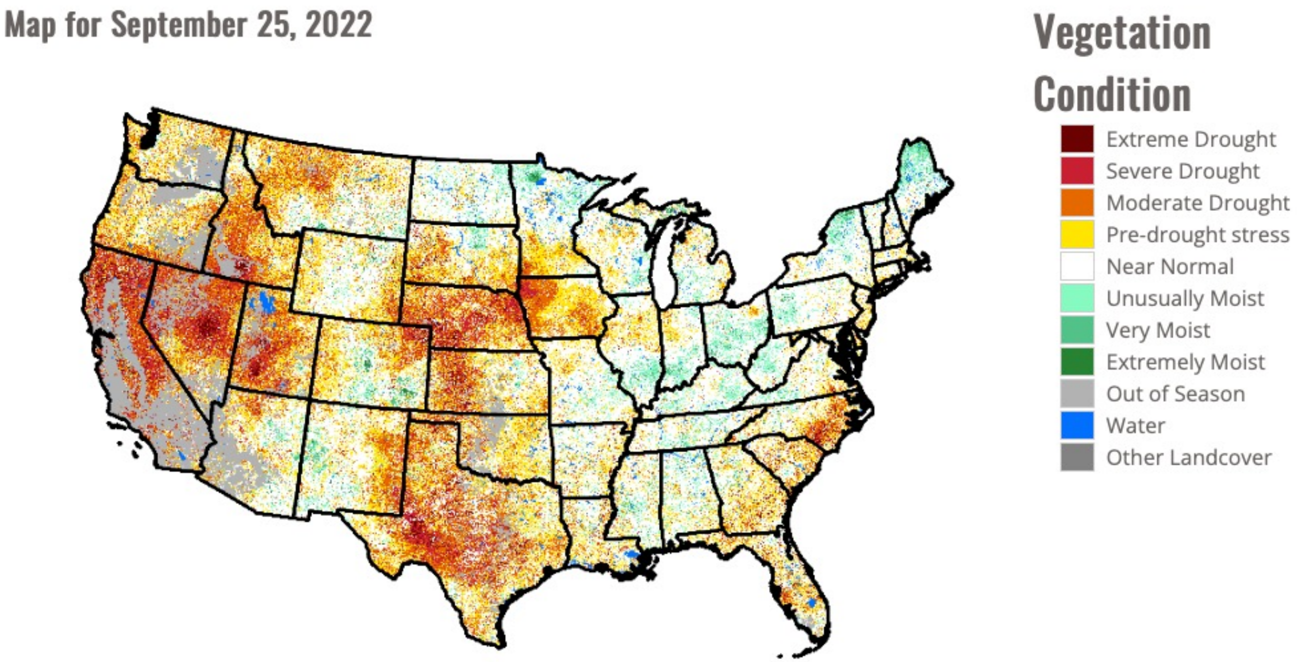
NASA, Global Climate Change: Vital signs of the planet

Rebecca Lindsey and LuAnn Dahlman. Climate Change: Global Temperature. Climate.gov.

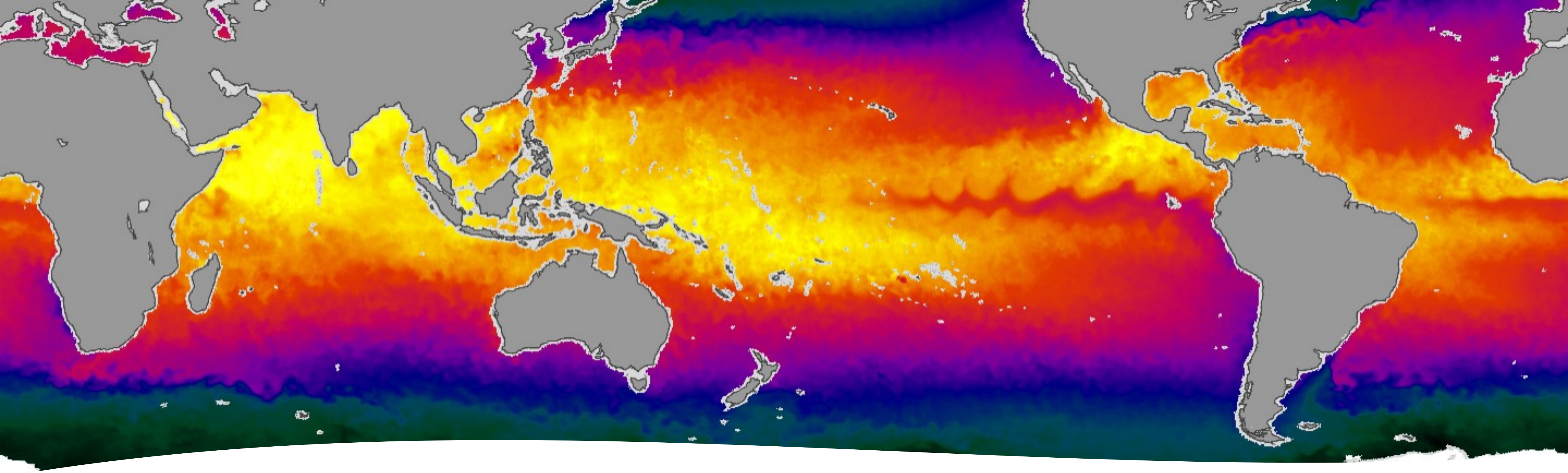
Extreme weather events

NASA, Global Climate Change: Vital signs of the planet

Vegetation condition



Vegetation Drought Response Index (VegDRI)



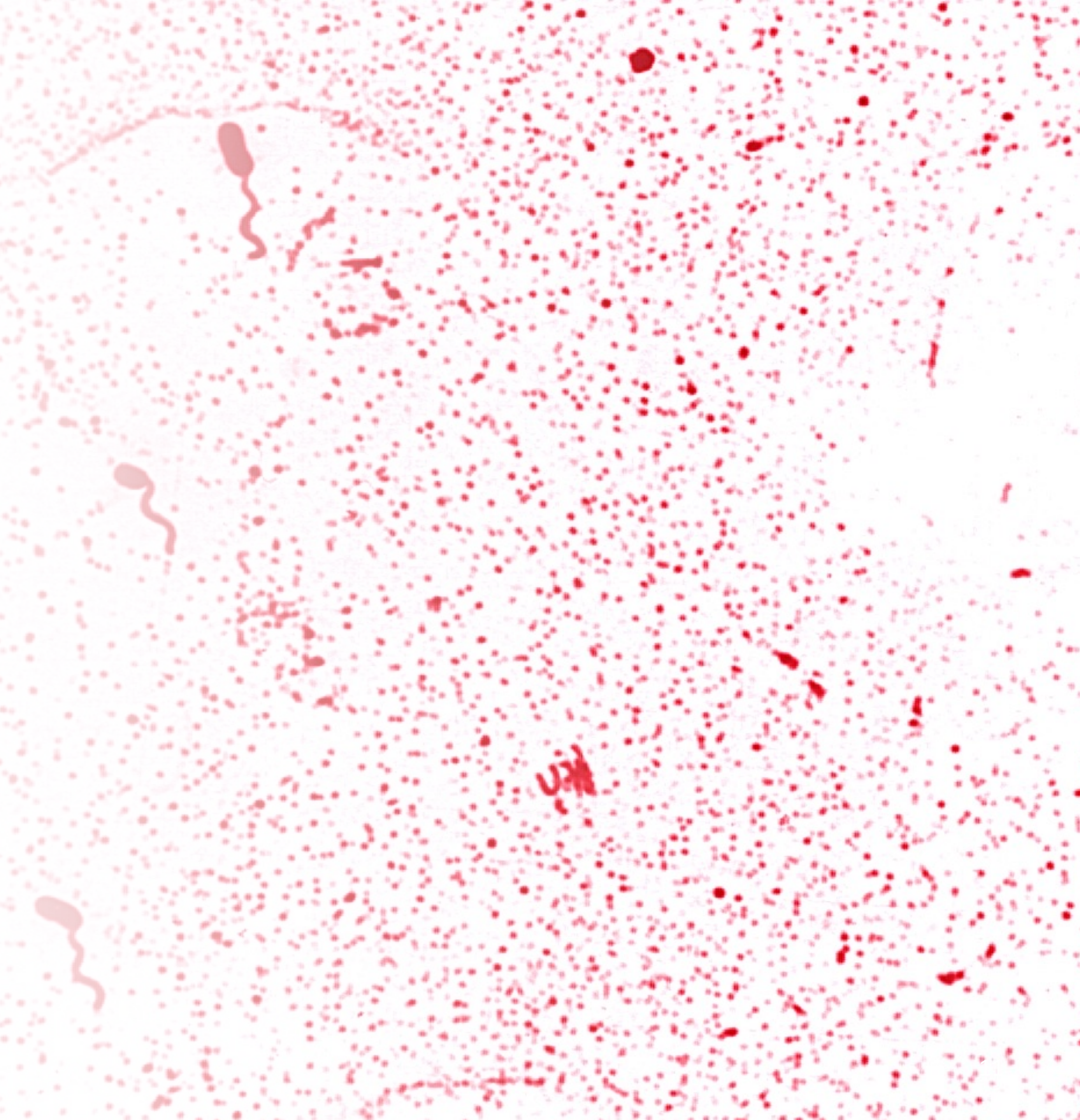
Water

- Temperature
- Salinity
- Currents
- Seasonality patterns

- Water-borne infections
  - Ingestion, inhalation, direct inoculation

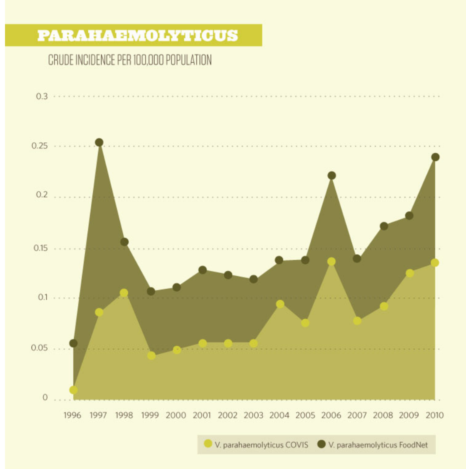
Vibrio spp.

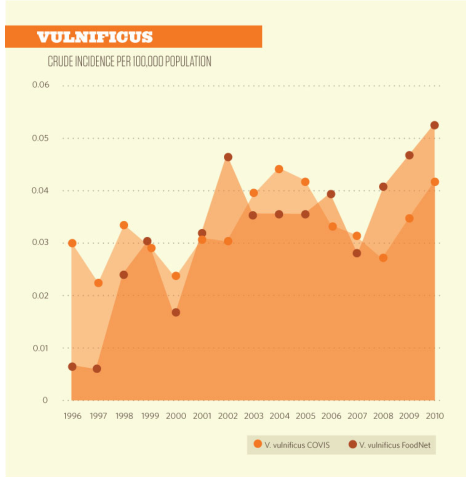
- Sea surface temperatures are associated with the abundance, geographic distribution, and duration of risk of *Vibrio* spp. infections
- V. cholerae
- Non-cholera Vibrio
  - V. parahaemolyticus
  - V. vulnificus
  - V. alginolyticus
- GI infection via ingestion, wound infection via direct inoculation
- 80,000 illnesses and $300 million in the US each year

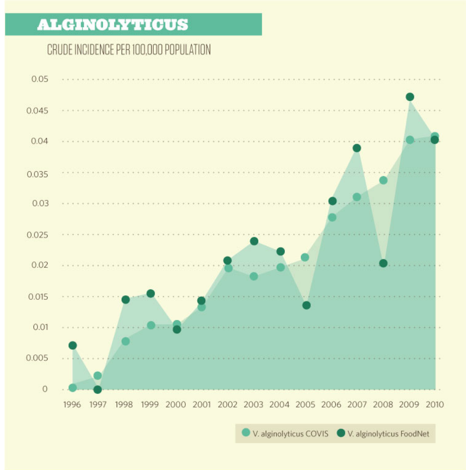


Vibrio spp.

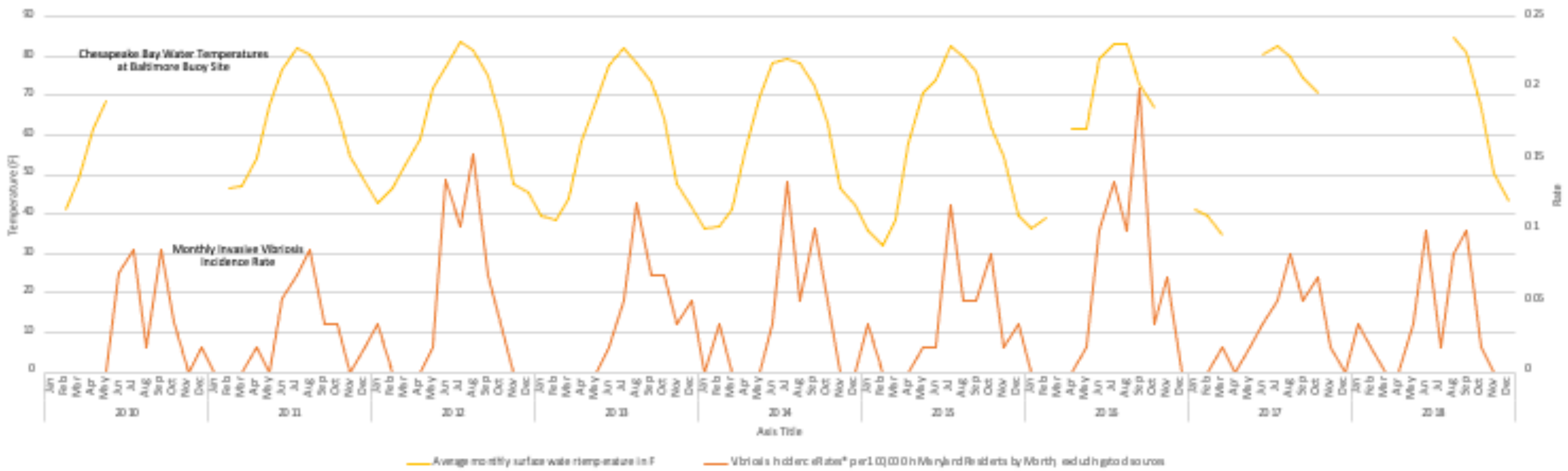
- Coastal and estuarine water – warm and brackish
- Gulf Coast, Mid-Atlantic, Northeast, Washington, Hawaii
- 15yr increase in vibriosis incidence from 1996-2015
- Warming sea surface temperatures associated with increased incidence of V. vulnificus
- Prolonged warm sea surface temperatures associated with longer detection period for V. vulnificus and parahaemolyticus
- Broader salinity tolerance with higher temperatures

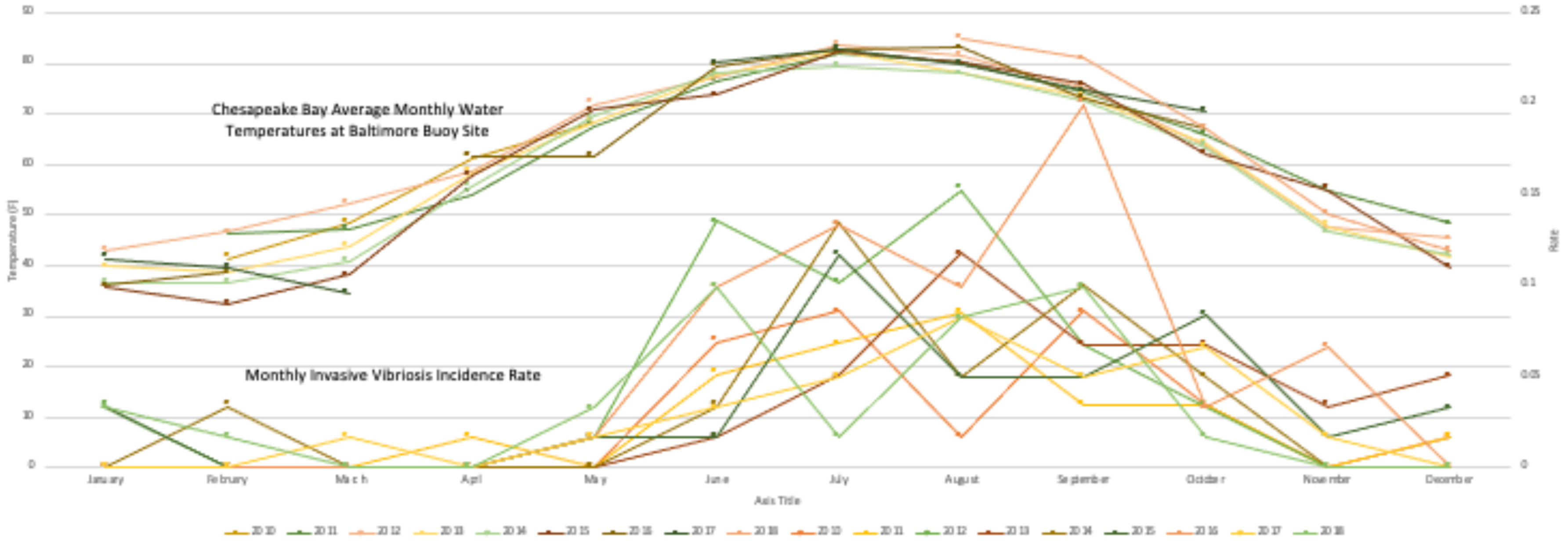






Temperature in degrees Fahrenheit



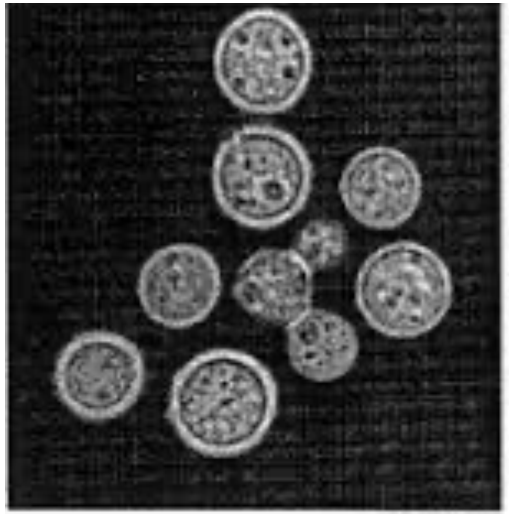


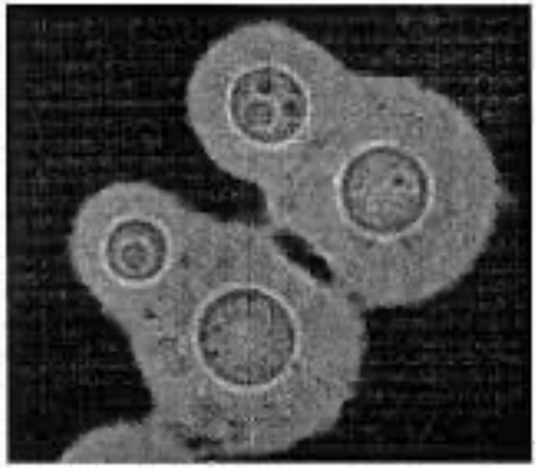
Soil and Plant Biota

- Soil- and plant-dwelling pathogenic microbes
- Human infectious diseases
- Agricultural crop infectious diseases

Cryptococcus gattii

- Wood and soil reservoirs
- Inhalation of spores followed by dissemination
- First identified in Vancouver Island, Canada in 1999
- Sunny, moderate temperature, above-freezing winters
- Melanization in response to environmental stress
- Associated with increased temperature tolerance (heat and cold)
- Now found in WA, OR, CA, ID





Wildfires

- Longer fire seasons
- Longer droughts
- Inhalation of microbes
- Infections of burns

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL REPORT

Wildfires, Global Climate Change, and Human Health

Rongbin Xu, M.B., B.S., Pei Yu, M.B., B.S., Michael J. Abramson, M.B., B.S., Ph.D., Fay H. Johnston, B.M., B.S., Ph.D., Jonathan M. Samet, M.D., Michelle L. Bell, Ph.D., Andy Haines, M.B., B.S., M.D., Kristie L. Ebi, Ph.D., M.P.H., Shanshan Li, M.D., Ph.D., and Yuming Guo, M.D., Ph.D.

- Burns
- Injuries
- Mental illness
- Eye irritation
- Corneal abrasion
- Asthma
- COPD
- Respiratory infection
- CV events
- Pregnancy outcomes

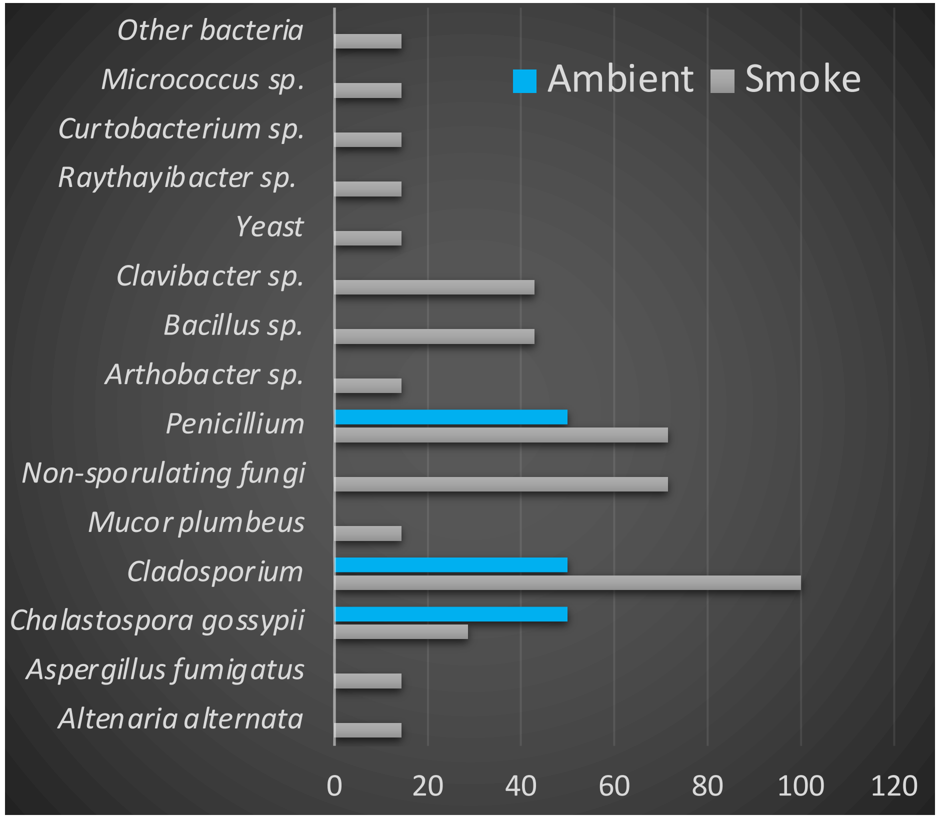
MB Rongbin Xu et al. 2020. Wildfires, global climate change, and human health. NEJM 2020; 383:2173-2181.

Table I: Incidence rate ratios (95% CI) for IFI admissions by wildfire exposure and season		
	Large wildfire within 200 miles (compared to months with no fire)	Fall season (compared to Summer)
Invasive mold	1.18 (1.11-1.25)	1.24 (1.15-1.33)
Aspergillosis	1.22 (1.11-1.32)	1.35 (1.21-1.50)
Coccidioidomycosis	1.22 (1.07-1.40)	1.36 (1.14-1.62)
Invasive *Candida*	1.03 (0.90-1.18)	1.01 (0.85-1.20)

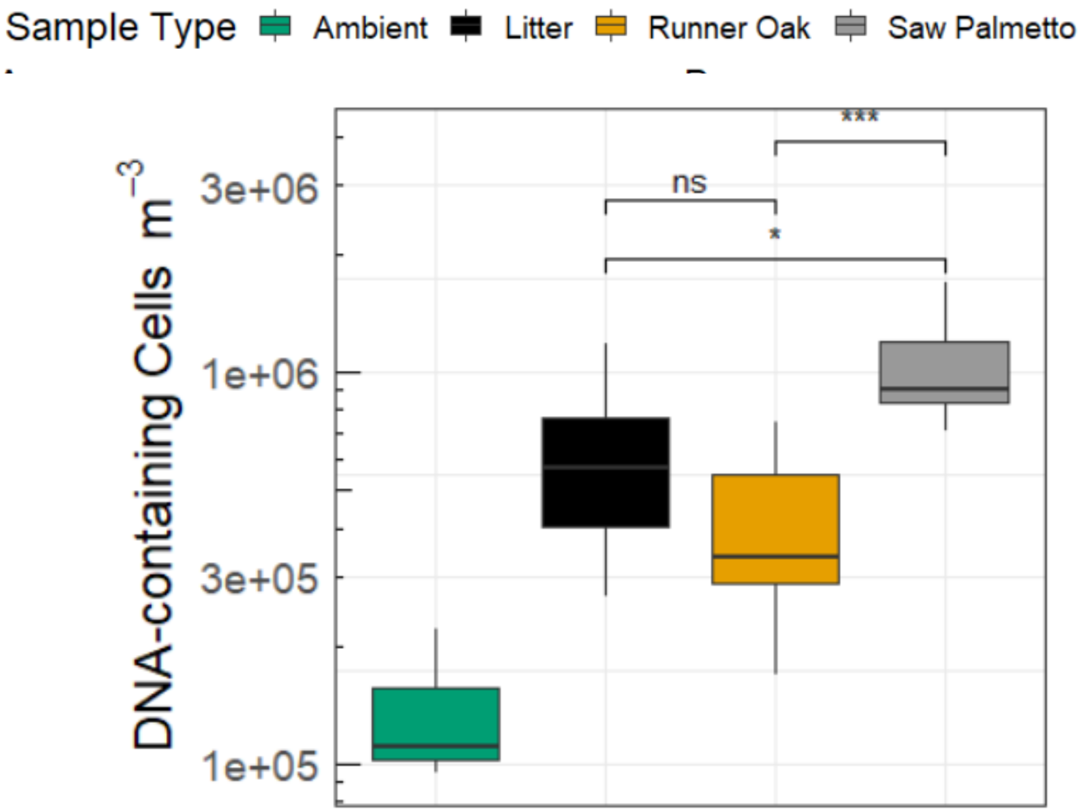
Is Exposure to Wildfires Associated with Invasive Fungal Infections?

J. S. Mulliken[1], A. G. Rappold[2], M. Fung[1], J. M. Babik[1], S. B. Doernberg[1]

[1]Division of Infectious Diseases, University of California San Francisco, San Francisco, CA,
[2]National Health and Environmental Effects Research Laboratory, United States Environmental Protection Agency, Durham, NC



Comparisons among fuel types



Moore, Bomar, Kobziar, Christner. 2020. Wildland fire as an atmospheric source of viable bioaerosols and biological ice nucleating particles. ISME Multidisciplinary Journal of Microbial Ecology.

Microbiology of wildfire victims differs significantly from routine burns patients: Data from an Australian wildfire disaster

Norelle L. Sherry [a,b], *Alexander A. Padiglione* [a,c,*], *Denis W. Spelman* [a,b], *Heather Cleland* [c]

[a] *Department of Infectious Diseases, Alfred Hospital, Prahran, Victoria, Australia*
[b] *Department of Microbiology, Alfred Hospital, Australia*
[c] *Victorian Adult Burns Service, Alfred Hospital, Australia*

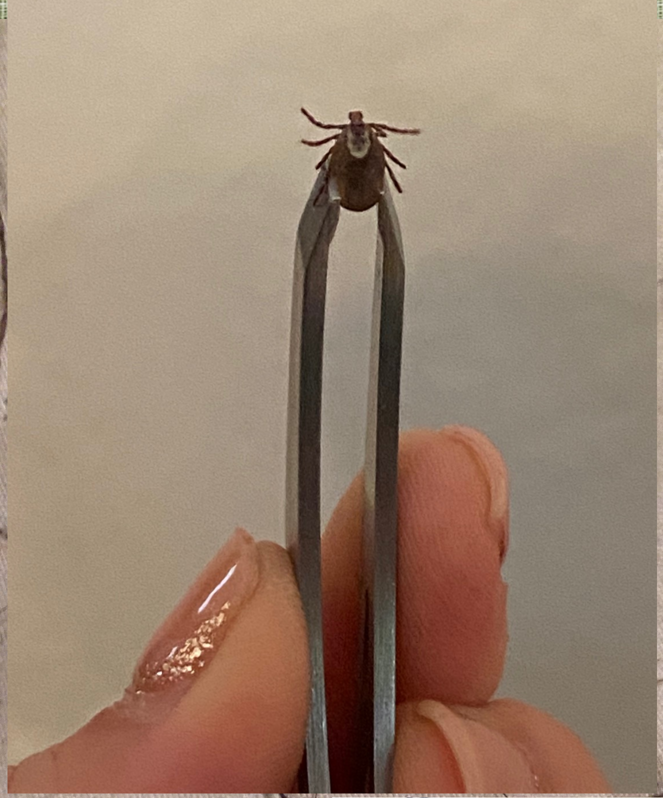
No. patients with any positive culture (respiratory or wound) at 72 h	10 (56%)	7 (19%)	0.04
Wound cultures			
No. patients with positive wound culture at 72hrs	7 (39%)	7 (19%)	0.18
Monomicrobial	5 (71%)	3 (8%)	
Polymicrobial	2 (29%)	4 (11%)	0.59
Gram positives	2 (15%)	9 (75%)	
Gram negatives	11 (85%)	3 (25%)	0.005
Respiratory cultures			
No. patients with positive respiratory culture at 72 h	4 (22%)	3 (8%)	0.21
Monomicrobial	2 (50%)	1 (33%)	
Polymicrobial	2 (50%)	2 (66%)	1
Gram positives	3 (50%)	2 (40%)	
Gram negatives	3 (50%)	3 (60%)	1

NL Sherry et al. Microbiology of wildfire victims differs significantly from routine burns patients: Data from an Australian wildfire disaster, Burns, Volume 39, Issue 2, 2013, Pages 331-334.

Insect vectors

- Anthropogenic change
- Extreme weather events
- Habitats
- Geographic distribution

Any idea what kind of tick this is?



Is that a tick?

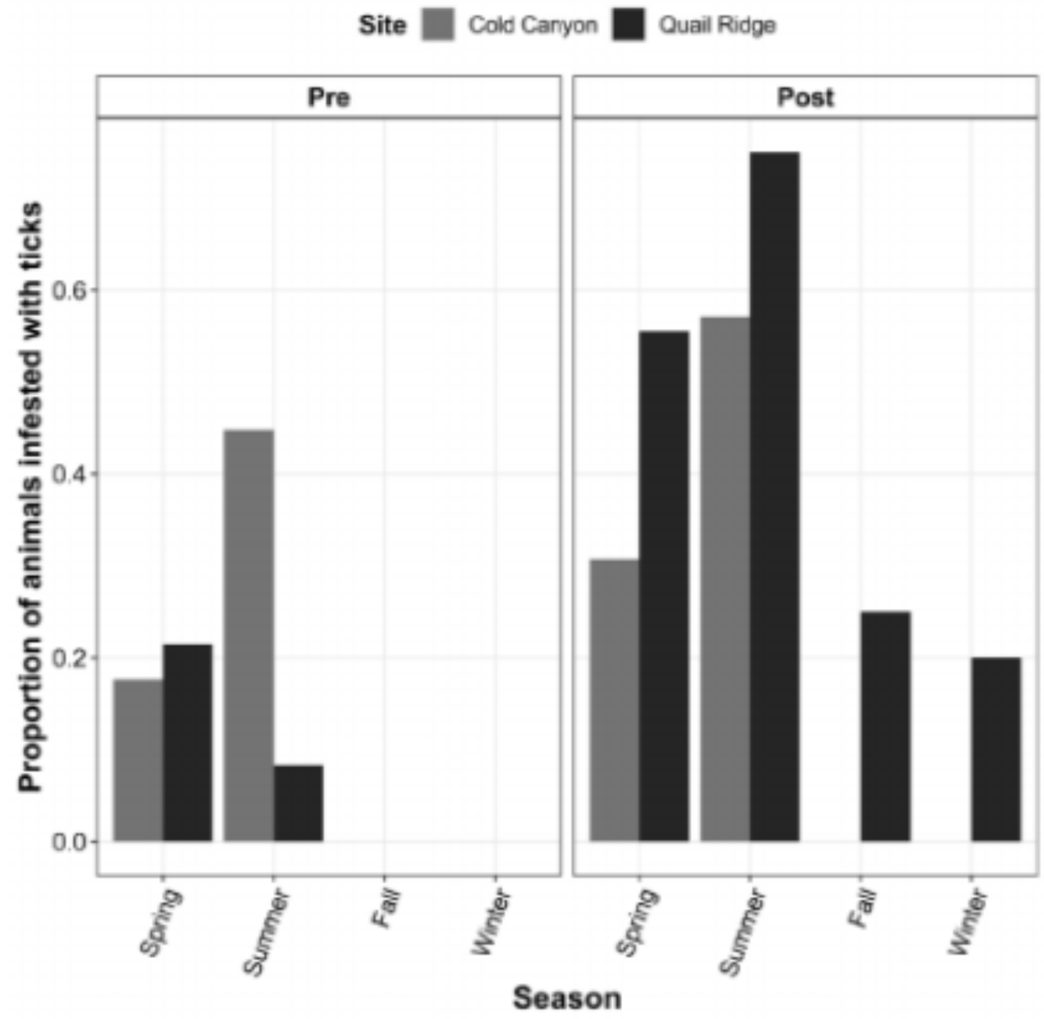
Lyme disease

- Most prevalent vector-borne disease in the US
- Endemic to the Northeast and Midwest
- Caused by Borrelia burgdorferi
- Transmitted by Ixodes ticks
- Early disease defined by bullseye rash
- Identified in the US in the 1970s
- Identified in Canada in 2004
- Geographic range of the tick vector and reservoir host (white-footed mouse) are expanding northward with warming climate

Response of small mammal and tick communities to a catastrophic wildfire and implications for tick-borne pathogens

Emily L. Pascoe, Benjamin T. Plourde, Andrés M. Lopéz-Perez, and Janet E. Foley✉

Tick species	Percentage of ticks collected			
	Cold Canyon		Quail Ridge	
	Pre	Post	Pre	Post
***Ixodes* spp.**	**100% (n=42)**	**55.81% (n=24)**	**87.50% (n=7)**	**31.25% (n=45)**
Ixodes pacificus	59.52 % (n=25)	41.86% (n=18)	75.00% (n=6)	28.47% (n=41)
Ixodes spinipalpis	2.38% (n=1)	0%	12.50% (n=1)	0%
Ixodes woodi	38.10% (n=16)	6.98% (n=3)	0%	0%
Unidentified *Ixodes* sp.	0%	6.98% (n=3)	0%	2.78% (n=4)
***Dermacentor* spp.**	**0%**	**44.19% (n=19)**	**12.5% (n=1)**	**68.75% (n=99)**
Dermacentor occidentalis	0%	44.19% (n=19)	0%	68.06% (n=98)
Dermacentor variabilis	0%	0%	12.5% (n=1)	0%
Unidentified *Dermacentor* spp.	0%	0%	0%	0.69% (n=1)



Wildfires change host ecology

Table 2. Numbers of each small mammal species trapped before and after the Wragg Fire in 2015 which burned Stebbins Cold Canyon Reserve in northern California, compared with nearby Quail Ridge Reserve, a control site that did not burn. Number of captures includes all successful trap events, including animals that may have been recaptured. Individuals were distinguished from all captures by the presence of uniquely numbered metal eartags and only counted once.

	Pre-fire		Post-fire	
	CC	**QR**	**CC**	**QR**
Number of captures	**120**	**37**	**371**	**67**
Microtus californicus	0	0	12	1
Mus musculus	0	0	20	0
Neotoma fuscipes	120	37	7	2
Peromyscus species	0	0	332	64
Number of individuals (% of all captures)	**85**	**24**	**291**	**53**
Microtus californicus	0	0	12 (4.12%)	1 (1.89%)
Mus musculus	0	0	20 (6.87%)	0
Neotoma fuscipes	85 (100%)	24 (100%)	5 (1.72%)	2 (3.77%)
Peromyscus species	0	0	254 (87.29)	50 (94.34%)
Mean recapture rate (range of number of recaptures)	**1.41 (1–3)**	**1.54 (1–3)**	**1.27 (1–4)**	**1.26 (1–4)**
Microtus californicus	0	0	1 (1)	1 (1)
Mus musculus	0	0	1 (1)	0
Neotoma fuscipes	1.41 (1–3)	1.54 (1–3)	1.40 (1–2)	1 (1)
Peromyscus species	0	0	1.31 (1–4)	1.28 (1–4)

Population displacement

- In 2019, 33.4M people were displaced worldwide
- 23.9M were displaced due to weather-related events
- Floods, hurricanes, fires often associated with temporary movement
- Droughts and famines may lead to more permanent relocation
- Temperature extremes and natural disasters may be associated with food insecurity and changes in infectious disease epidemiology

Overcrowding in shelters and camps

- 2005, Hurricane Katrina
- 27,000 people were evacuated from LA to a single shelter in Houston, TX
- Within 2 weeks, >1,000 people developed gastroenteritis
- Half of the people tested positive for Norovirus

Long-term health impacts

- Delayed or missed diagnoses
- Changing ID epidemiology
- Missed routine childhood vaccinations

- Doubled rate of gonorrhea among high school students after Katrina
- 25% decreased rate of HIV screening during Hurricane Sandy, 2012

Missed childhood vaccinations

- Known factors to account for vaccine disparities:
- Religious beliefs
- Safety worries
- Healthcare barriers
- War and conflict

- Retrospective study of 22 countries in sub-Saharan Africa
- Droughts were associated with 1-2% reduction in vaccination rate

Nagata JM, Epstein A, Ganson KT, Benmarhnia T, Weiser SD (2021) Drought and child vaccination coverage in 22 countries in sub-Saharan Africa: A retrospective analysis of national survey data from 2011 to 2019. PLOS Medicine 18(9): e1003678. https://doi.org/10.1371/journal.pmed.1003678

Why do droughts lead to missed immunizations?

- Food insecurity
- Financial instability
- Intimate partner violence
- Poorer mental health
- Human displacement and migration
- Erosion of health infrastructure
- Vaccine storage issues

Nagata JM, Epstein A, Ganson KT, Benmarhnia T, Weiser SD (2021) Drought and child vaccination coverage in 22 countries in sub-Saharan Africa: A retrospective analysis of national survey data from 2011 to 2019. PLOS Medicine 18(9): e1003678. https://doi.org/10.1371/journal.pmed.1003678

DISASTER SAFETY

Impact of Power Outages on Vaccine Storage

- Most refrigerated vaccines are relatively stable at room temperature for limited periods of time
- MMR and Varivax are very temperature sensitive
- Record the duration of power outage and the temperature as soon as the power returns and then discuss with public health authorities before discarding or administering

CDC, Disaster Safety. 2005. *https://emergency.cdc.gov/poweroutage/pdf/poweroutage-vaccinestorage.pdf*

Immunizations for displaced people

- Treat as if up-to-date with vaccine record
- Unless documentation of previous vaccine or infection, evacuees in crowded group settings should also receive:
- Influenza (6+ months old)
- Varicella (12+ months old)
- MMR (12+ months old)

Extreme weather events and COVID-19

- February 2021 TX snowstorms
  - Delayed delivery of around 1 million

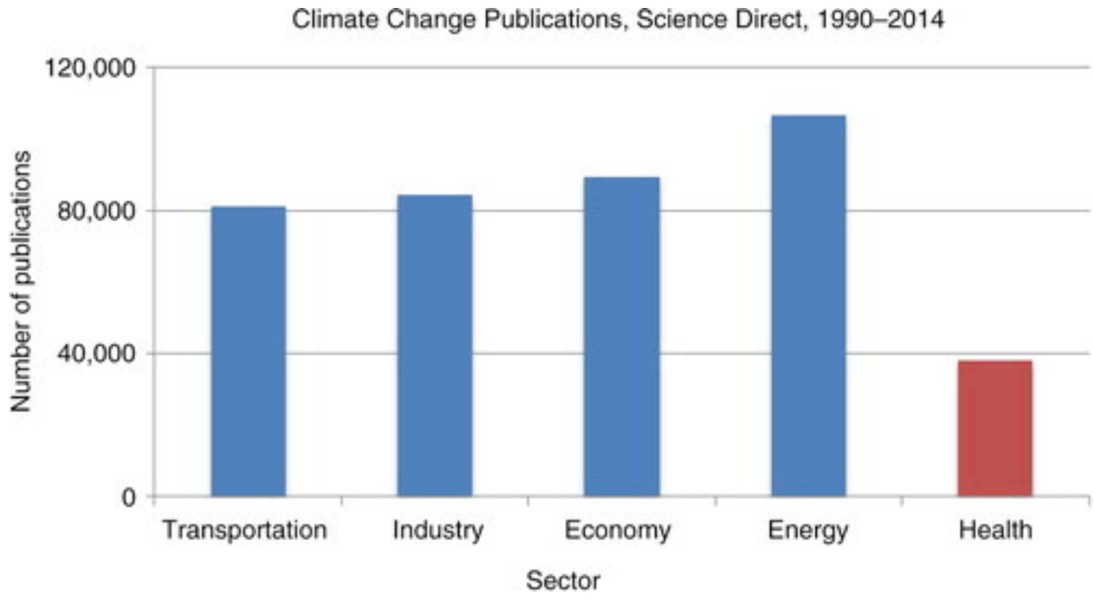
  COVID-19 vaccines, >700k to TX

- Fall 2020 NV wildfires
  - "A 10ug/m3 increased in the 7-day average PM2.5 concentration was associated with a 6.3% relative increase in the SARS CoV2 test positivity rate"
  - "corresponded to an estimated 17.7% increase in the number of cases during the time period most affected by wildfire smoke"

D. Kiser et al. SARS-CoV-2 test positivity rate in Reno, Nevada: association with PM2.5 during the 2020 wildfire smoke events in the western United States, Journal of Exposure Science & Environmental Epidemiology, 2021, 31, 797-803.

The healthcare sector

- 5% of global greenhouse gas emissions
- 10% of domestic greenhouse gas emissions



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Contact info

- nehauser@ucdavis.edu