

# New York State Department of Health Building Resilience Against Climate Effects (BRACE) in New York State



## Climate and Health Profile

June 2015



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Hurricane Sandy: CDC/Rob Gutro/Hal Pierce/Marshall Shepherd. Photo credit: NASA GOES Project. NOAA's GOES-13 satellite captured this visible image of the massive Hurricane Sandy on Oct. 28 at 1302 UTC (9:02 a.m. EDT). CDC Public Health Image Library. Accessed August 14, 2014 at: <http://phil.cdc.gov/phil/quicksearch.asp> (image 15184).

Hot sun: NYC Hazards–Extreme Heat page. New York City (NYC) Office of Emergency Management website. Accessed May 27, 2014 at: <http://home2.nyc.gov/html/oem/html/hazards/heat.shtml>.

Mosquito: CDC/Paul I. Howell, MPH; Prof. Frank Hadley Collins. Photo credit: James Gathany. *Aedes aegypti* female mosquito. CDC Public Health Image Library. Accessed November 13, 2014 at: <http://phil.cdc.gov/phil/quicksearch.asp> (Image 9533).

# CONTENTS

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List of Tables.....	vi
List of Figures .....	vii
Definitions Used in this Report .....	viii
Abbreviations Used in this Report .....	x
Executive Summary.....	1
1 Introduction .....	3
1.1 Background/Overview .....	3
1.2 History of Engagement with Climate and Health.....	5
1.3 Geographic Scope .....	6
2 A Changing New York Climate.....	8
2.1 Baseline Climate Description .....	8
2.2 Causes of Climate Change and NYS Climate Trends .....	9
2.3 Sources of Information on Climate Projections .....	11
2.3.1 Emissions Scenarios .....	11
2.3.2 Projection Models .....	13
2.4 Summary of Climate Projections.....	14
3 Climate-related Health Impacts .....	20
3.1 Health Impacts from Precipitation Extremes (Drought, Floods, Heavy Rainfall).....	21
3.2 Heat-related Illness .....	21
3.3 Illnesses Related to Air Pollution .....	22
3.4 Allergies.....	23
3.5 Vector-borne Disease.....	23
3.6 Food- and Water-borne Disease .....	23
3.7 Food Security.....	24
3.8 Rationale/Method for Prioritization of Climate Impacts .....	25
4 Vulnerable Populations.....	26
4.1 Older Adults .....	29
4.2 Children .....	29
4.3 New Yorkers of Low Socioeconomic Status (SES) .....	30
4.4 Ethnic, Racial Minorities.....	30
4.5 Tribal Populations .....	31

4.6	New Yorkers who are Experiencing Social Isolation .....	32
4.7	New Yorkers who are Homeless .....	32
4.8	New Yorkers with Diabetes or who are Obese .....	33
4.9	New Yorkers with Asthma, Allergies, or Other Respiratory Illness.....	33
4.10	New Yorkers with Cardiovascular Disease .....	34
4.11	New Yorkers with Mental Illness.....	35
4.12	Women who are Pregnant.....	35
4.13	New Yorkers Living in Flood-prone Areas or Along the Coast .....	36
4.14	New Yorkers who Rely on Private Wells and Small Water Systems .....	36
4.15	Outdoor Workers .....	37
4.16	Migrant and Seasonal Farmworkers .....	37
5	Assessing Vulnerability to Climate-related Health Impacts .....	39
5.1	Evaluating Exposures .....	39
5.2	Prioritizing Climate Impacts for BRACE Step 2 Health Risk Assessment .....	44
5.3	Quantitative Analysis (Methodology) .....	46
5.4	Understanding Vulnerability to Health Impacts from Climate Change .....	46
5.4.1	Assessing Extreme Heat Vulnerability.....	46
5.4.2	Assessing Extreme Weather Vulnerability .....	51
5.4.3	Assessing Vector-borne Disease Vulnerability .....	55
5.4.4	Assessing Food- and Water-borne Disease (FWBD) Vulnerability.....	57
6	Challenges and Opportunities.....	60
6.1	Division of State Climate Regions for Analysis.....	60
6.2	Applying Research Findings for Stronger Surveillance.....	60
6.3	Appropriate Selection and Use of Climate Models.....	61
6.4	Assessment and Implementation of Interventions.....	61
7	Collaborations and Existing NYS Initiatives .....	62
7.1	Value of Stakeholder Engagement.....	62
7.2	Summary of Existing NYS Government Interagency Climate Adaptation Initiatives .....	63
7.3	NYSDOH Needs Assessment Surveys of Stakeholders .....	65
7.4	Potential for Collaboration.....	66
8	NYSDOH Climate and Health Strategic Map Implementation .....	68
8.1	Framework for Action .....	69
8.2	Climate Impact Teams.....	71

9	Conclusion and Next Steps.....	72
	References.....	74

## LIST OF TABLES

---

**Table 1:** Summary of the emissions scenarios and their resolution, time, number of models, and outputs. (Page 14)

**Table 2:** New York State Department of Health (NYSDOH) Needs Assessment Survey of Internal Program Managers – NYSDOH program populations vulnerable to climate change impacts. (Page 26)

**Table 3:** Type(s) of climate and health impacts for which particular groups of people in New York State (NYS) have increased vulnerability compared to the general population in NYSDOH studies. (Page 28)

**Table 4:** Most common diagnoses in migrant and seasonal farmworker (MSFW) population, reported by clinics who are part of the NYSDOH Migrant and Seasonal Farmworker Health Program per 2012 annual reporting. (Page 38)

**Table 5:** Population factors to be evaluated when assessing vulnerability to heat. (Page 41)

**Table 6:** Social vulnerability factors for extreme heat were selected based on NYSDOH findings and other published literature. (Page 42)

**Table 7:** Environmental factors associated with a population’s vulnerability to heat in NYSDOH studies and other published literature. (Page 43)

**Table 8:** Top-ranked adaptation categories from NYSDOH surveys with NYSDOH leaders, local health departments (LHDs), and external stakeholders. (Page 45)

**Table 9:** Benefits of partnership with stakeholders. (Page 62)

**Table 10:** Public health adaptation recommendations from the NYS Climate Action Council (CAC) Interim Report. (Page 63)

**Table 11:** Public health adaptation recommendations, taken directly from the New York State Energy Research and Development Authority “Responding to Climate Change in New York State” (ClimAID) report. (Page 64)

**Table 12:** Selected stakeholder ideas for collaboration with NYSDOH on climate and health adaptation efforts. (Page 66)

**Table 13:** Stakeholder partnerships on health impacts of climate change. (Page 67)

## LIST OF FIGURES

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**Figure 1:** The 10 NYS climate divisions. (Page 6)

**Figure 2:** Overlaying the 10 NYS climate divisions with 11 NYS ozone regions yields 14 weather regions. (Page 7)

**Figure 3:** Global concentrations of long-lived greenhouse gases over the past 2,000 years. (Page 9)

**Figure 4:** Variations in Earth's average surface temperature over the past 20,000 years. (Page 10)

**Figure 5:** Evidence of increasing warming and wetness in NYS, 1948-2008. (Page 11)

**Figure 6:** Simulated difference in annual mean (average) precipitation (%) for the Northeast region, for each future time period (2021-2050, 2041-2070, and 2070-2099) with respect to the reference period of 1971-1999. (Page 16)

**Figure 7:** Simulated difference in annual mean temperature (°F) for the Northeast region, for each future time period (2021-2050, 2041-2070, and 2070-2099) with respect to the reference period of 1971-1999. (Page 17)

**Figure 8:** Baseline and projected ranges of temperature and precipitation increases by the 2020s and 2100, for NYS ClimAID-defined climate region. Baseline values represent averages for the period 1971-2000. (Map from 2011 ClimAID Report: Responding to Climate Change in New York State; projection data from 2014 update to ClimAID Report). (Page 18)

**Figure 9:** Climate risks and attributes that will be affected by climate change, NYS (Bullets from 2011 ClimAID Report: Responding to Climate Change in New York State). (Page 19)

**Figure 10:** Surface and air temperatures vary over different land use areas. (Page 22)

**Figure 11:** Map showing locations of Nation health clinics that are part of the American Indian Health Program. (Page 31)

**Figure 12:** Cardiovascular disease is the most common cause of death in NYS. (Page 34)

**Figure 13:** NYSDOH Internal Climate and Health Strategic Map, 2013-2015 strategic priorities. (Page 68)

**Figure 14:** Prioritized NYS climate and related public health impacts. (Page 70)

**Figure 15:** NYSDOH Climate and Health Project structure. (Page 70)

## DEFINITIONS USED IN THIS REPORT

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**Climate** refers to the average weather conditions in a certain place over many years. Weather is different than climate. One way to illustrate this difference is that weather tells you what to wear each day, but the climate helps you figure out what should be in your closet.

**Climate change** refers to the overall planetary climate changes related to increased carbon in the atmosphere over periods of several decades and longer. Global warming, a general rise in temperatures from a higher amount of greenhouse gases in the atmosphere, is just one component of climate change.

**Climate impacts** refer to the effects of climate change such as warming, increased precipitation, drought, and extreme weather. These effects can also be referred to as “climate consequences.”

**Climate models (or global climate models)** refer to a set of scientific mathematical assumptions about the relationships between factors that influence climate. Each model simulates physical exchanges among the ocean, atmosphere, land, and ice. These models are used to develop a set of climate projections.

**Climate projections** refer to numerical estimates of future climate impacts, including estimates of future temperatures and levels and patterns of precipitation. It is important to note that projections are not true probabilities and necessarily have a level of uncertainty embedded within them due to data and modeling constraints, the random nature of some parts of the climate system, and a limited understanding of some physical processes.

**Climate risks** refers to the particular climate impacts which may occur.

**Climate scenarios** refer to a set of emissions paths that are based on certain assumptions about the future (e.g., high economic growth, high population growth, slow technological development).

**Emissions scenarios (or representative concentration pathways** in this report) refer to a set of paths of greenhouse gas emissions, aerosols, and land-use changes that were developed for the climate modeling community for use in modeling experiments. The different scenarios represent a range of situations from stabilized greenhouse gas concentrations to increased greenhouse gas concentrations over time with high population growth and energy use. The emissions scenarios are input into the climate models to develop projections.

**Greenhouse gases** refer to gases like carbon monoxide, carbon dioxide, methane, and nitrous oxide that are released and accumulated in the atmosphere, largely due to human activities such as the burning of fossil fuels and land-use practices, causing a ‘blanket-like’ effect on the Earth that keeps warm air from escaping.

**Health impacts from climate change (or health outcomes)** refer to changes in health that are associated with climate change or specific climate impacts.

**Needs assessments** refer to surveys and/or interviews conducted to determine what stakeholders need related to climate change health impacts, including resources, information, education, infrastructure, technical assistance, and funding.

**Stakeholders** refer to a wide variety of groups interested in climate change and health issues. Stakeholders include staff at health and other governmental agencies, non-governmental organizations including healthcare providers, healthcare organizations, non-profit organizations, business organizations, advocacy organizations, academia, and groups representing impacted populations.

**Strategic map** refers to the visual diagram (flow chart) summarizing the health department's strategic plan for climate and health, that serves as a 'road map' or guide to priorities for implementing the plan.

**Vulnerable populations** refer to groups with increased risk of exposure to climate effects and/or risk for health effects from climate change, because of geographic, demographic, or health characteristics.

## ABBREVIATIONS USED IN THIS REPORT

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ACS = American Community Survey  
AHAR = Annual Homeless Assessment Report  
AOGCM = Atmosphere-Ocean General Circulation Model  
ARF = Acute Renal Failure  
BRACE = Building Resilience Against Climate Effects  
BRFSS = Behavioral Risk Factor Surveillance System  
BW = Birth Weight  
BWSP = Bureau of Water Supply Protection  
CAC = Climate Action Council  
CCH = Center for Community Health  
CEH = Center for Environmental Health  
CDC = Centers for Disease Control and Prevention  
CDESS = Communicable Disease Electronic Surveillance System  
CHAI = County Health Assessment Indicators  
CHSI = Community Health Status Indicators  
ClimAID = 2011 Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State (ClimAID) Report, “Responding to Climate Change in New York State” and 2014 update to this report  
CLIMS = Clinical Laboratory Information Management System  
CMIP3 and CMIP5= Coupled Model Intercomparison Project (Phase 3 and Phase 5, respectively)  
CO = Carbon Monoxide  
COPD = Chronic Obstructive Pulmonary Disease  
CRSCI = Climate-Ready States and Cities Initiative  
CSC = Climate Smart Communities  
CVD = Cardiovascular Disease  
DRC = Disaster Recovery Center  
EEE = Eastern Equine Encephalitis  
EPHT = Environmental Public Health Tracking  
FEMA = Federal Emergency Management Agency  
GAM = Generalized Additive Model  
GCM = General Circulation Model  
HFIS = Health Facilities Information System  
HRI = Heat-related Illnesses  
HW = Heat Wave  
ICD = International Classification of Diseases  
IPCC = Intergovernmental Panel on Climate Change  
LBW = Low Birth Weight  
LD = Lyme Disease  
LHD = Local Health Department  
MSFW = Migrant and Seasonal Farmworker  
NARCCAP = North American Regional Climate Change Assessment Program

NAWS = National Agricultural Workers Survey  
NCA = National Climate Assessment  
NCADAC = National Climate Assessment Development and Advisory Committee  
NCDC = National Climatic Data Center  
NDVI = Normalized Difference Vegetation Index  
NIEHS = National Institute of Environmental Health Sciences  
NLCD = National Land Cover Database  
NOAA = National Oceanic and Atmospheric Administration  
NYC = New York City  
NYS = New York State  
NYSDEC = New York State Department of Environmental Conservation  
NYSDOH = New York State Department of Health  
NYSDOS = New York State Department of State  
NYSDOT = New York State Department of Transportation  
NYSERDA = New York State Energy Research and Development Authority  
PHDI = Palmer Hydrological Drought Index  
Profile = Building Resilience Against Climate Effects (BRACE) in New York State Climate and Health Profile  
PsySTART = Psychological Simple Triage and Rapid Treatment  
PTB = Preterm Birth  
RCM = Regional Climate Model  
RCP = Representative Concentration Pathway  
SDWA = Safe Drinking Water Act  
SEHIC = National State Environmental Health Indicators Collaborative  
SES = Socioeconomic Status  
SPARCS = Statewide Planning and Research Cooperative System  
Strategic Map = New York State Department of Health Climate and Health Strategic Map  
Task Force = Sea Level Rise Task Force  
TBD = Tick-borne Diseases  
UHI = Urban Heat Island  
USDA = United States Department of Agriculture  
US EPA = United States Environmental Protection Agency  
WNV = West Nile Virus

## EXECUTIVE SUMMARY

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Increasing levels of greenhouse gases, particularly during the past century, have been associated with rising global average temperatures, extreme temperatures, and heat waves.<sup>1,2</sup> At the same time, other climatic changes in New York State (NYS) have included increased frequency and duration of extreme weather events and coastal storms, increased variability of temperature and precipitation, and higher average precipitation levels. These climatic changes have resulted in flooding events from extreme precipitation and rising sea level due to warmer waters and glacial and sea ice melt.

Warmer, wetter climate trends have already been experienced, as documented in the third National Climate Assessment (NCA).<sup>3</sup> For example, between the years 1958 and 2010, the Northeast saw a 71% increase in extreme precipitation (defined as that amount falling in the heaviest 1% of all its precipitation events). The NYS Energy Research and Development Authority (NYSERDA) 2014 “Responding to Climate Change in New York State (ClimAID) Report” has projected that NYS temperatures will rise from current baselines by a range of roughly 4 to 14 degrees Fahrenheit by 2100, dependent on NYS ClimAID climate region.<sup>2</sup> The NCA projects that NYS will experience an increase in precipitation between 3 to 9% by the end of the 21<sup>st</sup> century.<sup>3</sup>

Climate changes in NYS are connected to public health with reports describing morbidity and mortality following heat waves and severe flooding events. Expanding our understanding of this connection, and describing the potential burden and factors that modify risk, are tools that will advance efforts to improve the adaptive capacity and resiliency of communities across NYS. Climatic changes have been associated in the scientific literature with a host of health impacts, including heat-related illnesses (morbidity) and deaths (mortality), vector-, food-, and water-borne disease, respiratory distress, allergies, and exacerbation of cardiovascular impacts, to name a few.<sup>4</sup>

Impacts range from those that are direct (e.g., extreme heat) to secondary (e.g., vector-borne disease) to tertiary (e.g., food insecurity). The NYS Department of Health (NYSDOH) is prioritizing planning for extreme weather, extreme heat, and vector-, food-, and water-borne disease, all of which are projected to increase in frequency and severity. Certain conditions make people particularly vulnerable to extreme heat and urban heat island impacts such as having lower socioeconomic status (14.9% of New Yorkers live below the federal poverty line) or being in an older age group (14.4% of New Yorkers are age 65 or older).<sup>4,5</sup> Others are at greater risk from climate-health impacts due to working outdoors<sup>6</sup> or due to geography, such as those living near the coast or in a lower-lying flood-prone area.<sup>6,7</sup> Still others in NYS are more vulnerable to climate-health impacts such as excessive heat or air pollution due to a chronic condition such as diabetes<sup>8</sup> (an estimated 8.5% of New Yorkers)<sup>9</sup> or asthma<sup>4,10,11</sup> (an estimated 9.7% of the population).<sup>12</sup>

Because assessments done by NYSDOH staff and other experts have found that some groups have more weather-related health risks than others (Section 5.4), the validity of a composite vulnerability index is being evaluated by NYSDOH. The index will reflect factors such as social and

environmental characteristics which are associated with the population's susceptibility to climate exposures. NYSDOH is collaborating with other government agencies and non-governmental organizations to build community resilience and foster adaptation to prevent climate-related health impacts on the population.

The purpose of this Building Resilience Against Climate Effects (BRACE) in New York State Climate and Health Profile (Profile) is to provide public health professionals in NYS a summary of the public health impacts related to the changing climate. It identifies the populations who are most vulnerable to these health impacts and includes a section detailing collaboration and next steps on this important public health issue. The Profile provides a synthesis of major climate reviews and NYSDOH work for better understanding and quantification of these climate-health impacts and of those most vulnerable to them.

# 1 INTRODUCTION

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## 1.1 BACKGROUND/OVERVIEW

NYS has already been impacted by climate change, including increased annual average temperatures and greater frequency of intense precipitation events such as Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee.<sup>3,13</sup> While NYS is already experiencing these effects, climate projections indicate that it must also prepare for these and possibly other climate impacts to increase.<sup>2,3</sup>

Climate impacts, including extreme heat and extreme weather events as just some examples, pose a significant threat to public health, as stated in national and NYS-specific climate-health reports.<sup>2,4,6</sup> It is essential that planning and adaptation efforts take place now to minimize health impacts on the NYS population and to build resiliency and protection against projected future impacts. This report highlights work that has already been done in NYS and at the national level to provide an understanding of the projected climate impacts and their anticipated effects on public health and enable strategic adaptation planning.

One example of this work in NYS is the potential adaptation strategies, based upon projections (forecasts) from various carbon emissions scenarios, outlined in NYSERDA's 2011 Integrated Assessment for Effective Climate Change Adaptation Strategies in NYS (ClimAID) Report, "Responding to Climate Change in New York State."<sup>13</sup> Another example is the recent National Climate Assessment (NCA), released in April 2014, which includes projections for Northeast climate trends and an extremely detailed look at how a changing climate will impact New Yorkers' health, natural resources, and livelihoods.<sup>3,4</sup> Intervention strategies proposed have included those which reduce pollution, enhance the resiliency of water and sewage systems in our communities, improve how disease is managed, or increase real-time data monitoring surrounding extreme weather events.<sup>13</sup> Some of these are already being implemented in NYS.

NYSDOH was awarded a Climate-Ready States and Cities Initiative (CRSCI) grant from the Centers for Disease Control and Prevention (CDC) in 2010 to build capacity and develop a plan for reducing human health impacts of climate change. In 2013 NYSDOH was awarded three more years of continued funding for this work under receipt of a Building Resilience Against Climate Effects (BRACE) grant, focusing on adaptation planning, implementation, and evaluation.<sup>14</sup>

Following are the five steps of the BRACE Framework, as listed on the CDC website:<sup>14</sup>

- **Step 1:** Forecasting Climate Impacts and Assessing Vulnerabilities, where a health department identifies the scope of the most likely climate impacts, the potential health impacts associated with those climatic changes, and the populations and locations vulnerable to these health impacts within a jurisdiction.

- **Step 2:** Projecting the Disease Burden, where a health department as best as possible estimates or quantifies the additional burden of health impacts due to Climate Change – to support prioritization and decision making.
- **Step 3:** Assessing Public Health Interventions, where a health department seeks to identify the most suitable health interventions for the health impacts of greatest concern. The health impacts will have been quantified or better defined in the previous health risk assessment step.
- **Step 4:** Developing and Implementing a Climate and Health Adaptation Plan, where a health department develops and implements a health adaptation plan for climate change that addresses health impacts, gaps in critical public health functions/services, and a plan for enhancing adaptive capacity in the jurisdiction.
- **Step 5:** Evaluating Impact and Improving Quality of Activities step for the Framework, where a health department evaluates the processes used and determines the value of utilizing the framework and the value of climate and health activities undertaken. This step is also important for quality improvement and to incorporate refined inputs such as updated data or new information.

The creation of this Profile points out the challenges inherent in conducting Step 1 of BRACE and provides the current state of scientific study and surveillance efforts. The Profile presents a picture of the historical climate of NYS, changes experienced in climate as well as projections for future trends in climatic changes, and the impacts that those climate changes may have on the public's health. Section 1 explains the rationale for creating this report and provides context in terms of the BRACE Framework. Section 2 details the climate of NYS and highlights trends seen during the last century (e.g., increased temperature and temperature variability, increased heavy precipitation events) and projections for future climate taken from the ClimAID Report and most recent NCA. Section 3 expands on those climate impacts and provides what we know about the association of each climate impact with a host of health impacts that have been identified through the scientific literature. In Section 4, our most vulnerable populations for experiencing health impacts associated with climate change are highlighted and examples are provided on the population characteristics that could make them more at risk. Examples of populations most at risk include older adults, those of low socioeconomic status, outdoor workers, and others who may be more at risk due to living near the coast or other areas more prone to flooding.<sup>4,7</sup>

Section 5 presents the preliminary overview of initial efforts to assess vulnerability in these populations using this collective knowledge about current and anticipated climate impacts, associated health impacts, and those most at risk. Vulnerability maps are provided that can be used to target adaptation interventions. NYSDOH studies of association between climatic variables (e.g., temperature, universal apparent temperature) and health impacts include technical detail for audiences interested in study design and/or statistically significant results and a summary translating the key takeaway and potential influence on public health practice.

The report includes Section 6 on challenges, followed by Section 7 on collaborative efforts. This section includes descriptions of NYSDOH efforts centered on climate change and sustainability,

both as an independent agency and through interagency working groups or programs. The development of the NYSDOH internal Climate and Health Strategic Map (Strategic Map) is presented in Section 8 for audiences that may be interested in creating a similar plan for their own jurisdiction, including a brief description of needs assessment surveys that were conducted to obtain direction from stakeholders on which issues and which adaptation categories of activities ought to be prioritized. The section ends with an explanation of how the Strategic Map is being acted upon, including current development of a NYSDOH Climate and Health framework utilizing four Climate Impact Teams, focused on prioritizing development of adaptation interventions for extreme heat, extreme weather, food- and water-borne disease, and vector-borne disease. The Profile finishes with the conclusion in Section 9.

## 1.2 HISTORY OF ENGAGEMENT WITH CLIMATE AND HEALTH

NYSDOH has engaged in multiple activities with other government agencies, academia, and nongovernmental organization stakeholders to identify knowledge gaps for the impacts of climate change on human health, craft a research agenda to address these health impacts, communicate findings, and work with decision-makers to incorporate this information into sound health policy and actions. Under the projects entitled “Climate Variability / Change and the Risks for a Spectrum of Diseases” (funded by CDC, 2009-2013) and “Climate Change and Adverse Birth Outcomes: Assessing the Vulnerability of Pregnancy” (funded by NIH, 2012-2014), NYSDOH has evaluated exposure to extreme weather conditions and different climate patterns and the risks they pose for birth defects, low birth weight (LBW), and respiratory, cardiovascular, water-/food-borne, and Lyme disease. The project “Identify Population Vulnerability to Climate Change in New York State and Plan Adaptation Strategies” (funded by NYSERDA, 2013-2015) is identifying and mapping vulnerabilities to heat exposure, related health risks, individual sensitivity, and community characteristics. The project also is mapping access to cooling centers and developing a heat vulnerability index.

NYSDOH was awarded two CDC grants for evaluation of the impacts of Superstorm Sandy, through which NYSDOH will assess multiple health impacts, individual and community vulnerabilities, and risk factors in the aftermath of this storm in NYS. Studies are looking at those who were most vulnerable to mental health problems or other adverse health outcomes after Sandy, depending on certain neighborhood characteristics (e.g., poor quality housing, low hospital density), high social vulnerability (e.g., age > 65 years and living alone, households with > seven residents), or individuals who have been relocated for long periods of time. Findings from this study will help guide state/county/community stakeholders to enhance recovery activities in the Sandy-affected areas and to improve public health practice for future emergency preparedness and response. Through the “Public Health Preparedness and Research to Aid Recovery from Hurricane Sandy” grant, NYSDOH is assessing the public health infrastructure and its capabilities to respond to extreme weather.



performed because there is often a need to address the influence of ozone when studying hospital admissions related to diseases such as respiratory or cardiovascular disease. This merging of climate divisions with ozone regions resulted in 14 regions of relatively homogeneous weather and ozone exposures that have been used in NYSDOH climate and health assessments (Figure 2).<sup>15</sup>

**Figure 2: Overlaying the 10 NYS climate divisions with 11 NYS ozone regions yields 14 weather regions.<sup>15</sup>**



Fletcher BA et al. *Am. J. Epidemiol.* 2012;175:907-916

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American Journal of  
**EPIDEMIOLOGY**

## 2 A CHANGING NEW YORK CLIMATE

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### 2.1 BASELINE CLIMATE DESCRIPTION

NYS is diverse in its topography, its elevations, and varying proximities to large bodies of water.<sup>18</sup> This naturally contributes to variation in climate in different regions of NYS as measured by its temperature, humidity, and precipitation (whether in the form of rain, ice, or snow). New York's 49,576 square miles include 1,637 square miles of inland water. In addition, NYS has boundary water areas including Long Island Sound, New York Harbor, and Lakes Ontario and Erie. It contains two highland regions, with its Adirondack mountain range to the northeast and part of the Appalachian Plateau to the south. Nearly half of NYS is >1,000 feet above sea level, yet valleys prone to flooding can be found in the Finger Lakes Region and along the many rivers that are tributaries to the Great Lakes and St. Lawrence River or that flow southward (e.g., the Hudson River system). NYS encounters storm systems that move across the continent, as well as storm systems moving northward along the Atlantic coast. The interior can be impacted by these coastal storms as well.

Flooding has the greatest potential to occur in spring as the snow is melting, producing runoff that overflows streams and rivers.<sup>18</sup> Heavy showers and thunderstorms can cause flash flooding, with urban areas that have impervious surfaces being at elevated risk compared with more rural areas. The coast, including Long Island's shores, is also at elevated tidal flooding risk from Atlantic storm surges, including those from high winds occurring with hurricanes or tropical cyclones coming up the coast.

Wide variation in temperature is characteristic of NYS, with long periods of abnormally cold or warm weather associated with high pressure systems that come into the eastern U.S.<sup>18</sup> The average annual mean temperature for NYS ranges from 40° Fahrenheit in the Adirondacks to nearly 55° Fahrenheit in NYC. Winters are long and cold, particularly in the Adirondack region which typically has 35-45 days with subzero temperatures. The southern part will have about 15 of those subzero temperature days. In the summer, the climate is cooler in the high elevation areas but warmer at lower elevations, ranging from the upper 70s to mid-80s in most parts. The Great Lakes Plain region has a frost-free growing season that ranges from 150-180 days each year, critical for New York's agricultural production.

The amount of precipitation NYS receives is dependent on a particular region's distance from either one of the Great Lakes or the Atlantic coast.<sup>18</sup> In the western Adirondacks, Tug Hill region, and the Catskill mountains, average annual rainfall is >50 inches annually, while areas in the extreme west receive an average of only 30-33 inches of rainfall. Precipitation amounts are fairly constant throughout the year, versus one season being characteristically drier than another, but the winter season is the time of lowest rainfall. The amount of snowfall received in different sections of NYS is impacted by proximity to the Great Lakes. More than half of NYS can expect to receive >70 inches of snow annually, with the Adirondack and Tug Hill areas averaging >175 inches. The area within

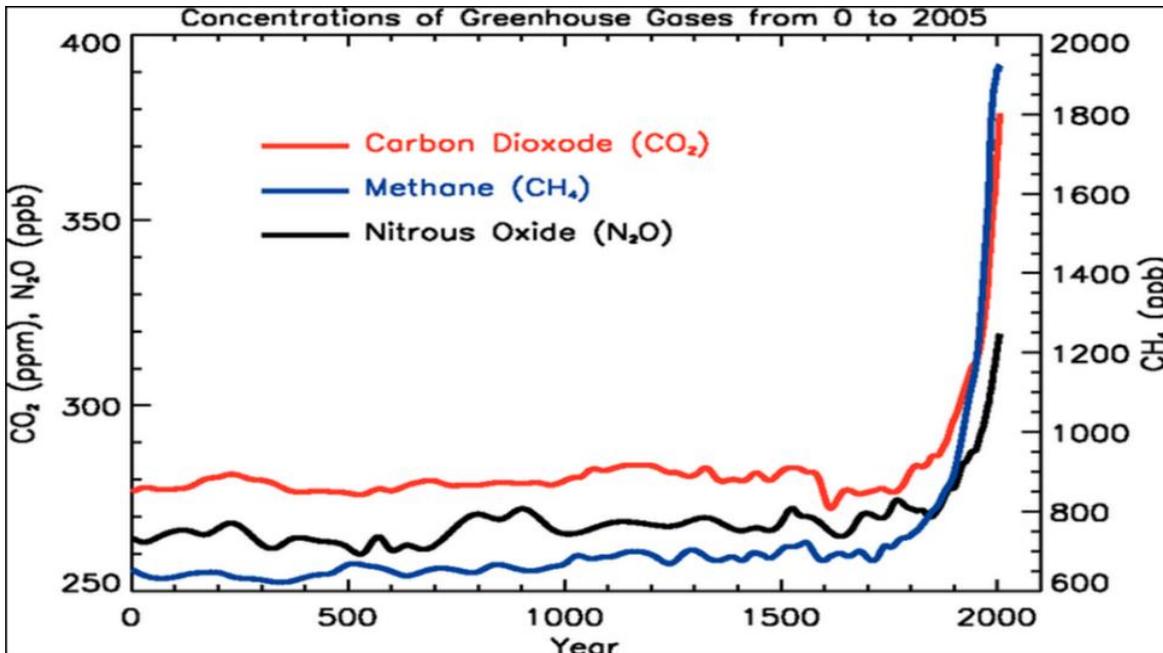
10-30 miles inland of Lake Erie receives 150-180 inches of snow annually, known as “lake-effect” snow. Snow cover begins to develop at some point in November and last through April in the Adirondack and northern lowlands, depending on how much snow falls during winter and how warm the early spring is.

## 2.2 CAUSES OF CLIMATE CHANGE AND NYS CLIMATE TRENDS

Climate change is defined as a statistically significant variation in either the mean (average) state of the climate or in its variability, persisting for an extended period, decades or longer.<sup>19</sup> Some changes in the Earth’s climate can be considered natural, such as climate regulation caused by internal climate system processes (e.g., the El Nino variation that affects rainfall distribution) and by external forcing factors (e.g., changes in solar radiation or volcanic activity). Natural internal processes refer to natural interactions between the atmosphere, the biosphere, and hydrosphere (the oceans). However, other changes to Earth’s climate system are caused by persistent anthropogenic changes (changes caused by humans) in the composition of the atmosphere or in land use.

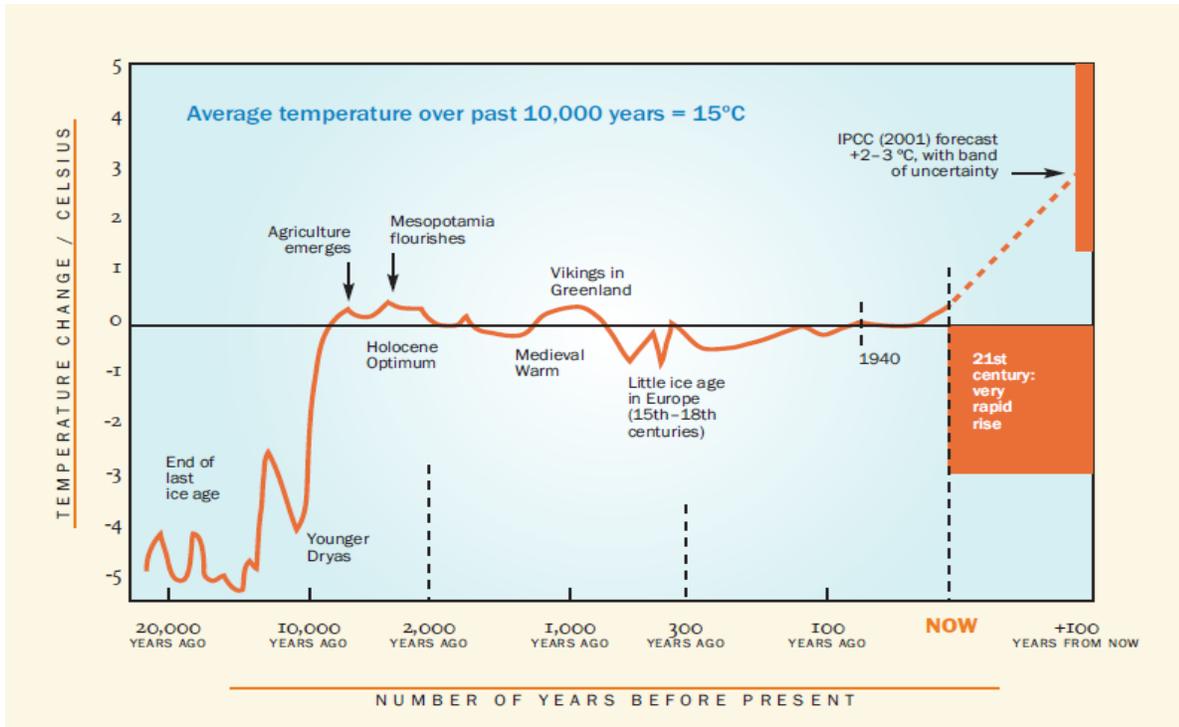
The overwhelming consensus of scientific studies and nearly all climate scientists is that human activity (e.g., transportation, manufacturing, and farming) has impacted climate change. These human activities lead to releases of greenhouse gases from the burning of fossil fuels (such as oil, gasoline, natural gas, and coal). Increases in atmospheric concentrations of long-lived greenhouse gases since about 1750 are attributed to human activities in the Industrial Era (Figure 3).<sup>20,21</sup>

**Figure 3: Global concentrations of long-lived greenhouse gases over the past 2,000 years. Concentration units are parts per million (ppm) or parts per billion (ppb). [Data in ppm indicates the number of molecules of the greenhouse gas out of a million total molecules.]<sup>20</sup>**



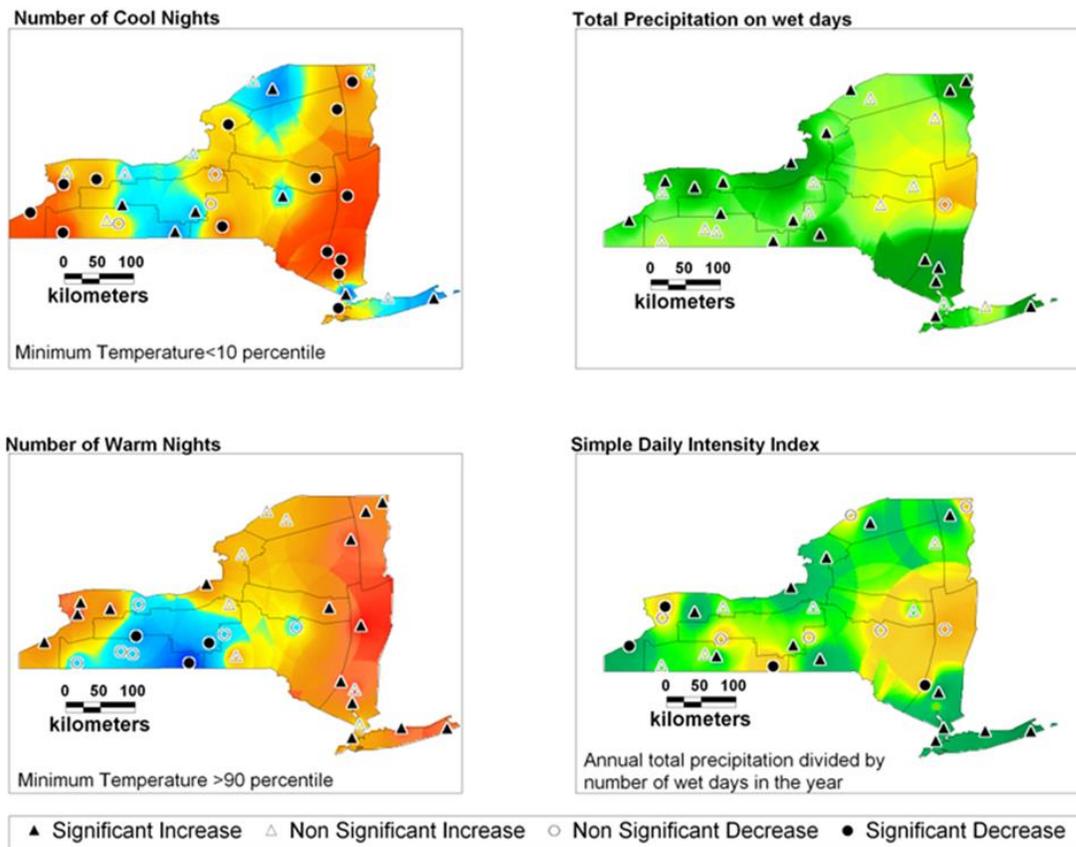
Over the course of the past 260 years, atmospheric concentrations of long-lived greenhouse gases, such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), have increased dramatically as the result of human activities. CO<sub>2</sub> concentrations are currently higher than any time in at least the last 850,000 years.<sup>20</sup> As a result, Earth’s average surface temperature is warmer than any time during the past 20,000 years and the warming is continuing (Figure 4).<sup>21</sup>

**Figure 4: Variations in Earth’s average surface temperature over the past 20,000 years.<sup>21</sup>**



The NCA reports that the Northeast has experienced a greater increase in extreme precipitation than has any other US region, with an increase of 71% in precipitation that falls during the heaviest 1% of all its precipitation events.<sup>3</sup> A NYSDOH study (Figure 5) looked at climate trends across NYS from 1948 through 2008 using indicators for temperature and precipitation.<sup>22</sup> The study found that the state warmed and received more precipitation overall during this period, although it is clear that variability exists between regions of the state. The number of heavy precipitation days increased by 0.99 days during each decade, while consecutive wet days increased by nearly half a day per decade. These findings indicate that NYS is trending towards being warmer and wetter, although not all regions of the state are uniform in their increased temperature or precipitation.

Figure 5: Evidence of increasing warming and wetness in NYS, 1948-2008.<sup>22</sup>



For temperature series on the left, redder hues symbolize warming trends while bluer hues indicate cooling. For precipitation series on the right, greener hues represent wetter and yellow/orange hues represent drier conditions over time.

## 2.3 SOURCES OF INFORMATION ON CLIMATE PROJECTIONS

### 2.3.1 Emissions Scenarios

Emissions scenarios are important for estimating current impacts of climate change and future disease burden associated with these climate impacts. Future climate is determined by the Earth’s response to the amount of future emissions of greenhouse gases, aerosols, and other natural and man-made forcing (changes that affect the energy balance of the planet), along with internal variability inherent in the climate system. These forcings are external to the climate system, but modify how it behaves. A range of assumptions about the amount of future emissions help scientists develop different emissions scenarios, upon which climate model projections are based. The emissions scenarios that have informed work to-date in the NYSDOH studies presented in this report are generated by the Intergovernmental Panel on Climate Change (IPCC).<sup>1,23</sup> They represent

different possible outcomes using alternative assumptions in the future, such as 1) social, 2) economic, 3) technological, and 4) demographic developments. Additionally, NYSDOH plans to obtain climate projections data from the National Oceanic and Atmospheric Administration (NOAA) to simulate future climate using several climate models based on different emissions scenarios. Emissions scenarios are used to describe future pathways of greenhouse gas emissions.

Here are three major emissions scenarios that have been developed and are being considered in NYSDOH work:<sup>1,23</sup>

- 1) The **A2 scenario** assumes a very heterogeneous world with continuously increasing population growth, slow and regionally oriented economic development, and slow technological change;
- 2) The **A1B scenario** assumes a world of very rapid economic growth, a global population that peaks in midcentury and then gradually declines, and rapid introduction of new and more efficient technologies with a balance across all energy sources;
- 3) The **B1 scenario** assumes a convergent world, with the same population growth as in scenario A1B, but with more rapid changes toward a service and information economy, reduction in material intensity, and an increase in clean, resource-efficient technologies.

For the 2013 climate scenarios report, the NCA Development and Advisory Committee (NCADAC) viewed the A2 emissions scenario as the primary basis for projecting the most rapidly warming future climate conditions, the A1B emissions scenario for projecting moderate warming future climate conditions, and the B1 emissions scenario for projecting relatively slower warming future climate conditions.<sup>24</sup>

This Profile also includes climate projections for NYS that are based on the 2014 updated ClimAID report which uses different, more recent emissions scenarios than those mentioned above that have informed NYSDOH studies to-date.<sup>2</sup> The 2014 ClimAID update uses emissions scenarios that consider advances in the modeling science since the initial 2011 ClimAID report. These updated scenarios show trajectories (or pathways) of the concentrations of factors that impact climate change (such as greenhouse gases, aerosols, and land-use changes).

The two scenarios used in the ClimAID 2014 modeling are termed “Representative Concentration Pathways (RCPs)”:

- 1) The **RCP 4.5** assumes substantial reduction in emissions before 2100.
- 2) The **RCP 8.5** assumes greenhouse gas emissions keep increasing to very high concentrations by 2100, and that increasing population places a high demand on energy sources.

Interactive graphics are available for precipitation simulations using the RCP 2.6 (a scenario that assumes more rapid emissions reductions than the RCP 4.5 scenario used by ClimAID 2014 mentioned above) and RCP 8.5 representative concentration pathways emissions scenarios from the third NCA at <http://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change>.<sup>25</sup>

*In practice: Applying emissions / global climate model scenarios to the study of health impacts*

## Projecting respiratory disease hospitalization

A NYSDOH study using global climate model scenarios to estimate future respiratory hospitalization health burden in NYS<sup>11</sup>

**Major Findings:** Based on the assumptions of low to high emissions scenarios, a constant population at baseline level, a standardized 2004 U.S. dollar value, and a 0.93% increased risk of respiratory disease per 1°F increase, the estimated respiratory disease burden (including hospital admissions, days hospitalized, direct hospitalization costs, and lost productivity after adjusting for inflation) attributable to extreme heat at baseline (1991–2004) in NYS was 100 hospital admissions, US\$644,069 in direct hospitalization costs, and 616 days of hospitalization per year. Projections for 2080–2099 based on three different climate scenarios ranged from 206–607 excess hospital admissions, US\$26–\$76 million in hospitalization costs, and 1,299–3,744 days of hospitalization per year. Estimated impacts varied by geographic region and population demographics.

**What this tells us:** This study projects an excess of respiratory admissions in NYS due to excessive heat, which will be 2-6 times higher in 2080–2099 than in 1991–2004.

### 2.3.2 Projection Models

NYSDOH studies have been informed by three NOAA climate projection data sources, listed below:<sup>24</sup>

- 1) Coupled Model Intercomparison Project phase 3 (**CMIP3**): CMIP3 multi-model dataset included fifteen coupled Atmosphere-Ocean General Circulation Models (AOGCMs) from the World Climate Research Programme. Its spatial resolution was 2-3° (100-200 miles). The model simulations based on these 15 AOGCMs cover the 20<sup>th</sup> century and the 21<sup>st</sup> century with both the A2 and B1 scenarios. They also serve as the basis for the following downscaled dataset.
- 2) Downscaled CMIP3 (**Daily\_CMIP3**): Daily\_CMIP3 were downscaled from CMIP3 using the bias-corrected spatial disaggregation method for the period 1961-2100 and its resolution was 1/8° (~8.6 miles latitude and ~6.0-7.5 miles longitude).

#### What does it mean when data are referred to as “downscaled”?

“Downscaled” data are like a zoomed-in view of a map. Before you zoom in on a map of the US, for example, you might see one city represented per state. But when you zoom in closer on NYS, for example, you see more cities represented. With climate data, using the downscaled data lets us look more closely at smaller regions where we can get a more detailed view of the climate impacts.

- 3) North American Regional Climate Change Assessment Program (**NARCCAP**): NARCCAP is producing simulations of regional climate models (RCMs) driven by general circulation models (GCMs). The simulations with a resolution of approximately 30 miles were performed for the period of 1971-2000, 1979-2004, and 2041-2070 for the A2 emissions scenario.

The models in these sources differ in spatial resolution, which relates to the geographic scale at which the model provides information. Most AOGCMs provide information on scales larger than a few hundred miles. The effective size or scale on which climate impacts public health can be much smaller. NYSDOH therefore uses downscaled AOGCMs (the second and third sources listed below), allowing climate impact assessment on smaller geographic areas. The differences of these three projection models are summarized in Table 1.

**Table 1: Summary of the emissions scenarios and their resolution, time, number of models, and outputs.**<sup>24</sup>

Characteristics of Emissions Scenarios			
	CMIP3	Daily_CMIP3	NARCCAP
<b>Downscaling Method</b>	not applicable	statistical	dynamically
<b>Time</b>	1901-2000, 2001-2100	1961-2100	1971-2000, 1979-2004, & 2041-2070
<b>Scenario</b>	A2 & B1	A2 & B1	A2
<b>Resolution</b>	100-200 miles	≈8.6 miles latitude by ≈6.0-7.5 miles longitude	30 miles
<b># of GCMs</b>	15	15	4
<b># of RCMs</b>	not applicable	not applicable	6
<b># of Outputs</b>	15	8	11
<b>Data Type</b>	simulation	simulation	simulation + reanalysis (1979-2004)

## 2.4 SUMMARY OF CLIMATE PROJECTIONS

The Northeast climate trends, based on the NOAA Regional Climate Trends and Scenarios report, were published January 2013 for use in the US NCA.<sup>24</sup> The Northeast in general can expect a continuation of the types of climate hazards that it has faced recently, including heat waves and heavy downpours. NYSDOH has summarized these trends below:

1. Temperature:
  - a. CMIP3 models suggest a significant increase in annual mean temperature for the Northeast. For 2035, 2055, and 2085, the increases range from 1.5-3.5°F (variation depends on region within the Northeast).
  - b. NARCCAP simulations indicated that NYS will experience an increase of around 0-3 days in number of hot days (maximum temperature  $\geq 95^\circ\text{F}$ ) and large decreases in number of days with minimum temperature  $\leq 10^\circ\text{F}$  for the 2041-2070 time period with respect to the reference period of 1980-2000 (A2 scenario). (Note that

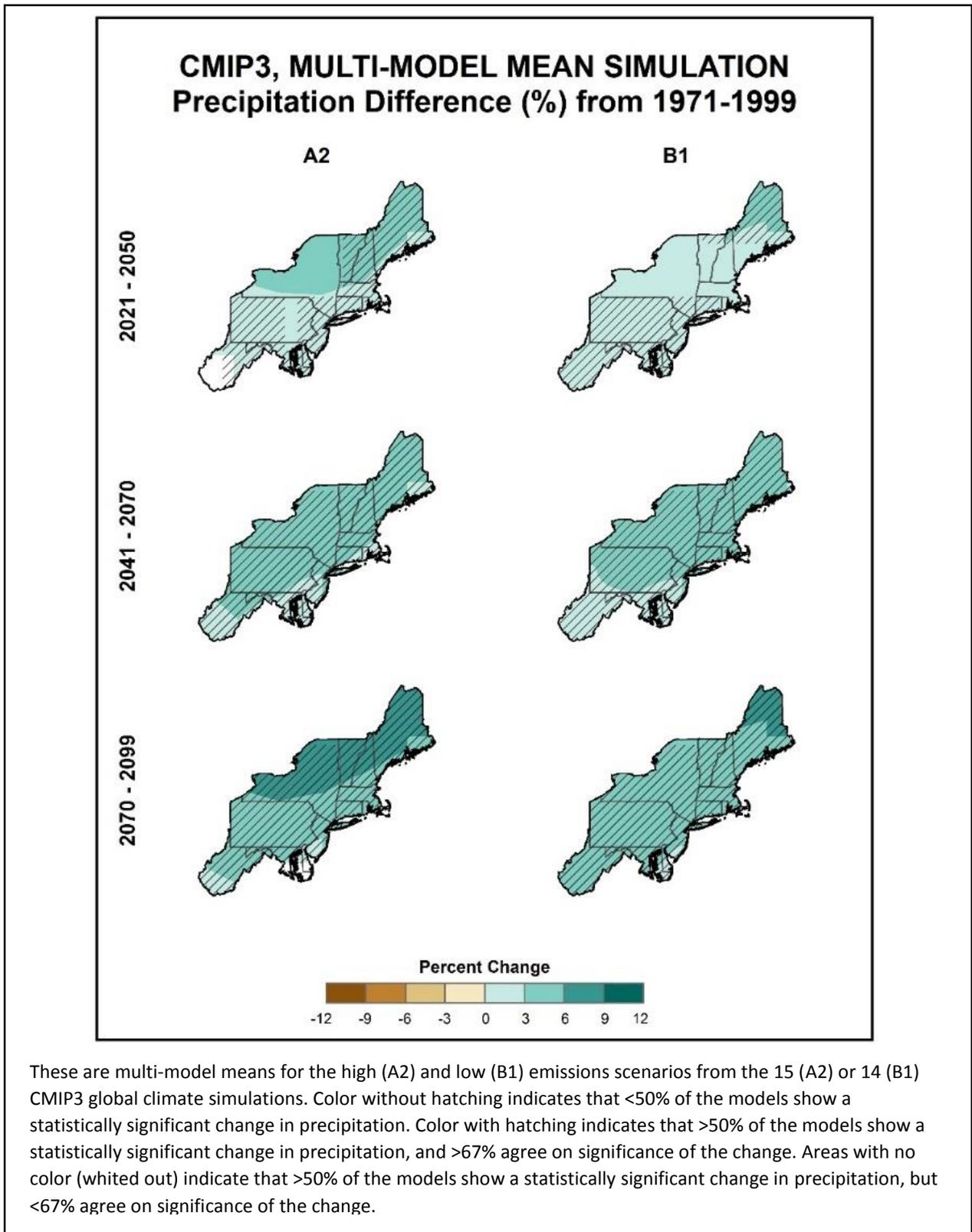
although the overall trend shows this, another important aspect is an increase in number of extreme heat and extreme cold events as NYS experiences greater temperature variability.)

## 2. Precipitation

- a. CMIP3 models suggest an annual precipitation increase under both emissions scenarios. NYS is projected to have an increase of around 0-6% in annual precipitation by 2085 with respect to the reference period of 1971-1999 (A2 scenario). The US Global Change Research Program has projected in the NCA that NYS will experience an increase in precipitation of 3-9% from the 1971-1999 reference period by the end of the 21<sup>st</sup> century, using the CMIP3 global climate simulations (Figure 6).<sup>24</sup>
- b. NARCCAP simulations indicate seasonal changes in precipitation with increases for spring, fall, and winter, and a decrease for summer.
- c. NARCCAP simulations also show that most of NYS is projected to increase 27-30% in number of wet days with precipitation  $\geq 1$  inch by the 2041-2070 time period with respect to the reference period of 1980-2000. The projected increase in the number of consecutive dry days with precipitation  $\leq 0.1$  inches is not significant for the 2041-2070 time period with respect to the reference period of 1980-2000 (A2 scenario).

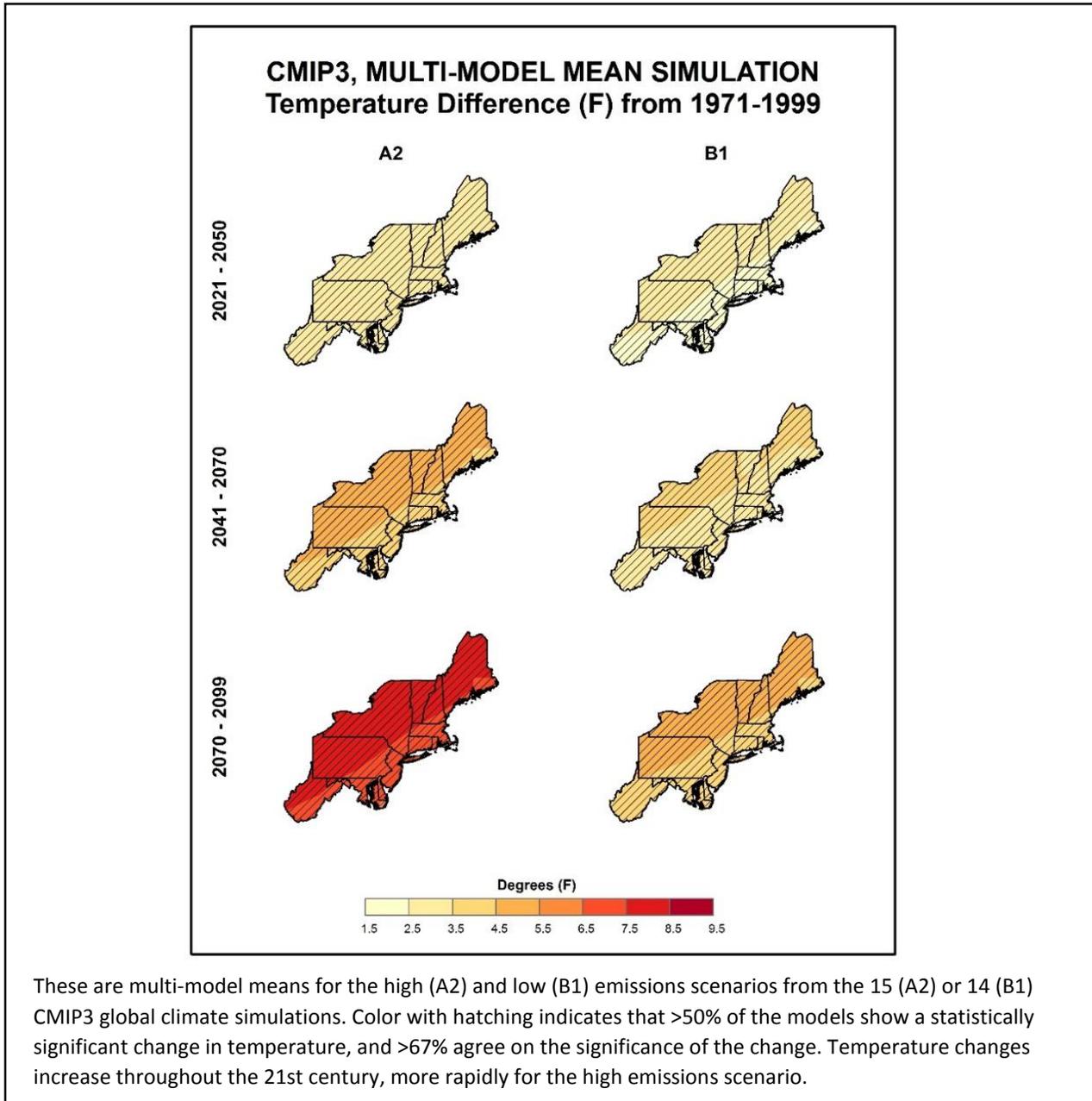
Projections using a more recent model for the Northeast and for specific regions of NYS are presented in Figures 6-8. These projections are important to understand because they provide an estimate of what the Northeast and NYS climate will be like in coming years. The following section discusses NYS climate projections, including movement towards a warmer, wetter climate. Estimating future climate conditions is critical to help NYSDOH focus on the specific health impacts that might be associated with these climate conditions.

Figure 6: Simulated difference in annual mean (average) precipitation (%) for the Northeast region, for each future time period (2021-2050, 2041-2070, and 2070-2099) with respect to the reference period of 1971-1999.<sup>24</sup>



Heat waves are projected to increase in number and in intensity.<sup>3,4</sup> NYS annual mean temperature is projected to increase by a range of 3.5° F to 8.5° F by the end of the century according to the NCA, relative to the 1971-1999 range used as a baseline (Figure 7).<sup>24</sup>

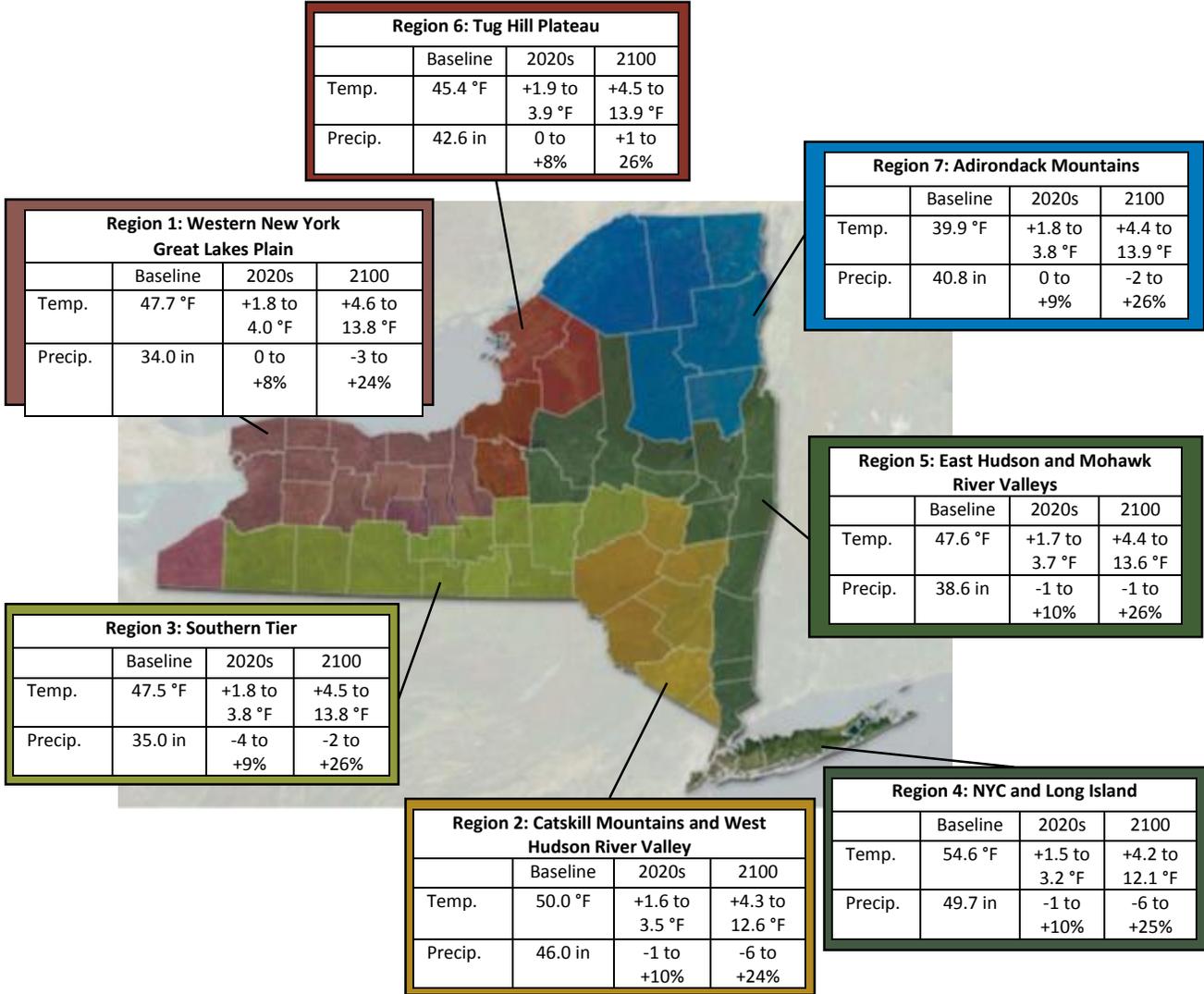
**Figure 7: Simulated difference in annual mean temperature (°F) for the Northeast region, for each future time period (2021-2050, 2041-2070, and 2070-2099) with respect to the reference period of 1971-1999.<sup>24</sup>**



This projection is similar to the ClimAID projection for 2100 that NYS temperatures will rise from current baselines by a range of roughly 4-14° F, dependent on ClimAID-defined climate region (Figure 8).<sup>2</sup>

**Figure 8: Baseline and projected ranges of temperature and precipitation increases\* by the 2020s and 2100, for NYS ClimAID-defined climate regions. Baseline values represent averages for the period 1971-2000. (Map from 2011 ClimAID Report: Responding to Climate Change in New York State; projection data from 2014 update to ClimAID Report).<sup>2,13</sup>**

**ClimAID Temperature and Precipitation Projections for NYS (updated, 2014)**



\*Although there is a range of possible values depending on climate model, on average, the overall projections are for an increase in temperature and precipitation in NYS.

While heavy downpours and heat waves are projected to become more frequent, there is also an estimated increase in temperature fluctuation and more extremes between periods of heavy downpours and periods of drought.<sup>2,3</sup> Changes to ecosystems are projected to occur, that will cause shifts in the geographical ranges of species that could affect our health.<sup>2</sup>

The projections for a warmer, wetter NYS may impact New Yorkers in a variety of ways. Figure 9 lists some unique characteristics and climate impacts for the seven NYS ClimAID-defined regions mentioned in the 2014 ClimAID Report.<sup>2</sup>

**Figure 9: Climate risks and attributes that will be affected by climate change, NYS (Bullets from 2011 ClimAID Report: Responding to Climate Change in New York State).<sup>13</sup>**



While the primary risks have been detailed in this Profile, please refer to the 2011 ClimAID Report (<http://www.nyserda.gov/-/media/Files/Publications/Research/Environmental/EMEP/climaid/ClimAID-synthesis-report.pdf>) and the Third NCA (<http://www.globalchange.gov/>) for more detail on the full range of anticipated climate impacts and risks.<sup>3,13</sup> Section 3 focuses on the specific health impacts associated with a warmer, wetter NYS climate.

### 3 CLIMATE-RELATED HEALTH IMPACTS

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Observations in NYS have demonstrated trends of changing temperature, precipitation, and frequency and intensity of extreme weather events.<sup>2</sup> Climate change projections for the Northeast predict increases in extreme temperatures and precipitation, with NYS projected to become warmer and wetter.<sup>2,3</sup> Primary concerns resulting from these projections include continuation of observed trends, including increased precipitation, greater extremes of temperature, wider variability, and the spread of vectors that carry disease. It is therefore important to examine these observed trends and climate projections in order to characterize current and potential health risks in NYS. This is especially the case for certain vulnerable populations who will experience the negative impacts with greater severity. There is a wide variety of potential health impacts that may be either associated with or exacerbated by climate change, based upon the scientific literature and key climate research reports (e.g., the NCA) detailed in this section. These risks and impacts are being studied in order to design interventions and combat negative health impacts. NYS climate projections coupled with research and evidence of health impacts can be used so that public health agencies may best concentrate their resources and efforts.

NYS is already experiencing the impacts from severe weather. Superstorm Sandy demonstrated to New Yorkers the impact severe storms can have, with 97 deaths in the NYC metropolitan area.<sup>26</sup> While storms like Sandy have direct health impacts, these storms also result in thousands being displaced from their homes and can disrupt regular access to health care services. Severe storms can overwhelm municipal wastewater treatment plants and lead to septic system failures.<sup>3</sup> They have the potential to disrupt the power supply, which can result in risky behaviors (such as improper use of generators) that have health consequences.<sup>27</sup> As demonstrated from Sandy, improper generator use resulted in illness with 80 CO exposures reported to poison centers in NYS.<sup>27</sup> Large scale disasters such as this storm have potential to necessitate sheltering in place, evacuation, relocation, recovery, and rebuilding efforts, all of which have potential health outcomes associated with them.

Exposure to extreme temperatures, both hot and cold, has been linked to higher morbidity and mortality rates, especially among certain populations with greater vulnerability.<sup>28-31</sup> NYS is projected to have an increase in the number of days over 90°F.<sup>3</sup> The net mortality impacts from milder winters and increased summertime heat are being debated in the literature and differ by region.<sup>32</sup> When compared to other weather events, extreme heat events have been shown to cause more deaths than hurricanes, floods, and tornadoes combined.<sup>33</sup> In 2013, NYS ranked second in the US in number of deaths occurring as a result of extreme heat, with ten heat-stroke deaths directly attributed to heat.<sup>34</sup>

With the projections of a warmer and wetter NYS comes a shift in suitable habitats for disease vectors resulting in a change in the survival rates and population density of these vectors.<sup>3</sup> Increased precipitation and flooding brings more standing water and increased breeding and survival opportunities for mosquitos. Health impacts, like an increase in West Nile virus cases, are

thus a concern for NYS. An increase in mean temperature can change the distribution of disease vectors like ticks, making adverse outcomes like Lyme disease a challenge facing regions of NYS not previously familiar with the disease.

The following sections briefly describe the primary health impacts that can be anticipated based upon the climate projections for a warmer, wetter NYS:

### 3.1 HEALTH IMPACTS FROM PRECIPITATION EXTREMES (DROUGHT, FLOODS, HEAVY RAINFALL)

As stated previously, there is an indication that northern areas of the US will be getting wetter and there is further evidence for the continued increase in frequency of heavy downpours.<sup>3,32</sup> This increase in frequency along with projected increases in duration can potentially overwhelm our sewage and water treatment systems, lead to a rise in mold hazards that threaten indoor air quality, and result in an elevation in water-borne disease.<sup>4</sup> The frequency and severity of storms and flooding have increased. Floods are a direct health hazard that can result in injury and death; floods cause approximately 98 deaths per year in the US, on average. Storms and flooding also bring health risks associated with displacement, like the exacerbation of chronic conditions, mental health issues, and increase in infectious disease.<sup>30</sup> Drought can increase environmental risks to public health such as exposure to degraded water quality, reduced water quantity, dust storms and flash flooding.<sup>4</sup>

Displacement and sheltering in place are not without risk. Sanitary conditions, outbreaks, transmission of infectious disease, and falls among older adults are some of the complex public health concerns for evacuated populations in shelters.<sup>35</sup> Displacement due to extreme weather events can result in the disruption of access to health care services that can result in worsening of chronic conditions.<sup>6,32</sup> Power outages leading to an increased use of generators can become a health concern as it was during Hurricane Sandy when carbon monoxide poisonings from improper generator use were reported.<sup>27</sup>

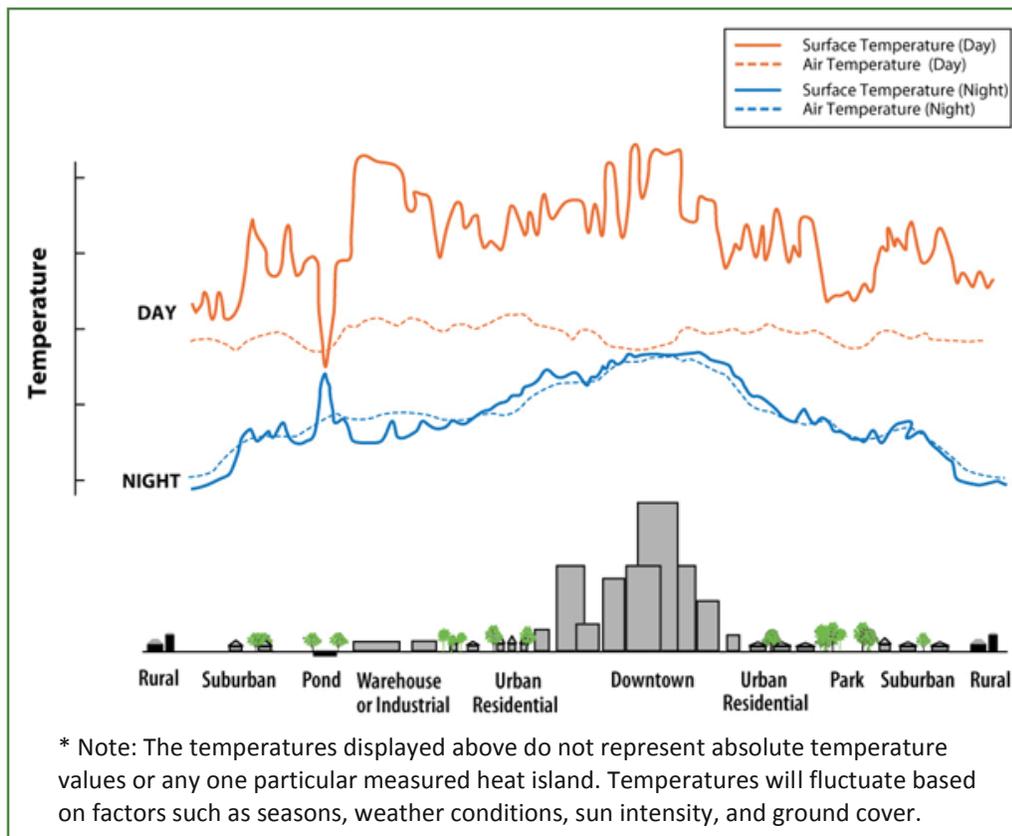
### 3.2 HEAT-RELATED ILLNESS

Measurable outcomes from heat include direct impacts like heat-related illnesses including heat edema, heat stroke, heat cramps, heat stress, and dehydration,<sup>36-38</sup> as well as mortality.<sup>39-43</sup> Outcomes also go beyond direct impacts to include the exacerbation of other existing health conditions such as renal, lung, and cardiovascular disease, especially among children and the elderly.<sup>7,43-44</sup> Increases in emergency department visits, admissions to hospitals, and deaths are observed during and following extreme heat events.<sup>10,37,45-47</sup> Urban areas heighten the risk for heat-related morbidity and mortality due to overall higher temperatures, physical microenvironments like apartments, and high nighttime temperatures brought about by the urban heat island (UHI) effect that prevent the physical environment from cooling off sufficiently.<sup>38</sup> UHIs are defined as higher air temperature (as measured from a sensor generally about six feet off the ground, per the National Weather Service standard) and surface temperature (as measured from a sensor at ground level) in cities compared to rural surroundings due to factors such as heat

absorption by buildings and heat-trapping canyons between high-rise buildings (Figure 10).<sup>48-49</sup> In NYS, it is often the neighborhoods that are home to lower income populations and higher concentrations of older adults where the influence of UHIs on public health are realized.<sup>50</sup>

Increased temperatures are also associated with an increase in the duration and intensity of harmful algal blooms which humans can be exposed to through recreation, drinking water contamination and shellfish contamination.<sup>51</sup> These algal blooms can produce liver and nerve toxins that can cause skin irritation, cramps, vomiting, diarrhea, fever, and weakness.

**Figure 10: Surface and air temperatures vary over different land use areas.<sup>49</sup>**



### 3.3 ILLNESSES RELATED TO AIR POLLUTION

Weather and climate are important determinants of air quality.<sup>28</sup> For example, climate change is projected to increase concentrations of ground-level ozone and particulate matter in many locations.<sup>4,52</sup> Warm-season climate is associated with variability in ozone, and increased summertime ozone concentration is predicted for many regions in the US including the Northeast.<sup>53</sup> Ground-level ozone and fine particles have been linked to negative impacts on human health.<sup>28,53</sup> For example, ground-level ozone has been shown to have harmful effects on those with respiratory conditions like asthma and chronic pulmonary disease with increased hospitalizations and mortality.<sup>1</sup> Additionally, days of high concentration of ground-level ozone and other pollutants in the Northeast often occur alongside the hottest days, and this combination can exacerbate

existing respiratory conditions. Particulate matter exposure can affect morbidity and mortality and has been linked with respiratory conditions and lung disease.<sup>52</sup> Changes in air quality and airborne particulates can also be linked to an exacerbation of cardiovascular disease.<sup>30</sup>

While wildfires are not one of the highest climate-related concerns in NYS, the projected change in warmer, earlier springs may lead to their increased incidence.<sup>51</sup> Data have shown that wildfires in the US have already been increasing in frequency and duration. More frequent wildfires can affect the concentration of particulate matter which could have an impact on air quality and human health, especially respiratory illnesses.<sup>54</sup>

### 3.4 ALLERGIES

The projected changes in climate could have an impact on allergen exposure in the Northeast and NYS. Allergens affected by climate change include pollens and indoor and outdoor molds. Climate change can affect allergic disease due to increased duration of allergy seasons and increased duration and severity of symptoms.<sup>55</sup> Trends in increasing duration of pollen seasons have occurred alongside increases in allergic diseases like asthma and hay fever.<sup>28</sup>

### 3.5 VECTOR-BORNE DISEASE

The Northeast is also projected to experience an increase in and shift in distribution of vector-borne diseases.<sup>3</sup> Vector populations, like tick and mosquito populations, are impacted by a variety of factors including climate.<sup>4</sup> Increases in precipitation and flooding can result in increased breeding opportunities for mosquitos and an increased risk of arboviral diseases such as West Nile. Climate change can potentially expand the geographical range of the vector and shorten the incubation period.<sup>30</sup> Ticks require a humid climate to thrive.<sup>56</sup> The types of changes projected for NYS (i.e., warmer and wetter) have been linked to an elevation in instances of tick activity and Lyme disease.<sup>3</sup> There is evidence that warmer winter weather and an increase in moisture levels in Northeast states were associated with increased Lyme disease incidence between 1993 and 2001.<sup>56</sup>

### 3.6 FOOD- AND WATER-BORNE DISEASE

The Interagency Working Group on Climate and Health summarized ways that climate change increases the risk of health effects related to food and water.<sup>30</sup> These include extreme weather and temperature/precipitation changes directly damaging food crops or contaminating them with toxic chemicals after flooding; higher sea surface temperatures increasing the levels of bacteria like *Vibrio* which contaminate seafood; and higher land/air temperatures increasing the proliferation of enteric bacteria in soil and surface water. In addition, an increase in harmful algal blooms (HABs) due to warmer climate can lead to contaminated seafood causing illness if consumed.<sup>51</sup> Both food and water can be sources of pathogens that cause diarrheal disease to which children and older adults can be extremely vulnerable.<sup>4</sup> Rainfall and runoff have been linked to water-borne disease

outbreaks with significant associations found between precipitation events and water-borne diseases.<sup>57</sup>

Warmer winters have caused NYS shellfish beds to close due to high levels of HABs that poison shellfish.<sup>58</sup> In 2012, shellfish beds in Southold, Suffolk County were closed for the first time in history due to bio-toxins. With NYS projected to have higher temperatures, higher precipitation, and more severe weather and storms, this source of food-borne illness is of concern.

Flooding, increases in temperatures, and nutrient loading all potentially degrade the quality of surface and ground waters used as sources for public water systems. For example, the largest documented outbreak of water-borne illness in the US occurred in Wisconsin following a period of heavy rainfall and runoff that overwhelmed a drinking water treatment plant in 1993.<sup>57</sup> Significant efforts are required to maintain the quality of the finished water when source water degrades. HABs are one such concern for public water systems served by surface water. Concern about HAB contamination of drinking water was heightened nationally when Toledo, Ohio in 2014 ordered a “do not use” for the public water system based on the finding of low levels of a specific HAB toxin in their water. Efforts are ongoing to understand HABs and their potential health impacts in NYS from recreational use as well as drinking water. In addition to public water systems, which serve about 95% of the NYS population, there are as many as 1.1 million households that rely on a private well for drinking water. These individual wells are not regulated under the Safe Drinking Water Act and individual homeowners' ability to respond to the challenges posed by climate change on their drinking water will vary greatly.

A very specific issue being investigated by NYSDOH are the associations between wet weather/rainfall<sup>59-61</sup> or humidity<sup>62</sup> and the occurrence of legionellosis. For waterborne disease outbreaks reported to CDC in 2009-2010, *Legionella* accounted for most (58%) of the drinking water-associated outbreaks and most (58%) of outbreaks associated with other non-recreational water.<sup>63</sup> *Legionella* also accounted for almost all (14/15) of the deaths in these outbreaks.

### 3.7 FOOD SECURITY

Agriculture is impacted by climate and available land and water resources. The projected changes in precipitation include a wetter climate, potentially delaying planting and reducing yields.<sup>64</sup> Increased demands for water during hotter summers could strain the water supply. Heat events, an increase in aggressive weeds, and a change in pest populations may also potentially impact harvest yield. These changes in pests and weeds may bring a need for increased use of herbicides, fungicides, and insecticides, resulting in a health risk for farm workers and their families.<sup>30</sup> Droughts can also impact the growing season and food supply.<sup>64</sup> Their impact can have an effect on the cost and availability of food, causing food security issues.

### 3.8 RATIONALE/METHOD FOR PRIORITIZATION OF CLIMATE IMPACTS

A comprehensive literature review, surveillance data, and reports such as ClimAID and the National Climate Assessment provide NYSDOH with an understanding of the current burden of disease associated with climate and weather and the current state of the science on the climate change projections. Assuming all other factors remain unchanged, the climate projections for NYS (e.g., ClimAID, National Climate Assessment Northeast Report) provide reasonable evidence that the current public health burden associated with certain climate variables will increase.

Concomitantly, needs assessments were developed and conducted with interested stakeholders so that findings from the review could be coupled with a detailed understanding of where the greatest needs were for adapting to these climate and health impacts. In their needs assessment responses, stakeholders identified their currently-faced climate-health impacts. They also expressed the need for guidance and data to work on developing adaptations and for supporting infrastructure needs. Based upon the needs assessment results, scientific literature, and climate projections, NYSDOH has prioritized efforts targeted at adapting to the climate impacts of extreme heat, extreme weather, and vector-borne disease.

## 4 VULNERABLE POPULATIONS

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Identifying which groups are most vulnerable can help NYS more efficiently target climate adaptation efforts and help the LHDs leverage climate change into their existing interactions with these groups. Populations most vulnerable to climate change are those that may experience a greater severity of impact, be less able to engage in adaptive behaviors to minimize exposure, or have less ability to recover from climate related events (i.e., less resilience). This may be due to physiological factors, socioeconomic reasons, or both. Understanding the population makeup of NYS, and the reasons for differing vulnerabilities, is a necessary first step.

A NYSDOH needs assessment survey asked state health department program managers which of their programs' populations are most vulnerable to climate change impacts; answers ranged from "none" to "the entire population." A long list of vulnerable populations was identified and is consistent with the scientific literature. The populations identified included the young, the elderly, certain racial/ethnic populations such as Native Americans, those with low socioeconomic status, those with chronic disease, residents of health care facilities, people who use well water or live in coastal areas or near hazardous waste sites, and people who work outdoors including migrant and seasonal farmworkers (Table 2).

**Table 2: NYSDOH Needs Assessment Survey of Internal Program Managers – NYSDOH program populations vulnerable to climate change impacts. Survey results from 41 NYSDOH program managers, Jan./Feb., 2011 (N=number providing specific answer).**

All--diseases don't discriminate, everyone is vulnerable to some effects (5) and changes in pest/vector/animal habitat (2)
Age: Older adults (4), young children (4), unborn children (1)
Race/ethnicity: American Indians on tribal lands (1), other non-specific groups (1)
Income: Low (3), especially for women, infants, children
Health status: Asthma (1), other respiratory/pulmonary conditions (2), cardiac problems (2), heat sensitive (1), immunocompromised (1), dialysis (1), disabled (1), pregnancy (1), needing nutrition assistance (1), other chronic conditions (4)
Location: Living near hazardous waste sites that are not well contained (1), live in flood prone areas (1), inpatients/healthcare facilities (2), living in coastal areas (1), on residential well water (1)
Occupation: Outdoor workers (farmers/construction) (2), migrant/seasonal workers (1), Certified water operators (1), Bottled/Bulk water facilities (1), inspected facilities (1)
Behavior: Those not using vector protective measures (1)

This list of populations vulnerable to climate change impacts was one of several inputs to inform the identification of stakeholder organizations who were contacted for participation in a survey and/or interview, to ensure that input from stakeholder organizations representing vulnerable

populations informed the prioritization of climate adaptation activities (see more detail regarding stakeholders in Section 7 – Collaborations). In terms of how the most vulnerable populations may be affected by climate change, the NYSDOH program managers indicated that climate change could impact livelihood, could cause increased risk of water contamination (e.g., resulting from unusual weather or flooding), could increase food costs, could make access to care or services more difficult, and increase risk for a wide scope of illnesses or diseases such as heat-related illness or arboviral infections.

Many of the populations identified by the program manager survey are consistent with research on potential health impacts of climate change. Because NYS is projected to become warmer,<sup>2,3</sup> people whom research has shown to be most vulnerable to heat-related illness due to factors such as age or pre-existing chronic conditions like cardiovascular disease may be impacted more than others.<sup>10,38,53,65</sup> Vector-borne diseases are a particular challenge faced by NYS as it has had some of the highest numbers of reported cases with West Nile virus infection on the East Coast and of reported cases with Lyme disease in the nation.<sup>25,66</sup> There is a need to understand how climate change produces a shift in vector-borne diseases and which populations might be affected by these shifts. Both Lyme disease and West Nile virus are most prevalent in the Hudson Valley, Long Island and NYC areas and warmer climate is a potential factor affecting the concentration of these vector-borne diseases.<sup>28</sup> Surveillance and education can help protect vulnerable populations like outdoor workers who may be an increased risk for exposure to Lyme disease.<sup>6</sup> Worsening air quality is projected to be an issue facing NYS.<sup>28</sup> Changes in levels of pollutants and allergens can impact respiratory health especially for children and New Yorkers with allergies and asthma.<sup>4,38</sup>

Potential displacement in populations due to a rise in sea level, flooding, and drought can result in increased health impacts and difficulty in accessing services.<sup>67,68</sup> Hurricane Sandy brought to light populations in NYS with limited capacity to adapt to extreme weather events.<sup>69</sup> Factors like socioeconomic status, age, and being socially isolated impact one's ability to mitigate and recover from the impacts of extreme weather events. The impacts of Sandy included power, heat, and water outages and placed stress on the elderly, the infirm, and those who could not easily evacuate.<sup>69</sup> Evacuation has risks and benefits as does sheltering in place. The factors that determine when to recommend one versus the other for climate related events are still not fully elucidated. Often, the data to make these decisions needs to be local and granular. Awareness of these and other potential climate impacts to NYS coupled with the needs assessment and identification of specific vulnerable populations are the first steps in mitigating their health effects.

The recently released NCA, the ClimAID Report, and the scientific literature provide a more detailed picture about which groups are at a higher risk for the range of climate-related health impacts. Table 3 shows which groups of people have more sensitivity than the general population to the various climate impacts that the NYSDOH has prioritized, including: extreme heat; flooding, drought, hurricanes, and other extreme weather events; vector-borne and other infectious diseases; and food- and water-borne diseases.

**Table 3: Climate-Related Impacts and Vulnerability: NYS population groups with increased vulnerability as determined from NYS specific, Regional or published reports from other geographic regions.**

Characteristic/ Group of People	Type of Climate or Health Impact		
	Extreme Heat Events	Flood, Hurricanes, Droughts and Other Extreme Weather Events	Vector-borne and Other Infectious Diseases
Older Adults	*	*‡	*
Children	*	‡	‡
Low Socioeconomic Status	*	*‡	
Ethnic, Racial Minority	*	†‡	‡
Tribal Populations	‡	‡	‡
Socially Isolated	*	‡	
Homeless	‡	‡	‡
Obese/Diabetic	*		
Those with Asthma, Allergies, or Other Respiratory Illness	*		
Those with Cardiovascular Disease	*	‡	‡
Those with Mental Illness	*	*	
Those who are Pregnant	*	‡	‡
Those with History of Dehydration or who Take Medications that Impact Sensitivity to Sun or Ability to Sweat	‡		
Those Living in Flood-prone Areas or Along the Coast		*‡	
Those who Rely on Private Wells and Small Water Systems		†‡	
Outdoor Workers	‡		†
Migrant and Seasonal Farmworkers	‡	‡	‡

\*NY Study

†Regional Study

‡Relevant evidence from general literature or studies outside of Northeast

## 4.1 OLDER ADULTS

14.4% of New Yorkers are 65 or older.<sup>5</sup> Older adults are particularly at risk for health impacts from heat waves and other extreme weather events, poor air quality, and infectious diseases.

- Older adults have greater sensitivity to climate change due to a variety of physiological and socioeconomic factors including disease prevalence, limited mobility, social isolation, and income loss.<sup>65</sup>
- Older adults have a reduced ability to regulate their own body temperature, are more likely to be taking medications that increase their risk, and are at greater risk of heart failure.<sup>32</sup>
- Older adults have been shown to be more susceptible to effects of air pollution.<sup>7</sup>
- Older adults have also be shown to be more vulnerable to food- and water-borne disease with a greater chance of developing more severe outcomes.<sup>70</sup>



**An older woman protects herself from the sun by wearing a loose-fitting, long-sleeved shirt and long pants. (Photo credit: CDC/Amanda Mills)<sup>71</sup>**

## 4.2 CHILDREN

6% of the population of NYS is under five years of age.<sup>5</sup> Physiologic characteristics of children and infants make them particularly vulnerable to aspects of climate change.<sup>36</sup>

- Children and infants have increased sensitivity to heat events and are at higher risk for heat-related illness and death due to factors like their small ratio of body mass to surface area, higher metabolic rate, inability to increase cardiac output, and a lower amount of sweat produced per gland.<sup>36</sup>
- Children have heightened sensitivity to air pollution due to developing respiratory tracts and an increased breathing rate relative to body size.<sup>32</sup>
- Developmental factors, such as having immature immune systems increase their sensitivity to water-borne and food-borne illnesses.<sup>32</sup>
- They are more vulnerable to complications from infections and have a higher risk of mortality.<sup>7</sup>
- Children are further vulnerable due to their dependence on caregivers and limited ability to make appropriate decisions or take steps to protect themselves independently.<sup>29</sup>

### 4.3 NEW YORKERS OF LOW SOCIOECONOMIC STATUS (SES)

14.9% of New Yorkers live below the federal poverty line.<sup>5</sup> SES is important to examine as financial stress can potentially reduce resilience to climate change and impact the ability to engage in protective and adaptive behaviors.<sup>6,72,73</sup>

- Socioeconomic position has been shown to be a factor in determining health, with the highest risks of premature mortality and morbidity concentrated among those of low SES.<sup>74</sup>
- Lower SES is linked with lower housing quality, reduced access to services, and poorer physical, social, and environmental conditions.<sup>74</sup>
- Studies have shown that socioeconomic factors like housing conditions, access to air conditioning, and educational level are linked to health impacts of extreme heat events.<sup>7</sup>
- Climate change impacts like extreme weather events can adversely affect those with inadequate shelter or those who lack abilities to find alternative shelter when their communities are disrupted.<sup>6</sup>
- Following Hurricane Sandy, a report was issued examining home affordability and insurance rates in NYC's flood-prone neighborhoods. The report found these neighborhoods to be largely working and middle class. Those of lower SES residing in these neighborhoods may experience higher vulnerability to extreme weather events and decreased resiliency.<sup>75</sup>
- Low-income families spend a larger portion of their income on food, energy, and other household needs.<sup>76</sup> As climate change has effects on the cost of these resources, those of lower SES will feel these effects more heavily.

### 4.4 ETHNIC, RACIAL MINORITIES

Within NYS, 18.4% of the population identifies as Hispanic or Latino, 17.5% identifies as Black or African American, 8.2% identifies as Asian, and 1% identifies as American Indian.<sup>5</sup>

- Racial minorities are more likely to have a lower socioeconomic status and are also overrepresented in neighborhoods with constrained economic opportunities, which can increase sensitivity to impact and decrease resilience.<sup>77</sup> A synthesis of recent literature on climate change and vulnerability found evidence that ethnic and racial minorities are more vulnerable to the effects of climate change on health, housing, and the economy.<sup>76</sup>
- Minority neighborhoods have been shown to have higher rates of mortality, morbidity, and health risk factors, and increased exposure to environmental toxicants.<sup>77</sup>
- For those with limited English proficiency, a lack of feasible access to English-based media and health messages can affect their ability to follow weather reports and protective behavior instructions from government organizations.<sup>78</sup> This may contribute to their being unaware of warnings and a reduction in adaptive behaviors, making them more vulnerable to extreme weather events.

## 4.5 TRIBAL POPULATIONS

There are eight federally recognized tribes in NYS.<sup>79</sup> Responses to climate change will need to take into account each tribe’s political and legal status along with the complex history of tribal and state relationships.<sup>80</sup> NYSDOH administers health clinic services (see Figure 11 for locations of Nation health clinic sites) and should be aware of potential increase in demand due to climate change.

- Native communities are at increased risk due to adverse socioeconomic factors such as high poverty and high unemployment.<sup>80</sup>
- Tribes have cultural and economic ties to the land and environment that shape traditions and indigenous ways of life, and these ways may be impacted by projected changes in climate.<sup>80</sup> This includes unique cultural practices that are tied to water, hunting, and fishing rights that are potentially vulnerable to climate change.



Janine Rourke cuts the ribbon at the opening of the new Diabetes Center for Excellence on February 12, 2014. (Photo credit: Saint Regis Mohawk Tribe.)<sup>81</sup>

Figure 11: Map showing locations of Nation health clinics that are part of the American Indian Health Program.<sup>82</sup> Note that Cayuga Nation is a NYS and Federally-recognized Nation that does not have tribal land so it is not listed on this map showing clinic sites.



#### 4.6 NEW YORKERS WHO ARE EXPERIENCING SOCIAL ISOLATION

Social isolation can be characterized by the relative absence of social relationships and networks.<sup>83</sup> Research has examined how social relationships impact individuals and their day-to-day lives. Social networks and relationships are important as they can provide valuable support and resources for individuals, influence behaviors, and affect physical and mental health.<sup>84</sup>

- In creating a heat vulnerability index, Reid, et al. found that social isolation was one of four variables that explained over 75% of the total variance in vulnerability.<sup>85</sup>
- The Semenza, et al. examination of the 1995 Chicago heat wave and the Poumadère, et al. analysis of the 2003 heat wave in France demonstrated that living alone or having limited human interaction was associated with an increased risk of death during hot weather.<sup>86,87</sup>
- Limited social networks and resources may also impact the ability to recover from these extreme weather events. Researchers, in examining impacts of Hurricane Katrina on survivors with chronic medical conditions, found that the presence of social networks was related to lower rates of interruption of medical treatments after the event.<sup>88</sup>

#### 4.7 NEW YORKERS WHO ARE HOMELESS

According to the Annual Homeless Assessment Report (AHAR) to Congress, an estimated 77,430 people were homeless in NYS in 2013 and the state experienced an increase in homelessness between 2012 and 2013.<sup>89</sup> New Yorkers who are homeless and living outdoors are more susceptible to conditions related to exposure to the elements.<sup>90</sup>

- Homeless individuals are more likely to live in marginalized areas that are more susceptible to environmental hazards.<sup>90,91</sup> This means an increase in extreme weather events could impact the homeless more severely. In studying neighborhood effects and heat-vulnerability in Arizona, researchers found that the majority of heat deaths among the homeless were reported in areas that experience an urban heat island effect and low socioeconomic status.<sup>91</sup>
- The homeless are more likely to have health risk factors that are impacted by climate change and chronic conditions that can be exacerbated by climate change (including lung, cardiovascular, and renal conditions).<sup>90</sup>
- Chronic conditions including asthma, bronchitis, emphysema, hypertension, and diabetes are often poorly controlled among those who are homeless.<sup>90</sup>
- Delays seeking health care and low adherence to medical treatment regimens increases the severity of chronic diseases among homeless populations.<sup>90</sup>
- Lung conditions can be affected by increased amounts of air pollutants, making homeless individuals with these conditions more vulnerable due to greater exposure to outdoor air.<sup>90</sup>
- Certain medical conditions that are more common among the homeless compromise their immune system which heightens vulnerability to infectious diseases.<sup>90</sup>

#### 4.8 NEW YORKERS WITH DIABETES OR WHO ARE OBESE

An estimated 8.5% of the NYS population has been diagnosed with diabetes.<sup>9</sup> The prevalence of diagnosed diabetes is highest (approximately 20%) among older adults (65+ years of age).<sup>9</sup> The older adult population is already at increased vulnerability for a number of climate-related health impacts.<sup>65</sup> In 2003, NYS ranked second-highest for healthcare spending related to obesity for its adult population, spending over \$6 billion.<sup>92</sup>

- Extreme heat can pose greater risk to individuals with diabetes because glucose levels are already unstable and fluid and electrolyte imbalances can exacerbate these further.<sup>8</sup>
- Peripheral neuropathy can also cause a decrease in ability to sweat, and diabetes is known to cause poor ability to regulate temperature,<sup>8</sup> posing an increased risk of heat-related illness during periods of extreme heat.
- An analysis of the relationship between high ambient temperatures and mortality cited obesity as one factor contributing to heat-related mortality.<sup>93</sup>
- In addition to studies showing that obesity can make an individual more vulnerable to the climatic impact of extreme heat;<sup>94,95</sup> research has shown that obesity can result in multiple health conditions which are themselves risk factors for increased vulnerability to extreme heat, such as cardiovascular disease, type 2 diabetes, and respiratory problems.<sup>95-97</sup>
- It is more challenging for an obese individual to dissipate heat than an individual of healthy weight, and people who are obese have a greater temperature baseline due to their generation of more heat than a person in a healthy weight range.<sup>98</sup>

#### 4.9 NEW YORKERS WITH ASTHMA, ALLERGIES, OR OTHER RESPIRATORY ILLNESS

According to the NYS Asthma Surveillance Summary Report (2013), an estimated 1.4 million NYS adults, or 9.7% of the population, have asthma.<sup>12</sup> The prevalence in the adult population for NY adults is above the national average, and the number of adults diagnosed has generally been trending upward. The prevalence for children was 10.4% during 2006-2010 or an estimated 456,000 cases. Asthma was a cause of >38,000 hospitalizations and >160,000 emergency department visits during 2009-2011. A number of New Yorkers also suffer from chronic respiratory conditions like chronic obstructive pulmonary disease (COPD). In 2012, chronic lower respiratory disease was the cause of 6,986 deaths in NYS and was the third leading cause of death.<sup>99</sup>

- Climate change can have an impact on respiratory conditions and allergic disorders. It can contribute to shifts in pollen concentration and production and worsen outdoor and indoor air quality.<sup>4</sup>
- Scientific literature has established that asthma can be exacerbated by certain triggers. These triggers can be allergic or non-allergic and include weather patterns, pollen and mold seasons, air pollution, and indoor allergens.<sup>28</sup>
- Climate change can affect allergic disease by increased duration of allergy seasons and symptoms, and increased severity of symptoms.<sup>55</sup>

- There is evidence that air pollution is associated with impaired respiratory health, and that pollution interacts with pollen grain allergens to increase the risk of being prone to allergies and exacerbate allergic symptoms.<sup>44</sup> This can have an impact on New Yorkers with asthma, allergies, and other respiratory conditions.
- Respiratory hospital admissions have been associated with excessive heat and this is projected to increase with the change in climate.<sup>10,11</sup>

#### 4.10 NEW YORKERS WITH CARDIOVASCULAR DISEASE

Biological sensitivity to climate change that increases vulnerability can include existing chronic medical conditions.<sup>7</sup> Cardiovascular (heart) disease is the leading cause of death in NYS, representing 29% of the deaths (See Figure 12).<sup>99</sup> Age-adjusted prevalence estimates for NYS demonstrate that 7.6% of adults have some form of cardiovascular disease.<sup>100</sup>

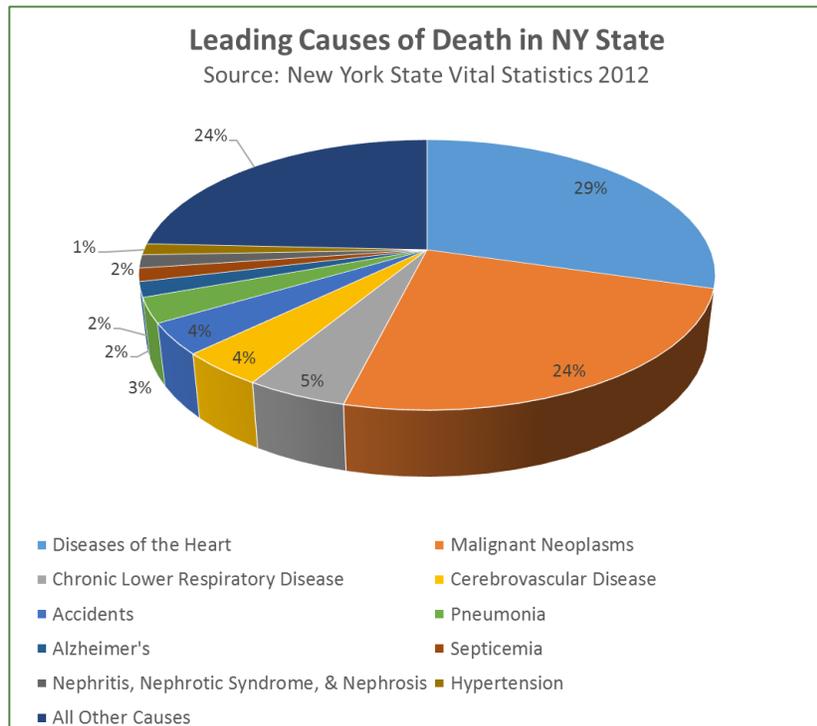
- There is evidence that cardiovascular disease can increase sensitivity to extreme heat and extreme cold.<sup>30</sup>

Underlying

cardiovascular disease can interfere with a body's ability to regulate temperature and respond to heat stress.<sup>28</sup>

- Hospitalizations for cardiovascular conditions are shown to increase with exposure to extreme heat.<sup>10</sup>
- Extreme weather events have been associated directly with cardiovascular-related mortality, including stress-induced myocardial infarction, and indirectly, such as delays in accessing medical care for chronic cardiovascular conditions.<sup>7,30</sup>
- Increases in airborne particulate matter have been associated with hospitalization and mortality from cardiovascular disease, and heat has been shown to further exacerbate these negative impacts of particulates.<sup>30</sup>
- Cardiovascular conditions can also increase risk of susceptibility to vector-borne diseases.<sup>30</sup>

**Figure 12: Cardiovascular disease is the most common cause of death in NYS.<sup>99</sup>**



#### 4.11 NEW YORKERS WITH MENTAL ILLNESS

18.6% of people in NYS report experiencing mental illness and 3.6% report experiencing serious mental illness.<sup>101</sup> A growing body of research is demonstrating that climate change can have an influence on mental health in a number of ways. Potential climate change impacts include increases in mental disorders and worsening of mental health outcomes.<sup>43</sup>

- Extreme weather events (and other kinds of disasters) can contribute to immediate worsening of prevalence and severity of mental health issues.<sup>102</sup> This was evident in the response to Hurricane Katrina.<sup>103</sup> Outcomes associated with loss, displacement, and disruption of normal life need to be taken into account in mitigating the impacts of these events.
- Social, economic, and environmental aspects of communities that promote mental health can experience disruptions due to climate-related events; climate change emerging as a global threat also can cause general distress and anxiety in community members.<sup>102</sup>

#### 4.12 WOMEN WHO ARE PREGNANT

Most women have one or more pregnancies in their lifetime, and environmental exposures during pregnancy may have a significant health impact for both the women themselves and their children. Studies are limited which document the health consequences of maternal exposure to extreme weather factors, although biological plausibility for adverse effects is suggested by prior research.

- Studies of seasonality have found birth weight and pregnancy complications to be associated with variation in meteorological factors. Lower birth weights are associated with extreme heat exposure, and breastfeeding practices can be interrupted by extreme weather.<sup>29</sup>
- Women who are pregnant have unique health concerns to be considered both during and after disasters, especially if the disaster occurs in a region where women are already at greater risk for adverse pregnancy and infant outcomes.<sup>104</sup> These events can result in exposure to toxins, limited access to safe drinking water, a disruption in health care services, and psychological distress; all of these factors can contribute to adverse health outcomes.<sup>7</sup>
- Adverse outcomes, like risk of some birth defects, have been associated with extreme heat events; e.g., heat waves were associated with congenital cataracts.<sup>105</sup>
- Evidence also suggests that pregnant women may be more vulnerable to vector-borne diseases like malaria.<sup>106</sup>
- During pregnancy, women may be at greater risk for enteric viruses with the potential to transmit the infection during birth or shortly afterwards.<sup>70</sup>



**Women who are pregnant should be aware that environmental exposures may impact themselves and their children. (Photo credit: CDC)<sup>71</sup>**

#### 4.13 NEW YORKERS LIVING IN FLOOD-PRONE AREAS OR ALONG THE COAST

Areas prone to flooding are increasing, as documented in maps updated to show additional vulnerable areas.<sup>107</sup> For example, Federal Emergency Management Agency (FEMA) 2013 flood plain maps show 400,000 NYC residents living in the flood plain and 270,000 working in high risk areas, compared to 1983 maps indicating 218,000 residents at risk. The number of NYC residents at risk is projected to be 800,000 by mid-century.

- Populations living in certain regions may experience increased vulnerability to coastal surges or riverine flooding.<sup>6,7</sup>
- Precipitation trend data show an increase in the frequency and intensity of heavy downpours in the Northeast—an indication that northern areas will be getting wetter.<sup>32</sup>
- The increase in extreme precipitation and total precipitation has been linked to flooding events.<sup>108</sup>
- For example, the heavy rains that came with Hurricane Irene were part of a larger pattern of wet weather that predisposed the region to flooding.<sup>3</sup>
- Increase in frequency and intensity of rain events can contribute to an overwhelming of water treatment systems and an increase in disease outbreaks.<sup>6</sup>
- As climate change affects sea levels and the frequency of intense storms, those who live in flood-prone areas or along the coast of NYS are at increased risk of impact including having water supplies threatened.<sup>6</sup>



**Impact of flooding following Hurricane Sandy, Long Beach, NY. (Photo credit: Nassau County Health Department)<sup>109</sup>**

#### 4.14 NEW YORKERS WHO RELY ON PRIVATE WELLS AND SMALL WATER SYSTEMS

Dependence on private wells for drinking water may increase risks for climate-sensitive health impacts.<sup>7</sup> Research is ongoing to determine just how climate change will affect the water supply, particularly drinking water. Studies indicate that private wells and small water systems are vulnerable to a variety of conditions.

- Drought can mean a private well does not experience a recharge rate capable of meeting demands, whereas flooding and extreme precipitation can impact the ability of a well to produce a safe supply of water.<sup>110</sup>



**Simple Pump installed in an old pit well provides water to the community garden in Clay, New York. (Photo credit: SunshineWorks.com)<sup>111</sup>**

- The increase of extreme weather events can overwhelm small water systems and affect the hydrologic cycle, impacting quality of surface and groundwater.<sup>110</sup>
- The Northeast region is experiencing greater frequency and intensity of rainfall and this pattern is projected to continue.<sup>32</sup> Rainfall and runoff have been linked to water-borne disease outbreaks.<sup>57</sup>
- Proper construction and maintenance of these water systems can help prevent some of the possible health impacts.<sup>112,113</sup>

#### 4.15 OUTDOOR WORKERS

Outdoor workers are at a higher risk for adverse climate-related health impacts like extreme heat or vector-borne disease due to spending a greater amount of their day outdoors than people with indoor professions.<sup>6</sup>

- Climate change is predicted to increase the suitable habitat for mosquitos that transmit West Nile Virus, and has also been linked in several studies to increased Lyme disease incidence.<sup>3</sup>
- Outdoor workers in certain areas, like electricity and pipeline utility workers in rural and suburban areas, have an increased risk of infection with Lyme disease.<sup>6</sup>
- Outdoor workers are at risk for hantavirus infection, which may be increased due to climate impacts on infected rodents.<sup>114,115</sup>
- Outdoor workers have greater exposure to ozone air pollution and are vulnerable to heat stress, particularly if the job requires heavy exertion.<sup>7</sup>
- Guidelines have been produced to help eliminate or reduce work conditions (e.g., long hours, insufficient breaks, underuse of protective clothing) that may exacerbate exposure and health risks.<sup>116,117</sup>

#### 4.16 MIGRANT AND SEASONAL FARMWORKERS

There are an estimated 24,000 migrant and seasonal farmworkers (MSFW) in NYS; of these, 15,000 received services as reported by health clinic contractors for the migrant and seasonal farmworker program in 2012. Findings from the National Agricultural Workers Survey (NAWS) released in 2005 demonstrated that a large portion of farmworkers had limited English proficiency and the highest grade completed on average was seventh grade.<sup>118</sup> While wages had seen an increase, many farmworkers still reported income levels at or below the federal poverty line.<sup>118</sup>

- The most common diagnosis categories reported by clinics that serve migrant and seasonal farmworkers in NYS include musculoskeletal problems, diabetes, respiratory illness, and dental care (see Table 4).

**Table 4: Most common diagnoses in MSFW population, reported by clinics who are part of the NYSDOH Migrant and Seasonal Farmworker Health Program per 2012 annual reporting.**

<b>Most Common Diagnoses in NYS MSFW Population (2012)</b>	
<b>Diagnosis Category Provided by MSFW Program Health Clinic</b>	<b>Number of Cases</b>
Dental care	4,300
Musculoskeletal problems	2,051
Diabetes	1,148
Respiratory	785

- With climate change causing more variability in precipitation and temperature, migrant and seasonal farmworkers may also potentially be exposed to more risk due to a fluctuation in length of work periods, sometimes needing to work longer than normal hours over short periods of time when required by type of crop or farm task.<sup>118</sup>
- As the Northeast climate changes, summers are predicted to become longer and hotter.<sup>3</sup> This can result in a longer growing season with increased heat exposure and greater vulnerability for those employed on farms and in the fields, especially during those periods of longer work days.
- Another approaching challenge of climate change is one of increased insect pests and more aggressive weeds;<sup>3</sup> farmers may need to use greater amounts of herbicides and pesticides in response to an increase growth of pests and weeds.<sup>4</sup> Those employed on farms will potentially come into increased contact with these substances.
- Migrant and seasonal farmworkers are also vulnerable in terms of confounding factors like a lower socioeconomic status, limited English proficiency, less access to social networks and resources, and lower resilience in terms of ability to recover from negative impacts of a climate event.<sup>119</sup>
- Housing conditions of farmworkers can consist of factors (such as structural damage, mold, rodent infestation, and unsanitary facilities) that have been associated with infectious disease.<sup>120</sup>



**Apple harvesting by a migrant worker in NY. (Photo credit: Joyce Dopkeen for The New York Times)<sup>121</sup>**

## 5 ASSESSING VULNERABILITY TO CLIMATE-RELATED HEALTH IMPACTS

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### 5.1 EVALUATING EXPOSURES

Studies conducted by NYSDOH staff have found large variations in observed associations between weather factors and health impacts in various geographic areas of NYS. One possible explanation for this heterogeneity is that regional socioeconomic, environmental and behavioral factors may interact with weather factors to lead to different human health impacts. These social or neighborhood-level factors may affect individual response or adaptive capacity to extreme heat, and contribute to a population's susceptibility to heat exposures. The population, social, and environmental characteristics indicative of heat-health vulnerability according to the scientific literature and our preliminary findings are identified throughout this section. These characteristics have been derived from the individual level information available in the Communicable Disease Electronic Surveillance System (CDESS)<sup>i</sup> incident cases and the Statewide Planning and Research Cooperative System (SPARCS)<sup>ii</sup> hospital discharge databases, and community environment and social vulnerability data from the US Census and the American Community Survey (ACS).<sup>iii</sup> NYSDOH also generates County Health Assessment Indicators (CHAI)<sup>iv</sup> for major public health indicators such as chronic disease morbidity and mortality and socio-demographic information. Data on health care access and relevant comorbidities are available from the annual Behavioral Risk Factor Surveillance System (BRFSS)<sup>v</sup> survey conducted in NYS.

The primary reason to evaluate exposures is to help identify and implement interventions designed to reduce the effects of climate change. To begin evaluating exposures we are evaluating the validity and utility of a "composite index" that reflects the population, social, and environmental factors that contribute to people's vulnerability to heat-related health effects. Indices for other climate-related health impacts also will be developed based on studying vulnerability to climate impacts.

A first step in assessing vulnerability to climate impacts is to develop health impact definitions that are associated with sub-categories of diseases and illnesses, and with specific ICD 9 and/or E Codes, such as tick-borne diseases, respiratory diseases, and heat-related illness. Variables including temperature (daily, annual average, diurnal), number of days >90°F, heat index/apparent

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<sup>i</sup> The Communicable Disease Electronic Surveillance System is a database used for morbidity case reporting.

<sup>ii</sup> The Statewide Planning and Research Cooperative System is a comprehensive all payer data reporting system created to collect information on discharges from hospitals at the patient level.

<sup>iii</sup> The American Community Survey is an on-going survey that the Census Bureau has implemented to obtain community data on an annual basis versus Census data that is provided once every ten years.

<sup>iv</sup> County Health Assessment Indicators are a series of tables presenting selected public health indicators by 14 health topic areas (as determined by state and local health department representatives), defining a list of indicators, the source for the indicator data, and a contact person.

<sup>v</sup> The Behavioral Risk Factor Surveillance System is an annual statewide telephone surveillance system designed by CDC to monitor modifiable risk behaviors and other factors contributing to the leading causes of morbidity and mortality in the population.

temperature (combination of temperature and relative humidity), relative humidity, ozone level, wind speed, number of extreme heat events, and length of heat event can be used to track impact of climate on extreme heat-related morbidity and mortality.

Following are examples of indicators that could be used to monitor these climate impacts and health impacts:

- Daily monitoring of temperature
- Daily monitoring of humidity
- Daily monitoring of ozone
- Daily monitoring of wind speed
- Daily monitoring of dew point
- Hourly (where available) measurements of ozone, fine particulate, carbon monoxide, sulfur dioxide, nitrogen oxides, methane/nonmethane hydrocarbons, and meteorological data
- Daily monitoring of air quality
- Daily heat-related emergency department visits and hospitalizations, e.g., as activated during heat waves

Next, exposure definitions must be defined for metrics such as daily temperature, universal apparent temperature, and heat waves. For example, the definition NYSDOH uses in its studies for the temperature indicator “Heat Wave 97” is when daily maximum temperatures are  $\geq 97^{\text{th}}$  percentile of daily maximum temperatures for two or more days. These outcome and exposure definitions can be seen in practice in the boxed studies on heat featured in this section.

To develop the composite index referred to above, we must assess vulnerabilities related to projected climate impacts. In accordance with projections from ClimAID and the NCA Northeast section, NYSDOH has begun to look at vulnerabilities for a broad range of health impacts that are associated with heat, extreme weather, vector-borne disease, and food- and water-borne disease. This section uses NYSDOH efforts related to heat-health impacts as an example of the steps necessary to inform a composite heat index and assess vulnerability. These health impacts include direct and indirect effects of heat. Also presented in this section is information from the scientific literature on vulnerability for the other health impacts mentioned.

A population’s vulnerability to heat-related health impacts can be estimated from one or more indicators that reflect people’s sensitivity to heat, as determined by previous studies in NYS and in other areas. Factors that impact vulnerability may be population factors (see Table 5), social factors (see Table 6 for factors and Appendix 1 for maps), or environmental factors (see Table 7 for factors and Appendix 2 for maps). Depending on the group using the vulnerability assessments, a table or a map displaying the results may be more useful. NYS is developing maps which are based on a composite index of multiple risk factors and will evaluate their validity and utility.

**Table 5: Population factors to be evaluated when assessing vulnerability to heat.**

<b>Characteristic Associated with Heat Vulnerability</b>	<b>Subgroups to be Evaluated</b>
Gender	Male, female
Race/Ethnicity	Race varies by study to include: white, black, Native-American, Asian, others Ethnicity: Hispanic/Non-Hispanic
Age	Sub-groups of age vary by study
Residential area	Defined by the 14 weather regions (NIEHS); based upon geocoded patient address  Regions include: LaGuardia, John F. Kennedy, Staten Island, Long Island, Westchester/White Plains, Hudson Valley South, Hudson Valley North, Binghamton, Mohawk Valley, Adirondack & North, Great Lakes-Rochester, Central Lakes, Western Plateau, and Great-Lakes-Buffalo  Note: These regions were based on the NCDC’s 10 NYS Climate Divisions. Because there is often a need to address the influence of ozone when studying hospital admissions related to diseases, such as respiratory or cardiovascular disease, the 10 NYS Climate Divisions were modified by overlaying and merging them with the 11 ozone regions developed for NYS. This resulted in 14 regions of relatively homogeneous weather and ozone exposures.
Income	Varies by study: Low, high, or defined by quartiles
Insurance type	Uninsured, Private, Medicare, Medicaid
% population that owns/uses air conditioning	Air conditioning present and uses, air conditioning present but not used, no air conditioning

**Table 6: Social vulnerability factors for extreme heat were selected based on NYSDOH findings and other published literature.**

<b>Social Factor Associated with Heat Vulnerability</b>	<b>Definition</b>	<b>Data Source</b>
Living alone	Percentage of household within a county with one household member	Census <sup>122</sup>
Households with ≥ seven residents	Percentage of household within a county with seven or more household members	Census <sup>122</sup>
Chronic disease rates	Percentage of population with chronic diseases or morbidities including diabetes, hypertension, obesity, endocrine- or renal-related disease, cardiopulmonary disease, mental illness	CHSI Risk Factors for Premature Death <sup>123</sup>
Disability	Percentage of unemployed and severely work disabled population (defined as those with inability to work due to mental or physical health problems) within a county	CHSI Vulnerable Populations <sup>123</sup>
Low education	Percentage of population in a county with less than high school diploma	Census <sup>122</sup>
Below poverty	Percentage of households with 1999 income below the poverty level	CHSI Demographics <sup>123</sup>
Smoking rate	Percentage of population within a county that smokes	CHSI Leading & Risk Factors <sup>123</sup>
Substance use disorders	Percentage of population within a county that has a substance use disorder	CHSI Vulnerable Populations <sup>123</sup>
House built before 1980	Percentage of houses built before 1980	Census <sup>122</sup>
Non-citizen/Non-English speaking	Percentage of population within a county that is foreign born	Census <sup>122</sup>

**Table 7: Environmental factors associated with a population’s vulnerability to heat in NYSDOH studies and other published literature.**

<b>Environmental Factor Associated with Heat Vulnerability</b>	<b>Definition</b>	<b>Data Source</b>
Land coverage	Percentage of open/undeveloped land in a county	National Land Cover Database (NLCD) <sup>124</sup>
Built environment	Percentage of low-, medium- and highly-developed land in a county	NLCD <sup>124</sup>
Housing density	Total housing units in a county per square mile of land area (count)	Census; <sup>122</sup> NLCD <sup>124</sup>
Population density	Total population in a county per square mile of land area (count)	CHSI Demographics <sup>123</sup>
Hospital density	Total number of hospitals in a county per square mile of land area (count)	NYS Health Facilities Information System (NYS HFIS) <sup>125</sup>
Average Temperature	Daily Average Temperature by county	NCDC <sup>126</sup>
Air pollution level	Average Daily eight-hour mean Ozone and Average Daily 24 hour PM2.5 at county level	US Environmental Protection Agency (US EPA) <sup>127</sup>
Factory Density	Density of factories =total number of factories [Toxics Release Inventory (TRI) facilities] in a county per square mile of land area (count)	NYS Department of Environmental Conservation (NYSDEC); <sup>128</sup> NLCD <sup>124</sup>
Heavy traffic	Traffic counts at county level (more than 10% trucks and assumes at least half of the trucks are at or near the legal maximum weight)	NYS Department of Transportation (NYSDOT) <sup>129</sup>
Public transport	Intercity bus routes	NYSDOT/NYSGIS <sup>130</sup>
Flood risk	% population living in a flood zone	To be determined

## 5.2 PRIORITIZING CLIMATE IMPACTS FOR BRACE STEP 2 HEALTH RISK ASSESSMENT

Health impacts associated with climate change are broad in their scope and potential severity. The most immediate health impacts are those which are direct impacts, such as health impacts due to frequent or heavy precipitation events (e.g., the evacuation of a health care facility) or health impacts following extreme heat events (e.g., heat-related illness or heat-induced exacerbation of an existing chronic condition, injuries, or death). While these direct impacts perhaps come most immediately to mind when considering climate change-related health impacts, secondary and tertiary impacts must also be considered when approaching the issue. Examples of secondary impacts include more vector-borne disease (i.e., diseases due to a shift in disease vector distribution as a result of environmental change) and poorer fresh water quality or lack of potable water (i.e., resulting from drought or flood conditions). Further down the chain of climate change impacts are tertiary impacts, those that can be thought of as more distal. An example of a tertiary impact is mental health consequences from economic dislocation.

To aid in part in prioritizing adaptation efforts for an issue with such a diverse range of health impacts, NYSDOH program managers, LHDs, and stakeholders were surveyed about what climate-related health issues they face. It should be noted that while surveys help to inform, deciding on which priorities to pursue ultimately is based on multiple sources of information. As might be expected, LHDs and stakeholders cited direct climate impacts more frequently than secondary or tertiary impacts. The most-frequently cited climate-related health issue category was “Issues related to severe weather events (e.g., storm sheltering, power outages, displaced persons),” with 19.8% of respondents citing a related issue (22.1% of LHD responders and 15.8% of external stakeholder responders, respectively). LHDs cited several climate-related health issues stemming from severe weather events, including: “Alternate housing and sheltering during bad weather,” “Flooding,” “Natural disaster (e.g., Hurricane Irene) response,” “Population displacement during coastal storms, particularly institutionalized populations,” “Increased destruction,” and “Changes in winter storms.”

Vector-borne disease was the second most-frequently cited issue overall (17.0%) although this issue was cited only by LHDs and was their most-cited issue (cited by 26.5%). LHD responses regarding vector-borne disease included: “Tick populations and mosquito populations increasing,” “Milder winters are causing problems with increases in insects,” “Increase in Lyme disease,” and “Increase in invasive species and vector-borne disease.” Issues related to extreme heat events and respiratory illness followed in frequency of citation, with 12.3% and 11.3% of the combined respondents citing these issues, respectively.

External stakeholders expressed concern for populations most vulnerable to climate change health impacts, with one stakeholder saying, “While I don’t consider myself at all an expert on the health impacts of climate change, I would guess that food costs (or food insecurity) and heat would hit sooner and have a greater impact on those who are already disenfranchised.” Four responding LHDs shared this concern of food insecurity, with related comments as follows: “Malnutrition,” “Increase in invasive species,” and “[Our County] is now a Zone 5 United States Department of Agriculture (USDA) climate designation, when not very long ago, [we were] a Zone 3. . . climate

change will impact farmers with crops and food growth, and farmers will thus need to be prepared. Climate change will also initiate invasive plant and insect species into the County. Just today, it has been reported in the local newspaper that army worms have been identified on farms in the County, decimating crops."

Surveys also asked NYSDOH leaders, LHDs, and external stakeholders to prioritize which health impacts they thought NYSDOH should prioritize for immediate focus. While results from each of these groups were not identical, their prioritization was close, with several impacts being cited as a top-four priority by all of the groups (Table 8).

**Table 8. Top-ranked adaptation categories from NYSDOH surveys with NYSDOH Leaders, LHDs, and external stakeholders.**

	Leaders	LHDs	Stakeholders
Monitoring and Surveillance	1	4	1
Policy Development and Planning	3	2	2
Education and Awareness	4	1	3

Note: A ranking of "1" is highest priority ranking. Note that the top External Stakeholder categories were all within the top 4 rankings for DOH Leadership and for LHDs.

Based upon this collective input, review of the literature and reports (including the ClimAID Report), and internal discussions amongst NYSDOH staff working in programs involved in or potentially impacted by climate change, the decision was made to initially focus on health impacts related to the climate impacts of extreme heat; extreme weather; and impacts resulting from a generally warmer, wetter climate (namely vector-, food- and water-borne disease). Efforts are focused on prioritizing the adaptation activity categories that received the highest survey rankings: monitoring and surveillance, policy development and planning, and education and awareness. Building on previous studies, research will also address the risks of cardiovascular and respiratory diseases associated with a changing climate.

### 5.3 QUANTITATIVE ANALYSIS (METHODOLOGY)

Climate change studies conducted by NYSDOH have relied upon different epidemiologic methods. To assess the association between extreme temperature, climate variability, and the effect of seasonal differences in modifying adverse health outcomes, NYSDOH has used the case cross-over design. Used frequently in recent environmental epidemiologic studies, the case-crossover design enables the identification of environmental exposures that trigger acute or transient adverse health outcomes. A more conventional time-series method, the generalized additive model (GAM), has been used to estimate the health effects of special climate events (e.g., heat-waves, ice-storms, and those resulting in power outages), cumulative weather variables (e.g., weekly weather variation, early seasonal effect), the burden of health care (e.g., length of stay and cost), and tick-borne diseases related to weather factors at each weather region. A case-control study design has been used to assess the effects of weather factors on adverse birth outcomes.

### 5.4 UNDERSTANDING VULNERABILITY TO HEALTH IMPACTS FROM CLIMATE CHANGE

NYSDOH is performing analyses to expand the understanding of vulnerability to a range of health effects associated with climate change. Highlighted throughout this section are summaries and takeaway messages of CDC-funded studies that NYSDOH has conducted to evaluate potential associations between heat and occurrence of or hospitalization for a variety of health impacts. These studies on heat vulnerability, in addition to the literature outside of work done by NYSDOH and reports such as the NCA, provide evidence for characterizing heat-health risk. Following these heat vulnerability studies are other abstracts of NYSDOH studies related to extreme weather, vector-borne disease, and food- and water-borne disease.

Some of the studies' findings in this section can be directly translated to public health practice or used for improving surveillance. An example of the latter is a study on extreme heat and respiratory disease, where some of the temperature variability indicators can potentially be integrated into the NYSDOH Environmental Public Health Tracking (EPHT) Program so that various programs can track changes in climate factors over time and apply trend knowledge to disease prevention through enhanced surveillance. Other studies, due to their targeted focus on a specific segment of the population, are more applicable for sharing with partners who work with or treat these populations, whether clinical or community partners. For example, findings from a study of the association between extreme heat and renal disease could be shared with clinicians who treat patients with renal disease so that these patients can understand their particular vulnerability and know how to stay hydrated and cool to protect their health.

#### 5.4.1 Assessing Extreme Heat Vulnerability

When compared to other weather events, extreme heat events have been shown to cause more deaths than hurricanes, floods, or tornadoes.<sup>33</sup> Measureable outcomes include increased direct impacts like heat-related illnesses (e.g., heat edema, heat stroke, and dehydration).<sup>36-38</sup>

Extreme heat events have been shown to cause excess mortality.<sup>39-43</sup> In 2013, NYS ranked second in the nation for the number of deaths resulting from extreme heat, with ten deaths.<sup>34</sup> Outcomes also go beyond direct impacts to include the exacerbation of existing health conditions such as renal, lung, and cardiovascular disease, especially among children and older adults.<sup>7,43,44</sup> Increases in emergency department visits, hospital admissions, and deaths have been observed during and following extreme heat events.<sup>10,37,45-47</sup> For NYS populations who are most vulnerable to extreme heat impacts, see Table 3.

#### **NYSDOH Study Abstracts Related to Extreme Heat and Health Impacts:**

### **Extreme Heat and Respiratory and Cardiovascular Disease**

A study of high ambient temperatures and temperature variability on NYC hospital admissions<sup>10</sup>

**Major Findings:** For all three exposure indicators (daily mean temperature, mean apparent temperature, and three-day moving average of apparent temperature), each 1°C (1.8°F) above the threshold of the temperature-health effect curve (29°C–36°C) was associated with a 2.7%–3.1% increase in same-day hospitalizations due to respiratory diseases, and an increase of 1.4%–3.6% in lagged hospitalizations due to cardiovascular diseases. These increases for respiratory admissions were greater for Hispanic persons (6.1%/°C) and the elderly (4.7%/°C). At high temperatures, admission rates increased for chronic airway obstruction, asthma, ischemic heart disease, and cardiac dysrhythmias, but decreased for hypertension and heart failure.

**What this tells us:** Extreme high temperature appears to increase hospital admissions for cardiovascular and respiratory disorders in NYC. Elderly and Hispanic residents may be particularly vulnerable to temperature effects on respiratory illnesses.

## Extreme Heat Association with Birth Defects

A study of extreme summer temperatures and birth defects<sup>105</sup>

**Major Findings:** This case-control study compared NYS Congenital Malformations Registry cases with non-malformed infant controls from a 10% random sample of live births. A 5°F (2.78°C) increase in mean daily minimum universal apparent temperature was significantly associated with a 51% increase in odds of congenital cataracts. Congenital cataracts were significantly associated with indicators including heat wave, number of heat waves, and number of days above the 90th percentile.

**What this tells us:** This study is one of the first to lay the groundwork for exposure assessments of meteorological factors during pregnancy. Positive, consistent associations with congenital cataracts were found between multiple heat indicators during the relevant developmental window; this should be confirmed using other data.

## Extreme Heat and Renal Disease

A study of the association between high temperatures and risk of hospitalization for renal disease<sup>131</sup>

**Major Findings:** An overall 9% increase in risk of hospitalization for acute renal failure (ARF) per 5°F (2.78°C) was found for mean temperature at a one-day lag (odds ratio = 1.09, 95% confidence interval: 1.07, 1.12). The results suggest increased susceptibility to ARF hospitalization for Blacks, Hispanics and people aged 25-44 years. Strongest risk associations were found in urban regions. Increased risk of hospitalization was also found for urinary tract infections, renal calculi, lower urinary tract calculi, and other disorders.

**What this tells us:** The findings suggest a role for temperature in hospitalizations for ARF. Differential effects occur based on demographic characteristics and geographic location. The findings could be used by health care providers to counsel those with renal disease on the increased risk for hospitalization posed by extreme heat. The findings can identify vulnerable sub-populations and inform adaptation strategies.

## Extreme Heat and Respiratory Disease

A study assessing the potential impact of high temperatures and temperature variability on summertime respiratory admissions<sup>11</sup>

**Major Findings:** Each 1°C increase in daily minimum temperature above the six-day average was associated with a statistically significant higher risk (0.52%) of respiratory morbidity. Each 1°C increase in weekly temperature variation (the difference between the maximum value and the minimum value of daily temperature for that week) was associated with a 0.40% increase in respiratory morbidity. There were regional differences in effects across all variability indicators.

**What this tells us:** This study is one of the first to assess the impact of high summer temperature variability on respiratory disease hospital admissions in a large geographic area with urban and suburban/rural settings. Some of the indicators may be used in the NYS EPHT Program and the National State Environmental Health Indicators Collaborative (SEHIC) Climate website, which will help states track changes in climate factors for disease prevention and surveillance.

## Extreme Heat and Heat-related Illnesses

A study assessing the relationship between extreme heat and heat-related illnesses (HRI) – Under review

**Major Findings:** In comparison to daily minimum and maximum temperatures, mean (average) temperature showed the highest association with HRI. There were regional differences in the distribution of temperature and HRI between NYC and the rest of NYS, with hospital admissions peaking at lower temperatures in the rest of the state compared to NYC. An increase in magnitude of effect was observed with an increase in heat wave duration, but frequency of heat waves did not show a dose-response relationship with HRI. Analysis of daily mean temperature identified females, Blacks, and people ≥ 65 years old to be most vulnerable to high temperatures.

**What this tells us:** These findings indicate that illnesses related to higher average temperatures vary geographically and by population demographics. This information can help focus intervention strategies to better protect the NYS public especially vulnerable populations like females, Blacks, and older adults.

## Extreme Heat Events and Preterm Birth (PTB)

A study of association between heat events and PTB – Under review

**Major Findings:** Two regional heat wave (HW) indicators were assigned: 1)  $\geq$  three consecutive days with maximum temperature  $\geq 90^{\circ}\text{F}$  (HW90); 2)  $\geq$  two consecutive days with maximum temperature  $\geq$  97th percentile of the maximum temperature distribution (HW97). Both HW97 and HW90 were consistently associated with PTB if exposure occurred in the 3rd trimester of the pregnancy (3% and 5% increases in odds of PTB, respectively). Exposure during the 3rd trimester to one HW97 resulted in a 2% increase in odds of PTB while exposure to two or more HW97 yielded a 10% increase in odds of PTB.

**What this tells us:** This study suggests a role for heat waves in the occurrence of PTB. The study also shows that extreme heat, especially in the 3rd trimester, is associated with PTB. Mothers with inadequate prenatal care may be more vulnerable to these effects on PTB. These findings could inform interventions to protect pregnant women in the warm seasons.

## Extreme Heat Effects on Low Birth Weight (LBW)

A study assessing extreme heat and birth weight (BW) – Under review

**Major Findings:** Cases were defined as LBW (BW < 2,500 grams) term babies (gestational age > 37 weeks). Controls were normal BW term babies. Two heat wave (HW) indicators were assigned for each region: 1)  $\geq$  three consecutive days with maximum temperature  $\geq 90^{\circ}\text{F}$  (HW90); 2)  $\geq$  two consecutive days with maximum temperature  $\geq$  97th percentile of the maximum temperature distribution (HW97). HW frequency and duration were examined. HW97 showed a 5% increase in odds of LBW for the entire pregnancy, and a 10% increase in odds of LBW for the 1st trimester. HW97 exposure in the 1st trimester was associated with a significant 11.25 g decrease in BW. HW90 showed similar yet statistically weaker results.

**What this tells us:** The study shows that extreme heat in the warm season, especially extreme heat in the 1st trimester, is associated with LBW among term babies, particularly among certain racial/ethnic groups. These findings could be useful for planning interventions to reduce the risk for pregnant women exposed to an extreme heat event.

## Extreme Heat and Cardiovascular Disease (CVD)

A study assessing the association between high temperatures, temperature variation, and risk of hospitalization for CVD – Under review

**Major Findings:** Significant increases (range: 0.49%-1.5%) in cardiovascular morbidity were associated with extreme heat using the 95th percentile of apparent temperature and temperature above the previous six days' maximum and minimum temperature. Daily temperature variation did not affect CVD. There was a 0.23% increase in CVD per 1°C (1.8°F) increase in weekly variation. Increases in maximum or minimum temperature ranges between the current and prior weeks were associated with 0.16% and 0.19% increased risks of CVD, respectively.

**What this tells us:** This study suggests that extreme heat and higher temperature variation increase CVD admissions in NYS. The underlying biological mechanism for the health effects of temperature variation on CVD is not clear. However, a possible explanation is that a rapid change in temperature may increase blood pressure, clots, and cardiovascular work load.

### 5.4.2 Assessing Extreme Weather Vulnerability

Flooding, prolonged rain, and storms cause physical destruction and inundation. The climate-sensitive health impacts of inundation and water surges are many, some related directly to the arrival of flood waters, and others related indirectly to water impacts as critical infrastructures such as electrical power and water utilities are disrupted. Given the breadth for types of extreme weather, the vulnerable populations are diverse. For a summary of NYS populations who are most vulnerable to extreme weather events, see Table 3.

Vulnerable groups include older populations with lower levels of trust in TV and reverse-911 warning systems.<sup>132</sup> As seen in Hurricane Sandy, higher risk groups include those not knowing where else to go, who have a physical disability, or require prescription medications.<sup>133</sup> Those with no or nonfunctional carbon monoxide detectors were at risk of carbon monoxide (CO) poisoning when using alternative sources of fuel for heating and cooking, and those with lower SES had greater risk of psychological stress, particularly related to food access. Those dependent on oxygen were also vulnerable with power outages.<sup>134</sup>

In Hurricane Katrina, incarcerated populations were at high risk because they were left alone without power, food, water, ventilation, or medical care.<sup>135</sup> Residents of nursing homes were vulnerable due to inadequate emergency preparations, staffing, and medications. Hospitalized

patients and those with chronic diseases were at risk of complications and death when medical functions could not be maintained. Children and infants with naïve immune systems were particularly vulnerable to waterborne illnesses and other infectious diseases spread in shelters. There were racial disparities in access to contraceptives and disruptions in prenatal care for pregnant women. Weather-related disasters can exacerbate existing mental health conditions, and occupational injuries and fatalities can occur during storm clean-up and reconstruction.

A review of national data from 2006-2010 indicates that older persons, males, non-Hispanic blacks, and those in lower income counties had higher weather-related mortality rates.<sup>136</sup> Mortality rates from cold, floods, storms, and lightning were highest in the most rural counties.

There are a number of tools and indicators that can be used to assess vulnerability related to extreme weather. The Psychological Simple Triage and Rapid Treatment (PsySTART) system was used by the Red Cross to record mental health risk factors related to Hurricane Sandy.<sup>137</sup> New York City identified 18 neighborhood indicators of vulnerability in the domains of mental and physical health, socioeconomic status and housing, and developed maps to identify the most vulnerable areas.<sup>135</sup> Variables such as coastal or riverine water levels, amounts of rainfall, the frequency and intensity of storms, and source water quality can also be used to track vulnerability to extreme weather events. Changes in the quality and quantity of potable water sources are expected to reflect climate changes.

NYSDOH conducts several tracking actions to monitor impacts related to extreme weather. The NYSDOH Bureau of Water Supply Protection (BWSP) implements the drinking water program under the Safe Drinking Water Act (SDWA) in NYS. As such, the BWSP tracks violations and maintenance issues with public water systems including those which occur during floods when water systems are brought off-line. The BWSP works through the county and local health units to track water systems that are off-line and those that must issue boil water notices or other protective measures due to water quality issues. The BWSP works with other agencies as appropriate to help facilitate the return of the water system to a fully operational mode. The BWSP does not track private well status, but it does provide guidance on actions to take if private wells are inundated.

After Superstorm Sandy, DOH personnel who staffed Disaster Recovery Centers (DRCs) tracked the subject matter of the questions posed by impacted residents. CO poisoning data are not tracked by NYSDOH except during activation of DRCs. Mold calls from the public are tracked within NYSDOH by the Bureau of Toxic Substance Assessment.

Finally, a number of indicators to assist in determining vulnerability were provided in Council of State and Territorial Epidemiologists Guidance for Local Health Departments, which are being considered for inclusion in the EPHT program.<sup>138</sup> These include environmental exposure indicators from NCDC, human health outcome indicators from CDC, and population vulnerability indicators from CDC, the US Census, and FEMA.

## **NYSDOH Study Abstracts Related to Extreme Weather and Health Impacts:**

### **2003 Northeast Blackout**

A study assessing the health effects of the 2003 blackout on mortality and hospital admissions due to respiratory, cardiovascular, and renal diseases in New York City<sup>139</sup>

**Major Findings:** This study compared the disease patterns and socio-demographic profiles of cases during the blackout with those on control days. Mortality and respiratory hospital admissions in NYC were found to increase significantly (2- to 8-fold) during the blackout, but cardiovascular and renal hospitalizations did not. The most striking increases occurred among elderly, females, and chronic bronchitis admissions. Stronger effects were identified during the blackout than on comparably hot days. In contrast to the pattern observed for comparably hot days, individuals of higher socio-economic status were more likely to be hospitalized during the blackout.

**What this tells us:** This study suggests that power outages may have important health impacts, even stronger than the effects of heat alone. The findings provide some direction for future emergency planning and public health preparedness.

### **Low Temperature and Birth Defects**

A study exploring association between extreme cold winter temperatures and birth defects<sup>140</sup>

**Major Findings:** The New York State Congenital Malformations Registry was linked to birth certificates for the years 1992–2006. Among 13,044 cases and 59,884 controls with at least 1 week of embryogenesis in winter, coarctation of the aorta was associated with a 6% increase per a 1°C (1.8°F) decrease in mean universal apparent temperature, 61% increase with a cold spell, and 4% increase with at least 1 extreme cold day.

**What this tells us:** Most birth defects were not associated with cold indicators; however, the positive associations found between cold indicators and coarctation of the aorta in the biologically-relevant developmental window should be further studied.

## Low Temperature and Ischemic Heart Disease

A study examining the effects of winter temperatures on hospital admissions due to acute myocardial infarction (AMI)<sup>141</sup>

**Major Findings:** A time-stratified case-crossover design was employed. The study population included hospitalizations from 1991-2004 in 14 NYS weather regions with a primary diagnosis of AMI during the cold season. The temperature indicators assigned for each region were daily average universal apparent temperature (UATavg); 3-day moving average UATavg; and extreme temperature, defined as the 10th percentile of UATavg distribution. Exposure odds ratios (OR) and 95% confidence intervals (CI) were calculated using conditional logistic regression after controlling for other weather factors. UATavg below 35°F increased the odds of being hospitalized due to AMI. The most elevated association was observed for the -20°F to -15°F temperature group, with ORs ranging from 1.25 (95% CI 1.00, 1.57) to 1.29 (95% CI 1.03, 1.61) at Lag 4 and Lag 5, indicating a 25%-29% increase in odds of AMI if the temperature ranges from -20°F to -15°F. Extreme temperature showed similar associations with AMI for the same 4-6 day lags. Being male, white, 65-74 years old, Medicaid insured, and living in areas with high PM<sub>2.5</sub> concentration increased the odds of AMI hospitalization at UATavg below 30°F. In conclusion, temperatures below the freezing point are associated with AMI hospitalizations 4-6 days later, and certain demographic factors may change the temperature-AMI association.

**What this tells us:** The findings suggest a role for low temperature in hospitalizations for AMI. Extreme low temperature in winter was associated with increased risk of AMI, especially during Lag4 - Lag6, but cold temperature was not associated with other cardiovascular sub-group diseases. Low maximum temperature in winter was a more sensitive predictor of AMI than minimum temperature. Certain demographic groups such as older adults, people with Medicaid insurance, races other than White and Black, and people living in areas with a high concentration of fine particles showed higher vulnerability to cold temperature with respect to AMI than other groups. Further studies are needed to confirm these findings and continue to examine delayed lag effects and sensitive weather indicators. Interventions based on these findings, such as targeting risk reduction information to people at risk for AMI, should be considered in climate change adaptation efforts.

## Low Temperature and Asthma

A study to investigate whether prolonged periods of very cold temperatures were associated with an increased risk of hospitalization for asthma<sup>142</sup>

**Major Findings:** Hospitalization admissions with a principal diagnosis of asthma were identified in NYS for the months November through April from 1991 to 2006. Cold spells [defined as three or more consecutive days where the daily mean of Universal Apparent Temperature (UAT) within a week prior to admission was at the 10th percentile or less for a given month] during the winter months were associated with a mean decline of 4.9% in daily asthma admissions statewide. After a cold spell, no statistically significant changes were apparent during the winter months, but asthma hospitalizations increased after cold spells in the transitional months of November (mean = 9.6%) and April (mean = 5.0%). April also noted a mean increase of asthma hospitalizations of 6.8% during cold spells.

**What this tells us:** The results suggest that during prolonged periods of severe cold asthmatics may adhere to medical guidelines and limit their exposure, thereby preventing exacerbations. They may be less likely to alter their behavior in the more moderate months of November and April.

### 5.4.3 Assessing Vector-borne Disease Vulnerability

Vector-borne diseases are those transmitted primarily by mosquitoes, ticks, and fleas. In NYS, the major concern related to climate change is for Lyme disease (LD) and other tick-borne diseases (TBD); as well as West Nile virus (WNV) and Eastern Equine Encephalitis (EEE) virus spread by mosquitoes. NYS populations who are most vulnerable to vector-borne diseases are summarized in Table 3.

LD vulnerability increases with more infected ticks in a geographic area, more activities that increase risk of tick bites, and fewer preventive actions. Climate change models predict an expansion of the geographic area with infected ticks in the northeast,<sup>143</sup> which will increase the risk of tick bites for northern and western areas of NYS which currently have lower LD rates.<sup>144</sup>

People who do not wear protective clothing or use tick repellents are more likely to get tick bites.<sup>145</sup> Those who do not perform tick checks on themselves, family members, and pets are more vulnerable to tick attachment long enough (>36-48 hours) for infection to occur.<sup>145</sup> Individuals and communities not using integrated pest management practices to reduce the number of infected ticks on mice, deer, and vegetation are more vulnerable.<sup>146</sup>

Outdoor recreational and occupational activities increase LD vulnerability because of the greater likelihood of tick exposure. Those with >30 hours per week of outdoor leisure activities were 2.5 times more likely to be infected.<sup>147</sup> Infection rates were 5.9 times higher in those with a history of outdoor employment.

Timely LD diagnosis and treatment with antibiotics is critical to reducing risk of more serious cardiac and joint problems. Young males are disproportionately affected by a particular type of heart electrical conduction blockage if the Lyme spirochete invades heart tissue.<sup>148</sup> Pregnant women need to be particularly vigilant about avoiding tick bites, removing ticks quickly if found, and getting prompt diagnosis and treatment. Untreated Lyme disease during pregnancy may lead to infection of the placenta and possible stillbirth.<sup>145</sup>

Other TBDs with lower incidence in NYS include babesiosis, ehrlichiosis (both human granulocytic anaplasmosis and human monocytic ehrlichiosis) and Rocky Mountain spotted fever.<sup>149</sup> These diseases are currently found most often on Long Island and in the lower Hudson Valley region, but the warmer temperatures and higher humidity preferred by ticks may increase the vulnerability for New Yorkers in other areas of the state.

Vulnerability to WNV infection varies geographically within NYS. Incidence is greatest in the warmer areas of Long Island, New York City, and the lower Hudson Valley. Climate change is expected to increase the risk of WNV and other flaviviruses as average temperatures increase.<sup>150</sup> Mosquito activity is increased when nighttime temperatures are  $\geq 50^{\circ}\text{F}$ .

Studies have indicated that humans are more vulnerable to WNV infection if they live in areas with greater amounts of vegetation, older housing, low population density, a predominance of older Caucasian residents, and proximity to dead birds.<sup>151</sup> Those infected with WNV are more likely to develop encephalitis if they are older, diabetic, or have a history of alcohol abuse. Mortality is increased with age, immunosuppression, requirement of mechanical ventilation, and stroke. About 1% of Caucasians have defective genes that increase risk of fatal infections.

Those with outdoor work or recreation, particularly if they do not wear protective clothing or use repellent, are more vulnerable to mosquito bites and WNV infection.<sup>152</sup> Laboratory, field, and clinical workers handling dead birds or WNV-infected tissues or fluids are also at increased risk.

New Yorkers living in the swampy central areas are most vulnerable to infection with EEE virus.<sup>153</sup> Freshwater hardwood swamps are the preferred location for mosquitoes which maintain the disease in nature with birds.<sup>154</sup> People at the greatest risk of developing severe disease are those >50 or <15 years of age.<sup>153</sup>

Climate change indicators that could assist in tracking vulnerability include variables such as temperature, humidity, the Normalized Difference Vegetation Index (NDVI), and snow cover. NYSDOH has several activities and systems in place to monitor vectors and vector-borne diseases:

- Twice yearly statewide surveys of host-seeking ticks
- Hunter-killed white-tailed deer survey

- Mosquito surveillance performed by NYSDOH and LHDs
- Human case reporting of tick-borne diseases
- Human case reporting of mosquito-borne diseases

At a state scale, it is important to realize that climate change impact on mosquitoes may be different than the impact on ticks. Climate change may foster proliferation of some species while reducing others. These changes will likely happen in small increments, and the role of climate change may be difficult to distinguish from other factors.

**NYSDOH Study Abstract Related to Vector-borne Disease:**

### Weather and Lyme Disease Incidence

A study using surveillance data to identify biologically relevant seasonal indicators of Lyme disease incidence – Under review

**Major Findings:** A one-day increase in spring with minimum temperature range of 40-50°F in the disease incident year and preceding year was associated with a 15-23% increase in summer Lyme disease cases, and an 8-12% increase in summer tick reports. A one-day increase in severe winter days in the previous two years was associated with a 4% decrease in Lyme disease, and a one-day increase in mild winter days was associated with a 7% increase in summer tick reports. A unit increase in summer Palmer Hydrological Drought Index (PHDI) and a day increase in summer with maximum temperature > 75°F in the previous year were associated with an 18% decrease and a 4% increase in disease risk, respectively.

**What this tells us:** The study has identified several biologically relevant seasonal indicators of Lyme disease incidence. These indicators can be utilized by public health officials to develop Lyme disease risk advisories.

#### 5.4.4 Assessing Food- and Water-borne Disease (FWBD) Vulnerability

Each year in the US, infection with 31 major foodborne pathogens results in an estimated 9.4 million cases of foodborne illness, 55,961 hospitalizations, and 1,351 deaths.<sup>155</sup> Identification of vulnerable populations is essential for targeting disease prevention and control methods. In the US almost 20% of the population is considered more susceptible to food-/water-borne disease than the general population.<sup>156</sup> Vulnerability often stems from immunosuppression due to disease or medication.<sup>157</sup> NYS populations who are most vulnerable to FWBD are summarized in Table 3.

Diseases such as salmonellosis may increase in incidence because the bacteria that causes it can grow faster in warmer temperatures.<sup>32,158</sup> Having conditions that provide the ideal setting and

temperature for pathogen growth in combination with human behaviors that increase exposures to these pathogens results in disease peaks.<sup>158</sup>

Climate variability may increase the risk of contamination of water supply due to current weaknesses in storm drainage systems and infrastructure, which in turn could increase exposure to water- and food-borne pathogens.<sup>159</sup> Heavy rainfalls that cause runoff may introduce bacteria into areas used for recreation, such as lakes or beaches, increasing risk for illnesses such as gastroenteritis. Rainfall causing sewage treatment plant overflow can also contaminate crops from pathogens found in sewage waste.<sup>160</sup> However, more investigation of the public health infrastructure is needed to adequately assess risk.<sup>159</sup>

Wet weather, rainfall<sup>59-61</sup> and humidity<sup>62</sup> have been associated in the literature with the occurrence of legionellosis. Males are typically more frequently impacted by legionellosis.<sup>161</sup> In the 2013 non-point source legionellosis outbreak still under investigation, 61% of the cases were male.<sup>162</sup> In addition, multiple co-morbidities predispose individuals to this form of pneumonia.<sup>163</sup> One sample of acute- and long-term care patients indicates that the most common underlying medical conditions in NYS that contribute to legionellosis are malignancy (29.8%), diabetes (26.6%) and cardiac disease (22.6%).<sup>164</sup> Smokers and ex-smokers are more likely to become ill.<sup>163,165,166</sup> Legionellosis in young children and young adults tends to be rare.<sup>167</sup>

## **NYSDOH Study Abstract Related to Food- and Water-borne Disease:**

### **Joint Weather Factors and Water- and Food-borne Disease (WFBD)**

A study to investigate the joint effects of extreme heat, humidity, and precipitation on WFBD in the summer season and to identify vulnerable population subgroups – Under review

**Major Findings:** Among 26,814 WFBD hospitalizations, bacterial infection accounted for 81%. Females, older adults (>75 years), and non-Hispanics had a significantly higher proportion of WFBD hospitalizations than other groups. Maximum temperature, minimum temperature, and maximum universal apparent temperature (UAT) showed that each 1°C increase in temperature was significantly associated with an increase (0.7-1.0%) in daily WFBD hospitalizations, with the greatest impacts observed at a one-day lag (Lag 1). Extreme heat (>90th percentile) (3.68% at Lag 1) and precipitation (8.22% at a four-day lag) showed larger impacts on increases of WFBD. The impacts of extreme heat on WFBD hospitalization tend to be greater among Hispanics, blacks, those <50 years old, females, and those with bacterial infections.

**What this tells us:** The observed significant associations between WFBD hospitalizations and weather factors (maximum temperature, minimum temperature, UAT, precipitation, extreme heat and number of extreme heat days) suggest the existence of a relationship between weather conditions and WFBD in summer in NYS. Stratified analysis showed a significant increase in hospitalizations for bacterial WFBD, suggesting that bacteria might be a significant cause for WFBD in the summer. These findings can help identify subgroups potentially vulnerable to the effects of climate change and inform public health preparedness.

## 6 CHALLENGES AND OPPORTUNITIES

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While much progress has been made in terms of climate projections and understanding of associations between climate impacts and health impacts in NYS, there is of course the opportunity for better characterizing these impacts. This section details some of the areas where further analysis is necessary in order to improve our understanding of associations between climate impacts and related health impacts in NYS. Further efforts in these areas can enable even more targeted and effective intervention strategies to be implemented for community climate impact adaptation, resulting in greater protection of the public's health.

### 6.1 DIVISION OF STATE CLIMATE REGIONS FOR ANALYSIS

For the purposes of climate projection analysis and for understanding how climate impacts will differ across NYS, it is logical to delineate the State into regions based upon the NCDC's 10 NYS climate divisions.<sup>16</sup> When ozone is considered, there is the need to modify regions of analysis by overlaying and merging the NCDC climate divisions for NYS with the 11 ozone regions as developed for NYS.<sup>17</sup> As explained in Section 1.3, this merging of weather regions with ozone regions allows analysis of regions where the population is exposed to relatively homogeneous weather and ozone conditions.

While it is ideal for scientific research to study associations between climate impacts and health impacts using the above divisions of NYS in accordance with their similar climate characteristics, it is problematic for translating findings that use these divisions into policy and action, such as implementing regional adaptation strategies. This is because several of the NCDC NYS climate divisions cross through county lines, so a single jurisdiction may fall into more than one climate division and the population may experience climate change differently depending on which part of the county a person is in. One idea is to use the ClimAID regions for future studies, because the ClimAID regions are divided along county lines. Regardless, further discussion within NYSDOH and input from external partner agencies and organizations should take place before coming to a conclusion of the best solution for this issue.

### 6.2 APPLYING RESEARCH FINDINGS FOR STRONGER SURVEILLANCE

The majority of climate studies conducted by NYSDOH have helped to describe the relationships between certain climate variables and specific health impacts. While continuing to pursue these kinds of studies is important, NYSDOH also needs to take advantage of opportunities to expand its capacity to conduct climate-health surveillance. Prior work by NYSDOH identified a number of existing surveillance systems (e.g., Clinical Laboratory Information Management System [CLIMS] – Arboviral, Congenital Malformations Registry) with potential relevance to climate and health that could be adapted towards these efforts (e.g., to monitor existing or new disease, monitor a population or site that is particularly vulnerable to climate change). Use of these kinds of surveillance systems may help NYSDOH more readily identify climate-health relationships and the

kinds of interventions that should be pursued. Using these surveillance systems can also facilitate evaluating the effectiveness of interventions.

### 6.3 APPROPRIATE SELECTION AND USE OF CLIMATE MODELS

One difficulty in conducting studies examining the association between climate impacts and health impacts is the question of which climate model to use and when to use it. Many climate models are available, as described earlier in this report; however, which of these is best suited for particular climate-health impacts? On September 22, 2014, the Community Risk and Resiliency Act was put into legislation in NYS to increase the resilience of NYS communities against climate change effects such as extreme weather and sea level rise. This act required that the NYSDEC adopt official projections for sea level rise by January 1, 2016 and update the projections every five years. NYSDEC and the NYS Department of State (NYSDOS) are also required to prepare templates for local laws that would help communities incorporate climate measures in their jurisdictions.

With this recent legislation in mind, discussion is needed on climate projections and modeling and which models are most relevant for NYSDOH research and surveillance. The 2014 ClimAID Report, for example, uses the CMIP5 modeling whereas NYSDOH studies use the CMIP3. This is because NYSDOH does not yet have the data from NOAA, but the data has been requested. Building consensus on which of the models is most appropriate for various health and climate impact endpoints is essential for improving climate-health projections.

### 6.4 ASSESSMENT AND IMPLEMENTATION OF INTERVENTIONS

A challenge in determining which interventions are most appropriate, effective, and realistic for implementation at the state level or for recommendation to LHDs is the limited evidence in the scientific literature of formally evaluated adaptation efforts. When there is evidence for measuring effectiveness through evaluations (e.g., heat-health warning systems), often they are evaluated in terms of the system as a whole versus individual intervention or adaptation components. Intervention or adaptation planning therefore must move forward without the level of evidence-based practice that is available for many other public health issues, taking more of a “promising practices” versus “best practices” approach for a rationale. It is critical that state and local health departments build evaluation measures into planned interventions wherever feasible so that effectiveness of process and outcomes can be assessed and contribute to the evidence base for climate-health intervention.

As critical as the assessment and selection of the most appropriate climate-health interventions is the ability to optimally implement those interventions for maximum effectiveness. As part of the recently established NYS Early Warning Weather Detection System, the NYS Mesonet will provide richer data from 125 weather stations for variables including temperature, humidity, and wind speed and direction. Access to this real-time data will improve NYSDOH decision-making, for example, activating interventions for extreme heat or weather once a particular temperature threshold has been reached.<sup>168</sup>

## 7 COLLABORATIONS AND EXISTING NYS INITIATIVES

While NYSDOH can provide technical expertise, evidence, and data for use in planning adaptations to reduce the impacts of a changing climate on health, it takes engagement with stakeholders during planning, and then to transform planning and recommendations into implementation, to adequately reach the most vulnerable populations. Stakeholders that are relevant to NYSDOH efforts to address climate-related health impacts include academic, business, community, environmental, health, and policy organizations as well as other government agencies. One way in which NYSDOH worked with stakeholders was by implementing a Climate and Health Stakeholder Needs Assessment, with the goal of learning the level of organizational awareness about the health impacts of climate change and providing education and increased awareness while collecting survey information. This section provides a summary of NYSDOH climate and health needs assessment surveys, as well as a description of some interagency climate and health collaborations in which NYSDOH is a participant.

### 7.1 VALUE OF STAKEHOLDER ENGAGEMENT

NYSDOH has realized many benefits (Table 9) from developing partnerships with stakeholders in addressing the health impacts of a changing climate. Partners provide access to knowledge from a broad range of sectors, cultures, and disciplines. Partnership establishes a broadened base of support for prioritizing climate change in NYSDOH, and an outside perspective from our “clients” or “customers” can be very powerful in moving forward on priority adaptation activities. The candid input received during discussions with stakeholders is critical to mounting a relevant and effective communications campaign.

**Table 9. Benefits of partnership with stakeholders.**

Benefits of Stakeholder Partnership	
• Broad range of expertise	• “Real-time” qualitative data
• A measure of existing networks and activities	• Opportunities for project collaboration
• Unfiltered input on current climate impacts	• Input fuels health department prioritization of issues
• Access to decision makers, networks, membership, populations represented	• Outside perspectives from powerful policy-movers
• Eyes and ears “on the ground”	• Mutual awareness of roadblocks
• Knowledge gap clarification	• Diverse connections to health

Stakeholders have voiced a need for information on the health impacts associated with a changing climate, which can help to justify the prioritization of climate and health as an issue within the health department. Stakeholders have specifically requested NYSDOH interpretation of how the projected climate impacts may result in climate-related health impacts, and what those health impacts will be, in terms of which populations may be most vulnerable, what the impacts will cost, and how people’s overall quality of life may be affected. NYSDOH has data and the capacity to study the associations of climate-related health impacts using this data, and stakeholders can use the translation of these findings to understand what they mean for the populations they serve and develop appropriate interventions to address this. This information, once fully analyzed, summarized, and translated, will support the NYSDOH (and general public health) cause for action.

## 7.2 SUMMARY OF EXISTING NYS GOVERNMENT INTERAGENCY CLIMATE ADAPTATION INITIATIVES

Five NYS interagency teams were established as efforts to provide decision-makers with information on NYS’s vulnerability to climate change, develop climate projections, and/or promote climate adaptation: the Climate Action Council (CAC), ClimAID, the Sea Level Rise Task Force, the Interagency Adaptation Workgroup, and the Climate Smart Communities (CSC) program.

The CAC was created under the Governor’s Executive Order 24 and was directed to develop a climate action plan that included recommendations for both mitigation and adaptation. The CAC was comprised of State agency representatives and was jointly coordinated by NYSDEC and NYSERDA. An Adaptation Technical Working Group considered background information, including a catalog of other state adaptation actions, and the ongoing ClimAID and Sea Level Rise Task Force work (see below). The Interim Report, released in November 2010, includes approximately 40 adaptation recommendations for eight sectors, including public health (Table 10).<sup>169</sup> The adaptation recommendations serve as the basis of adaptation initiatives in several state agencies.

**Table 10. Public health adaptation recommendations from the CAC Interim Report.**<sup>169</sup>

<b>Recommendation 1.</b> Improve or establish robust public health mechanisms to reduce the potential for heat-related morbidity and mortality in New York State.
<b>Recommendation 2.</b> Educate, empower, and engage all New Yorkers to foster a better understanding of the public health consequences of climate change and take actions to reduce or eliminate those consequences.
<b>Recommendation 3.</b> Assess and improve the capacity of existing public health preparedness, response, and recovery programs to respond to climate-related impacts and direct resources where needed.
<b>Recommendation 4.</b> Build community resilience and integrated public health capacity to reduce human health impacts of climate change.
<b>Recommendation 5.</b> Evaluate and enhance, as necessary, the capacity of existing surveillance programs for vector-, food-, and water-borne diseases and disease-causing agents to monitor and respond to the anticipated climate change-related increase in such public health threats.
<b>Recommendation 6.</b> Assess and prepare for the significant public health risks associated with hazards related to sea level rise.
<b>Recommendation 7.</b> Conduct and support research on the public health consequences of climate change and their effective incorporation into adaptation strategies.

The ClimAID project is funded by NYSERDA and led by researchers at Columbia and Cornell universities and the City University of New York, with the objective of bringing together the most recent scientific information, technical expertise, and knowledge of stakeholders from key sectors around the state. ClimAID assessed risks from climate change, recommended adaptive measures, and identified needs for additional research in eight sectors: agriculture, ecosystems, coastal zones, energy, public health, transportation, communication, and water resources. Climate projections have been updated in 2014 (see Section 2.4). The ClimAID report has recommended expanding capacity to integrate adaptation strategies into existing health programs (Table 11).<sup>13</sup>

**Table 11. Public health adaptation recommendations, taken directly from the ClimAID Report.<sup>13</sup>**

<p><b>Operations, Management, and Infrastructure Strategies</b></p> <ul style="list-style-type: none"> <li>• Extend surveillance of climate and health indicators, including data monitoring of airborne pollen and mold.</li> <li>• Evaluate extreme heat response plans, focusing particularly on expanding access to cooling services during heat events. Build on this knowledge to develop similar systems for other climate health risks. Target strategies and messages for the most vulnerable populations.</li> <li>• Plant low-pollen trees in cities to reduce heat without increasing allergenic pollen.</li> </ul>
<p><b>Larger-scale Strategies</b></p> <ul style="list-style-type: none"> <li>• Further integrate environment and health initiatives to address both human and ecosystem health and avoid the divide that often exists between them.</li> </ul>
<p><b>Co-benefits</b></p> <ul style="list-style-type: none"> <li>• Prioritize adaptation strategies that maximize co-benefits (e.g., cleaner air, improved nutrition, or increased physical activity).</li> <li>• Invest in structural adaptations to reduce heat vulnerability (e.g., tree planting, green roofs, high-reflectivity building materials) to reduce energy demand and expense while reducing heat-related risks.</li> </ul>

The Sea Level Rise Task Force was created in 2007 by the NYS Legislature to assess impacts to the State's coastlines from rising seas and to recommend protective and adaptive measures for the State's coastal communities and ecosystems. The geographic scope included NYC and Westchester, Nassau, and Suffolk counties, as well as the main stem of the Hudson River drainage. Members were drawn from state, county, and municipal government and public citizens appointed by the legislature. Much of the work was carried out by a steering committee of state and non-governmental specialized work groups (e.g., ecosystems and natural resources, infrastructure, community resilience). The Task Force provided its report and recommendations to the legislature and then-Governor Paterson in December 2010. The report pointed out that recovery from flooding can be impaired by a lack of understanding of the risk factors for disease outbreaks that occur after the floods and how best to treat those outbreaks. A concern for coastal communities should be obtaining the specific data and analysis to understand each community's vulnerability to

flood-dispersed contamination (e.g., soil or housing) after a storm, and taking action on this before the next storm occurs.

The Interagency Adaptation Workgroup is an ad hoc, self-directed workgroup that began with efforts to collaborate on developing adaptation guidance for local governments and expanded its membership to include agencies most involved with the Task Force. It now consists of NYSDEC, NYSDOS, NYSDOT, NYSDOH, NYSERDA, State Office of Emergency Management, State University of New York, and the Office of the Attorney General. It is focused on developing recommendations for adaptation to sea level rise, coastal hazards and riverine flooding, cost/benefit analysis to support local adaptation planning, and advising on NYSERDA-funded adaptation research. The Workgroup's current primary interest is developing a NYS-specific framework for community vulnerability assessment and adaptation planning, pending availability of staff resources. The Workgroup serves as a clearing house for information and interagency exchange on efforts to build community resilience to climate change, which indirectly protects health.

The CSC program is an interagency effort to encourage and provide guidance for local mitigation and adaptation. The CSC funds four regional coordinators and statewide coordinators to assist CSC with smart growth and transportation planning. In 2013, the program released Climate Smart Resiliency Planning, a tool to facilitate local self-assessments of whether and how climate change considerations have been incorporated into local planning (e.g., comprehensive, emergency management, floodplain management, and capital investment plans). In 2014, the CSC Certification Program was launched and a CSC Certification Manual was released. The certification program is intended to inspire local action by recognizing leaders and providing a more rigorous framework for local climate action, including vulnerability assessments, adaptation planning, and implementation of resiliency projects. More information about the CSC Program can be accessed at: <http://www.dec.ny.gov/energy/50845.html>.

### 7.3 NYSDOH NEEDS ASSESSMENT SURVEYS OF STAKEHOLDERS

In addition to enabling the identification of associations between climate and its health impacts presented in Section 5 of this report, the initial CRSCI grant provided the opportunity to conduct needs assessment surveys with both internal and external climate and health stakeholders. It also allowed NYSDOH to ascertain a baseline measurement of gaps and needs to inform development of a Department-wide Strategic Map and adaptation planning efforts. These surveys supplemented what had been found in the Climate Action Plan Interim Report and the ClimAID Report and aided prioritization of the health impacts discussed in this report.<sup>13,169</sup> A more complete summary of the survey methods and the results is available in a separate publication.<sup>170</sup> In summary, seven surveys were conducted with NYSDOH program managers and surveillance database managers, LHD directors, and external stakeholder organizations to obtain feedback on needs, perceptions, available surveillance databases, and priorities for adaptation.

## 7.4 POTENTIAL FOR COLLABORATION

A variety of ideas for collaboration were expressed by stakeholders during the survey interviews (Table 12). A common theme heard throughout the interviews was the need to clarify climate change as a public health issue. Climate-health presentations or webinars were cited most frequently as ideas for stakeholder collaboration with NYSDOH. Other ideas focused on educating or broadening awareness, for example, by stakeholders distributing NYSDOH information to their networks or by a partnership to develop content together.

**Table 12: Selected stakeholder ideas for collaboration with NYSDOH on climate and health adaptation efforts.**

Stakeholder responses to “What ideas do you have for how your organization could collaborate with NYSDOH for reducing the impacts of climate change on the public’s health?”
"We should develop better networks for monitoring the movement of insects and disease paths."
"We try to applaud the local (NYS) efforts like this grant, so we are open [to collaboration with NYSDOH]...institutionally we have a big reach online so we do what we can to link to data that's out there and develop the tools to get the information out there."
"We can do informational sessions at our office [particularly to explain the connection between climate change and health, and what impacts are anticipated]...we could invite educators, our partners in County health and aging, and the general public."
"Moving climate change from an environmental issue to a public health issue I think is absolutely key...[and] engaging the medical community and having clinicians talk about this as a health issue is how you're going to best educate New Yorkers. People will trust physicians versus government. If [the Commissioner] were to hold a summit of health organization CEOs, a roundtable where he tries to have he and senior staff discuss this in a health framework and get buy-in from these organizations...that would be ideal."
"There are grant opportunities to collaborate on publications (e.g., Health Impact Assessment work)."
"We have a wealth of researchers who could partner with [NYSDOH]."

Stakeholders perceived two key barriers to collaboration: the first was "We can't collaborate until we know what the [health] impacts will be", and the second was "Need funding before collaborating." These barriers were echoed in other interview questions, where "lack of money" and "lack of resources" were the two most frequently cited barriers to adaptation cited by stakeholders, and "climate change health costs not quantified (e.g., years life lost)" was also one of the most-mentioned barriers.

Both LHDs and stakeholders were asked who they partner with on climate and health issues, and multiple responses were allowed. LHDs cited emergency management services most frequently as a partner on climate and health issues (19 responses), with academic institutions being the second most frequently cited partner (seven responses). Stakeholders most frequently cited local agencies and universities or other academic partners, state agencies, federal agencies, and national

organizations such as the American Planning Association or American Public Health Association (Table 13).

**Table 13: Stakeholder partnerships on health impacts of climate change.**

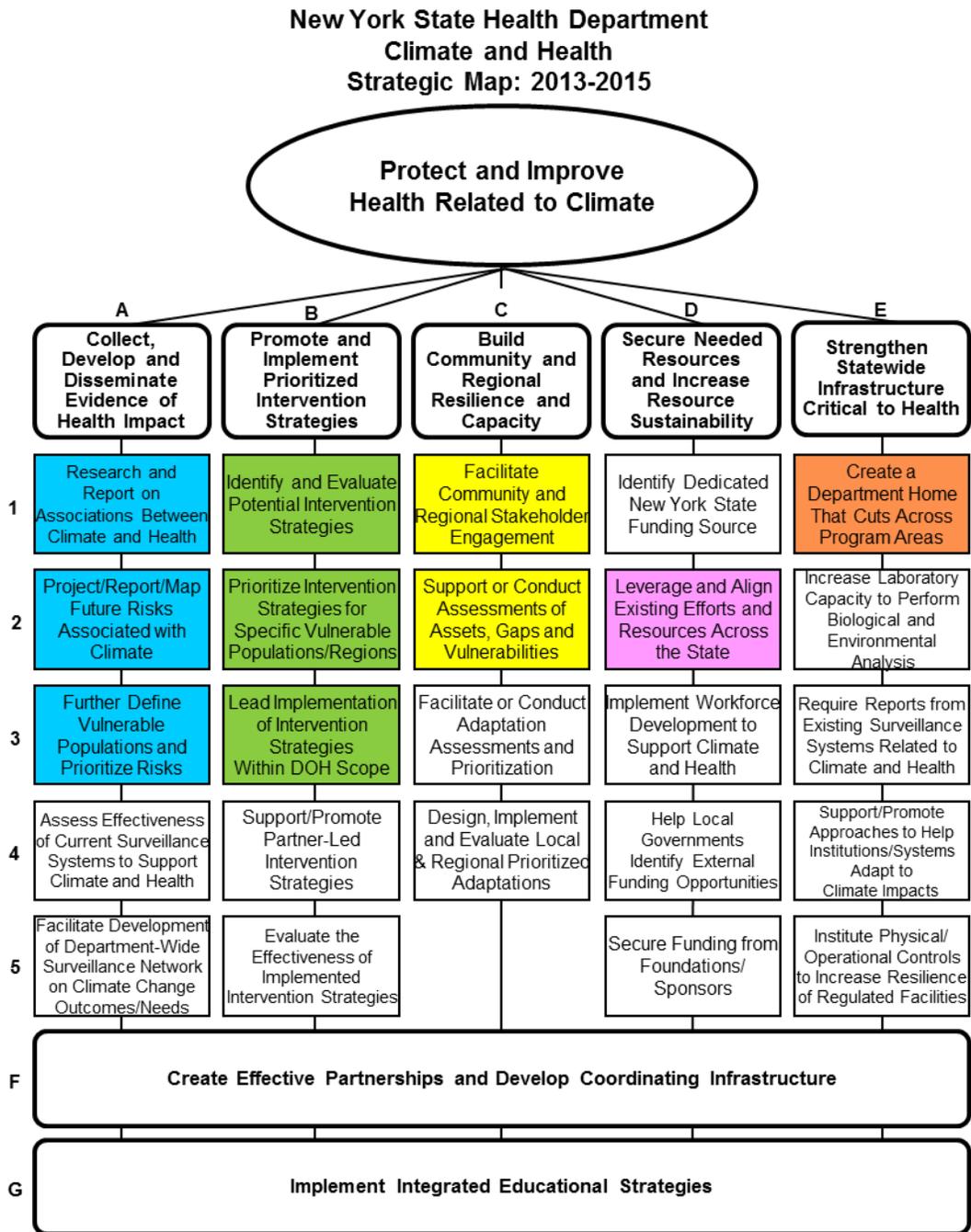
Partner	LHD (# times cited, N=54)	Stakeholders (# times cited, N=44)
Emergency Management Services	19	1
Community Health Center/Hospital/Provider	8	3
University/School/Educational Program	7	8
Law Enforcement/Public Safety	4	1
NYSDOH	4	2
State Agency	3	5
State/Local Community Organization	3	1
Local Officials	3	0
Other (e.g., Social Services, Farmworker Legal Service)	3	1
Local Agency	0	5
Federal Agency	0	6
National Organization	0	7
Environmental Group	0	2
None or N/A	0	2

While there were distinct differences between LHDs and external stakeholders, responses showed a solid base from which adaptation activities could be implemented, using existing networks. The overall goal from conducting the Stakeholder Survey and other surveys was to understand stakeholders’ level of awareness and current needs so that adaptation planning could continue; one component of adaptation planning was the development of the NYSDOH Climate and Health Strategic Map, detailed in Section 8.

## 8 NYSDOH CLIMATE AND HEALTH STRATEGIC MAP IMPLEMENTATION

The NYSDOH Climate and Health Strategic Map (Figure 13) depicts key elements in the Department’s plan for climate and health action. A group representing diverse programs within NYSDOH developed this map during a strategic planning session in July 2013.

**Figure 13: NYSDOH Internal Climate and Health Strategic Map: 2013-2015**



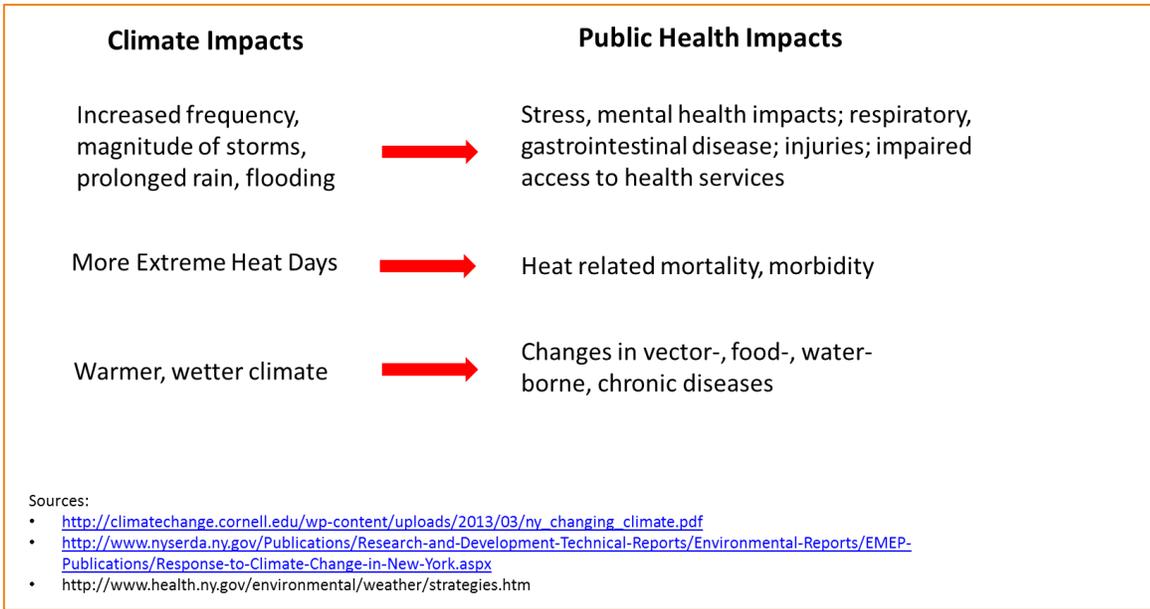
At the top of the Strategic Map is the central challenge that NYSDOH faces over the next three years (2013-2015), which is to “protect and improve health related to climate.” The central challenge is supported by five strategic priorities (A through E) and two cross-cutting strategic priorities (F and G).

For 2013, the initial year of Strategic Map implementation, NYSDOH identified five key areas of emphasis. These areas are called tracks of work because the prioritized objectives have been grouped together in terms of the work required to complete them. These areas of emphasis/tracks of work are represented by five colors for the prioritized objectives under each strategic priority A through E on the Strategic Map. For Strategic Priority A, NYSDOH is placing emphasis on more clearly describing the associations between climate impacts and health impacts, mapping future risks associated with climate, and further defining those populations most vulnerable to these impacts. Strategic Priority B efforts will focus on identifying and evaluating potential intervention strategies, prioritizing those strategies for particular vulnerable populations, and guiding the implementation of those interventions with a goal of enhancing resilience at the local level. Local resilience will also be built through actions to implement Strategic Priority C, where we are working to increase stakeholder engagement and provide communities with the information and tools needed to assess gaps and vulnerabilities inherent to each community. The emphasis related to Strategic Priority D will be to leverage and align the work that is already occurring in NYS, whether by government agencies, LHDs, or non-profit organizations. To accomplish this, Strategic Priority E’s objective to create a Department home for climate and health that cuts across program areas has been a top priority, with a future NYSDOH Climate and Health Program as the result of this effort. Throughout all this work, and evident in the Climate and Health framework, is the focus on fostering partnerships and implementing educational strategies, essential towards maximizing the project’s impact in effecting adaptation and increased resilience to climate-related health impacts.

## 8.1 FRAMEWORK FOR ACTION

The overall NYSDOH framework for action is to protect and improve health by integrating climate change as a determinant of health into all relevant public health programs and services including other agencies (e.g., Office of Mental Health), focusing on identifying, implementing, and evaluating evidence-based interventions. The framework for action centers on integrated outreach efforts and on leveraging partnerships with programs across NYSDOH as well as with LHDs, largely undertaken by Climate Impact Teams. These climate impact teams were established to prioritize the following climate impacts and their associated public health impacts (Figure 14), based upon several NYS reports, needs assessment survey results and strategic planning (described in Section 7.3):

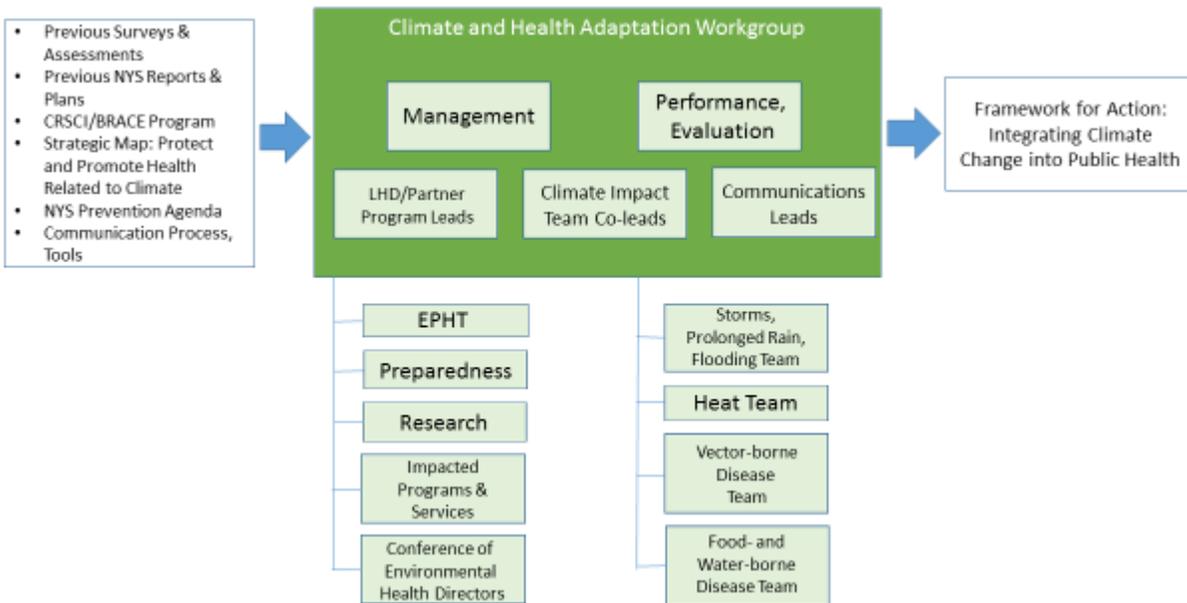
**Figure 14: Prioritized NYS climate and related public health impacts.**



These Project activities will align with the NYSDOH Climate and Health Strategic Map, the NYS Prevention Agenda (see [https://www.health.ny.gov/prevention/prevention\\_agenda/2013-2017/](https://www.health.ny.gov/prevention/prevention_agenda/2013-2017/)), BRACE, and other on-going NYS strategies. The Project is coordinated through the NYSDOH Center for Environmental Health.

A Climate and Health Adaptation Workgroup comprised of Climate Impact Teams will guide implementation of the Strategic Map and ultimately produce an overall Framework for Action. Figure 15 depicts the organization of the NYSDOH Climate and Health Project framework.

**Figure 15: NYSDOH Climate and Health Project structure.**



## 8.2 CLIMATE IMPACT TEAMS

The majority of the Project's planning and work will be produced by four Climate Impact Teams, led each by three co-leads, for the prioritized climate-health impacts. These teams are:

- **Storms, Prolonged Rain, and Flooding Climate Impact Team.** This team is creating a survey to be administered to personnel involved in recent flooding emergencies to solicit input on the impacts and consequences of storms, prolonged rain and flooding at the local level, with emphasis on vulnerable geographic areas, services, and populations. This information will be used to inform future actions. This team will also use the results of CDC-funded Superstorm Sandy grants investigating the morbidity and mortality associated with Sandy, as well as the public health infrastructure impacts.
- **Heat Climate Impact Team.** The Heat Climate Impact Team is comprised of NYSDOH representatives from programs for which the health impact is sensitive to the climate impact of heat and from programs focused on protecting populations who are most vulnerable to the impacts from extreme heat. The team is combining input from these programs and the results of a literature review to summarize the available information on interventions to address the generally warming environment as well as hot periods classified as extreme heat events. The team is also developing a Heat Toolkit that will provide LHDs with recommendations for preparing for and responding to warming temperatures and extreme heat events.
- **Vector-borne Disease Climate Impact Team.** In addition to serving as a hub for cross-Departmental communication surrounding vector-borne diseases as related to a changing climate, the group will ensure study findings are translated into practice. The team will be contributing its collective programmatic knowledge for completion of a template to inform the NYSDOH Climate and Health Project Framework for Action, which will provide recommendations for both formally evaluated and promising practice adaptation interventions to be shared with LHDs for local implementation.
- **Food- and Water-borne Disease Climate Impact Team.** This team will be assessing the literature and studies done or ongoing within the NYSDOH in order to provide recommendations to LHDs for adaptations to decrease the public's risk for contracting food- and water-borne diseases such as salmonellosis and legionellosis. Similarly to the other climate impact teams, this team will be providing input into the development of the NYSDOH Climate and Health Project Framework for Action that will be shared as a resource for LHDs to take action in implementing promising practices and interventions.

## 9 CONCLUSION AND NEXT STEPS

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Due to the changing climate in NYS and related impacts on the public's health, it is imperative that the NYS public health infrastructure be well-positioned to address these health impacts. This preparedness for adaptation to climate-related health impacts includes several components as detailed in this Climate and Health Profile Report:

1. The climate of NYS is projected to become warmer and wetter, with an increase in both precipitation and temperature variability. Select key projections include:
  - **NYS will experience an increase in yearly average temperature of 4.5 to 8.5 degrees Fahrenheit by 2100, relative to the 1971-1999 baseline range according to the NCA,<sup>24</sup> and by roughly 4 to 14 degrees Fahrenheit by 2100 according to the ClimAID report.<sup>2</sup>**
  - **NYS will experience an increase in precipitation of 3 to 9% by 2100 according to the NCA.<sup>24</sup>** However, this impact will vary by NYS climate region, with some areas experiencing a reduction in precipitation of up to 6%, and other areas experiencing an increase in precipitation of up to 26%, according to the ClimAID report.<sup>2</sup>
  - **Heavy downpours are projected to become more frequent, and extreme variations between periods of heavy downpours and periods of drought is also estimated to occur.<sup>2,3</sup>**
2. Health impacts associated with these changes to the NYS climate are broad and include:
  - Exacerbation of respiratory conditions (e.g., pneumonia, asthma, chronic pulmonary disease, cardiovascular disease).
  - Increased duration and severity of allergy symptoms.
  - Increased risk for vector-borne diseases such as Lyme disease and West Nile virus.
  - Increased risk for food- and water-borne diseases such as shellfish poisoning from harmful algal blooms and legionellosis.
  - Increased heat-related illness (e.g., heat edema, heat stroke, heat cramps, heat stress, dehydration) and heat-related mortality.
  - Increased risk for water-borne disease due to overwhelmed water systems following heavy downpours and greater risk of injury and death following flooding.

3. Some populations are more vulnerable to each of these climate and health impacts than others, whether due to demographic factors, socioeconomic status, physiological condition, place, or occupation. These populations include:
  - Older adults
  - Children
  - New Yorkers of low socioeconomic status
  - Ethnic and racial minorities
  - Tribal populations
  - New Yorkers experiencing social isolation
  - New Yorkers who are homeless
  - New Yorkers with chronic diseases (e.g., diabetes, asthma, allergies, cardiovascular disease)
  - New Yorkers with mental illness
  - Women who are pregnant
  - New Yorkers living in flood-prone areas or along the coast
  - New Yorkers who rely on private well water and small water systems
  - Outdoor workers, including migrant and seasonal farmworkers
4. NYSDOH is studying climate and health indicators and translating those findings into recommendations or promising practices for interventions. Adaptation planning is also informed by several key state reports including the NYSCAP, the Sea Level Rise Task Force Report, the ClimAID Report, as well as the broad climate and health body of scientific literature.
5. Promising interventions do not solely fall under the purview of the NYSDOH. Therefore, collaboration with agencies that address infrastructure, social services, and community resources are key. This includes LHDs, other government agencies, and stakeholder organizations for focused implementation of recommended climate-health adaptations, prioritizing our most vulnerable populations at the local level. The implementation of the NYS Climate and Health Strategic Map will focus on supporting local communities in planning for the health impacts related to our changing climate by leveraging existing health programs to expand capacity.

As efforts continue to better characterize climate indicators, the relationship between climate impacts and health effects, and the evaluation of promising practices for adaptation, this report may be revised to reflect the state of New York's climate and health impacts so that NYSDOH and NYS LHDs can confront the challenges ahead in the interest of protecting our population's health.

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