Yale Center on Climate Change and Health Annual Report

July 1, 2022 to June 30, 2023

Executive Summary

The following is a summary of major accomplishments of the Yale Center on Climate Change and Health (YCCCH) at Yale School of Public Health (YSPH) during the period July 1, 2022 to June 30, 2023:

- **Successful integration of Dr. Daniel Carrión, the new YCCCH Director of Education, into the core YCCCH team**
- **Research publications in high-impact journals**, including *The Lancet*, *Lancet Planetary Health*, and *JAMA Network Open*
- **Continued membership in *The Lancet Countdown on Health and Climate Change***, with authorship of two indicators in the 2022 Report
- **Leadership of the *Lancet Commission on Sustainable Healthcare***, which was established to assess resource consumption and environmental emissions in the healthcare sector and to recommend sustainable research, practices, policies, and parameters
- **Expanded enrollment in the Climate Change and Health Concentration** for MPH students, from 13 in the Class of 2023 to 17 in the Class of 2024
- **Continued offering of climate and health courses for Yale students**, including *Climate Change and Public Health*; *Methods in Climate Change and Health Research*; *Clinic in Climate Justice, Law, and Public Health*; and *Seminar in Climate Change and Health*
- **Development of a new course, *Climate Equity and Health Policy Methods***, to be taught by Suzi Ruhl, JD in Fall 2023
- **Continuation of the two-semester *Clinic in Climate Justice, Law, and Public Health***, with a focus on energy security, energy justice, and energy efficiency in relation to housing and real-world impact in New Haven, the State of Connecticut, New York City, and nationally
- **A new YCCCH Student Fellows Program,** which engaged 12 Yale students in YCCCH's research, public health practice, communications, and operations through paid fellowship opportunities during the academic year
- **Graduation of two climate change and health pre-doctoral fellows, Sappho Gilbert and Lingzhi Chu**
- **A major overhaul of the online Climate Change and Health Certificate Program for working professionals** to reflect the most recent science, (inter)governmental and non-governmental organization reports, and relevant climate events since the original program and to increase the program's global (as opposed to United States) focus
- **Development of a nascent partnership with the RMI Carbon-Free Buildings program**
- **Implementation of a partnership with the Connecticut Department of Public Health on a grant funded by the Centers for Disease Control and Prevention entitled *Advancing local capacity for health effects from heat, air quality, and extreme events***
- **Hosted Admiral Rachel Levine, Assistant Secretary for Health for the U.S. Department of Health and Human Services**, for a roundtable on climate change and public health

YCCCH Structure and Administration

Since January 2020 YCCCH has operated as a University Center, as reflected in our updated name: the Yale Center on Climate Change and Health. To support our expanded mandate, we developed a four-year strategic plan (2020-24), expanded our staff, and created an Advisory Board. In 2022-23, we continued to build out our work as a University Center by securing additional funds, expanding our research projects, and reaching more students through our educational programs, among other activities.

YCCCH Core Team

- **Dr. Robert Dubrow**, Faculty Director; Professor of Epidemiology (Environmental Health Sciences)
- **Dr. Martin Klein**, Executive Director; Senior Advisor, YSPH Dean's Office; Lecturer (Health Policy and Management); Director, Executive MPH Program
- **Dr. Kai Chen**, Director of Research; Assistant Professor of Epidemiology (Environmental Health Sciences)
- **Dr. Laura Bozzi**, Director of Programs; Lecturer (Environmental Health Sciences)
- **Dr. Jodi Sherman**, Director of Program on Healthcare Environmental Sustainability; Associate Professor of Anesthesiology
- **Dr. Daniel Carrión,** Director of Education; Assistant Professor of Epidemiology (Environmental Health Sciences)
- **Mr. Mauro Diaz-Hernandez**, Program Administrator

Mr. Diaz-Hernandez left YCCCH and Yale in June 2023. He moved to Columbus, Ohio with his partner, who was entering a PhD program at Ohio State University. Dr. Bozzi left YCCCH and Yale in June 2023 to take a position as Senior Director of Environmental Health Policy for the New York City Department of Health and Mental Hygiene.

Advisory Board

The YCCCH Advisory Board includes students, faculty from other universities, and representatives from government, non-profit organizations, and industry. The following constitutes the Advisory Board membership:

- **Paul Anastas, PhD**, Teresa and H. John Heinz III Professor in the Practice of Chemistry for the Environment, Yale School of the Environment
- **Michelle Bell, PhD,** Mary E. Pinchot Professor of Environmental Health, Yale School of the Environment
- **Tekisha Dwan Everette, PhD, MPA**, Executive Director, Trust for America's Health; Assistant Clinical Professor (Social and Behavioral Sciences), Yale School of Public Health
- **Paulette Frank**, Chief Sustainability Officer, Johnson & Johnson
- **Rebecca French, PhD**, Director, Office of Climate Planning, Connecticut Department of Energy and Environmental Protection
- **Howard Frumkin, MD, DrPH**, Senior Vice President, The Trust for Public Land; Professor Emeritus, Environmental and Occupational Health Sciences, University of Washington School of Public Health

- **Shelley Geballe, JD, MPH**, Professor of Clinical Public Health (Health Policy), Yale School of Public Health; Clinical Lecturer, Yale Law School; Distinguished Senior Fellow, Connecticut Voices for Children
- **Emily Goddard**, MPH Candidate, Yale School of Public Health
- **Rachel Hennein,** MD/PhD Candidate, Yale School of Medicine
- **Tara Houska, JD,** Zhaabowekwe (Couchiching First Nation) tribal attorney, land defender, and climate justice activist
- **Mark Mitchell, MD, MPH, FACPM**, Associate Professor of Climate Change, Energy & Environmental Health Equity, George Mason University; Co-chair, Commission on Environmental Health, National Medical Association
- **Michael Pascucilla, MPH, REHS,** Chief Executive Officer/Director of Health**,** East Shore District Health Department, Branford, Connecticut
- **Surili Patel, MS,** Vice President, The Metropolitan Group
- **Peggy Shepard,** Co-founder and Executive Director, WE ACT for Environmental Justice
- **Vasilis Vasiliou, PhD,** Department Chair and Susan Dwight Bliss Professor of Epidemiology (Environmental Health Sciences), Yale School of Public Health
- **Nick Watts, MD,** Chief Sustainability Officer, National Health Service, United Kingdom
- **Daniel Weinberger, PhD,** Associate Professor of Epidemiology (Microbial Diseases)**,** Yale School of Public Health
- **Sacoby Wilson, PhD,** Professor, the Maryland Institute for Applied Environmental Health and Department of Epidemiology and Biostatistics, School of Public Health, University of Maryland-College Park
- **Elizabeth Yeampierre, JD,** Executive Director, UPROSE

Affiliated Faculty

On June 30, 2023, we had 52 Affiliated Faculty, 29 with primary appointments at YSPH and 23 with primary appointments in other schools or departments.

Affiliations

YCCCH has affiliated with the following organizations:

- Global Consortium on Climate and Health Education
- Planetary Health Alliance
- US Climate and Health Alliance
- Lancet Countdown: Tracking Progress on Health and Climate Change
- Connecticut Governor's Council on Climate Change
- Alliance for Transformative Action on Climate and Health (ATACH)
- Medical Society Consortium on Climate Change and Health

Communications

YCCCH maintains a website, hosted on the YSPH website, and we continue to expand the site to reflect the Center's extensive work. We maintain several social media accounts, including Facebook, LinkedIn, Twitter, YouTube, and our newly formed Instagram account. We also

maintain a collection of recorded lectures and guest talks on our website. We continue to work closely with the YSPH Communications Office to produce news articles and social media posts highlighting YCCCH efforts, which lead to increased engagement across platforms. Our monthly newsletter reaches over 3,500 recipients and boasts an impressive open rate of approximately 40%. Finally, in partnership with the YSPH Communications Office, YCCCH was featured in a promotional video, which can be viewed on the YCCCH website landing page.

Program Accomplishments

Research

Core Research Program

The core research program is led by Dr. Kai Chen, the YCCCH Director of Research. Through this program, we are building a vibrant community of doctoral students, postdoctoral researchers, visiting scholars, and collaborating faculty who apply multidisciplinary approaches – including climate and air pollution sciences, exposure assessment, mathematical and statistical modeling, and environmental epidemiology – to investigate a) interactive effects on human health of ambient temperature, air pollution, extreme weather events, demographic factors, and social determinants; b) future climate change impacts as determined by modeling of alternative scenarios; c) health co-benefits of climate change mitigation and adaption measures and related policies; d) effects of mitigation and adaptation policies on reducing disparities in environmental exposures and their adverse health effects; and e) adaptation strategies, especially to extreme heat. The program aims to produce policy-relevant knowledge that can be used to advance climate change mitigation and adaptation in a manner that promotes health and protects vulnerable populations.

During the 2022-23 academic year, the core research program included Drs. Chen, Dubrow, and Carrión, two postdoctoral associates (Dr. Pin Wang and Dr. Lingzhi Chu), four doctoral students (Sappho Gilbert (graduated in May 2023), Lingzhi Chu (graduated in May 2023 and stayed on as a postdoctoral associate), Yiqun Ma, and Chengyi Lin), a visiting doctoral student (Pak Hung Lam), two visiting scientists (Dr. Jie Ban and Dr. Xuguo Zhang), seven master's students (Mitchell Manware, Emily Goddard, Julia Sweatman, Caroline Sutton, Saira Prasanth, Anna Stouffer, and Weixi Wu), and three undergraduate students (Isabelle Thomas, Rhea Cong, and Oluwaseminire Oloyede).

In 2022-23, the core research faculty continued the following funded research projects:

- ***Effect of air pollution reductions on mortality during the COVID-19 lockdown: A natural experiment study*** (funded by Health Effects Institute). This study aims to evaluate whether changes in mortality are associated with changes in ambient NO_2 and $PM_{2.5}$ levels before, during, and after COVID-19 lockdowns and to disentangle the short-term effects of NO_2 versus $PM_{2.5}$ on mortality. The analysis is being conducted in four countries: China, Germany, Italy, and the United States. Research progress was presented at the International Society for Environmental Epidemiology Annual Meeting in Athens, Greece in September 2022, and at the Health Effects Institute Annual Conference in Boston in April 2023.
- ***Associations between extreme precipitation, floods, or drought and childhood diarrhea in low- and middle-Income countries*** (funded by the Reckitt Benckiser Global Hygiene Institute). This study aims to quantify the relationship between extreme precipitation, floods, or drought and risk of childhood diarrhea in children under age five

years in low- and middle-income countries and to evaluate whether the effects of extreme precipitation, floods, and drought are modified by water, sanitation, and hygiene practices. The study's first paper was published in *Nature Communications* in June 2022, and the second manuscript was submitted in March 2023.

- ***Ethane cracker plants in the United States: emissions and community vulnerability*** (funded by the High Tide Foundation). This study, led by Dr. Nicole Deziel with Dr. Dubrow and Affiliated Faculty Michelle Bell as co-investigators, characterized emissions profiles of ethane cracker plants in the U.S., as well as sociodemographic characteristics of people living near the plants. Twenty-nine of the 32 plants are located in Texas and Louisiana. The chemicals emitted in the greatest quantities were (in decreasing order) ethylene, propylene, hydrochloric acid, benzene, n-hexane, 1,3-butadiene, ammonia, toluene, vinyl acetate, and methanol. In 2019, 68 million metric tons of CO_{2e} were emitted. Census block groups within 5 km of a facility had more vacant housing, lower income, lower educational attainment, higher unemployment, and a higher proportion of people who are non-Hispanic Black than block groups further away. This work was presented at the International Society for Environmental Epidemiology Annual Meeting in Athens, Greece in September 2022 and at the Physicians for Social Responsibility Pennsylvania virtual conference entitled *Shifting paradigms: A grassroots response to industry and climate* in December 2022. A manuscript was accepted for publication by Environmental Research -- Health.
- ***Environmental justice: Tools, processes and protocols supporting credible measurement*** (funded by the Environmental Defense Fund). This project is a partnership with Resources for the Future, New York City Environmental Justice Alliance, Northeastern University, and the University of California at Davis Institute of Transportation Studies. The project is assessing the environmental justice implications regarding air quality of New York State climate policy proposals under the state's *Climate Leadership and Community Protection Act*. The study has been completed and a final report was submitted. A manuscript has been drafted and will be submitted for publication in 2023-24.
- ***Heat-related mortality, air conditioning and inequality in the U.S.*** (funded by a Yale Planetary Solutions Project Seed Grant). This project aims to estimate 1) nationwide U.S. county-level air conditioning use, 2) the extent to which air conditioning use reduces heat-related mortality, and 3) race/ethnicity and income disparities in heat-related mortality reduction. Two manuscripts have been published, one in *GeoHealth* on heat vulnerability and inequality in the US, and the other in *PLOS Climate* on heat-related mortality in Connecticut. A follow-up grant proposal to the National Science Foundation has been submitted.
- ***Yale-China Training Program in Climate Change and Health*** (funded by the Li Foundation). This training program has established a *Li Foundation Climate Change and Health Fellowship Program*, which trains one researcher per year from China on climate change and health research. Dr. Jie Ban from the Chinese Centers for Disease Control and Prevention, our first trainee, arrived at Yale in November 2022 and submitted three first-authored manuscripts for publication by June 30 2023: 1) Extreme heatwaves may enhance the risk of night onset pulmonary embolism; 2) Future acute coronary syndrome onset associated with short-term ozone exposure under the dual threats of climate change and population aging in China; and 3) Association of flood exposure with cause-specific mortality in North Carolina. Dr. Ban attended the Health Effects Institute Annual Conference in Boston in April 2023 and the International Society for Environmental Epidemiology – North American Chapter Regional Conference in June 2023.

New grants to support research

Planetary Solutions Project Seed Grants

The Yale Planetary Solutions Project awarded over $1.5 million to 23 proposals in the second round of its Seed Grant Program. These grants support the Yale community's work in addressing climate change, biodiversity loss, and climate-linked health and justice issues. Multi-disciplinary teams that include YCCCH core and/or Affiliated Faculty (core and Affiliated Faculty are bolded below) received five of these awards. Each grant was for the period July 1, 2023, to June 30, 2024:

- ***High ambient temperatures during pregnancy and risk of offspring cerebral palsy*.** This project explores the hypothesis that high ambient temperatures during pregnancy increase the risk of cerebral palsy among the offspring using a comprehensive dataset of births in California during 2000-2015. This research could significantly impact the way we understand cerebral palsy, providing new insights that could lead to a shift in approaches to preventing the condition.
    - Team: **Tormod Rogne** (YSPH), Zeyan Liew (YSPH), **Kai Chen**, **Joshua Warren** (YSPH)
    - Total award for project period: $80,000
- ***Addressing urban heat in the Dwight neighborhood of New Haven: A prototype for neighborhood-level planning*.** This project seeks to develop and test a model six-component methodology for research and analysis of environmental heat exposure, its impacts, and potential solutions in the low-income, inner-city Dwight neighborhood of New Haven. The study aims to 1) test the hypothesis that there is meaningful heterogeneity in temperature exposure even within a small neighborhood such as Dwight; 2) to show that a deep- dive assessment of heat exposure, impacts, and potential solutions at the "micro" neighborhood scale will inform cooling solutions in a way that cannot be done using more "macro" approaches; 3) to provide a model that will be transferable to other neighborhoods in New Haven and in other cities; and 4) to provide primary data as scientific input into a Dwight neighborhood planning process, contributing directly to the development and siting of specific strategies and project proposals to mitigate the impacts of urban heat.
    - Team: Andrei Harwell (School of Architecture), **Robert Dubrow**, Alan Plattus (School of Architecture), **Laura Bozzi**
    - Total award for project period: $80,000
- ***Breathing inequality: Air pollution and cardiovascular health in the U.S*.** This research aims to address the inequalities in air pollution exposure, health risk, and cardiovascular disease burden in socioeconomically disadvantaged neighborhoods in the U.S. Such communities have a higher burden of exposure to fine particulate matter ($PM_{2.5}$) pollution, face greater risk of related cardiovascular disease, and are disproportionately burdened by cardiovascular disease. The pilot project aims to understand and find strategies to eliminate these disparities. The first phase will determine the variability of $PM_{2.5}$ exposure by neighborhood, assess if cardiovascular disease risks are higher in disadvantaged neighborhoods, and identify which neighborhoods face the largest disease burden from $PM_{2.5}$. The team will use the results to design location-specific strategies to eliminate these inequalities.
    - Team: **Kai Chen,** Yuan Lu (School of Medicine)
    - Total award for project period: $87,806
- ***Healthcare organization greenhouse gas emissions accounting tool for strategic management*.** This project, now funded for a second year, is developing a carbon accounting tool to aid healthcare organizations in tracking and strategically managing their carbon emissions. The tool is being designed to accurately measure and track greenhouse

gas emissions for healthcare organizations, including the especially elusive emissions from supply chain activities. Although many emissions tracking tools exist, none provide the granularity required for the many activities and products involved in safe healthcare provision.
    - Team: **Jodi Sherman,** Michael Oristaglio (Department of Earth and Planetary Sciences), Robert Klee (School of the Environment); Matthew Eckelman (Northeastern University), Todd Cort (School of Management)
    - Total award for project period: $80,000 in Year 1; $85,150 in Year 2
- ***Passive cooling with terracotta and hydrogel*.** Building systems play a crucial role in climate adaptation, but they can be expensive and inaccessible to many communities. The aim of this study is to develop adaptable prototypes of exterior walls designed to provide passive cooling in diverse climates. The project tests two different terracotta and hydrogel wall prototypes in Mexico City and Jujuy, Argentina using local variations of construction methods employed in almost every part of the world.
    - Team: Celia Toche (School of Architecture), Susana La Porta Drago (School of Architecture), **Jeannette Ickovics** (YSPH), **Kai Chen**
    - Total award for project period: $80,000

Other grants

- ***Climate smart technology and home medical devices for affordable housing*.** This project seeks to understand the needs of people with home medical devices who live in affordable housing in Connecticut and how investment in Climate Smart Technology, including back-up power (e.g., solar power, battery storage) and stable indoor temperature (e.g., efficient heating and cooling, weatherization), can increase their resilience during power outages.
    - Funder: Robert Wood Johnson Foundation through a sub-contract from the Connecticut Green Bank
    - Principal Investigator: Bryan Garcia (Connecticut Green Bank).
    - Yale Principal Investigator: **Laura Bozzi**
    - Total award for project period: $234,343
    - Project period: October 1, 2022 to September 30, 2024
- ***Identifying temperature disparities, energy insecurity, and social vulnerability for energy justice in New York State*.** This project, a collaboration with the Green & Healthy Homes Initiative, is a feasibility study to create a *Temperature and Energy Justice Mapping Tool* for New York State that will provide a template for assessing energy justice for socially vulnerable populations nationwide.
    - Funder: National Aeronautics and Space Administration (NASA)
    - Principal Investigator: **Daniel Carrión**
    - Total award for project period: $149,995
    - Project period: September 1, 2022 to August 31, 2023

Publications

The following relevant articles were published by core research program faculty during the period of this annual report:

- Alahmad B, Vicedo-Cabrera AM, **Chen K**, Garshick E, Bernstein AS, Schwartz J, Koutrakis P. Climate change and health in Kuwait: Temperature and mortality projections under different climatic scenarios. Environmental Research Letters 2022;17:074001.

- **Carrión D**, Rush J, Colicino E, Just AC. The case-crossover design under changing baseline outcome risk: A simulation of ambient temperature and preterm birth. Epidemiology 2022;33:e14-e15.
- **Chen K, Dubrow R**, Breitner S, Wolf K, Linseisen J, Schmitz T, Heier M, von Scheidt W, Kuch B, Meisinger C, Peters A. Triggering of myocardial infarction by heat exposure is modified by medication intake. Nature Cardiovascular Research. 2022;1:727-31.
- **Chu L**, **Chen K**, Crowley S, **Dubrow R**. Associations between short-term temperature exposure and kidney-related conditions in New York State: The influence of temperature metrics across four dimensions. Environment International 2023;173:107783.
- Esenther S, Schlick K, Jossart C, Wang N, MPH, **Dubrow R**, Pascucilla M. Improving water quality in the Short Beach neighborhood of Branford, Connecticut, 2019 – A Citizen Science project. American Journal of Public Health 2022;112:1261-1264.
- Festa N, Throgmorton KF, Davis-Plourde K, Dosa DM, **Chen K**, Zang E, Kelly J, Gill TM. Assessment of regional nursing home preparedness for and regulatory responsiveness to wildfire risk in the Western US. JAMA Network Open 2023;6:e2320207.
- **Goddard E, Lin C, Ma Y, Chen K**. The mortality burden of extreme heat in Connecticut: A time series analysis. PLOS Climate 2023;2:e0000164.
- Gould C, Mujtaba M, Yang Q, Boamah-Kaali E, Quinn A, Manu G, Lee A, Ae-Ngibise K, **Carrión D**, Kaali S, Kinney P, Jack D, Chillrud S, Asante K. Using time-resolved monitor wearing data to study the effect of clean cooking interventions on personal air pollution exposures. Journal of Exposure Science & Environmental Epidemiology 2022,33:386-395.
- Gutiérrez-Avila I, Arfer K, **Carrión D**, Rush J, Kloog I, Naeger A, Grutter M, Páramo-Figueroa V, Riojas-Rodríguez H, Just A. Prediction of daily mean and one-hour maximum PM2.5 concentrations and applications in Central Mexico using satellite-based machine-learning models. Journal of Exposure Science & Environmental Epidemiology 2022,32:917-925.
- Hebbern C, Gosselin P, **Chen K**, Chen H, Cakmak S, MacDonald M, Chagnon J, Dion P, Martel L, Lavigne E. Future temperature-related excess mortality under climate change and population aging scenarios in Canada. Canadian Journal of Public Health 2023;doi https://doi.org/10.17269/s41997-023-00782-5.
- Janevic T, Lieb W, Ibroci E, Lynch J, Lieber M, Molenaar NM, Rommel AS, de Witte L, Ohrn S, Carreño JM, Krammer F, Zapata LB, Snead MC, Brody RI, Jessel RH, Sestito S, Adler A, Afzal O, Gigase F, Missall R, **Carrión D**, Stone J, Bergink V, Dolan SM, Howell EA. The influence of structural racism, pandemic stress, and SARS-CoV-2 infection during pregnancy with adverse birth outcomes. American Journal of Obstetrics & Gynecology MFM 2022,4:100649.
- **Lin C, Ma Y**, Liu R, Shao Y, Ma Z, Zhou L, Jing Y, Bell ML, **Chen K**. Associations between short-term ambient ozone exposure and cause-specific mortality in rural and urban areas of Jiangsu, China. Environmental Research 2022;211:113098.
- **Manware M**, **Dubrow R, Carrión D**, **Ma Y**, **Chen K.** Residential and race/ethnicity disparities in heat vulnerability in the United States. GeoHealth 2022;6:e2022GH000695..
- Nikolaou N, Dallavalle M, Stafoggia M, Bouwer LM, Peters A, **Chen K**, Wolf K, Schneider A. High-resolution spatiotemporal modeling of daily near-surface air temperature in Germany over the period 2000-2020. Environmental Research 2023;219:115062.
- Rai M, Breitner S, Wolf K, Peters A, Schneider A, **Chen K**. Future temperature-related mortality considering physiological and socioeconomic adaptation: a modelling framework. Lancet Planetary Health 2022;10:e784-e792.

- Ramsden D, Esenther S, Marks B, Lehane A, Chen R, **Dubrow R**, Pascucilla MA. Bacterial contamination in Long Island Sound: using preemptive beach closure to protect public health. Journal of Environmental Health 2023;85:26-28.
- Romanello M, Di Napoli C, Drummond P, Green C, Kennard H, Lampard P, Scamman D, Arnell N, Ayeb-Karlsson S, Ford LB, Belesova K, Bowen K, Cai W, Callaghan M, Campbell-Lendrum D, Chambers J, van Daalen KR, Dalin C, Dasandi N, Dasgupta S, Davies M, Dominguez-Salas P, **Dubrow R**, Ebi KL, Eckelman M, Ekins P, Escobar LE, Georgeson L, Graham H, Gunther SH, Hamilton I, Hang Y, Hänninen R, Hartinger S, He K, Hess JJ, Hsu SC, Jankin S, Jamart L, Jay O, Kelman I, Kiesewetter G, Kinney P, Kjellstrom T, Kniveton D, Lee JKW, Lemke B, Liu Y, Liu Z, Lott M, Batista ML, Lowe R, MacGuire F, Sewe MO, Martinez-Urtaza J, Maslin M, McAllister L, McGushin A, McMichael C, Mi Z, Milner J, Minor K, Minx JC, Mohajeri N, Moradi-Lakeh M, Morrissey K, Munzert S, Murray KA, Neville T, Nilsson M, Obradovich N, O'Hare MB, Oreszczyn T, Otto M, Owfi F, Pearman O, Rabbaniha M, Robinson EJZ, Rocklöv J, Salas RN, Semenza JC, Sherman JD, Shi L, Shumake-Guillemot J, Silbert G, Sofiev M, Springmann M, Stowell J, Tabatabaei M, Taylor J, Triñanes J, Wagner F, Wilkinson P, Winning M, Yglesias-González M, Zhang S, Gong P, Montgomery H, Costello A. The 2022 report of the Lancet Countdown on health and climate change: health at the mercy of fossil fuels. Lancet 2022;400:1619-1654.
- **Wang P**, O'Donnell KJ, Warren JL, **Dubrow R**, **Chen K**. Temperature variability and birthweight: Epidemiological evidence from Africa. Environment International 2023;173:107792.
- Wang Y, Hu J, Huang L, Li T, Yue X, Xie X, Liao H, **Chen K**, Wang M. Projecting future health burden associated with exposure to ambient $PM_{2.5}$ and ozone in China under different climate scenarios. Environment International 2022;169:107542.

Other research program highlights

- *Lancet Countdown on Health and Climate Change*

The *Lancet Countdown on Health and Climate Change* is an international collaboration that produces an annual report, published in *The Lancet*, that tracks indicators of global progress (or lack of progress) on climate change and health. Since 2018, Yale, represented by YCCCH, has been a member of the collaboration. Drs. Dubrow and Sherman were among the co-authors of the 2022 report, contributing indicators on (1) mitigation in the healthcare sector and (2) air conditioning: benefits and harms. Drs. Sherman and Bozzi served as reviewers for the ancillary *2022 Lancet Countdown on Health and Climate Change Policy Brief for the United States of America*.

- *Dr. Carrión appointed as a Fellow to the New York Academy of Medicine*

Dr Carrión was inducted in Fall 2022 as a Fellow to the New York Academy of Medicine (NYAM). The NYAM is a community of distinguished professionals, elected by their peers, who share NYAM's commitment to achieving health equity. Dr. Carrión's work focuses on the intersection of climate, energy, and health (in)equity. His work explores the role of the home and neighborhood environments as opportunities for intervention towards climate and health equity, largely focused on energy transitions.

- *Sappho Gilbert, YCCCH pre-doctoral Fellow, featured on National Institute of Environmental Health Sciences podcast*

YCCCH pre-doctoral Fellow Sappho Gilbert was interviewed for the National Institute of Environmental Health Sciences' podcast, *Environmental Health Talk.* Sappho discussed her research on the effect of climate change and other environmental change on nutrition and food security for Inuit peoples. Her work takes place in the Canadian Arctic territory of Nunavut,

where she explores health and financial challenges caused by the shift from “country food,” or food acquired from hunting, to store-bought food.

- *Stakeholder dialogue on climate change and health in the Caribbean*

Representatives of YCCCH, the Caribbean non-governmental organization EarthMedic and EarthNurse Foundation for Planetary Health, Emory Rollins School of Public Health, Pan American Health Organization/World Health Organization, and the University of the West Indies formed the *Research for Action on Climate Change and Health in the Caribbean Project* to develop the first comprehensive research agenda for action on climate and health in the Caribbean. On May 9-10, 2023, they conducted a virtual stakeholder dialogue to receive feedback about the agenda, with more than 70 participants. The agenda is scheduled to be completed in August 2023.

- *Dr. Chen named to editorial board of PLOS Climate*

Dr. Chen joined the editorial board of *PLOS Climate* in December 2022. *PLOS Climate* is an open-access journal that furthers understanding of climatic patterns, processes, impacts and solutions by publishing transparent, rigorous and open research from diverse perspectives.

- *CHEN Lab publishes interactive heat vulnerability map*

Led by Mitchell Manware, MPH '23 and Climate Change and Health Concentration student, the CHEN Lab published a study in GeoHealth that developed a metric to gauge heat vulnerability at the census-tract level. The metric, and the publicly-available interactive map, can "help officials identify areas that may need more public health and policy interventions to combat the adverse effects of heat stress," according to Dr. Chen. The study was supported by a seed grant from the Yale Planetary Solutions Project, as well as by the High Tide Foundation.

- *Yale news outlets featured YCCCH research*

YCCCH faculty and their research were featured in Yale news outlets. For instance, Yale School of Medicine reported on a study published in *European Urology* by Dr. Sherman and co-authors in a news article, *Estimating the environmental impact of certain prostate cancer procedures*, and YSPH published a news story, *Two heart medications tied to greater heart attack risk during very hot weather* highlighting an article published in *Nature Cardiovascular Research* by Drs. Chen and Dubrow and German colleagues.

- *YSPH 2023 Research Award: Planetary Health*

The 2023 YSPH Research Award for Planetary Health went to Drs. Chen, Dubrow, Virginia Pitzer (Affiliated Faculty), and Pin Wang (Postdoctoral Associate) for their *Nature Communications* paper *Associations between long-term drought and diarrhea among children under five in low- and middle-income countries* and to Drs. Chen, Dubrow, and Carrión, Yiqun Ma (doctoral student), and Mitchell Manware (MPH student) for their *GeoHealth* paper *Residential and race/ethnicity disparities in heat vulnerability in the United States*.

Yale Program on Healthcare Environmental Sustainability (Y-PHES)

The Yale Program on Healthcare Environmental Sustainability, led by Dr. Jodi Sherman, is housed within YCCCH. The health sector is a leading emitter of greenhouse gas and non-greenhouse gas pollution. Y-PHES seeks to improve the environmental performance of the healthcare sector by a) quantifying its environmental impacts to aid decision-making and b) designing and testing interventions to reduce unnecessary resource consumption, waste, and greenhouse gas emissions. The program is a partnership among the Schools of Public Health, Nursing, and Medicine, working in close collaboration with Yale-New Haven Health System.

The following articles were published by program faculty during the period of this annual report:

- Sittig DF, **Sherman JD,** Eckelman MJ, Draper A, Singh H. i-CLIMATE: a "clinical climate informatics" action framework to reduce environmental pollution from healthcare. Journal of the American Medical Informatics Association 2022;29:2153-2160.
- Hennein R, Goddard E, **Sherman JD**. Stakeholder perspectives on scaling up medical device reprocessing: A qualitative study. PLOS One 2022;17:e0279808.
- Howard C, MacNeill AJ, Hughes F, Alqodmani L, Charlesworth K, de Almeida R, Harris R, Jochum B, Maibach E, Maki L, McGain F, Miller J, Nirmala M, Pencheon D, Robertson S, **Sherman JD**, Vipond J, Yin H, Montgomery H. Learning to treat the climate emergency together: social tipping interventions by the health community. Lancet Planet Health 2023;7:e251-e264.
- **Sherman JD**, MacNeill AJ, Biddinger PD, Ergun O, Salas RN, Eckelman MJ. Sustainable and resilient health care in the face of a changing climate. Annual Review of Public Health 2023;44:255-277.
- Leapman MS, Thiel CL, Gordon IO, Nolte AC, Perecman A, Loeb S, Overcash M, **Sherman JD**. Environmental impact of prostate magnetic resonance imaging and transrectal ultrasound guided prostate biopsy. European Urolology 2023;83:463-471.
- Singh H, Eckelman M, Berwick DM, **Sherman JD**. Mandatory reporting of emissions to achieve net-zero health care. New England Journal of Medicine 2022;387:2468-2476.
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Y-PHES highlights

- *Lancet Commission on Sustainable Healthcare*

Led by co-chairs Dr. Sherman and Dr. Andrea MacNeill (University of British Columbia), the *Lancet Commission on Sustainable Healthcare* (LCSH) was initiated in 2022 to assess resource consumption and environmental emissions in the healthcare sector and to recommend sustainable research, practices, policies, and parameters. In 2023, Drs. Sherman and MacNeill recruited 48 representatives from 23 countries to join the LCHS. In addition, four working groups were established: 1) environmental performance and healthcare quality measures; 2) clinical practice change; 3) adaptation, risk, and resilience; and 4) health system transformation. Funded by the University of British Columbia and the Canadian Medical Association, the LCSH will publish a 25,000-word policy document in *The Lancet* (expected 2025) that reviews the state of the science, identifies information gaps and implementation barriers, proposes performance indicators to drive actionable improvement and accountability, and establishes research and policy agendas.

- *Dr. Sherman delivered testimony to a Congressional hearing on healthcare sustainability*

Dr. Sherman appeared before the US House Committee on Ways and Means in September 2022 to discuss the healthcare sector's role in mitigating greenhouse gas emissions and other pollutants. In her testimony, Dr. Sherman stressed three key points:

1. Pollution and climate change are harming health and health care delivery, increasing care requirements and costs, and depleting health care resources. Health care requirements are expected to worsen in the years and decades to come, and urgently improving the preparedness and resilience of our health care infrastructure is paramount.
2. Health care itself is a leading contributor to pollution and climate change, against the mission to first, do no harm, and mitigating health care pollution is a fundamental requirement for safe and high-quality health care delivery.

3. Voluntary measures are insufficient to transform the health care sector, and legislative action is urgently required to compel decarbonization in accordance with science-based targets and timelines, and to avoid greenwashing.

The recorded session is available on the Ways and Means Committee YouTube channel.

- *New partnerships with the Centre for Sustainable Healthcare & Project ECHO*

Y-PHES has established partnerships with the *Centre for Sustainable Healthcare* and *Project ECHO*. The *Centre for Sustainable Healthcare*, based in the United Kingdom, offers strategic input and consultancy on sustainable healthcare research and practice to national and local programs; Y-PHES and the Centre plan to co-host educational courses for a U.S. audience. *Project ECHO* offers evidence-based training on the science of climate change, climate-related health effects, and the most effective communication skills. In February 2023, Dr. Sherman led a training with Project ECHO entitled *Health-related effects of the climate crisis and introduction to healthcare sustainability*.

- *Dr. Sherman received a grant from The Commonwealth Fund for work on sustainable healthcare*

In October 2022, Dr. Sherman received a $199,999 grant from *The Commonwealth Fund* for the project, *Policy strategies and initiatives for delivering sustainable health care*. The project will identify key regulatory and policy barriers to implementing changes that would result in more sustainable and resilient health care delivery and identify opportunities for mitigating those barriers.

Climate Change and Health Pilot Research Grant

In 2022-2023, we did not award a Climate Change and Health Pilot Research Grant due to other funding priorities for the Center.

- In 2018, we awarded a pilot research grant to Dr. Judith Lichtman for a project entitled *Ambient temperature and risk of ischemic stroke in the elderly*. The following publication has resulted from the pilot grant: Tran PM, Warren JI, Leifheit EC, Goldstein LB, Lichtman JH. Associations between long-term air pollutant exposure and 30-day all-cause hospital readmissions in US patients with stroke. Stroke 2023;54:e126-e129.
- In 2022, we awarded a pilot research grant to Dr. Tormod Rogne for a project entitled *Ambient temperature during pregnancy and risk of childhood leukemia*. The project observed an association between increasing ambient temperatures in early pregnancy and risk of childhood acute lymphoblastic leukemia. A manuscript was submitted for publication in May. In addition, the project provided preliminary data for Dr. Rogne's successful application for a Yale Center for Clinical Investigation Scholar Award. This is a two-year award that covers 75% of Dr. Rogne's salary and provides $25,000 per year in research support.

Education

Climate Change and Health Concentration for MPH Students

In 2022-23, YCCCH enrolled 17 MPH students into the third cohort of its Climate Change and Health Concentration. The students spanned five YSPH departments, nine students in the Department of Environmental Health Sciences, four in Health Policy, three in the Epidemiology of Microbial Disease, and one in Social and Behavioral Sciences. YCCCH also celebrated the graduation of 13 students from the Class of 2023 who completed the Climate Change and Health Concentration.

We offered four climate change and health courses, with the *Clinic in Climate Justice, Climate Policy, Law, and Public Health* course and the *Seminar in Climate Change and Health* offered in both semesters. In addition, Dr. Carrión worked with Suzi Ruhl, JD. Senior Research Scientist, Yale School of Medicine Child Study Center and Director of Policy, Elevate Policy Lab at YSPH, to develop a new course, *EHS 544, Climate Equity and Health Policy Methods*, that she will teach in Fall 2023 and will fulfill the "methods' requirement for the Concentration as an alternative to EHS 560 (see below). The following are descriptions of our courses:

EHS 547: Climate Change and Public Health

This course is the foundational climate change and public health course offered at YSPH. It is a required course for Concentration students, as well as a course that is open to other students at YSPH and to students across the university. In Spring 2023, it was taught by Dr. Carrión with 22 students and 1 auditor enrolled in the course. The following is the course description:

> This course takes an interdisciplinary approach to examining relationships between climate change and public health. After placing climate change in the context of the Anthropocene, planetary boundaries, and planetary health, and exploring the fundamentals of climate change science, the course covers impacts of climate change on public health, including extreme heat, wildfires, hurricanes and flooding, vector-borne diseases, population displacement, and mental health effects. The course covers the public health strategies of adaptation (secondary prevention) and mitigation (primary prevention) to reduce adverse health impacts of climate change and discusses the substantial non-climate immediate health benefits of these strategies. Policy, vulnerability, and climate justice considerations are integrated into the course throughout. The course is reading-intensive and makes ample use of case studies. This course should be of interest to students across YSPH and the University.

See the course syllabus here.

EHS 560/ ENV 606: Methods in Climate Change and Health Research

This course, offered by Dr. Chen, fulfills the "methods" requirement for the Concentration and is an important component of the course sequence for doctoral students working with YCCCH faculty. In Fall 2022, 22 students took the course. The following is the course description:

> Climate change is recognized as one of the greatest public health challenges of the twenty-first century. This course takes multidisciplinary approaches to identify, assess, quantify, and project public health impacts of climate change and of measures to address climate change. It first introduces the fundamental principles of health impact assessment and gives a brief overview of the public health approaches to address climate change. Then it applies advanced data analysis methodologies in environmental epidemiology, including time-series analysis, spatial epidemiology, and vulnerability assessment, to characterize the present climate-health (exposure-response) relationships and to identify vulnerable populations. The course discusses key concepts of scenario-based climate projections and their applications in projecting future health impacts, evaluating health co-benefits of climate mitigation polices, and assessing climate change adaptation measures. Emphasis is placed on hands-on computer lab exercises with real-data examples and R scripts.

See the course syllabus here.

EPH 555/ ENV 959: Clinic in Climate Justice, Law, and Public Health

In 2022-23, Dr. Carrión joined the teaching team for this course with Dr. Bozzi. The course, which is no longer taught jointly with Vermont Law School, is offered both semesters and is cross-listed as a Yale School of the Environment (YSE) course. The course is required for Concentration students, and it fulfills the capstone requirement for YSE students. The following is the course description:

> In the course, interdisciplinary student teams carry out applied projects at the intersection of climate justice, law and public policy, and public health. Each team works with a partner organization (e.g., state agency, community organization, other nongovernmental organization) to study, design, and implement a project, typically through community-based participatory research practices. The course affords the opportunity to have a real-world impact by applying concepts and competencies learned in the classroom. This course should be of interest to graduate and professional students across the University and is open to Yale College juniors and seniors. In addition, this course is one of the options available to students to fulfill the practice requirement for the M.P.H. degree at YSPH and the capstone requirement for the M.E.M. degree at YSE. Students who plan to enroll must complete an application, which will be used to match each student with a clinic project. Check the course's Canvas site or contact the instructor at laura.bozzi@yale.edu for more information.

Fourteen students took the course in the fall term and thirteen students took the course in the spring term. The 2022-23 projects were:

Project Title	**Organizational Partner**
Achieving health and climate justice through energy retrofits in family child care educator homes (project description: Fall)	Service Employees International Union (SEIU) Local 509 (Massachusetts)
Activating tenants to advocate for energy justice: Barriers and solutions. (project description: Fall)	Neighborhood Housing Services of New Haven / I Heart New Haven
Energy transitions, indoor air quality and report-backs for low-income New Haven tenants (project description: Fall)	Neighborhood Housing Services of New Haven / I Heart New Haven
Disaster preparedness for residents with mobility impairments in New York City public housing (project description: Spring)	Community Voices Heard (New York, NY)
The emerging health and climate needs for climate smart technology in affordable housing (project description: Spring)	Operation Fuel (Hartford, CT)

See the fall semester syllabus here and the spring semester syllabus here.

YCCCH has set a goal of real-world impact from the clinic projects. We accomplish this through developing trusted partnerships with non-profit or government partners; sharing clinic project findings with policymakers, study participants, residents, and researchers; and continuing project implementation even after the semester project has ended. The following are examples of our work toward achieving real-world impact:

- Findings from a 2021-22 clinic project were summarized into a project brief, *Energy justice and health in a changing climate*, released in July 2022. The brief was shared widely by Yale, Vermont Law School, and project partner Operation Fuel, including through a Yale news story and extensive social media. The study was featured in an Energy News Network article: *Study provides deeper insights on the health impacts of utility shutoffs* (8/9/22). Operation Fuel filed the report as correspondence in three CT Public Utility Regulatory Authority (PURA) dockets entitled *Energy affordability annual review*, *performance based regulation*, and *low-income discount rates*.
- The clinic was featured in the Yale School of Public Health's Fall 2022 magazine. The edition, entitled *Celebrating our collaborative culture*, highlights the work of the clinic course and features comments from Erika-ann Kim, YSPH '22 and member of the Climate Change and Health Concentration's inaugural class, and Dr. Bozzi, on the value of working in an interdisciplinary group.
- A Spring 2019 clinic project in partnership with the *East Shore District Health Department* (ESDHD), led by Dr. Michael Pascucilla, resulted in an article published in the American Journal of Public Health in September 2022 entitled *Improving water quality in the Short Beach Neighborhood of Branford, Connecticut, 2019—A citizen science project*. In addition, ESDHD received the *States Organization for Boating Access* 2022 President's Award for its solar-electric pumpout boat program. A Spring 2018 clinic project worked with ESDHD to study the environmental and health impacts associated with using electric service vessels in the recreational boating industry. The *Solar Shark,* the first fully electric, zero emissions, solar-powered pumpout vessel, has been in operation since Spring 2020. Finally, a Spring 2017 clinic project in partnership with ESDHD resulted in an article published in *Journal of Environmental Health* in April 2023 entitled *Bacterial contamination in Long Island Sound: using preemptive beach closure to protect public health*.
- The Fall 2022 project, *Activating tenants to advocate for energy justice: Barriers and solutions*, held an in-person (with Zoom option) community feedback session in December 2022 with approximately 15 tenants, organizers, and project advisory board members in attendance. This clinic project was part of a study funded by the *Planetary Solutions Project* (Principal Investigator: Dr. Annie Harper) that partners with local organizations and uses community-based participatory methods to learn from low-income renters in New Haven about barriers to tenant engagement around energy efficiency, and what could motivate them to engage and advocate, both for upgrades for their own homes and for the larger community. Some of the clinic team members continued to work with Dr. Harper on the project in Spring 2023 to produce a public-facing project brief in English and Spanish, and to host a community report-back session in June 2023.
- The Fall 2022 student team that partnered with *Service Employees International Union* (SEIU) Local 509 traveled to Washington DC in December 2022 to present their results to the national SEIU policy conference. Building from this project, Local 509 has included energy retrofits as part of the homebased childcare educators' contract negotiations; specifically, they have requested a $1 million environmental fund to support environmental projects completed by its membership.

EPH 570 and 571: Seminar in Climate Change and Health

The 2022-23 *Climate Change and Health Seminar* speaker series continued to invite experts in their fields to speak with YCCCH's audiences. The seminar series is a required course for Concentration students, who are required to attend the seminar in person, read articles by the seminar speaker, and submit questions in advance. The seminar also is open to the Yale community and the public, either in-person or via Zoom, allowing us to expand our reach to

audiences beyond Yale. The speakers and their topics are listed below, and recordings of their seminars are available on our website and YouTube page:

- Dr. Drew Gentner, Associate Professor of Chemical & Environmental Engineering, Yale School of Engineering & Applied Science and Dr. Kenneth Gillingham, Professor of Economics, Yale School of the Environment. *The climate and health benefits from intensive building energy efficiency improvements.* [28 virtual attendees]
- Dr. Evi Samoli. Associate Professor of Epidemiology & Medical Statistics, Medical School of the National and Kapodistrian University of Athens, Greece. *Air pollution health effects under climate change: a complex interaction with various pathways.* [33 virtual attendees]
- Dr. Rebecca French. Director of the Office of Climate Planning, Office of the Commissioner, Connecticut Department of Energy and Environmental Protection. *Addressing the climate crisis through carbon emissions reduction policy and implementation in the Governor's Council on Climate Change*. [19 virtual attendees]
- Dr. Joan Casey. Assistant Professor of Environmental Health Sciences, Columbia Mailman School of Public Health."*Fossil fueled environmental injustice: Population health studies from extraction to climate change repercussions*. [28 virtual attendees]
- Dr. Allan C. Just. Associate Professor, Department of Environmental Medicine and Public Health, Icahn School of Medicine at Mount Sinai. *Environmental epidemiology from space: Leveraging satellite-based exposure models to advance climate and health*. [37 virtual attendees]
- Dr. Susan Anenberg. Associate Professor and Chair, Environmental and Occupational Health Department, Director of the GW Climate and Health Institute, George Washington University. *Climate change, air pollution, and public health: Bridging science to policy.* [68 virtual attendees]
- Suzi Ruhl, JD. Senior Research Scientist, Yale School of Medicine's Child Study Center and Director of Policy, Elevate Policy Lab at the Yale School of Public Health. *Navigating to climate equity through policy methods*. [33 virtual attendees]
- Dr. Jaime Madrigano. Associate Professor, Department of Environmental Health and Engineering, Johns Hopkins Bloomberg School of Public Health. *Climate change and health: Research to inform equitable policy.* [33 virtual attendees

EHS 544: Climate Equity and Health Policy Methods

This new course, taught by Suzi Ruhl, JD, will be taught for the first time in Fall 2023 and will fulfill the "methods" requirement for the Concentration as an alternative to EHS 560 (see above). The following is the course description:

> Climate change presents threats to human health and well-being, while escalating health inequities. These health impacts can be direct, indirect, and cumulative. Concomitantly, efforts to prevent and respond to climate change can offer beneficial health impacts to vulnerable and disadvantaged populations. This course focuses on policy research methods, offers a policy to practice approach, and is accountable to communities most vulnerable to climate change. As a foundation, the course explores the "face of climate inequity" considering structural biases, social inequities, and racism that undermine health and create challenges for those most vulnerable to climate change. It also increases awareness of cultural values and practices that should be considered in the design, implementation, and evaluation of climate equity and health policies and programs. Further, the framework of the course triangulates rule of law, evidence-based methodologies, and meaningful engagement. It introduces the basic principle of "rule of

law" as a means to navigate government policy making with an understanding of administrative law and relevant environmental laws. It builds on this foundation to explore policy methods buttressed by evidence that is based on academic and lived experience expertise. It addresses mapping tools and data analysis accountable to disadvantaged populations. It incorporates consideration of "meaningful engagement" of vulnerable populations, with a special focus on the disproportionate impacts of climate change on the whole health of disadvantaged individuals, families, and communities. Further, key health topics are highlighted through integrative case studies, including climate resiliency and family mental health and health care systems. Innovation at the state and local levels of government are also addressed. Throughout the course, attention is directed to integration of these concepts through applied learning.

Yale Global Initiative on Climate Change and Public Health Ethics

Led by Affiliated Faculty member Dr. Laura Bothwell and sponsored by YCCCH, this seminar series discussed issues at the intersection of climate change and public health ethics, including financial accountability and civil disobedience. Our speakers were:

- Lucie Pinson. Executive Director, Reclaim France; Winner of the 2020 Goldman Environmental Prize for Europe. *Holding financial institutions ethically accountable for defunding fossil fuels.* [28 virtual attendees]
- Dr. Oscar Berglund. Lecturer in International Public and Social Policy, University of Bristol. *Should we break the law to save the world?: Civil disobedience in the climate change movement*. [89 virtual attendees]

YCCCH Student Fellows

In the 2022-23 academic year, YCCCH converted the Student Associates Program into the YCCCH Student Fellows Program, which was designed to engage Yale students in YCCCH research, public health practice, communications, and operations through paid fellowship opportunities during the academic year. Fellows worked closely with YCCCH faculty and staff, as well as participated in community-building and educational activities.

The following were the twelve 2022-23 Fellows:

- Gabriella Crivelli. Research Fellow in sustainable and equitable cooling.
- Riena Harker. Policy Fellow in the Policy Impact Unit.
- Claire Latendresse. Communications and Visual Content Fellow.
- Mitchell Manware. Research Fellow in climate and health equity.
- Pawel Maslag. Policy Fellow in the Policy Impact Unit.
- Nick Page. Research Fellow in sustainable healthcare.
- Saira Prasanth. Research Fellow in climate and energy justice.
- Ruihan Qin. Research Fellow in sustainable healthcare.
- Alix Rachman. Sustainability Fellow for YSPH Sustainability Committee.
- Anna Stouffer. Research Fellow in environmental and energy justice.
- Caroline Sutton. Research Fellow in climate epidemiology.
- Weixi Wu. Research Fellow in environmental and energy justice.

The trainings received by our Fellows included:

- Claire Latendresse, YCCCH Communications Fellow. *Effectively communicating your climate and health work*
- Xóchitl García, Save the Sound. *Show don't tell: A justice-centered language workshop*
- Ann Gadwah, CT Sierra Club. *Legislative training with the Sierra Club*
- Two All-Fellows Roundtable Discussions, held at the end of the Fall and Spring semesters, in which Fellows shared updates on their work

Summer Internships in Climate Change and Health

YCCCH expanded its summer internship program for the third year in a row to meet the significant student interest in climate change and health, with 14 students participating in 16 internship offerings (with two students each taking two internships). The 2023 program was open to MPH students, undergraduate students in the Environmental Studies major, and graduate students at the Yale School of the Environment. In a two-step process, eligible students first applied to be matched with one of the summer internship projects, and then the selected students applied for funding from sources including – but not limited to – YCCCH. All students secured funding from YCCCH (partial or full stipends to eight students) and/or other Yale sources.

In Summer 2023, interns will have the opportunity to attend weekly lunchtime get-togethers (on Zoom and in-person), which is especially important for students interning remotely to create a sense of community. The lunch program will be led by two of the interns. In Fall 2023, students will be expected to participate in an internship colloquium to report back and reflect on their internship experiences. A recording of the 2022 colloquium is available. The Summer 2023 students, their host organizations, and internship projects are listed below.

Host organization	Project title	Student	Affiliation
CDC Foundation	Educational curriculum development for CDC Disease Detective Camp	Gabriella Crivelli	MPH Environmental Health Sciences, Climate Change and Health Concentration
	An assessment of effective communication tools to engage youth in climate and health	Shivani Dayal	MPH Social and Behavioral Sciences
	Development of a toolkit linking rvidence-based climate and health interventions with reporting by businesses on Environment, Sustainability, Governance (ESG) factors	Charlotte Hawes	Yale College, Environmental Studies
		Yunyue Shi	MPH Environmental Health Sciences
City of Austin Office of Climate Resilience	Incorporating health equity into community resilience planning	Chloe Ames	Yale School of the Environment, Master of Environmental Management
Climate Psychiatry Alliance	The Ecopsychepedia Project	Zaida Rio Polanco	Yale College, Environmental Studies

Connecticut Equity and Environmental Justice Council	Introduction to climate justice community presentations	Zaida Rio Polanco	Yale College, Environmental Studies
Heidelberg Institute of Global Health	One Health materials to reduce the risk of zoonotic diseases under conditions of climate change	Sydney Jones	MPH Epidemiology of Microbial Diseases, Climate Change and Health Concentration
	Climate change-sensitive zoonotic diseases	Katie Soden	MPH Epidemiology of Microbial Diseases
Institute for Global Health and Development at Queen Margaret University, Scotland	ACCLIMATE: Co-fostering health system resilience in a changing climate environment in Bangladesh	Julianna McVeigh	MPH Health Policy, Climate Change and Health Concentration
Johnson & Johnson	Researching the impacts of climate change on pharmaceutical safety and efficacy	Haley Henry	MPH Health Policy, Climate Change and Health Concentration
Massachusetts General Hospital Center for Climate Change, Climate Justice, and Health	Website development for the Center for Climate Change, Climate Justice, and Health	Huiyi Xiong	MS Biostatistics
North Carolina Department of Health and Human Services - Occupational and Environmental Epidemiology Branch	North Carolina Climate and Health Program heat illness surveillance data analysis	Saira Prasanth	MPH Chronic Disease Epidemiology
University of the West Indies St. Augustine Campus - Caribbean Centre for Health System Policy and Development	Caribbean Climate Cares - Challenges affecting our planet also affect our minds, communities and healthcare systems	CJ Miles	MPH Environmental Health Sciences, Climate Change and Health Concentration
Vermont Department of Health	Climate and health communications	Haleigh Schultz	MPH Epidemiology of Microbial Diseases, Climate Change and Health Concentration
Yale Program on Healthcare Environmental Sustainability / Yale New Haven Health System	Greenhouse gas impacts of metered dose inhalers for ssthma and COPD and strategic guidance on performance improvement	Yunyue Shi	MPH Environmental Health Sciences

Climate Change and Health Pre-Doctoral Fellows

Sappho Gilbert completed her sixth year and graduated in May 2023. Her dissertation title is *Community Nutrition in Transition in Nunavut, Canada*. She also published the following papers:

- **Gilbert SZ**, Morrison C L, Chen Q, Punian J, Bernstein J, Jessri M. Algorithm-based mapping of products in a branded Canadian food and beverage database to their equivalents in Health Canada's Canadian Nutrient File. Frontiers in Nutrition 2023;9:3220.
- **Gilbert SZ**, Owen JB, Shirley J. Arctic research in the COVID-19 pandemic era: lessons learned & looking ahead in Nunavut, Canada. Arctic Yearbook (Special Issue: Arctic Pandemics) 2023.

She gave the following conference presentations:

- **Gilbert SZ**, Berz R. *Food basket price inequities across sextiles of remoteness from 2014 to 2018 in Nunavut, Canada*. ArcticNet, Toronto, Canada, December 2022.
- **Gilbert SZ**, Damstrom S, Li A, Kuhn N, Chan R, Spence J, Jessri M. *Scoping review of dietary guidelines developed for & applied in Indigenous communities in Canada & the United States*. 35th Annual Health Policy Conference of the Centre for Health Services and Policy Research, University of British Columbia, Vancouver, Canada, March 2023.

Her dissertation advisor was Dr. Dubrow. In 2022-23, she was supported by a National Institute of Environmental Health Sciences pre-doctoral fellowship award. In August, 2023, Dr. Gilbert will begin a position as Postdoctoral Research Fellow in the Department of Nutrition at Harvard T.H. Chan School of Public Health.

Lingzhi Chu completed her fifth year and graduated in May 2023. Her dissertation title is *Temperature, Air Pollution, and Risk for Kidney-Related Conditions*. She also published the following papers:

- **Chu L**, Chen K, Crowley S, Dubrow R. Associations between short-term temperature exposure and kidney-related conditions in New York State: The influence of temperature metrics across four dimensions. Environment International 2023;173:107783.
- Yoo EH, Roberts JE, Eum Y, Li X, **Chu L**, Wang P, Chen K. Short-term exposure to air pollution and mental disorders: a case-crossover study in New York City. Environmental Research – Health 2023;1:015001.

She gave the following conference presentations:

- **Chu L**, Chen K, Crowley S, Dubrow R. *Associations between short-term ambient temperature exposure and kidney-related diseases in New York State: The influence of exposure spatial resolution and adaptation adjustment*. International Society for Environmental Epidemiology Annual Meeting, Athens, Greece, September 2022.
- **Chu L**, Chen K, Crowley S, Dubrow R. *Associations between short-term ambient temperature exposure and kidney-related diseases in New York State: The influence of exposure spatial resolution, temperature scale, and temperature metric*. GEOMED Conference, Irvine, California, October 2022.
- **Chu L**, Chen K, Crowley S, and Dubrow R. *Associations between short-term exposure to $PM_{2.5}$, NO_2 and O_3 pollution and kidney-related conditions and the role of temperature-adjustment specification: A case-crossover study in New York State*. International Society for Environmental Epidemiology North America Chapter Regional Conference, Corvallis, Oregon, June 2023.

- **Chu L**, Chen K, Yang Z, Crowley S, Dubrow R. *A unified framework for assessing interaction effects among environmental exposures in epidemiologic studies: a case study on temperature, air pollution, and kidney-related conditions in New York State*. Society for Epidemiologic Research Annual Conference, Portland, Oregon, June 2023.

Her dissertation advisor was Dr. Dubrow. In 2022-23, she was supported by Dr. Dubrow's faculty fund. Dr. Chu completed her dissertation in March 2023 and started a Postdoctoral Associate position with Drs. Chen and Dubrow in April 2023.

Yiqun Ma completed her fourth year. Her dissertation title is *Intersection of air pollution, meteorological factors, and the COVID-19 pandemic: sensitivity and accountability*. She published the following papers:

- Lin C**, Ma Y**, Liu R, Shao Y, Ma Z, Zhou L, Jing Y, Bell ML, Chen K. Associations between short-term ambient ozone exposure and cause-specific mortality in rural and urban areas of Jiangsu, China. Environmental Research 2022;211:113098.
- Manware M, Dubrow R, Carrión D, **Ma Y**, Chen K. Residential and race/ethnicity disparities in heat vulnerability in the United States. GeoHealth 2022;6:e2022GH000695.
- Goddard E, Lin C, **Ma Y**, Chen K. The mortality burden of extreme heat in Connecticut: A time series analysis. PLOS Climate 2023;2:e0000164.

She gave the following conference presentations:

- **Ma Y**, Nobile F, Stafoggia M, Breitner S, Marb A, Kinney PL, Dubrow R, Chen K. *Mortality benefits due to air pollution changes induced by COVID-19 lockdowns in early 2020*. International Society for Environmental Epidemiology Annual Conference, Athens, Greece, September 2022.
- **Ma Y**, Zang E, Opara I, Lu Y, Krumholz HM, Chen K. *Racial/ethnic disparities in cardiovascular disease mortality attributable to long-term $PM_{2.5}$ exposure in the United States from 2001 to 2016*. American Geophysical Union Fall Meeting, Chicago, Illinois, December 2022.
- **Ma Y**, Nobile F, Marb A, Dubrow R, Stafoggia M, Breitner S, Kinney PL, Chen K. *Effect of air pollution reductions on mortality during the COVID-19 lockdown: a natural experiment study*. Health Effect Institute Annual Conference, Boston, Massachusetts, April-May, 2023.
- **Ma Y**, Zang E, Liu Y, Lu Y, Krumholz HM, Bell ML, Chen K. *Association between ambient wildfire smoke PM2.5 and mortality in the contiguous U.S.* International Society for Environmental Epidemiology - North America Chapter Regional Conference, Corvallis, Oregon, June 2023.

She also chaired the session on "Structural Determinants" at the International Society for Environmental Epidemiology - North America Chapter Regional Conference, Corvallis, Oregon, June 2023.

Her dissertation advisor is Dr. Chen. In 2022-23, she was supported by a graduate research assistantship on Dr. Chen's grant from the Health Effects Institute entitled *Effect of air pollution reductions on mortality during the COVID-19 lockdown: A natural experiment study*.

Chengyi Lin completed her third year. In April 2023, her dissertation prospectus, entitled *Midlife to late-life air pollution exposure and risk of dementia and related outcomes*, was approved with distinction. She published the following paper:

- Goddard E, **Lin C**, Ma Y, Chen K. The mortality burden of extreme heat in Connecticut: A time series analysis. PLOS Climate 2023;2:e0000164.

Her dissertation advisor is Dr. Chen. In 2022-2023, she was supported by Dr. Chen's Yale Planetary Solutions Project Seed Grant entitled *Heat-related mortality, air conditioning and inequality in the US*.

Online Certificate Program in Climate Change and Health

YCCCH has continued to offer the well-regarded online Climate Change and Health Certificate Program for working professionals. The program prepares public health professionals and those in related fields to address the health impacts of climate change and is open to any qualified person in the world. The curriculum includes video-recorded lectures that students can view at their convenience, readings, weekly quizzes or short assignments, weekly live discussion sessions conducted via Zoom, each with 15 or fewer students and led by a discussion leader (typically a doctoral student), and a concluding assignment for each of the three courses.

We carried out a major overhaul of the certificate program in time for Cohort 9 in Spring 2023. The overhaul updated the asynchronous lectures to reflect the most recent science, (inter)governmental and non-governmental organization reports, and relevant climate events since the original recordings. In addition, the lectures and other course materials now have increased relevance to the growing number of global participants by incorporating more climate and health research and events from across the world.

The updated 18-week program consists of three consecutive six-week courses: *Course 1: Introduction to Climate Change and Health* (instructor: Daniel Carrión), *Course 2: Climate Adaptation for Human Health* (instructor: Elena Grossman, Senior Research Specialist, University of Illinois at Chicago School of Public Health), and *Course 3: Communicating Climate Change and Health* (instructor: Kristin Timm, Research Associate, International Arctic Research Center, University of Alaska at Fairbanks). While focusing on distinct topics, all three courses interweave common themes of climate change health impacts, vulnerability and health equity, and the health co-benefits of mitigation and adaptation.

We began the revamped program in April 2023 (Cohort 9). This cohort included 71 students representing 24 countries and continues until September 2023. In student evaluations from Course 1, 94% rated the course as excellent or very good.

We charged a graduated tuition:

- Physicians, dentists, veterinarians or for-profit employees: $4,400
- Other clinical (e.g., nurses), non-profit, government or education workers: $3,000
- Lower-middle income country residents: $500
- Low-income country residents: $250

We charged an additional $350 for Continuing Medical Education credit.

For the Cohort 10 offering, which will begin in September 2023, we will add three simultaneous region-specific short-courses, each lasting three weeks, between Course 1 and Course 2. Each student will enroll in one of these short-courses: South Asia (instructor: Meghnath Dhimal, Chief Research Officer, Nepal Health Research Council, Government of Nepal), Sub-Saharan Africa (instructor: Robert Manteaw, Senior Research Fellow and Lecturer, Centre for Climate Change

and Sustainability Studies, University of Ghana), or the Caribbean (instructor: Ayanna Alexander, Fellow, Climate Change and Health Leaders Fellowship Program, EU CARIFORUM Climate Change and Health Project).

YCCCH coordinates online community activities for Certificate alumni. To foster community and encourage connections among our alumni, in Spring 2023 we began a monthly *First Friday Virtual Meetup*. In April 2023, we officially launched our bi-monthly *Yale Climate Change and Health Certificate Alumni Talks*, designed to encourage alumni to share their work and with members of the alumni community. In April, Dr. Kelsey Hudson of the Climate Psychiatry Alliance of North America discussed *Navigating the mental health impacts of climate change*. In June, Maggie Favretti, founder of DesignEd4Resilience, discussed *Regenerating well-being through a positive civic action cycle*. We have a list of alumni who will volunteer to give talks in the future, including perspectives from veterinarians, pharmacists, nurses, agricultural managers, directors of health departments, and more.

In academic year 2022-23, our alumni shared the following accomplishments:

- Dr. Patrice K. Nicholas (Cohort 1) was selected as a National Institutes of Health (NIH)/National Institute of Nursing Research Inaugural *Climate and Health Scholar 2023*. She is one of eight scholars selected to engage in training, policy, and scholarly activities at NIH and to share scientific knowledge to build NIH's Climate Change and Health Strategic Initiative.
- Maggie Favretti's (Cohort 2) book, Learning in the age of climate disasters -- Teacher and student empowerment beyond futurephobia, was published in Fall 2022 by Routledge.
- William F. Schnell (Cohort 5) published a chapter, *Migration and the metaproblem of climate change*, in the 2022 *Palgrave handbook of global social change*. His research for this chapter was distilled into a TEDx Talk delivered at Case Western Reserve University, and a presentation for the 2021 Harvard Extension Alumni Association Annual Symposium. He has submitted a chapter to the *Routledge handbook of language and mind engineering* entitled *The benefit of doubt: How big oil makes us think*, for peer review and possible publication.
- Rebecca Tamiru (Cohort 4) initiated and leads the Climate Advocacy Lab's *Climate and Health Peer Learning Circle*, a 6-month peer learning experience for health professionals who are interested in or passionate about combating climate change.
- Rebecca Werner (Cohort 6) initiated the *Primary Care Climate Change and Health Program* in the Center for Primary Care Research and Innovation, Department of Family Medicine, Oregon Health & Science University.
- In partnership with Collective Energy and Capital Link, Ben Money (Cohort 4), Senior Vice President for Population Health at the National Association of Community Health Centers, helped establish the *Community Health Access to Resilient Green Energy (CHARGE) Partnership*, which is creating a nationwide resilient power and clean energy program for Federally Qualified Health Centers.
- Rebecca Woodward (Cohort 8) will be offering a class in November 2023 on climate change and health in her town's adult education program.

Public Health Practice & Policy

In May 2022, YCCCH identified three topic areas for focused agenda-setting work: 1) sustainable and equitable cooling, 2) equitable building electrification, and 3) healthcare environmental sustainability. Each topic builds on the Center's research strengths and is an area where we believe there is important potential for policy change to improve health and reduce greenhouse gas emissions. In 2022-23, we further developed our strategic approach for each topic and have advanced this work through a project in the Clinic on Climate Justice, Law, and Public Health (*Energy transitions, indoor air quality and report-backs for low-income New Haven tenants*; see Education section of this report) and by securing Planetary Solutions Project Seed Grants (*Heat-related mortality, air conditioning and inequality in the US*; *Addressing urban heat in the Dwight neighborhood of New Haven: A prototype for neighborhood-level planning*; *Passive cooling with terracotta and hydrogel*; and *Healthcare organization greenhouse gas emissions accounting tool for strategic management*; see Research section of this report).

YCCCH continues to operate its Policy Impact Unit, launched in Fall 2020 to leverage YCCCH research and public health practice projects to inform climate policy. The initial focus of the unit, which has been led by Dr. Laura Bozzi, YCCCH Director of Programs, has been on Connecticut climate mitigation and adaptation policies, with a focus in 2022-23 on sustainable and equitable cooling and equitable building electrification (and its prerequisite energy efficiency upgrades).

Working with YCCCH Student Fellows, the Policy Impact Unit actively engaged in the Connecticut climate and energy policy process, as well as in the national process, focused on YCCCH priority area of electrification and energy justice:

- Public comment letter to the Connecticut Public Regulatory Authority (PURA) regarding Docket No. 22-08-08 (*Application of the United Illuminating Company to amend Its rate schedules*). The comment was based on the *Energy justice in a changing climate* issue brief developed by the Clinic students.
- Dr. Bozzi made a presentation during CT Comprehensive Energy Strategy (CES) 2022 Technical Sessions on potential health benefits of heat pumps, and she and Policy Fellow Riena Harker submitted written testimony to the CES regarding heat pumps.
- In November 2022, Riena Harker provided testimony in support of the American Public Health Association policy proposal *Gas stove emissions are a public health concern: Exposure to NO_2 increases risk of illness in children, older adults, and people with underlying health conditions*, which was submitted by RMI. The proposal was adopted.
- Dr. Bozzi co-authored a *Case study on health and climate impacts of methane gas in buildings* for the *2022 Lancet Countdown on Health and Climate Change Policy Brief for the United States of America*.
- Collaborating with Connecticut Sierra Club, YCCCH held meetings with Connecticut legislators about health harms of gas stoves and indoor combustion.
- YCCCH collaborated with RMI and the Sierra Club to advise Connecticut Representative Jonathan Steinberg on the health harms of gas stoves (and indoor combustion more broadly) and to discuss policy options. In January 2023, Representative Steinberg introduced Proposed H.B. No. 6491, which called for establishment of emission standards for gas-powered home appliances and a zero-interest loan fund for the replacement of older or defective gas-powered home appliances. Unfortunately, the proposed bill did not advance.
- Dr. Bozzi and Riena Harker submitted written testimony on the following bills:

- S.B. No. 961: *An Act Concerning Carbon-Free School Requirements for New School Construction and Establishing Other School Construction and Public Health Requirements for School Districts*
- S.B. No. 979: *An Act Promoting Energy Affordability, Energy Efficiency, and Green Cities*
- S.B. No. 4: *An Act Concerning Connecticut's Present and Future Housing Needs*
- H.B. 5634: *An Act Increasing Funding for Energy Efficiency Programs*
- S.B. No. 1147: *An Act Concerning the Environmental Justice Program of the Department of Energy and Environmental Protection*

YCCCH also supported MPH students to get involved in local legislative education and advocacy. For instance, four students penned a letter to the editor published in the *New Haven Register* in support of SB 1147, *An Act Concerning the Environmental Justice Program of the Department of Energy and Environmental Protection*.

In 2021, YCCCH collaborated with the Connecticut Department of Public Health (DPH) on a grant application to the Centers for Disease Control and Prevention entitled *Advancing local capacity for health effects from heat, air quality, and extreme events*. In April 2023, the contract with DPH was finalized for YCCCH to officially serve as the primary academic partner for this five-year grant. Among other activities, YCCCH developed a *Connecticut climate impacts compendium*, presented in June 2023 to the Commissioner's meeting of the Directors of Health about the health impacts of climate change and potential local solutions. Dr. Bozzi also met individually with local health directors across the state to learn about their priority issues and receive feedback on proposed climate health interventions.

Other public health practice and policy highlights

- *YCCCH hosts Admiral Rachel Levine for a roundtable on climate change and public health*

On February 6, 2023, YCCCH hosted a climate change and public health roundtable discussion with Admiral Rachel Levine, Assistant Secretary for Health for the U.S. Department of Health and Human Services and head of the U.S. Public Health Service Commissioned Corps. The session, moderated by Dr. Dubrow, included presentations by Drs. Dubrow, Carrión, Chen, and Sherman, and Suzi Ruhl, JD on a wide range of topics including energy insecurity, healthcare sustainability, environmental justice and equity, and community-led approaches to addressing the social determinants of health.

- *"Inequity at the boiling point:" YCCCH hosts New York Times Climate Reporter for 2-day campus visit*

YCCCH hosted *New York Times* international climate reporter Somini Sengupta for a Yale Poynter Fellowship visit, which included a public lecture entitled *Inequity at the boiling point*, a college tea, and meals with students, faculty, and staff. The events took place March 1-2, 2023 and were co-hosted by Yale College Environmental Studies, Yale Program on Climate Change Communication, Yale Center for Environmental Justice, and Pierson College.

- *Dr. Robert Dubrow named a Yale Sustainability Champion*

The Yale Office of Sustainability named Dr. Dubrow a *Yale Sustainability Champion* in December 2022. After a career focus on the epidemiology of HIV and cancer, Dr. Dubrow set his sights on tackling climate change, becoming the founding faculty director of the Yale Climate Change and Health Initiative (now YCCCH) in 2015. Despite the magnitude of addressing climate change and public health issues, he notes that "we are making a meaningful contribution, and that's as much as we can do—keep working and keep the goal in mind."

- *Blog on gas stoves*

Drs. Dubrow and Carrión collaborated with RMI on a blog entitled *The science behind gas stoves* that was published in June 2023 on the RMI website.

Major Year 9 (2023-24) Goals

- **Engage in a strategic planning process to develop a five-year strategic plan** (YCCCH is currently in the fourth year of a four-year strategic plan)
- **Develop a leadership succession plan for the Faculty Director**
- **Continue to apply for major research grants**
- **Fundraise to support YCCCH's core operations and policy impact work and to increase YCCCH's endowed funds**
- **Obtain approval for a new climate change and health faculty position** and begin the recruitment process
- **Recruit a new Executive Director** to replace Dr. Klein, who plans to step down
- **Recruit a new Program Administrator to replace Mr. Diaz-Hernandez**
- **Expand the online Climate Change and Health Certificate Program for working professionals** from an 18-week to a 21-week program by adding three region-specific short courses for the Cohort 10 offering, which will begin in September 2023
- **Develop more avenues for meaningful engagement of YCCCH Affiliated Faculty in YCCCH activities**
- **Continue work to maximize YCCCH's real-world policy impact**, with the focus on the three priority areas of 1) sustainable and equitable cooling, 2) equitable building electrification, and 3) healthcare environmental sustainability