

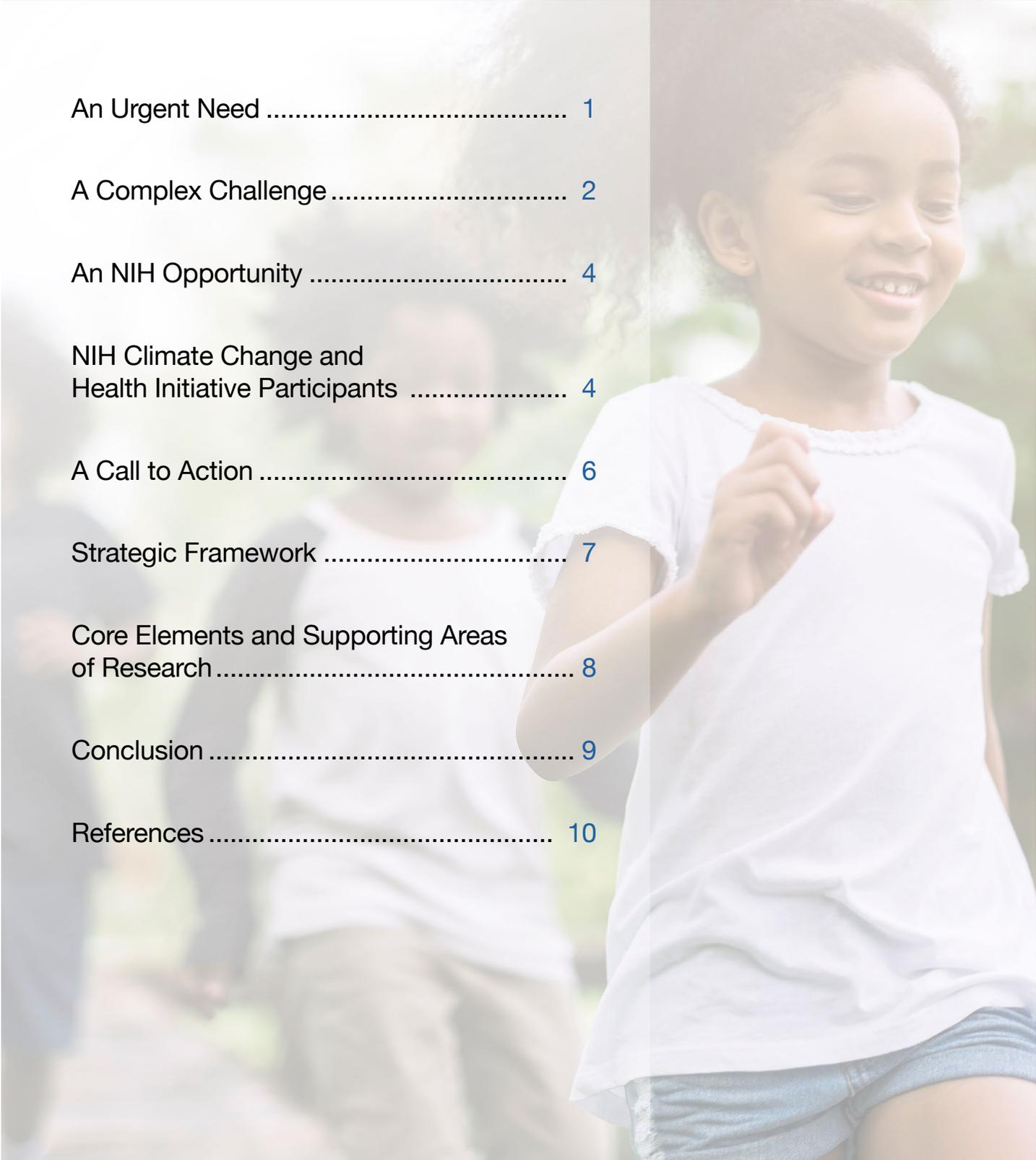
Climate Change and Health Initiative Strategic Framework





Table of Content

An Urgent Need	1
A Complex Challenge	2
An NIH Opportunity	4
NIH Climate Change and Health Initiative Participants	4
A Call to Action	6
Strategic Framework	7
Core Elements and Supporting Areas of Research	8
Conclusion	9
References	10

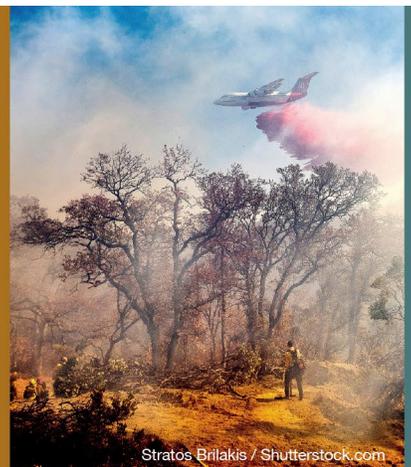


NIH Climate Change and Health Initiative Strategic Framework

This Strategic Framework presents the initial planning and development of an NIH research initiative on the impacts of climate change on people's health. It is a product of the NIH Climate Change and Health (CCH) Working Group and includes scientific community and stakeholder input. This framework will guide NIH research investments in the near term and inform the planning of such investments over the long term to generate knowledge vital for responding to the challenges of global climate change to the health and well-being of current and future generations.

An Urgent Need

For some time, international scientific consensus has been that climate change poses an existential threat to human beings. A report of the Intergovernmental Panel on Climate Change (IPCC), the United Nation's body for assessing the science related to climate change, concluded in a recent report: "Any increase in global warming is projected to affect human health, with primarily negative consequences (*high confidence*)."¹ The report further concludes that, "Compared to current conditions, 1.5°C of global warming would nonetheless pose heightened risks to eradicating poverty, reducing inequalities, and ensuring human and ecosystem well-being (*medium evidence, high agreement*)."²

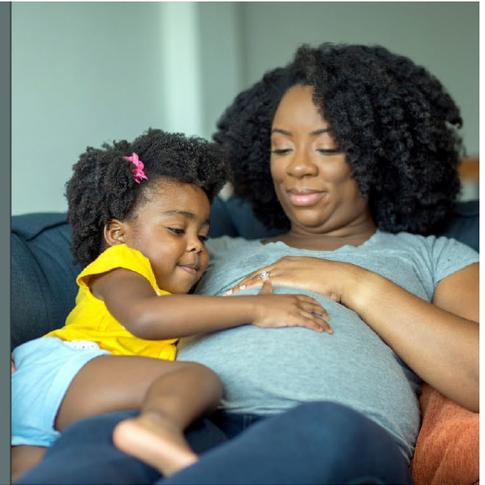


In 2010, NIH co-led with the Centers for Disease Control and Prevention (CDC) and Environmental Protection Agency (EPA), the creation of the first federal climate change and health research needs assessment, [A Human Health Perspective on Climate Change](#).³ Many of the research needs identified in that document have yet to be addressed, and new ones continually arise. Examples from the assessment and from those gathered in the development of this Strategic Framework include:

- Protecting pregnant women and older adults from the impacts of extreme temperatures, especially heat in urban settings.
- Determining how best to test and adapt protocols for the delivery of mental health services to communities during hurricanes, wildfires, and other extreme weather events.
- Assessing what kinds of behavior change strategies might provide health co-benefits during climate mitigation.
- Learning how population-based studies and implementation research might influence uptake and scale-up of clean fuels in global energy replacement programs.
- Applying modeling methods originally developed to assess health effects of air pollution to climate-sensitive diseases such as asthma.
- Elucidating the effects of ambient temperature on UV radiation-induced skin cancers, including non-melanomas.
- Modeling the likely effects of climate adaptations in infrastructure on waterborne and vector-borne disease incidence around the world.
- Quantifying co-benefits to cardiovascular health of reducing reliance on fossil fuels.
- Identifying aspects of food production and distribution that can reduce risk of contamination, maintain nutrient levels, and ensure sustainable access.
- Understanding the effects of climate change-induced stress on reproduction and development.
- Understanding how climate change might alter social and economic determinants of mental health and community well-being in the U.S. and in Low- and Middle-Income Countries (LMICs).

A Complex Challenge

NIH's broad scientific expertise uniquely positions the agency to tackle the complex set of factors that coalesce in the problem of climate change impacts on health. The U.S. Global Change Research Program (USGCRP), which coordinates the climate change work of federal agencies, has produced a conceptual framework for understanding the relationship of climate change to human health (Figure 1). This diagram illustrates the complex direct and indirect relationships that are mediated by exposure pathways and contextual variables in populations to create risks of health outcomes from climate change across the lifespan.



Climate Change and Health

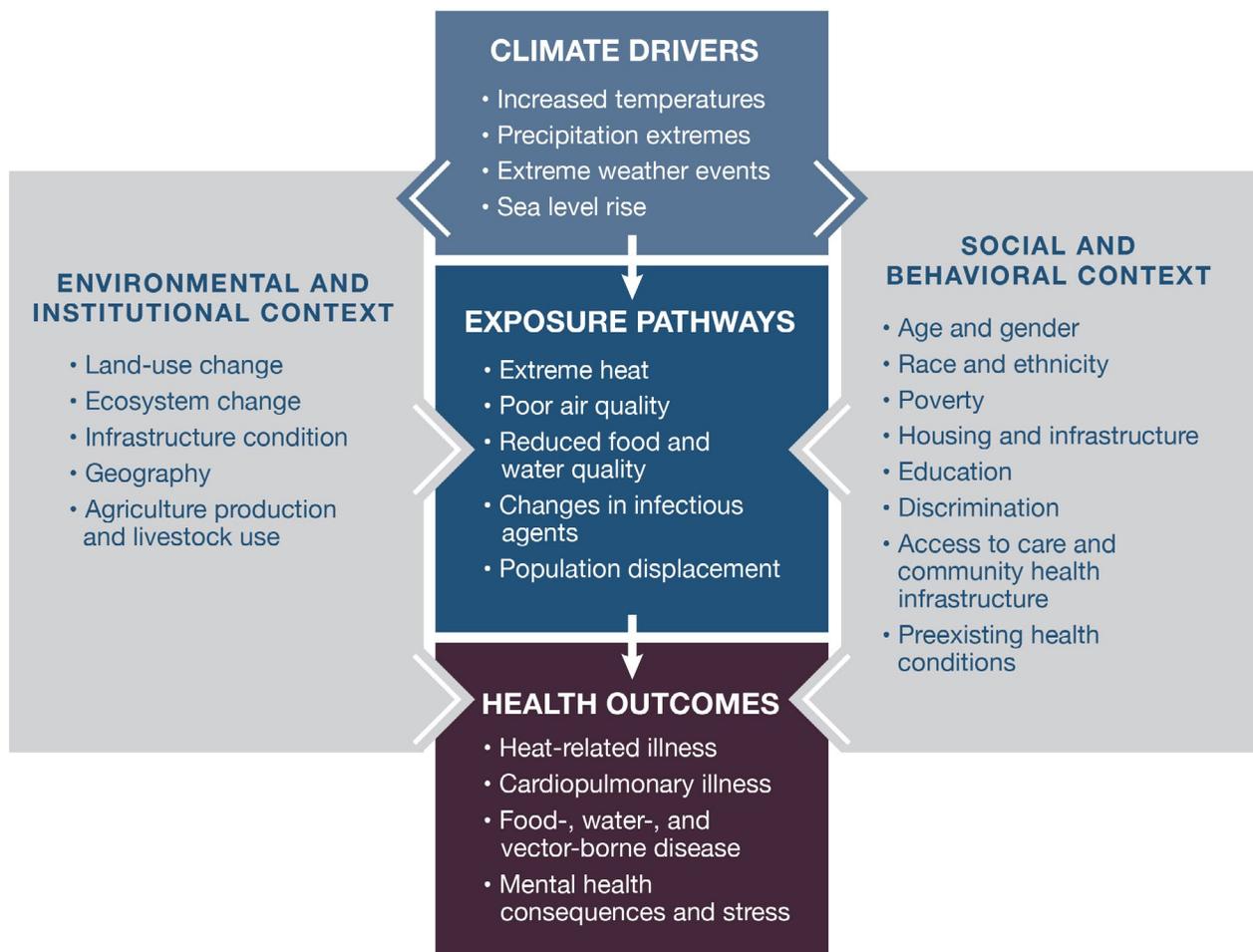


Figure 1: Conceptual framework for the relationship of climate change to human health (reprinted from U.S. NCA, 2018).⁴

Climate drivers affect health outcomes directly through weather events such as extreme heat, wildfires, droughts, storm surges, and floods, but also indirectly through a series of exposure pathways such as air and water quality, food quality, infectious diseases, and massive population displacement events. These pathways are themselves influenced by environmental contexts related to land use, geography, infrastructure, and agriculture, as well as social, behavioral, and economic contexts that create vulnerabilities associated with life stage, gender, poverty, discrimination, and access to care.⁵

Climate change greatly elevates threats to human health across a wide range of illnesses and injuries, including: asthma,⁶ respiratory allergies and airway diseases,⁷ cancers,⁸ cardiovascular disease and stroke,⁹ foodborne diseases and malnutrition,^{10,11} heat-related illness and deaths,¹² reproductive, birth outcome, developmental effects,¹³ mental health and neurological disorders,¹⁴ vector-borne and zoonotic diseases,¹⁵ waterborne diseases,¹⁶ and extreme weather-related morbidity and mortality.^{17,18} As with many diseases and disorders, some populations, including children,¹⁹ older adults, women and pregnant women,²⁰ and persons with disabilities,²¹ among others, may be disproportionately at risk. Strong evidence indicates that climate change also disproportionately adversely affects communities that experience socioeconomic, behavioral, and environmental vulnerabilities.²² Such communities include underserved and health-disparate populations, especially communities of color, rural populations, and those unduly burdened by exposure to environmental pollution. In the global community, these same populations, as well as all those living in extreme poverty with poor access to health and economic services, experience a higher risk of climate change consequences.^{23,24,25}

It is important to note that this list of influences, pathways, and health outcomes is not comprehensive, and the variability of these influences on health creates challenges for attribution to climate change. While the burden of disease attributable to climate change has not yet been reliably estimated, indicators point to a reversal of long-term U.S. and global trends of improvements in population health due to climate change.²⁶ As the impact of climate change on human health increases, attribution becomes less important than intervention.

Most climate change and health research has been focused on documenting and understanding these emerging threats to populations around the world.²⁷ Another rapidly growing body of research explores how climate adaptation efforts can minimize health hazards. Adaptation refers to a diverse array of institutional and environmental interventions, including urban planning, housing, transportation, air quality management, improved water systems, flood control, vector control, and changes in health services, among others.²⁸ Importantly, other research has demonstrated opportunities for health co-benefits from social mobilization and system changes to mitigate climate change, including active transport, healthy buildings, and improved agricultural practices and diets.²⁹ A complementary field of study is focused on health threats posed by potential unintended side effects of actions by energy, agriculture, transportation, health care, and other sectors to mitigate climate change and protect enterprises from losses due to extreme weather or gradually changing conditions.³⁰ These actions create “natural experiments” that are important in understanding how negative consequences can be avoided and health benefits maximized.



DEFINITIONS

Climate change refers to changes in global or regional climate patterns attributed largely to human-caused increased levels of atmospheric greenhouse gases.

Climate change adaptation or climate adaptation means taking action to prepare for, and adjust to, both the current and projected impacts of climate change.

Climate change mitigation refers to actions limiting the magnitude and rate of future climate change by reducing greenhouse gas emissions and/or advancing nature-based solutions.

Adaptive capacity is the ability of a human or natural system to adjust to climate change (including climate variability and extremes) by moderating potential damages, taking advantage of opportunities, or coping with the consequences.

Climate resilience can be generally defined as the capacity of a system to maintain function in the face of stresses imposed by climate change and to adapt the system to be better prepared for future climate impacts.

Adapted from EPA Strategic Plan FY 22-26.
<https://www.epa.gov/system/files/documents/2021-10/fy-2022-2026-epa-draft-strategic-plan.pdf>

An NIH Opportunity

NIH has supported climate change and health-relevant research for decades, although at a relatively modest level and concentrated primarily in a few Institutes. From 2010-2020, annual NIH support for climate change and health research hovered around \$10 million, the greatest portion of which passed through NIEHS. However, analysis of the NIH research portfolio during this timeframe shows that 21 other NIH components have funded at least one, and in several cases significantly more relevant projects. Funding level alone, however, belies the full NIH contribution to the evolution of the understanding of climate change and health. NIH has provided leadership on the issue of impacts of climate change on health through engagement of its scientists at national and global levels, beginning with the first IPCC.



Participating Institutes and Centers

Executive Committee:

The NIH Climate Change and Health Initiative is led by an Executive Committee comprising the Directors of seven NIH Institutes and Centers. The NIEHS Director chairs the Executive Committee and NIEHS provides the Initiative's administrative home.

National Institute of Environmental Health Sciences (NIEHS)

Rick Woychik, Ph. D. (Chair)

Fogarty International Center (FIC)

Roger I. Glass, M.D., Ph.D.

National Institute on Minority Health and Health Disparities (NIMHD)

Eliseo J. Pérez-Stable, M.D.

National Institute of Mental Health (NIMH)

Joshua A. Gordon, M.D., Ph.D.

National Institute of Nursing Research (NINR)

Shannon N. Zenk, PhD, MPH, RN, FAAN

Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD)

Diana W. Bianchi, M.D.

National Heart, Lung, and Blood Institute (NHLBI)

Gary H. Gibbons, M.D.

NIH Climate Change and Health Working Group

Aubrey Miller, M.D., NIEHS, Co-chair

Joshua Rosenthal, Ph.D., FIC, Co-chair

Gwen Collman, Ph.D., NIEHS, Strategic Advisor



*In 1993, the NIH-funded journal **Environmental Health Perspectives** was among the first global biomedical publications to explore the topic of climate change impacts on human health.*

Over the nearly 30 years since, NIH scientists have continued to inform the scientific, policy, and stakeholder communities on this critical emerging topic through a concentrated body of efforts, including through interagency working groups, international partnerships with the World Health Organization, and joint efforts with the National Academies of Science, Engineering, and Medicine, as well as a range of community-based workshops and training efforts.

With support from the White House, Congress, the scientific community, and the public, NIH could expand its leadership role on climate change and health through a more deliberate and comprehensive effort: one that takes advantage of NIH's experience in bringing the best minds to bear in generating biomedical breakthroughs and creating innovative tools, technologies, methodologies, and approaches for translating such breakthroughs into the means of relieving the global burden of disease. Through these and other key capacities, NIH will empower research on climate change and health

that exponentially increases the potential for understanding the complex drivers of adverse health outcomes and enables effective and impactful interventions. Other capacities include:

Workforce. A major strength is the ability to recruit and develop a premier scientific, informatics, and translational workforce to tackle the issue. NIH has demonstrated success in creating multidisciplinary teams to conduct and translate the kinds of transdisciplinary science that the complexity of climate change demands. Evidence suggests such research may best be accomplished through a systems approach that integrates data across domains of biomedical, geophysical, ecological, and social sciences. Of particular importance for the study of climate change impacts is NIH's experience in, and commitment to, creating a diverse biomedical workforce. Such a workforce will be vital to ensuring recognition and exploration of the impact of climate change on the most vulnerable communities here and around the world, as well as to creating the evidence base for equitable best practices that can generate inclusive solutions and build health resilience at the individual, local, regional, and global level.



Emphasis on Equity. Strong evidence points to substantially higher burdens of climate-related health impacts among the underserved, under-resourced, and health disparate communities, both domestic and global. NIH's long history of special consideration of the health inequities and increased health risks experienced by such communities has been even further elevated across the agency. This perspective, along with NIH's purposeful recognition of the special health vulnerabilities of other groups such as children, older adults, persons with disabilities, and pregnant women, provides the appropriate perspective for conducting climate change and health research. Prioritizing the needs of those who are most affected, often least able to effectively respond, and in large part, least responsible for the decisions that have led to this global environmental crisis, is vital to efforts to prevent or attenuate the most consequential health impacts of climate change.

Partnerships. NIH is a trusted and sought-after partner in research and translation, both at home and around the world. For more than a decade, there has been a call to bridge gaps across federal agencies in efforts on climate change and health research, funding mechanisms, program development, implementation, and research translation to provide comprehensive, whole-of-government solutions. Through a strategic focus on climate change and health, NIH will better integrate its own research activities and enhance the success of other federal efforts by providing critical public health and biomedical data and expertise to bridge these gaps. Partnerships, not only with traditional public health-oriented agencies like the CDC and EPA, but especially with geoscience-focused agencies such as The National Aeronautics and Space Administration (NASA), The National Oceanic and Atmospheric Administration (NOAA), The National Science Foundation (NSF), U.S. Geological Survey (USGS), and global partners, have high potential for new solutions to address these complex challenges. Studies that leverage information from non-health sectors, including agriculture, energy, and transportation, will be critical to understanding health outcomes and adaptation co-benefits. Current NIH partnerships in federal climate activities include the National Climate Assessment, the National Strategy for the Prevention of Vector-Borne Disease in Humans, the National Integrated Heat Health Information System, and many others. Other recommended partnerships include private-public collaborations, including major philanthropies, transdisciplinary academic centers, and with historically Black colleges and universities (HBCUs) and minority-serving institutions, community organizations, and local, state, and international government agencies.

Together these key NIH capacities present a strong basis for a strategic focus in this area. However, the most compelling argument for coordinated and expanded NIH leadership on climate change and health is articulated in the NIH mission, which is:

“To seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability.”

There is perhaps no greater opportunity for NIH to fulfill its mission than by providing global leadership in the response to the burgeoning climate change and health crisis.

A Call to Action

NIH leadership recognizes that this is the time for renewed energies to study the impacts of climate change on health and disease, and to couple that with the need for much needed data and knowledge for communities to adapt and prevent further harm from unprecedented climate impacts. Early in his tenure, President Joe Biden issued multiple relevant executive orders, one of which directed the U.S. Department of Health and Human Services (HHS) to identify, understand, and address impacts of climate change on people's health, with emphasis on creating greater health equity among populations of concern.³¹ HHS also has framed the response to climate change as an opportunity to build capacity to protect and support health, especially in underserved and underrepresented communities. Furthermore, HHS has demonstrated its commitment to these efforts by prioritizing response to climate change impacts on health in its 2022-2026 draft Strategic Plan.³²



To meet the challenge laid before NIH, an executive committee comprising the directors of seven Institutes and Centers – National Institute of Environmental Health Sciences (NIEHS), Fogarty International Center (FIC), National Institute on Minority Health and Health Disparities (NIMHD), National Institute of Mental Health (NIMH), National Institute of Nursing Research (NINR), Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD), National Heart, Lung, and Blood Institute (NHLBI)—has committed to providing leadership and oversight of the NIH Climate Change and Health Initiative. The NIEHS director chairs the executive committee, and NIEHS provides the Initiative's administrative home. Staff of 23 NIH Institute, Centers, and Offices (ICOs) currently engage in the NIH Climate Change and Health Working Group, co-chaired by NIEHS and FIC. The purpose of the group is to support the Initiative in the design and implementation of a coordinated approach to research, training, and capacity building to respond to the urgent and ubiquitous threats posed by climate change to health globally.

The Initiative will first aim to leverage existing grant programs, cohorts, and networks to ensure the support of projects that can be effectively implemented in the near term, while leaving substantial flexibility in outyears to accommodate longer-term goals. NIH ICOs will work through existing, coordinated processes to develop, review, and support programs that align with both their individual missions and the goals of the Initiative. Coordination will also take place across the NIH and with external partners to ensure consistent communication and messaging, maximize information sharing with stakeholders including decision-makers and affected communities, and catalyze the movement of knowledge into interventions and treatments to mitigate climate impacts and build health, equity, and resilience.



Strategic Framework

NIH must address the extraordinary challenges of climate change to health and well-being immediately and over the long term with both the urgency and foresight this response requires. This Strategic Framework for the NIH CCH Initiative provides guidance for this response.

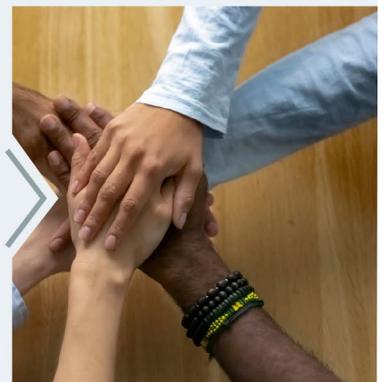
Development and Inputs

The proposed Strategic Framework is the product of the NIH CCH Working Group and reflects extensive efforts to collect, analyze, and synthesize a diversity of views, needs, and opportunities. These inputs are listed below, with process, outcomes, and analyses that will continue to be refined and applied to inform planning and funding decisions of the NIH CCH Initiative.

- [NIH Request for Information \(RFI\): Climate Change and Health Responses Summary](#)
- Portfolio Analysis of NIH Climate Change and Health Research, 2010-2020
- NIH Staff Input: Whiteboard Workshop Summary
- Landscape Report: Federal and International Climate Change and Health Research Funding
- IC Data Call of Potentially Relevant NIH Programs: Current and Planned

NIH Climate Change and Health Initiative Vision

NIH will address the climate crisis with the urgency, foresight, innovation, and collaborative spirit this challenge requires. NIH will strengthen capacity for climate and health research at home and abroad, and promote the best science and most impactful interventions, with an emphasis on health equity and community-engaged research. NIH will develop a sustainable model that spans the agency to support a pipeline of climate change and health workforce and research, and that promotes synergies through collaboration with other federal agencies and research organizations. Combined, these efforts will empower transdisciplinary solutions that will advance human health in the context of a rapidly changing world.



Goals and Objectives

The goals of the Initiative are to reduce health threats across the lifespan and build health resilience in individuals, communities, and nations around the world, especially among those at highest risk. These goals will be accomplished through the following initial objectives: Identify risks and optimize benefits to the health of individuals, communities, and populations from actions to mitigate or adapt to climate change.

- Develop the necessary research infrastructure and workforce to enable the generation of timely and relevant knowledge, drawing from the full spectrum of biomedical disciplines.
- Leverage partnerships with other scientific and social disciplines and organizations to achieve the most impactful results.
- Innovate across the research translation continuum to ensure findings are credible, accessible, and actionable for achieving these goals.
- Identify risks and optimize benefits to the health of individuals, communities, and populations from actions to mitigate or adapt to climate change.

Core Elements and Supporting Areas of Science

The framework of this Initiative will guide a community of practice comprising outstanding and committed scientists, trainees, and research implementation specialists. The Initiative will generate opportunities for new and sustained engagement among this community of practice with policymakers, industry and technology leaders, diverse communities, and other stakeholders, leading to collaborative and transformative science focused on the four core elements and supporting areas of science illustrated in Figure 2 and described below.

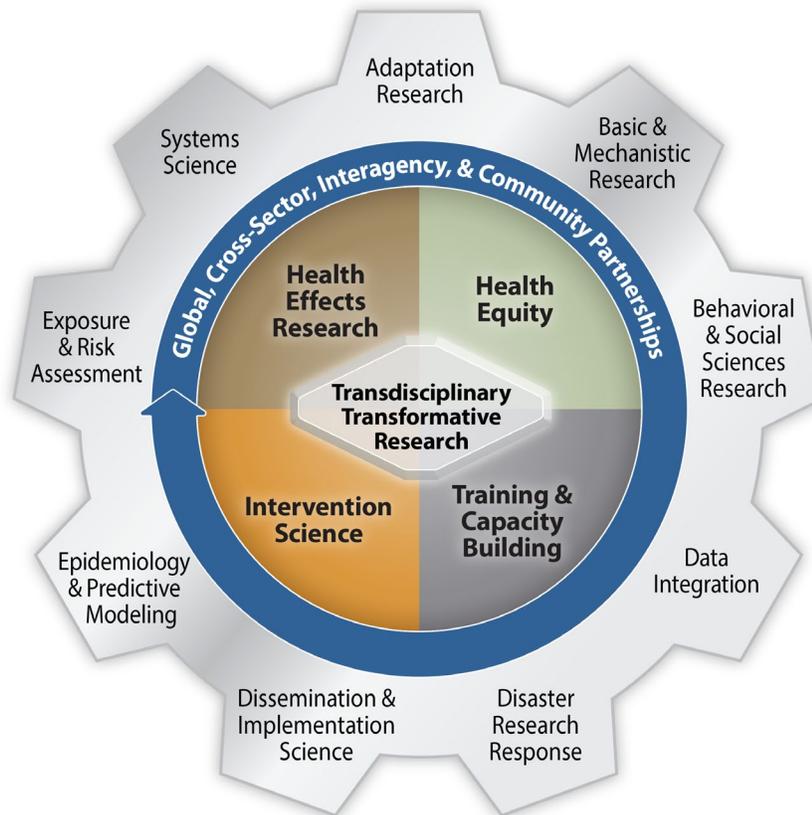


Figure 2: NIH Climate Change and Health Initiative Strategic Framework

Health Effects Research: Scientific investigation of the influences of climate change on health outcomes, including spatial and temporal scales, pathways, and mechanisms, and risks at specific times of vulnerability across the lifespan, as well as to special populations including children, older adults, women, pregnant women, differently abled persons, and others. Such research will inform the identification of trends, prediction of risks, and adoption of actions to prevent or respond to negative health outcomes.

Health Equity: Emphasis and integration throughout the Initiative on recognizing and responding to the needs of populations most at risk of climate change impacts to their health. Health equity requires elevation of the concerns and rights of under-resourced and historically disadvantaged communities, underserved and health disparate populations in the U.S. and in LMICs, including communities burdened by environmental injustice. Bringing focused attention to the lived experiences of the most affected individuals and communities will ensure the benefits of scientific discovery create greater health equity.

Intervention Research: Science that provides the evidence base for development and implementation of timely, effective strategies to prevent disease and disability and promote health. Intervention research uses experimental, modeling, and evaluative methods to study and design interventions to improve health, including engineered solutions, institutional and infrastructure changes, clinical, social, behavioral, and communication tools that influence beneficial decision-making. The urgency of a changing climate provides the imperative for research that can guide both individual actions and policies at the community and population levels to improve health outcomes now and in the future.

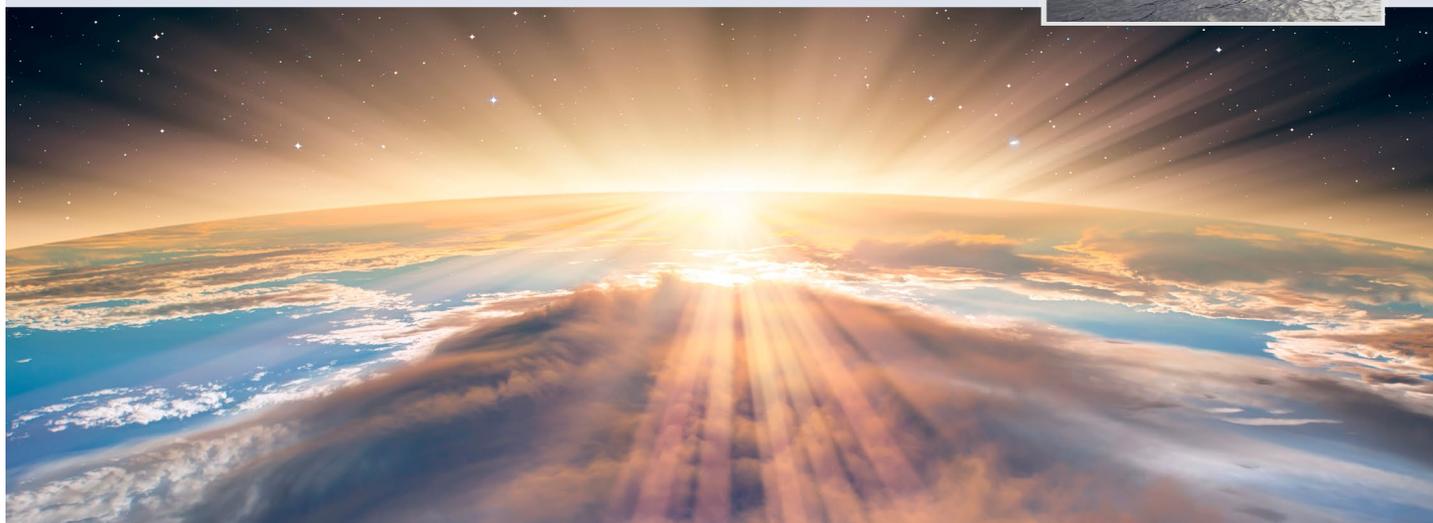
Training and Capacity Building: Transmission of the fundamental knowledge and skills to conduct transdisciplinary climate and health science, develop innovative supporting technologies, and translate findings to facilitate understanding of, and adaptation to, the growing threat of climate change on health. Efforts should include training and education on climate change and health at all curriculum levels, as well as allied professions, including law, media, economics, and others. Training should be provided to community members to facilitate their active participation in research design and implementation through community-scientist partnerships.

Supporting Areas of Science: The process of developing the Strategic Framework identified key areas of supporting science for climate change and health research, which are depicted in Figure 2 as cogs on the wheel. These areas represent highly relevant fields of inquiry, and include:

- Adaptation Research
- Basic and Mechanistic Studies
- Behavioral and Social Sciences Research
- Data Integration
- Disaster Research Response
- Dissemination and Implementation Science
- Epidemiology and Predictive Modeling
- Exposure and Risk Assessment
- Systems Science

Conclusion

A mounting number of assessments and reports provide undeniable evidence that climate change is resulting in increasingly profound changes to the global environment with direct and indirect consequences for human health and well-being. Closely intertwined with this threat are the more tangible and proximal risks of natural disasters, a global pandemic, societal unrest, and the ever-familiar menaces of poverty and inequity. The need for NIH to lead this science-based initiative, in partnership with communities throughout the world, is now warranted and vitally necessary to address the imminent threat that climate change poses to our health, humanity, and our planet.



- ¹ IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, Chapter B5.2. Available: [Chapter 5 — Global Warming of 1.5 °C \(ipcc.ch\)](https://www.ipcc.ch)
- ² IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, Chapter 5.
- ³ Portier CJ, Thigpen Tart K, Carter SR, Dilworth CH, Grambsch AE, Gohlke J, Hess J, Howard SN, Luber G, Lutz JT, Maslak T, Prudent N, Radtke M, Rosenthal JP, Rowles T, Sandifer PA, Scheraga J, Schramm PJ, Strickman D, Trtanj JM, Whung P-Y. 2010. A Human Health Perspective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. Research Triangle Park, NC: **Environmental Health Perspectives**, National Institute of Environmental Health Sciences. doi:10.1289/ehp.1002272. Available: <https://niehs.nih.gov/climate-report>
- ⁴ Ebi K.L, Balbus JM, Luber G, Bole A, Crimmins A, Glass G, Saha S, Shimamoto MM, Trtanj J, and White-Newsome JL. 2018: Human Health. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 539–571. doi: 10.7930/NCA4.2018.CH14
- ⁵ Balbus J, Crimmins A, Gamble JL, Easterling DR, Kunkel KE, Saha S, and Sarofim MC. 2016: Ch. 1: Introduction: Climate Change and Human Health. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 25–42. <http://dx.doi.org/10.7930/J0VX0DFW>
- ⁶ Nassikas N, Spangler K, Fann N, Nolte CG, Dolwick P, Spero TL, Sheffield P, Wellenius GA. 2020. Ozone-related asthma emergency department visits in the US in a warming climate. **Environ Res**, 2020 Apr;183:109206. doi: 10.1016/j.envres.2020.109206. Epub 2020 Jan 31. PMID: 32035409; PMCID: PMC7167359. Available: <https://pubmed.ncbi.nlm.nih.gov/32035409>
- ⁷ Fann N, Brennan T, Dolwick P, Gamble JL, Ilacqua V, Kolb L, Nolte CG, Spero TL, and Ziska L, 2016: Ch. 3: Air Quality Impacts. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 69–98. <http://dx.doi.org/10.7930/J0GQ6VP6>
- ⁸ Prohaska TR, and Peters KE. 2019. Impact of natural disasters on health outcomes and cancer among older adults. **The Gerontologist**, 59. Supplement 1 (2019): S50-S56. Available: <https://pubmed.ncbi.nlm.nih.gov/31100141>
- ⁹ Mohsen M, Speakman JR. 2020. Predicted impact of increasing average ambient temperature over the coming century on mortality from cardiovascular disease and stroke in the USA. **Atherosclerosis**, 313 (2020): 1-7. Available: <https://pubmed.ncbi.nlm.nih.gov/32980563>
- ¹⁰ Hellberg RS, Chu E. 2016. Effects of climate change on the persistence and dispersal of foodborne bacterial pathogens in the outdoor environment: A review, **Critical Reviews in Microbiology**, 42:4, 548-572, DOI: 10.3109/1040841X.2014.972335. Available: <https://pubmed.ncbi.nlm.nih.gov/25612827>
- ¹¹ Macdiarmid J, Whybrow S. 2019. Nutrition from a climate change perspective. **Proceedings of the Nutrition Society**, 78(3), 380-387. doi:10.1017/S0029665118002896. Available: <https://doi.org/10.1017/S0029665118002896>
- ¹² Campbell S, Remenyi TA, White CJ, Johnston FH. 2018. Heatwave and health impact research: A global review. **Health & Place**, 53 (2018): 210-218. Available: <https://doi.org/10.1016/j.healthplace.2018.08.017>
- ¹³ Buthmann, Jessica, Ham J, Davey K, Finik J, Dana K, Pehme P, Zhang W, Glover V, Nomura Y. 2019. Infant temperament: repercussions of Superstorm Sandy-related maternal stress. **Child Psychiatry & Human Development**, 50.1 (2019): 150-162. Available: <https://pubmed.ncbi.nlm.nih.gov/30030653>
- ¹⁴ Cianconi P, Betrò S, and Janiri L. 2020 The impact of climate change on mental health: a systematic descriptive review. **Frontiers in Psychiatry**, 11 (2020): 74. Available: <https://doi.org/10.3389/fpsyt.2020.00074>

- ¹⁵ Beard C.B, Eisen R.J, Barker C.M, Garofalo J.F, Hahn M, Hayden M, Monaghan A.J, Ogden N.H, and Schramm P.J, 2016: Ch. 5: Vectorborne Diseases. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 129–156. <http://dx.doi.org/10.7930/J0765C7V>
- ¹⁶ Levy K, Smith SM, Carlton EJ. 2018 Climate Change Impacts on Waterborne Diseases: Moving Toward Designing Interventions. **Curr Environ Health Rep**, 2018;5(2):272-282. doi:10.1007/s40572-018-0199-7. Available: <https://pubmed.ncbi.nlm.nih.gov/29721700>
- ¹⁷ McGeehin, MA, and Mirabelli M. 2001. The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States. **Environmental Health Perspectives**, 109.suppl 2 (2001): 185-189. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240665>
- ¹⁸ Portier CJ, Thigpen Tart K, Carter SR, Dilworth CH, Grambsch AE, Gohlke J, Hess J, Howard SN, Luber G, Lutz JT, Maslak T, Prudent N, Radtke M, Rosenthal JP, Rowles T, Sandifer PA, Scheraga J, Schramm PJ, Strickman D, Trtanj JM, Whung P-Y. 2010. A Human Health Perspective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. Research Triangle Park, NC: **Environmental Health Perspectives**, National Institute of Environmental Health Sciences. doi:10.1289/ehp.1002272 Available: <https://niehs.nih.gov/climate-report>
- ¹⁹ Helldén D, Andersson C, Nilsson M, Ebi K, Friberg P, and Alfven T. 2021. Climate change and child health: a scoping review and an expanded conceptual framework. **The Lancet Planetary Health**, 5.3 (2021): e164-e175. Available: <https://pubmed.ncbi.nlm.nih.gov/33713617>
- ²⁰ Ward A, Clark J, McLeod J, Woodhul R, Moser H, and Konrad C. 2019. The impact of heat exposure on reduced gestational age in pregnant women in North Carolina, 2011–2015. **International Journal of Biometeorology**, 63.12 (2019): 1611-1620. Available: <https://doi.org/10.1007/s00484-019-01773-3>
- ²¹ Zottarelli, LK, Sharif HO, and Sunil TS. 2020. Effects of social vulnerability and heat index on emergency medical service incidents in San Antonio, Texas, in 2018. **J Epidemiol Community Health**, 75.3 (2020): 271-276. Available: <https://jech.bmj.com/content/75/3/271>
- ²² Balbus JM, Malina C. 2009. Identifying Vulnerable Subpopulations for Climate Change Health Effects in the United States. **Journal of Occupational and Environmental Medicine**, January 2009 - Volume 51 - Issue 1 - p 33-37 doi: 10.1097/JOM.0b013e318193e12e. Available: <https://pubmed.ncbi.nlm.nih.gov/19136871>
- ²³ Hall, N.L., and Crosby, L. 2020. Climate change impacts on health in remote indigenous communities in Australia. **International Journal of Environmental Health Research**, (2020): 1-16. Available: <https://doi.org/10.1080/09603123.2020.1777948>
- ²⁴ Frumkin H, Hess J, Luber G, Malilay J, and McGeehin M. 2011. Climate Change: The Public Health Response. **American Journal of Public Health**, 98.3 (2008): 435-445. Available: <https://ajph.aphapublications.org/doi/10.2105/AJPH.2007.119362>
- ²⁵ Ajanovic S, Valente M, Rosauro, V, Quique Bassat. 2020. Climate change and the future health of children in low-income countries, **Journal of Tropical Pediatrics**, Volume 66, Issue 2, April 2020, Pages 111–113, <https://doi-org.eres.qnl.qa/10.1093/tropej/fmaa008>
- ²⁶ Tong S, and Ebi K. 2019. Preventing and mitigating health risks of climate change. **Environmental Research**, 174 (2019): 9-13. Available: <https://doi.org/10.1016/j.envres.2019.04.012>
- ²⁷ Barrang-Ford L, Sietsma AJ, Callaghan M, Minx JC, Scheelbeek, PF, Haddaway NR, Dangour AD. 2021. Systematic mapping of global research on climate and health: a machine learning review. **The Lancet Planetary Health**, 5(8), e514-e525. Available: [https://doi.org/10.1016/S2542-5196\(21\)00179-0](https://doi.org/10.1016/S2542-5196(21)00179-0)
- ²⁸ Mees H. 2017. Local governments in the driving seat? A comparative analysis of public and private responsibilities for adaptation to climate change in European and North-American cities. **Journal of Environmental Policy & Planning**, 19(4), 374-390. Available: <https://doi.org/10.1080/1523908X.2016.1223540>
- ²⁹ Scovronick, N., Budolfson, M., Dennig, F. et al. The impact of human health co-benefits on evaluations of global climate policy. **Nat Commun** 10, 2095 (2019). <https://doi.org/10.1038/s41467-019-09499-x>
- ³⁰ Suckling J, Hoolohan C, Soutar I, and Druckman A. 2021. Unintended consequences: Unknowable and unavoidable, or knowable and unforgivable? **Frontiers in Climate**, 124. Available: <https://doi.org/10.3389/fclim.2021.737929>
- ³¹ Office of the Federal Register, National Archives and Records Administration, Executive Order 14008 –Tackling the Climate Crisis at Home and Abroad, govinfo, (January 27, 2021), <https://www.govinfo.gov/app/details/DCPD-202100095>
- ³² Department of Health and Human Services. Strategic Plan, FY 2022 – 2026. Public Consultation on the Draft HHS Strategic Plan FY 2022 – 2026. <https://www.hhs.gov/about/draft-strategic-plan> (2021).