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Delaware Journal of Public Health

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COVER

The impact of climate change on health outcomes can be complex. Changes in climate can create new health problems, as well as exacerbate existing health problems, and are reliant on multiple factors. For example, inadequate housing in an environment with extreme temperatures, or living in an area with inadequate disaster management plans, can lead to negative health outcomes. Every American is at risk of being affected by changes in climate.

The Delaware Journal of Public Health (DJPH), first published in 2015, is the official journal of the Delaware Academy of Medicine / Delaware Public Health Association (Academy/DPHA).

Submissions: Contributions of original unpublished research, social science analysis, scholarly essays, critical commentaries, departments, and letters to the editor are welcome. Questions? Write chealy@delamed.org or call Liz Healy at **302-733-3989**.

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IN THIS ISSUE

Omar A. Khan, M.D., M.H.S.
President Elect

Timothy E. Gibbs, M.P.H.
Executive Director

Being nimble and responsive is a goal of the Academy/DPHA, so when we learned of the Climate + Health Conference presented in June of this year, we became engaged in the dialogue. The State's Department of Natural Resources and Environmental Control sponsored the conference, and to say that it was a success is an understatement. During the afternoon session, attendees were challenged to respond based on what we had learned about the connections between climate and health. This is when the concept of this issue, published a scant 4 months later, was born.

Ironically and sadly, the timing of this issue is coincident to the stunning, worldwide, natural disasters and unusual weather that have occurred in recent weeks. Hurricanes, typhoons, wildfires, unseasonable cold and early snows. We would be remiss if we did not mention earthquakes that affected our neighbors in Mexico – but that is not (strictly speaking) climate or weather. These are all tragedies, and as humans, we share in the frustration, pain, and prayer that accompanies times and circumstances such as these.

Since this was originally written, the impact of the devastating hurricanes (Maria and Irma) on Puerto Rico is still unfolding. The scope of the disaster is unprecedented for this island nation, already beleaguered by a downturn in the economic climate. We ask for your support and outreach to assist our fellow Puerto Rican Americans. You can provide financial resources to a variety of organizations, including Unidos por Puerto Rico/United for Puerto Rico at: http://unidosporpuertorico.com/en/

As public health professionals and advocates, we endeavor to understand, prepare for, and respond to the relationship between climate and population health. There is essentially no disagreement about the reality of global warming and climate change. The main areas of concern should be minimizing and mitigating the effects so that we may face fewer disaster relief efforts in the future.

As usual, we have a broad range of articles, lexicon of terms, a resource guide, and an extensive toolkit, which we link to online. Our guest editor is Kerri Yandrick, Climate Change Project Specialist for the State of Delaware. With her assistance, we have scratched the surface of the complexities we face in Delaware. There is a second conference in the early stages of planning, and we welcome your input.
As always, we hope you'll enjoy this edition of the Journal and we welcome your feedback and comments.

Guest Editors

We are only as healthy as the world around us—our air, our water, our land and ecosystems. When these things are threatened, so are we. Climate change is a buzzword that floats around our minds, an intangible but terrifying thought. How do we conceptualize it? How do we do something about it? A direct way to meet climate change head on is by understanding its connection to our public health, and how we can prepare and protect the health of our communities and families.

Climate change and public health are inextricably linked. As environmental professionals, we are honored to serve as guest editors for this issue of the Delaware Journal of Public Health on climate change and health. The articles in this issue address how climate change does and will continue to affect the health of Delawareans, how Delaware agencies and organizations have been taking action to combat negative health impacts, and how our neighboring state of Maryland is addressing this topic.

As a result of climate change, Delaware is experiencing hotter temperatures, increases in vectors, degrading air quality, more frequent flooding, and more extreme damage from storms. While it is easy to think about how climate change affects our infrastructure and natural resources, we must not forget climate change's effects on public health. Any climate change effect will have health impacts on individuals directly: a heat wave can cause a spike in heat exhaustion cases; a warmer and wetter climate can increase the risk of mosquito- and tick-borne diseases; degrading air quality can result in more asthma hospital admissions; coastal flooding can affect the mental stress and physical safety of homeowners. The list goes on.

Articles in this issue expand on how three primary climate drivers, heat, air quality and vector-borne illness—have the ability to affect our physical and mental health, in ways universal and specific to Delaware.

Still, it is not enough to understand the negative health impacts of climate change. We must also understand the health benefits of mitigating greenhouse gases and adapting to climate change. There are actions that Delaware agencies and organizations are already taking to address climate change in a way that improves the health of Delawareans. Articles in this issue discuss the expansion of green space in Wilmington, the Plan4Health initiative, the Climate Ready Workforce Pilot Project and the Delaware Environmental Public Health Tracking Network as initiatives working to better the health of Delaware's people and communities.

This issue also explores efforts by Maryland's Department of Health and Mental Hygiene. Looking beyond our state borders allows us to draw on the experiences and advice of our neighbor states.

Climate change has the ability to affect the health of our family, friends and neighbors, but we have the ability to project our people, resources, and environment by understanding the science at play and planning ahead. By understanding how climate change affects health, taking action in Delaware, and drawing from what others have done, we can have a healthy, climate-smart Delaware.

We hope that you enjoy reading this issue of the Delaware Journal of Public Health. We encourage you to use the information in this issue, whether that means applying it to your job or engaging in conversations with others on climate change and health.

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Greetings,

Recently, I had the pleasure of attending DNREC's Climate + Health Conference where I welcomed professionals in health care, infrastructure, transportation, emergency management, environmental concerns, and social causes on behalf of Delaware as your Lt. Governor. This diverse group shared a common interest: a professional and personal dedication to keeping Delawareans safe and healthy. This objective is one that I have fought for both as a public health nurse and elected official.

Today, one of the greatest long-term threats to the safety and health of Delawareans is climate change, which we must face with good planning and preparations.

When we think of climate change, we usually think first of heat. Higher average temperatures and more extreme weather events, including frequent heat waves which take a toll on outdoor workers, people with pre-existing health and heart conditions, children, and the elderly. With the number of people in Delaware aged 65 or older expected to double in the next 35 years, the rising temperatures and their effect on the elderly are a particular concern.

Air quality is also a primary health concern, as well as an economic stressor. Based on estimates from the American Academy of Allergy, Asthma and Immunology, the total financial burden of asthma in Delaware is about $200 million a year. Additionally, changing climate and ecosystems may bring a predicted increase in cases of Zika virus, Lyme's disease, the West Nile Virus, and other illnesses.

These are health challenges we face without considering climate change. After all, climate change is a risk-magnifier. The more we know about, and can work together to better understand climate change, the more prepared we will be for its impacts – including any additional threats we haven't yet identified.

As health professionals, we have a responsibility to protect our residents and our State from these threats. The first step is figuring out what our organizations' needs are both separately and collectively, and where there are opportunities for collaboration. That's why this issue of *The Delaware Journal of Public Health* is so important.

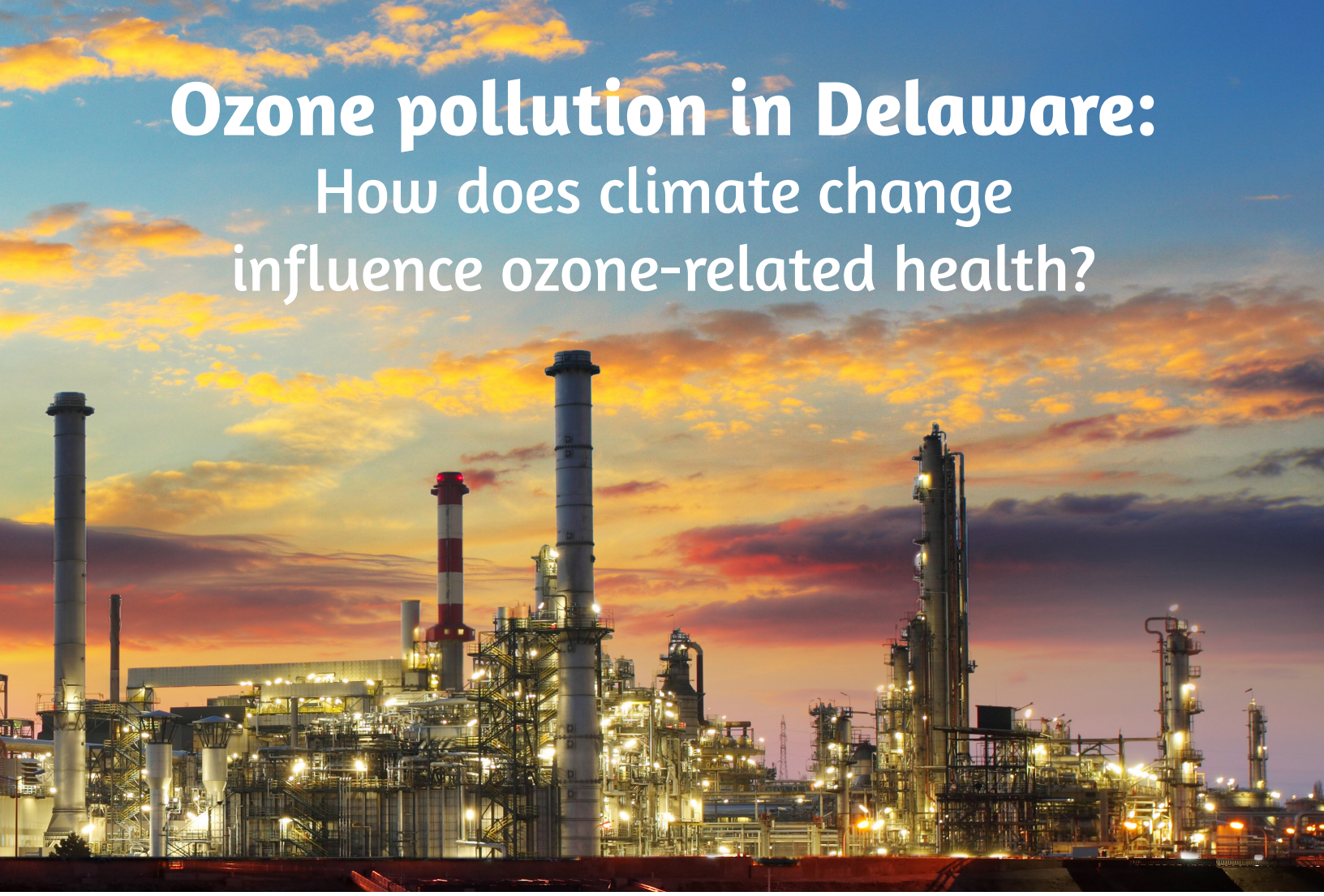
Again, as a nurse, a mother, a fellow Delawarean, and Delaware's Lieutenant Governor in an administration that remains committed to combating both the causes and effects of climate change in the First State, I thank you for the work you do every day to keep Delawareans safe and healthy.

Sincerely,

Bethany A. Hall-Long

Bethany A. Hall-Long, Ph.D, RNC, FAAN
Lt. Governor- Delaware

Ozone pollution in Delaware:
How does climate change influence ozone-related health?



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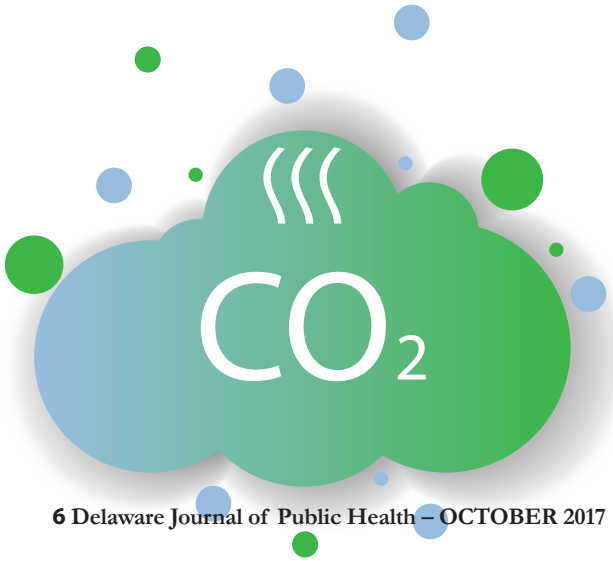
Abstract

Ozone is the only pollutant that exceeds national and state standards in Delaware. Using observations and two different climate models, the number of high-ozone days (days exceeding 70 ppb based on the 8-hour average in Delaware) is investigated for the late 20th and early to mid-21st centuries using a synoptic typing methodology, which relates surface conditions conducive to high-ozone events to atmospheric circulation. High-ozone days are associated with the absence of precipitation and southwesterly to west-northwesterly flow over Delaware, which tend to bring higher daily mean temperatures (exceeding 25.5°C). Models underestimate the number of observed high-ozone days in the 20th century, because the models do not include the effects of ozone regulation, which has decreased the number of ozone days. Meanwhile, higher concentrations of greenhouse gases and the resulting higher temperatures favor increased ozone days, an effect that is captured by the models. As temperatures continue to rise in the 21st century, climate projections indicate that high-ozone conditions will occur more frequently. By mid-century, the number of high-ozone days is projected to increase by about an extra day every two years, which is faster than it was in the previous 30 years. Thus global warming cancels out a quarter of the progress made in improving air quality in the state of Delaware, meaning



that the air quality in mid-century is expected to be the same as it was around 2006. In a warming world, air quality standards will need to stricter to maintain or reduce the number of high-ozone events in Delaware.

1. Background

Climate change is much more than simply an atmospheric phenomenon; it can have profound impacts on public health. The most recent report of the Intergovernmental Panel on Climate Change (IPCC) describes an average warming of the global climate of about 2°C by the end of the 21st century (IPCC, 2013), while regional studies have indicated a stronger warming along the east coast of the United States, between 2.5°C and 5.5°C (Maloney et al., 2013) the authors examine projections of twenty-first-century climate in the representative concentration pathway 8.5 (RCP8.5. Exacerbating the impact of this temperature increase is the expectation that heat waves will occur with greater frequency, intensity, and duration. If emissions of carbon dioxide (CO2) continue on their current trajectory, by mid-century the mid-Atlantic may experience 50 more days per year of high temperatures exceeding 32°C (90°F) (Melillo, Richmond, & Yohe, 2014), while in Delaware the number of days with maximum temperatures above 35°C (95°F) is expected to vary from less than 5 to 15-30 (Hayhoe, Stoner, & Gelca, 2013). These temperature increases are likely to impact Delaware's public health, due to the known relationship between high temperatures and increased mortality (Anderson & Bell, 2009; Roldán, Gómez, Pino, & Díaz, 2015). In particular, this link appears strongest in the eastern United States when compared to elsewhere in the country (Anderson & Bell, 2009; Curriero et al., 2002).

This increase in temperature influences public health in ways other than the direct mortality impact. One of these indirect impacts is the temperature influence on tropospheric (surface) ozone (O3) pollution. Tropospheric ozone, which is regulated by the U.S. Environmental Protection Agency (EPA), is a summer pollutant that forms in the lower atmosphere as a result of photochemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOC). Ozone is currently the only pollutant that exceeds national and state standards in Delaware. Ozone can: cause damage to the respiratory tracts, including shortness of breath and inflammation; exacerbate asthma, emphysema, and chronic bronchitis; and cause chronic obstructive pulmonary disease (COPD). Children are generally at higher risk than adults because their lungs are still developing, they are generally more active outdoors, and they are more susceptible to asthma; however, older individuals are also considered to be a more at-risk population (https://www.epa.gov/ozone-pollution/health-effects-ozone-pollution). Higher ozone levels have also been shown to increase hospital admissions for asthma and COPD for the elderly and children (Halonen et al., 2010).

There are three mechanisms by which ozone may reach higher concentrations and/or exceed regulatory standards more frequently in a warming climate. The first is that higher temperatures enhance the photochemical reactions that produce ozone (Seinfeld & Pandis, 1998). Secondly, episodes of high ozone are associated with certain large-scale weather conditions, such as the passage of mid-latitude cyclones or the western expansion of the Bermuda High (Shen, Mickley, & Tai, 2015). The weather conditions over a region of interest on a particular day are known as the "synoptic weather conditions". Due to climate change, the synoptic weather conditions conducive to high-ozone events may occur with greater frequency, leaving the potential for more high-ozone episodes. Finally, synoptic conditions that today are not typically associated with high-ozone events may become more conducive to the formation of ozone as the climate warms. This paper will focus on the second factor: the synoptic weather conditions associated with high ozone and their changes in frequency due to climate change.

The synoptic weather conditions can be grouped into a few "synoptic types", thus each day can be assigned to a synoptic type that represents all days of the year with similar synoptic weather conditions. This is done using a variety of meteorological variables, including temperature, sea-level pressure, humidity, precipitation, cloud cover, and wind speed and direction. Thresholds and/or spatial distributions of these variables are identified and used to classify each date into one of a limited number of synoptic types. The synoptic typing used in this study was developed by

a team at the University of Delaware and includes data spanning back to 1946 (Siegert, Leathers, & Levia, 2016; Suriano & Leathers, 2017). In the summer, the season most favorable to ozone formation, nine synoptic types were identified, four of which are associated with a high probability of high ozone (details in section 2). The number of days that belong to one of the four favorable synoptic types is evaluated in this study using future climate projections (details in section 3). The resulting trends are indicative of changes in the number of high-ozone days.

The extensive work performed in preparation of the climate assessment reports of the IPCC resulted in a plethora of available climate modeling data, which are publicly available online. Specifically, the Coupled Model Intercomparison Project (CMIP5; Taylor, Stouffer, & Meehl, 2012) database consists of dozens of climate models from agencies worldwide, along with a number of experiments for each model to assess model performance and make projections of climate in the past, present, and future. For this study, two climate modeling suites were selected, which are considered to be among the most accurate and have fine enough resolution to evaluate local Delaware climate. These are the Hadley Centre Global Environment Model (HadGEM2; Collins et al., 2011), run by the Met Office in the United Kingdom, and the Model for Interdisciplinary Research on Climate (MIROC5; Watanabe et al., 2010), run by the University of Tokyo and the National Institute for Environmental Studies in Japan. This research uses historical runs from both models to examine the past and present climate in Delaware from 1986 through 2015. Additionally, future projections are included from the Representative Concentration Pathway 8.5 (RCP 8.5; van Vuuren et al., 2011), which represents a "business-as-usual" scenario of future carbon emissions. Specifically, this paper examines the period 10 years into the future (2025–2034) and in the middle of the century (2045–2054).

2. What is a "high-ozone" event?

The EPA has established the Air Quality Index (AQI; Environmental Protection Agency, 2017) in order to assess the public health impacts of ozone and other pollutants as high levels of pollution are occurring. The AQI includes 6 color-coded levels that indicate the severity of the particular pollutant, ranging from "good" on the low end to "hazardous" at the high end (Table 1; Environmental Protection Agency, 2015). These levels help users see at a glance when they should consider seeking shelter from prolonged ozone exposure. An AQI exceeding 100 indicates an increased level of caution for at-risk groups; for ozone, this means that the 8-hour average exceeds 70 ppb. The maximum AQI index is 500, corresponding to the pollutant reaching the Significant Harm Level (SHL); for ozone, the SHL is 600 ppb using a 2-hour average.

*Table 1: US EPA Air Quality Index (AQI) for ozone, as defined by the 2015 standards. *SHL represents the Significant Harm Level, which is 600 ppb based on a 2-hour average.*

AQI Category	Index Value	8-hr Ozone (ppb)
Good	0 – 50	0 – 54
Moderate	51 – 100	55 – 70
Unhealthy for Sensitive Groups	101 – 150	71 – 85
Unhealthy	151 – 200	86 – 105
Very Unhealthy	201 – 300	106 – 200
Hazardous	301 – 500	201 – SHL*

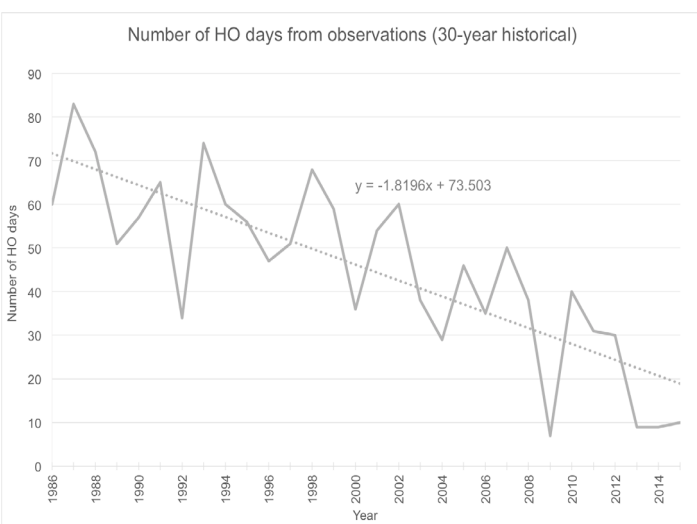
The Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Air Quality (DAQ) operates several air quality observing stations throughout the state of Delaware that track several pollution parameters, including ozone. The first of these stations reporting ozone became operational in 1980, and additional stations have been added, removed, or replaced since then. As of 2015, Delaware has 7 air quality stations that measure ozone (Figure 1). Due to Delaware's small size, the 7 stations (2 stations in Sussex County, 1 station in Kent County, and 4 stations in New Castle County) provide a good spatial coverage of ozone levels in the state. The data from these stations are archived by DNREC and are available online via the EPA Air Quality System (AQS) Data Mart at https://www.epa.gov/outdoor-air-quality-data.

Figure 1: Location of the Delaware air quality monitoring stations. Note that the Newark, Delaware City, and Dover stations do not record ozone levels.

In order to determine what qualifies as a "high-ozone" (HO) day using this observational data, it was necessary to set a threshold value. Since the AQI index value of 100 indicates a pollution level that can be considered harmful to sensitive populations, the corresponding ozone level of 70 ppb based on the 8-hour average was used to classify days that are considered HO events. Since Delaware is a small state, even if only one station's 8-hour average exceeds this level, the day is classified as HO.

Based on these criteria, the observational record of ozone for the historical 30-year period from 1986 through 2015 was analyzed. As can be seen in Figure 2, the number of HO days has been decreasing over the 30-year period. On average, each year during the study period had about 2 fewer days of high ozone per year (as the trend line in Figure 2 has a slope of -1.82 HO days/year), changing from about 70 HO days per year to less than 10 in the past few years. This steady decrease was not a random phenomenon, but rather the result of stricter regulation (such as federal and state air quality standards) and societal reductions in the emissions of ozone-forming pollutants. This improvement in air quality has occurred despite the underlying warming trends from climate change, which would have caused an increase, not a decrease, in the number of HO days. Since past or future regulation and emission controls are not simulated in climate models, only trends due to global warming will be identified in this study.

Figure 2: Number of high-ozone (HO) days in Delaware from historical observations during the 30-year period 1986-2015.



3. Detecting high-ozone events using climate models

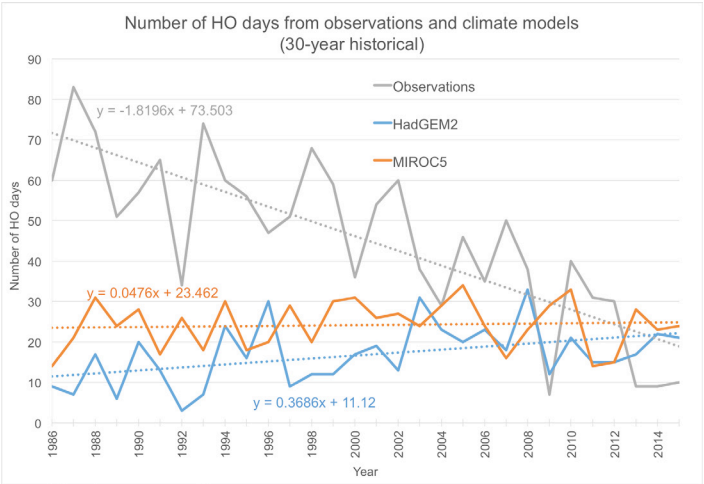
In order to evaluate how ozone levels in Delaware may change due to the changing climate, it is necessary to establish criteria to detect conditions in climate models that would be conducive to high ozone. This was done by evaluating the synoptic weather conditions that were present on days in the most recent decade of the period of interest (2006–2015) which were classified as HO based on the aforementioned criteria (i.e., 8-hour ozone exceeding 70 ppb). The calibration period was the last decade, as opposed to any other decade in the historical period, to ensure that the projected changes in HO days due to climate alone would be inclusive of current, not past, regulation. Several meteorological variables were used to detect synoptic weather conditions favorable for high ozone in climate models. First and foremost, the spatial distribution of sea level pressure (SLP) was used, since it is representative of the flow patterns near the surface. Only cases with an overall spatial distribution of SLP that would lead to transport of the ozone precursors (NOX and VOC) into the state were included, specifically, southwesterly to west-northwesterly flow. The second condition involves temperature, since higher temperatures make HO events more likely. Days with mean daily temperature in the state exceeding 25.5°C (78°F) had a high likelihood of high levels of ozone. Note that this is a mean daily temperature; the daily highest temperature on these days consistently exceeded 32°C (90°F), but mean temperature was used since that variable is more readily available in climate models. The third condition leading to a HO event was the absence of precipitation. Rain prevents ozone from forming, due to both a lack of sunlight that drives the photochemical reactions and the washout of the available precursor pollutants. As such, only days when there was no measurable precipitation (defined as less than 1 mm/day) in the climate model were considered to be favorable to high ozone.

These criteria were used to evaluate daily climate model output during the summer months (June through August hereafter) for the same 30-year period as the observations (1986–2015). Any day that met all three criteria was classified as a HO day. These results are shown in Figure 3. Since the criteria were tuned to the most recent decade, the model data match the observations very well in the last 10 years, but underestimate the number of HO days in the earlier decades. This is to be expected due to the aforementioned calibration, because earlier in the historical period the regulation was less strict and

therefore ozone concentrations were generally higher. Weather evolves in a climate model the same way as it does in the real word, but not exactly on a day-to-day or year-to-year basis. For example, if temperature was above 35°C on September 1, 2015, it is not expected to be above 35°C on the same day or year in the climate model. Rather, the climate model will have the same frequency of days above 35°C as the real world over the course of a decade. With respect to ozone, climate models are not expected to perfectly capture the number of ozone days year by year, but rather the characteristics of the underlying variability and frequency over time scales of a decade or longer. In other words, the model results show how the number of HO days would have changed over the past 30 years if the regulatory and societal factors were held constant at 2015 levels (i.e., a standard of 70 ppb for 8-hour average O3, along with 2015 emission standards and industry pollution controls). This allows the models to estimate how the number of HO days would fluctuate solely due to the climate, and not to societal and regulatory changes.

The HadGEM2 model indicates that, under the warming trend of the past 30 years, Delaware could expect about one extra HO day every 3 years, given that the trend line in Figure 3 has a slope of +0.37 HO days/year. This trend is not as strong in the MIROC5 model, which shows only about 1 extra HO day every 20 years (or +0.05 HO day/year). In terms of variability, both models exhibit a lower standard deviation than observed in the last decade (~6 vs. 16 HO days for models and observations, respectively (not shown).

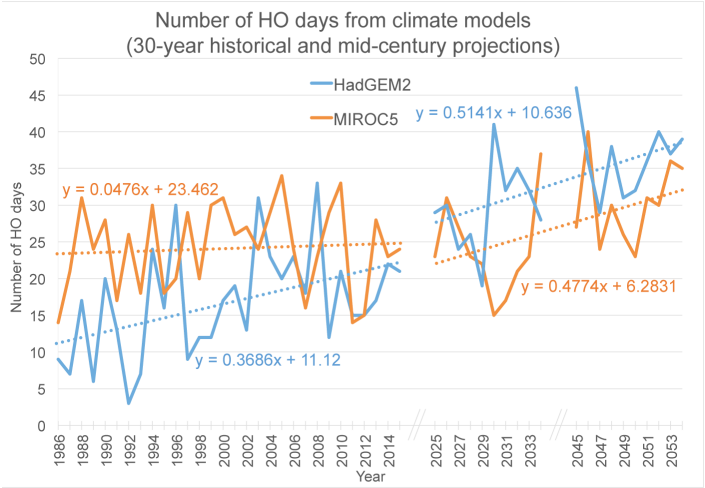
Figure 3: Number of high-ozone (HO) days in Delaware from the historical observations versus the two climate models (HadGEM2 and MIROC5) for the 30-year period 1986-2015.



4. Projected changes in the number of high-ozone events

The climate models were evaluated for 10 years from now (2025–2034) and mid-century (2045–2054) together. These results are shown next to the 30-year historical results in Figure 4. Once again, the assumption behind these results is that all regulatory and societal factors that impact the production of ozone remain at the 2015 levels and therefore the results indicate how the number of HO days may change solely due to the changing climate in Delaware. By mid-century, there is a clear increase in the number of HO days to between 30 and 40 days, depending on the model, from the current ~20 days per year. Both models also indicate an acceleration in the increase of the number of HO days, as indicated by the steeper slope of the trend lines (from +0.05 to +0.48 HO days/year for the MIROC5 and from +0.37 to +0.51 HO days/year for HadGEM2). Both models converge to the same estimate of one extra HO day every 2 years, as opposed to every 3 years (HadGEM2) or every 20 years (MIROC5). Global warming erases about 25% of the progress from regulation in reducing the number of HO days in the past 30 years (Figure 2), as the slopes went from approximately -2 to +0.5 HO days/year.

Figure 4: Number of high-ozone (HO) days in Delaware from the two climate models (HadGEM2 and MIROC5) for the historical 30-year period 1986-2015 and for two future periods, 2025-2034 and mid-century (2045-2054).



5. Conclusions and Future Work

The goal of this study was to investigate the impact of the changing climate in Delaware on the expected number of days with ozone levels high enough to be unhealthy for sensitive populations. A combination of observations and climate model data were used to identify and link synoptic conditions to days with high-ozone concentrations. High-ozone days are associated with: southwesterly to west-northwesterly flow over Delaware, which brings pollutants from upwind states; no precipitation; and high daily-mean temperatures

(exceeding 25.5°C). Future climate projections showed that these conditions will occur more frequently in mid-century, thus increasing the number of HO days by about an extra day every two years, which is faster than it was in the previous 30 years. As such, global warming basically undoes a quarter of the progress in air quality in the state of Delaware, meaning that the air quality in mid-century is expected to be the same as it was around 2006. To maintain the current ozone levels, therefore, regulation will need to be stricter than it is today, and even stricter to maintain the past negative trends. Future work includes: the analysis of additional climate models, such as the CCSM4, GFDL, and CNRM-CM5, to better represent the uncertainty around future climate projections; a quantification of the potential increases in ozone concentrations, not only in the frequency of high-ozone days; and an assessment of the health impacts of the expected changes in ozone.

Acknowledgments

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The DPH Bulletin – Special flu edition

From the Delaware Division of Public Health ***September 2017***

These Wesley College students got their 2016 flu shots at the Division of Public Health's drive-thru flu clinic in Dover.

Drive-thru, walk-up flu clinics offered

The Division of Public Health (DPH) has scheduled numerous flu clinics and urges all Delawareans, including those with access and functional needs, to get their flu shots. View the flu clinic schedule at flu.delaware.gov or call DPH at 800-282-8672. To find flu clinics in your ZIP code, visit www.flu.gov.

Two large flu clinics will be held, rain or shine, for ages 9 and up, on these dates:

- Oct. 5, 10:00 a.m. to 2:30 p.m. – Walk-up flu clinic outside Porter State Service Center, 511 W. 8th St., Wilmington, DE 19801. Staff speaking Spanish, Creole, Ibgo, Korean, Hebrew, Yoruba, and American Sign Language (ASL) will be onsite.
- Oct. 10, 6:00 a.m. to 6:00 p.m. – Drive-thru flu clinic, Department of Transportation campus, front parking lot, 800 S. Bay Rd., Dover, DE 19901. Any size vehicles and any number of people in one vehicle are welcome. Staff speaking Spanish, Haitian Creole, and ASL will be on site.

Attendees should wear short sleeves or loose fitting clothing for access to the upper arm. Leave pets at home. Pedestrians welcome.

Free materials on DPH's flu toolkit

Need a flu poster, handout, newsletter article, or video link for a mass email? Visit DPH's flu toolkit at flu.Delaware.gov.

DELAWARE HEALTH AND SOCIAL SERVICES
Division of Public Health

Get flu vaccines early, every year

All Delawareans 6 months of age and older who have not yet been vaccinated against the flu should get a flu vaccination as soon as possible. DPH advises young children, adults 65 and older, and those with underlying medical conditions to get their flu vaccinations by the end of October. Vaccinations help protect everyone.

Delawareans should first seek a flu vaccine from their doctors, pharmacies, or grocery stores. Uninsured people, those whose insurance does not cover flu vaccine, and those without doctors may be vaccinated at Public Health clinics, which accept donations, Medicaid, or Medicare Part B.

The Centers for Disease Control and Prevention (CDC) recommends receiving the flu shot (inactivated influenza vaccine or IIV) and the recombinant influenza vaccine (RIV). Read the flu vaccine guidance at www.cdc.gov/flu/.

Help prevent the flu!

- Get a flu shot for you and everyone in your household.
- Wash hands often with soap and water, or use hand sanitizer with 60 percent alcohol.
- When you cough or sneeze, cover your nose and mouth with a tissue or aim for your inner elbow.
- If sick with flu-like illness, stay home from work, school, and other gatherings. Do not return until you are free of fever (100 degrees F [37.8 degrees C]), without using fever-reducing medications, for at least 24 hours. If symptoms worsen, call your doctor.

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Delaware Chapter

Safeguarding Worker Health and Safety from a Changing Climate:

Delaware's Climate-Ready Workforce Pilot Project

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Abstract

Changing climate conditions threaten the health and safety of the State of Delaware's most important assets: its workforce. Building on momentum at the state level to assess climate risks and implement relevant adaptation actions, five state agencies implemented the Climate-Ready Workforce Pilot Project to identify and safeguard at-risk workers from the impacts of extreme events such as storms and floods as well as extreme temperatures. Findings indicate that the five participating agencies have an important foundation of worker health and safety policies, procedures and practices. Enhancing their climate resilience will require both strengthening the fundamentals of current policies and procedures by improving processes for policy development, implementation, and enforcement, more explicitly incorporating climate considerations, and sharing agency good practices are key actions.

1. Introduction

1.1 Delaware's Changing Climate

Delaware is already experiencing higher temperatures, increasing rainfall, and rising sea levels, and these changes are expected to continue—and become more serious—in the coming years. Findings from the *Delaware Climate Change Impact Assessment* (2014) indicate that:

- Annual and seasonal temperatures have increased by approximately 2˚F over the past century.
- Average temperatures are expected to increase by another 2.5 to 4.5˚F by 2050, and as much as 8˚F by the end of this century.
- The number of very hot days (over 95˚F) is expected to increase, and heat waves are projected to become longer and more frequent.
- Heavy rainstorms are expected to become more frequent and more intense, with an increasing number of very wet days with two inches or more of rainfall.
- Sea level rise is already occurring along Delaware's coast, with an increase of 13 inches over the past century.
- Higher sea levels will likely increase coastal flooding as storm surge reaches further inland.

1.2 Climate-related Risks to Worker Health and Safety

Changing climate conditions pose health and safety risks to state employees whose duties require extended periods of outdoor exposure. These risks include increased exposure to high heat days and other extreme weather conditions, including flooding and storm-related hazards, as well as indirect impacts related to air quality, vector-borne diseases, and water-related illnesses. Figure 1 summarizes climate change hazards that may affect workers, occupational health impacts, the work and individual factors that contribute to vulnerabilities, and the types of work environments that are most affected.

Climate change effects can be a "risk magnifier" for vulnerable populations, such as outdoor workers who face greater exposure to environmental conditions. Individual workers may have additional vulnerabilities that increase their risk. For example, people with underlying health conditions, such as asthma or cardiovascular disease, may be more sensitive to extreme heat and worsened air quality. Age, weight, and fitness can all affect an individual worker's vulnerability to weather-related challenges.

1.3 Climate Adaptation in Delaware

Delaware has been taking action to adapt to these changing climate conditions. In September 2013, former Governor Markell issued Executive Order 41: *Preparing Delaware for Emerging Climate Impacts and Seizing Economic Opportunities from Reducing Emissions*. The Executive Order acknowledged the challenges facing Delaware from climate change and the opportunities for building a cleaner, more sustainable state. It directed state agencies to develop strategies to address both the causes and consequences of climate change. One result was the development of the Delaware Climate Change Impact Assessment (2014), which summarizes the best available science on the potential impacts of climate change to people, places and resources in the State. The Climate Framework for Delaware was prepared in 2014 in response to findings in the Climate Change Impact Assessment and contains over 150 climate change adaptation recommendations from Delaware's eleven state agencies. Many agencies recognized a common concern—the risks climate change poses to one of the State's most valuable assets: its workforce.

The Climate-Ready Workforce Pilot Project was launched in 2016 to protect the health and safety of state workers, particularly in the face of changing and unprecedented extreme weather conditions. Four Twenty Seven and MDB, Inc. were hired as the consultants for this project, and five of Delaware's agencies were involved: the Department of Natural Resources and Environmental Control, the Delaware Department of Transportation, the Department of Health and Social Services, the Department of Safety

Figure 1. Climate Change-related Hazards and Impacts on Worker Health and Safety

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Climate Change Related or Induced Hazards	Impacts on Worker Health and Safety	Work-Related Factors	Individual Factors	Locations Most Affected
Air Quality				
-Increased particulates and pollutants such as ozone and pollen -Indoor air pollutants including mold	-Respiratory illnesses -Cardiovascular disease -Increased allergies	-Work practices -Work/rest cycles -Protective gear, personal protective equipment (PPE) -Indoor air quality -Hazard exposure -Proper ventilation	-Age -Weight -Metabolism -Degree of physical fitness -Medical conditions -Use of alcohol or drugs -Clothing worn	-Indoor -Outdoor -Rural -Urban
Extreme Weather				
-Hazards associated with clean-up following an extreme event (e.g., flood, storm) such as hazardous debris, mold, sediments, chemicals	-Respiratory illnesses -Cardiovascular disease -Vector-born infections -Skin irritations, rashes -Allergies -Heat stroke -Cold stress -Traumatic injuries -Mental stress, depression	-Work practices -Work/rest cycles -Access to water -Protective gear, PPE -Location and condition of work place	-Age -Weight -Degree of physical fitness -Medical conditions -Mental health -Previous experience with disasters -Clothing worn	-Indoor -Outdoor -Rural -Urban
Extreme Temperatures				
-Heat stress	-Dehydration -Heat cramps -Heat exhaustion, heat fatigue -Heat rash -Heat stroke -Heat syncope/ fainting	-Work practices -Work/rest cycles -Access to water -Access to shade, cooling -Properly worn PPE	-Age -Weight -Metabolism -Degree of physical fitness -Medical conditions -Degree of acclimatization -Prior heat injury -Use of alcohol or drugs -Clothing worn	-Outdoor -Rural -Urban
-Cold stress	-Frost bite -Hypothermia -Chilblains	-Work practices -Work/rest cycles -Access to heating -Properly worn PPE	-Age -Weight -Metabolism -Degree of physical fitness -Medical conditions -Degree of acclimatization -Use of alcohol or drugs -Clothing worn	-Outdoor -Rural -Urban
Infectious and Vector-borne Diseases				
-Greater incidence of and changes in pathogens -Greater incidence of and changes in insect distribution -More plant allergens	-Infectious diseases -Vector-borne infections -Allergies, asthma -Dermatitis	-Work practices -Protective equipment, PPE	-Age -Weight -Degree of physical fitness, -Medical conditions -Medications used -Clothing worn -Use of insecticides	-Healthcare facilities -Outdoor -Rural -Urban

Source: Content modified from Appendix A in National Institute of Environmental Health Sciences (NIEHS) (2015).

and Homeland Security, and the Office of Management and Budget. Representatives of each of these agencies created the inter-agency pilot project team which helped to steer the project. Four Twenty Seven and MDB, Inc. worked with the inter-agency pilot project team to:

- Review and evaluate current state agency health and safety policies and practices,
- Conduct outreach to at-risk state workers (e.g., outdoor workers) to identify opportunities to improve current policies and practices, and
- Recommend "best practices" for supporting worker health and safety and reducing risks posed by climate change.

1.4 Delaware's At-Risk Workers and Their Work Environments

The inter-agency pilot project team members identified the at-risk positions that work in six types of climate-exposed environments. Rather than focusing simply on "outdoor workers," participating agencies identified at-risk workers as individuals who spend time in work environments in which they are exposed to weather-related hazards, such as extreme heat, cold, storms, and flooding. At-risk work environments include both indoor and outdoor settings:

- **Indoor unconditioned spaces**, which vary in size and include both smaller spaces such as mechanic shops, electrical rooms, and fee booths, and larger spaces such as buildings, homes and warehouses.
- **Indoor confined spaces**, which include compost rooms, crawl spaces, drainage systems, and building mechanical spaces.
- **Outdoor urban spaces**, which consist of paved areas such as garages, bridges, and outdoor areas surrounding buildings, as well as unpaved areas such as crawl spaces, roofs, and outdoor open areas.
- **Outdoor natural areas**, which are commonly identified as wooded forests, meadows, state parks, beaches, and trails. Many of these outdoor work areas are adjacent to or near built infrastructure such as a rest area or a highway.

Outdoor suburban areas, which can be found in the suburbs or in neighborhoods, include residents' yards, streets, empty lots, and other grassy areas.

Heavy equipment, which are used by agencies' staff and include loaders, leaf vacuums, wood chippers, and spare tires, and **vehicles**, which include trucks, skid steers, snow plows, street sweepers, tractors, and fork lifts.

Agencies identified at-risk workers who spend time in each type of work environment. An at-risk worker in the climate change context is one who is more exposed to the negative impacts of climate change during her or his workday. The inter-agency pilot project team recognized that at-risk workers will be affected by changing climate conditions related to extreme heat, flooding, and storms, with impacts on air quality, vector-borne diseases, and water-related illnesses.

The vulnerability of at-risk workers is defined in part by the work environment (exposure) and the type of work being done (e.g., degree of physical exertion, use of tools). Other factors that contribute to risk is a worker's age, health and physical condition, level of safety training, availability of safety equipment or protective gear, and a workplace culture that values and supports health and safety.

Different agencies considered a variety of positions to be at-risk but there were commonalities among the five agencies. The positions that were most often classified as being at-risk by at least three of the five agencies include technicians, maintenance workers, engineers, those who provide support services and managers and supervisors. In addition, many agencies indicated that they had seasonal positions which accounted for a large number of employees, as in the case of DNREC, which employs more than 190 seasonal maintenance workers. Pilot project team members identified the types of job positions and work environments that could be considered at-risk, and estimated the numbers of positions in their agency divisions.

1.5 Framework for Analysis

The framework used for this analysis and good practice recommendations are the Occupational Health and Safety Administration's (OSHA) Publication 3885 entitled "Recommended Practices for Safety and Health Programs" (2016)[1]. Although OSHA's coverage in Delaware extends only to private sector employers and does not include public employers and employees, the federal agency's guidelines are a useful and widely accepted benchmark for assessing the effectiveness of occupational health and safety policies and procedures. The core elements in the OSHA guidelines, outlined below in Figure 2, informed the determination and organization of the key findings and recommendations.

Figure 2. Core Elements of OSHA Guidelines

Additionally, "Advancing the framework for considering the effects of climate change on worker safety and health" (Schulte et al., 2016) provided a climate change specific framework for the policy review. This framework for climate related occupational hazards includes: 1) increased ambient temperature, 2) air pollution, 3) ultra-violet radiation, 4) extreme weather, 5) vector-borne diseases and other biological hazards, 6) industrial transitions and emerging industries, and 7) changes in the built environment.

2. Methods

The Climate-Ready Workforce Pilot Project included three methodological components to inform the assessment of the five Delaware agencies' readiness for climate change. They were: 1) a thorough review of participating agencies' existing policy documents relevant to employee health and safety in changing climate conditions, 2) key informant interviews with staff responsible for defining or implementing health and safety policies and procedures, and 3) a survey targeted to obtain feedback from at-risk and other staff across the participating agencies.

2.1 Policy Review

The participating agencies provided the consultant team with the relevant written policy documents relating to worker health and safety. The consultant team reviewed each document to evaluate assurance of employee health and safety and the applicability of those policies to at-risk workers as climate conditions change. Relevant sections of each policy were highlighted as either good practices or gaps in assuring employee health and safety, and recorded in a policy review matrix.

Good practices were defined as policies that account for worker health and safety in a variety of climate conditions, including extreme heat, cold and severe storms. These policies identify the risks associated with these conditions, explain how to prepare for them, detail the training needed to prepare for and respond to these conditions, provide information on recognizing hazards and/or climate related illness, and/or instruct staff on how to respond to those hazards. Policies were categorized as gaps if they lacked the type and level of information that could be found in policies labeled as good practices. For example, policies could be defined as gaps because they include instructions limited to the care of equipment, or only provide information on reactive actions such as emergency response functions.

2.2 Key Informant Interviews

The goal of the interviews was to better understand key informant's thoughts, experiences, and knowledge about the existing safety and health policies and procedures in each agency and the potential impacts of climate change on those policies and procedures. The inter-agency pilot project team identified the key informants and provided their contact information to the consultant team. Key informants are agency staff that were identified by participating divisions as being important actors in the development or implementation of agency health and safety policies. Their insights were used to inform survey development, in order to obtain a broader understanding of issues highlighted during the interviews.

The consultant team reached out to these potential interviewees via email and conducted eleven interviews between December 19, 2016 and February 9, 2017. Based on availability, the consultant team was able to conduct interviews with representatives from four of the five agencies[2]. Each interview was approximately 45 minutes long, and interviewees included director-level, manager-level, supervisor-level, and technical-level staff. The interview questions focused on familiarity with and the perceived effectiveness of agency health and safety policies, procedures and training; the impact of climate conditions on interviewee's (or their staff's) work, and opportunities for improvement.

2.3 Surveys

An employee survey was also conducted to compile a broad range of feedback on agency health and safety policies and procedures from agency staff. The survey was deployed using SurveyMonkey and distributed to staff either via email or on paper depending on whether those staff had access to a computer. Each participating agency selected the employees to take the survey. While the focus was on employees who were considered "at-risk" to changing climate conditions, the agencies also disseminated the survey to staff who are not considered at-risk (e.g., work in offices) at their discretion.

Survey questions focused on staff familiarity with and perceived effectiveness of agency health and safety policies and procedures. Questions included inquiries into whether staff were informed of agency polices, how and by whom; whether they were notified before extreme weather, how and by whom; what the most significant hazards affecting staff work are; and what the most important improvements to make might be.

All electronic and paper survey responses were entered into SurveyMonkey for analysis. The analysis of survey responses was conducted using the SurveyMonkey "Analyze Results" feature, in addition to an agency-specific analysis conducted in Microsoft Excel.

3. Key Findings

Based on the policy review, key informant interviews, and surveys, the consultant team identified:

Cross-Agency –

- The strengths of the overall set of policies and procedures of all five participating agencies in incorporating climate resilience, and
- Opportunities for improvement in the overall set of policies and procedures of all five agencies.

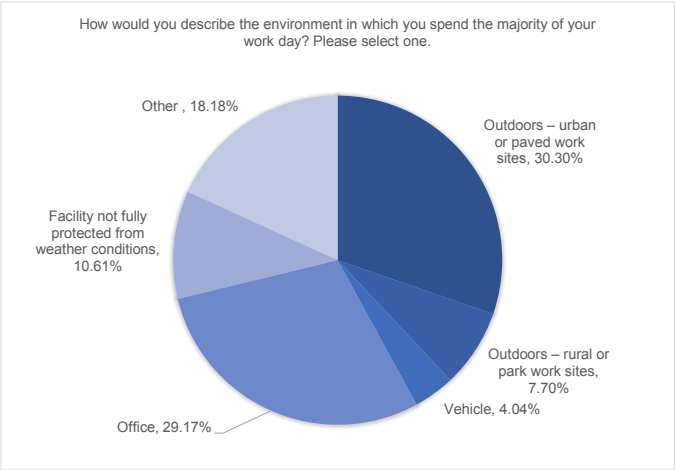
For Individual agencies –

- What each of the five agencies is doing well in regard to incorporating climate resilience into its worker health and safety policies and procedures, and
- What each of the five agencies is not addressing and/or could improve.

3.1 Background and Key Concerns

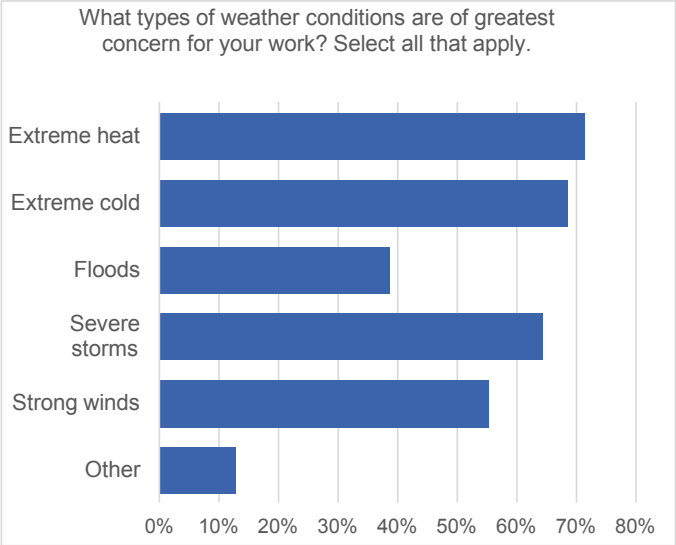
The work environments in which agency staff spend the majority of their work day is an important factor in exposure to climate change-related hazards. As noted in Section 1, the work environments that are subject to the greatest exposure to these hazards include outdoor urban spaces and natural areas as well as vehicles and facilities that are not fully protected from weather. Thirty percent of survey respondents spend the majority of their work day outdoors in urban or paved work sites, and another 30% spend the greatest part of their work day in an office. The remainder of respondents spend the majority of their work day in a facility that is not fully protected from weather conditions (11%), outdoors in rural or park work sites (8%), or in a vehicle (4%). (See Figure 3.)

Figure 3. Work Environments in which Survey Respondents Spend the Majority of their Work Day



In terms of climate hazards that affect their work, survey respondents indicated that extreme heat is the greatest concern (71%), followed by extreme cold (68 %), severe storms (64%), strong winds (55%), and floods (39%). (See Figure 4.)

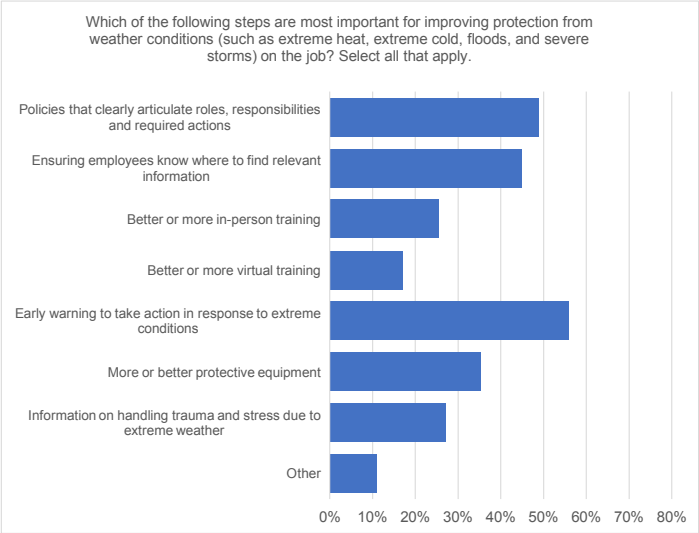
Figure 4. Weather Conditions of Greatest Concern in relation to Survey Respondent



Appropriate adaptation actions can help to reduce the impacts of climate change-related hazards on worker health and safety. While some of these actions may be more explicitly linked to weather and climate hazards (e.g., early warning), in many cases, strengthening the processes related to health and safety policies will enhance worker protection from climate change hazards. The greatest number of respondents (56%) indicated that early warning to take preventive action would be most valuable. A significant number of survey respondents also indicated that the following would be important: policies and procedures that clearly articulate

roles, responsibilities and required protective actions, and employees knowing where to find relevant policies, procedures and other information. (See Figure 5.)

Figure 5. Most Important Actions to Improve Worker Protection from Weather Conditions



3.2 Summary of Findings

Policy Guidance

- Addressing gaps in safety and health programs related to climate change is built on the foundation of core safety and health policies and procedures.
- In reviewing health and safety policies across the five agencies we discovered a high degree of variation in detail and implementation of the written policies.
- There is a need to improve clarity and consistency in agency-level policies and incorporate relevant weather and climate factors, including high heat, extreme cold, and vector-borne diseases, into safety and health policies and procedures.

Roles and Responsibilities

- Supervisory leadership was repeatedly rated highly by survey respondents, and many supervisors play a key role in informing workers about the agency's safety and health policies and guidance.
- There is a need for clearly defined agency-wide guidance on roles and responsibilities for leadership and staff, detailing specific actions required for safety and health policy development, implementation, training, and review.

Communications and Training

- Communications and alerts regarding severe weather events varied by agencies, and many surveyed employees reported being unaware of the location of relevant safety and health policy information. However, they also commonly expressed an interest in learning more about existing policies.
- Across the five agencies there is a need to increase communications and training regarding health and safety policies and procedures.

Implementation and Enforcement

- Effective implementation of policies requires a specific action plan with personnel assigned to action steps on a detailed time line.
- There is a need to develop systems for accountability to ensure policies are implemented, and time lines and responsibility are established for solving problems, and updating policies and procedures.

Evaluation and Improvement

- Managers are responsible for customizing, writing, and implementing health and safety policies for their staff.
- There appears to be a lack of systems for employee and union involvement across the agencies, and there was no evidence of cross-agency or inter-agency cooperation in developing policies and sharing good practices.
- There is a need to establish an appropriate process for reviewing and updating safety and health policies, engaging staff, eliciting feedback and sharing health and safety information, policies and good practices between and within agencies.

4. Recommendations

Our review of the impacts of climate change on Delaware state agencies' occupational safety and health policies and procedures reveals important opportunities for improvement. Strengthening the fundamentals of the current policies and procedures by improving processes for policy development, implementation, and enforcement, focusing on gaps specifically related to

climate change, and sharing agency good practices are key actions. Establishing a system of safety and health committees that include front line employees will be an important part of creating an ongoing process of management commitment and employee involvement to achieve continuous improvement of policies and procedures. In so doing, Delaware will provide a model of leadership on addressing the occupational safety and health impacts of climate change on employee well-being.

To help inform next steps in state agencies' efforts to take advantage of identified opportunities for improvement and integrate climate change considerations into worker health and safety policies, the consultant team developed a set of recommendations.

Policy Guidance

- Develop detailed agency occupational safety and health policies in recognition of the higher occurrence of extreme weather events. These policies should:
- Address thermal stress, working in hot and cold environments,
- Include detailed procedures,

Describe:

- The signs and symptoms of health effects,
- Employer provided equipment and clothing,
- Preventive actions such as hydration and response actions related to first aid procedures, and
- Mandatory training, early warning and communications.
- Use and reference relevant national and industry guidelines and standards in developing the above polices such as the NIOSH Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments, the American Conference of Governmental Industrial Hygienists' Threshold Limit Values on Thermal Stress (Cold Stress, Heat Stress and Heat Strain), and the CalOSHA Heat Illness Prevention Standard.
- Require development of Emergency Action Plans that set forth site-specific emergency and disaster plans (preparation for responding to floods, other extreme weather events, air pollution, and the mental health impacts of exposure to traumatic events and fatigue).
- Develop policies, procedures, information, and training on biological exposures certain field employees are likely to encounter such as Lyme Disease. Other biological exposures that may be of concern include Zika, Histoplasmosis, and mold.
- Convene an inter-agency working group to identify shared concerns and opportunities to develop policies, procedures or supporting materials (e.g., factsheets describing hazards) that may be used across agencies. Seek to leverage an existing inter-agency mechanism.

Roles and Responsibilities

- Ensure that policies clearly state that staff who are assigned safety responsibilities are adequately trained and have access to necessary resources and equipment.

Communications and Training

- Develop and implement a consistent method and process to provide early warning for at-risk employees to take action in extreme conditions based on established, clearly articulated thresholds as well as reminders of the appropriate protective actions.
- Include training on the impacts of climate change, and designate an individual to integrate the information into decision-making processes.
- Provide additional information and training such as factsheets with photos of potential threats (e.g., ticks) and training on hazard specific safety and health control policies.
- Create a regular schedule to update all staff about health and safety policies and procedures.
- Ensure that safety and health policies, standards and guidelines are posted in a visible and highly trafficked area, and that employees are aware of where they are posted.

Implementation and Enforcement

- Establish systems for accountability to ensure policies are implemented, and timelines and responsibility are established for solving problems and updating policies and procedures.
- Promote monitoring and accountability by:
- Tracking incidents, and
- Ensuring staff are aware of and implement relevant health and safety policies and procedures.

Evaluation and Improvement

- Create a system of safety and health committees to provide an ongoing process for employee participation and management leadership.
- Create a regular schedule to review and update safety and health policies.
- Create a product evaluation committee and process that is charged with incorporating risk evaluation information provided by relevant staff and selecting protective clothing, PPE, and other safety equipment.

Conclusion

The State of Delaware has already taken important steps to characterize changing climate conditions and identify potential opportunities to integrate climate considerations more explicitly into existing policies in order to safeguard the health and well-being of the State's most valuable asset, its workers. The findings from this project will be used to inform the next steps that the state should take with regard to health, safety and climate change.

Climate change does and will continue to affect all agencies' workers and operation. Looking forward and thinking about how health and safety policies and procedures address climate change is important to build resilience in the state as well as protect our workers. Participating State agencies now have an opportunity to leverage and share their experiences and lessons learned as well as use the results of the Pilot Project to more explicitly incorporate climate considerations into existing health and safety policies and improve relevant processes.

[1]These guidelines are an update from OSHA's Safety and Health Program Management Guidelines, first published in 1989. The supporting OSHA website has links to resources, tools, case studies, and recommended practices.
[2]The four agencies are DHSS, DNREC, DSHS, and OMB.

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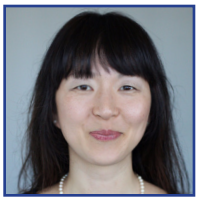

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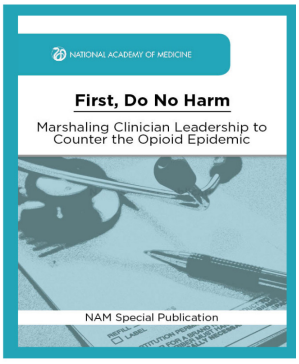
Dr. Yoon Kim is an adaptation expert with a decade of experience working with local and national governments to assess climate risks and identify opportunities for effectively integrating climate into critical sectors, including public health. At Four Twenty Seven, she leads the Advisory Services and works closely with public and private sector entities at different levels to assess climate risks, support adaptation planning, strengthen climate-relevant policy, and build capacity. Dr. Kim's previous experience includes working with California state coastal agencies to develop the coastal and ocean implementation plan of the State's Adaptation Strategy, and supporting the US Agency for International Development's efforts to facilitate national adaptation planning and mainstreaming of climate considerations through stakeholder processes, guidance development, and training development and delivery.

NATIONAL ACADEMY OF MEDICINE

NAM Special Publication

First, Do No Harm: Marshaling Clinician Leadership to Counter the Opioid Epidemic



There is no question that opioid use disorder has become the fastest growing, serious, and far-reaching public health crisis facing our nation today. The National Academy of Medicine convened a group of experts and field leaders to explore clinicians' roles in addressing opioid misuse and addiction. The resulting special publication is an action guide for clinicians if they are prescribing an opioid or managing a patient who presents with a likely opioid use disorder. *Download the Special Publication >>*

NAM Perspectives

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Public Health 3.0: A Call to Action for Public Health to Meet the Challenges of the 21st Century

Breaking a Culture of Silence: The Role of State Medical Boards

The Interplay of Community Trauma, Diet, and Physical Activity

Interventions Aimed at Reducing Antimicrobial Usage and Resistance in Production Animals in Denmark

Alternatives to Antibiotics: Why and How

Community Health Heroes

In the latest interview in this series, we talk to Colin and Karen Archipley, co-founders of Archi's Acres, a California Benefit Corporation that uses hydro-organic technology to grow certified organic produce for local residents. They offer a entrepreneurial incubator program, Archi's Institute for Sustainable Agricultural Training, which provides education opportunities for the surrounding community, including soldiers returning home from war. *Read the interview>>*

NAM Action Collaborative on Clinician Well-Being and Resilience

Every year in the United States, about 400 physicians take their own lives — a rate more than double that of the general population. Physicians experience high rates of depression, burnout, and poor work-life balance. This phenomenon cuts across all ages, stages, and career paths — from trainees to senior practitioners. And these challenges are not unique to physicians. Nurses and other clinicians experience similar effects on performance, health, and well-being. On July 14, the NAM hosted its first public meeting on establishing clinician well-being as a national priority. *View the recorded webcast>>*

Upcoming Webinar: Vital Signs Core Metrics: Reducing Measurement Burden

In 2015, *Vital Signs: Core Metrics for Health and Health Care Progress* proposed a streamlined set of 15 standardized measures with recommendations for their standardization and application at every level—national, state, local, and institutional. The study Committee concluded that this core set of measures—"vital signs" of the nation's health—is instrumental for attainmen of the nation's full health potential, functional capacity, and sense of well-being. NAM will hold a webinar on October 26 a 12:00pm ET to describe the current state of play of health care quality metric reporting and the opportunities for sharpening focus through concerted efforts to measure what matters most. *Register here>>*

More NAM News

The NAM Annual Meeting will be held October 14-16, 2017. The scientific symposium will focus on *Developmental Neurosciences Do We Know Enough to Prevent or Reverse Major Behavioral Disorders?* *Registration for the 2017 annual meeting is open >>*

Save the Date! The NAM will host its second public stakeholder meeting for its Culture of Health program November 9-10, 201 in Washington, DC. *Visit our Culture of Health Program meeting page for more information>>*

Woods Hole Research Center

Climate Change and Health

Phillip B. Duffy, Ph.D.
President and Executive Director, Woods Hole Research Center

What emerging public health threat is complex, multifaceted, dynamic, has the potential to get much worse, and won't be eliminated any time soon? If you answered "terrorism", you'd be right. But you'd also be right to answer "climate change." And in fact, climate change has killed more people than terrorism has—a lot more. It's perhaps understandable that terrorism generates much more attention and concern, yet public health responses should be proportionate to actual, not perceived, threats.

The World Health Organization (WHO, 2002) estimated that increases in three health risks (diarrhea, malnutrition, and malaria) caused by climate change were responsible for about 150,000 deaths per year as of 2000. Because it deals with only three specific risks, it is a partial accounting of total mortality from climate change. Like many impacts of climate change, human mortality is largely unrecognized to be a consequence of climate change because it takes the form of exacerbations of long-standing phenomena. In this case, climate change causes small percentage increases in amounts of mortality that are very high to begin with, which makes it especially difficult to recognize. For example, WHO estimates that climate change as of 2000 resulted in an increase of 1 to 2% in mortality from diarrhea in developing countries. That's a small increase in percentage terms, but the baseline mortality is high enough that it represents 47,000 deaths a year.

An analysis performed at Lawrence Livermore National Laboratory of terrorist events between 1968 and 2004 (Bogen and Jones, 2006) estimates a total of 25,408 related fatalities during that period, or an average of about 700 deaths a year.

If these numbers are right, then even a partial accounting of mortality from climate change indicated that it kills nearly 6 times more people in one year than terrorists did in 37 years. No doubt there is significant room for error in the epidemiology behind these numbers, and also for disagreements over what exactly constitutes terrorism. But even allowing for these considerations, it seems inescapable that climate change has been much more lethal than terrorism.

The health impacts of climate change come in many forms. Some are well-known: heat stress mortality is the most obvious and can be very significant. The European heat wave of 2003, for example, is estimated to have killed as many as 70,000 people (Robine et al. 2008). It is estimated that climate change doubled the likelihood of the weather conditions that caused this disaster, and that these conditions will become the "new normal", with half of summers in Europe being as warm as that of 2003, by the 2040s (Stott et al. 2004). Other forms of extreme weather that are intensified by climate change, for example drought and hurricanes, also have health impacts, especially in poorer regions. It is well-known that vector-borne diseases have spread into new regions as a result of shifting climatic zones (USGCRP, 2014). Through several mechanisms, warmer conditions can result in deteriorated air quality (especially increased tropospheric ozone; Jacob et al. 2009) and associated illness.

Some of the health consequences of climate change are perhaps more obscure, and others are surprising. For example, increases in food insecurity (resulting from decreased crop yields and other factors) have important health consequences. Violence at all scales (ranging from street crime to large-scale wars) is associated with extreme

heat events and with warmer overall temperatures (Hsiang et al, 2011, 2013, 2014). On a smaller scale, an anthrax outbreak in Russia in 2016 was attributed to the release of spores previously frozen in permafrost (Luhn, 2016). This raised the possibility of other frozen pathogens being activated, including those from the 1918 flu epidemic, which are known to be frozen in Alaskan tundra (Taubenberger et al. 2007).

Besides reducing direct health impacts of climate change, policies that mitigate climate change have additional health benefits by reducing the health consequences of fossil fuel use. For example, although particulate pollution from coal still kills roughly 13,000 Americans annually (Clean Air Task Force, 2010), this number has been greatly reduced by lessening use of coal and increasingly effective air quality regulations. If one should doubt the value of those regulations, a ton of coal burned in China—where regulation is much lighter—apparently produces nearly 20 times the mortality of the same quantity of coal burned in the US (Scott et al, 2005). In China, estimated mortality from poor air quality due to coal burning is enormous (estimated at 366,000 in 2013; Health Effects Institute, 2016).

By contrast, the health impacts of renewable and non-fossil energy production are minimal, despite some claims to the contrary. The primary documented health effect of wind turbines, for example, is "annoyance" (McCunney et al, 2014), and for all of the concern about the safety of nuclear power, harms from nuclear power have been dramatically less than from coal, especially in the United States (NAS, 2009).

Mortality from climate change is projected to increase to 250,000 per year globally in the period 2030-2050 (WHO, 2017). Partly as a result of unrealized effects of already-emitted greenhouse gasses, projections of future climate for that near-term time window show relatively little sensitivity to future greenhouse gas emissions (IPCC, 2014); i.e. to future climate policies. This means that there's little that can be done to prevent the climate and weather conditions responsible for this mortality. If this outcome is to be avoided, therefore, it will be up to the public health community to mobilize the resources to prevent it. To do this in the most cost-effective manner will require anticipating as much as possible the nature and location of emerging impacts. As is so often the case, socio-economically disadvantaged communities are at more risk and have fewer coping resources.

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DELAWARE HEALTH AND SOCIAL SERVICES
Division of Public Health

Frequently Asked Questions

CLIMATE CHANGE

Climate change will cause sea level rise, air pollution, and more frequent and extreme weather events, such as heat waves, droughts, heavy rainfall events, flooding, massive snowstorms, and more intense storms with high winds, hail, and tornadoes.

The difference between weather and climate is a measure of time. Weather is what the atmospheric conditions are over a short period of time, whereas climate is how the atmosphere "behaves" over relatively long periods of time. They both represent the state of the atmosphere with respect to wind, temperature, cloudiness, moisture, and atmospheric pressure.

What is Weather?
Weather is a short-term atmospheric condition occurring at a particular time and place. Rain, snow, wind, hurricanes, and tornadoes are weather events.

What is Climate?
"Climate" describes the prevailing weather conditions occurring in a region over a 30-year period or longer. Snow is expected in the Northeast in January just as hot and humid conditions are expected in the Southeast in July.

What is Climate Change?
Climate change is a non-random change in climate that is measured over several decades or longer. Climate change may be due to natural or man-made causes that alter the composition of gases in the atmosphere.

What are the layers of the Earth's atmosphere?
The atmosphere consists of several layers: the troposphere, stratosphere, mesosphere, ionosphere, and exosphere. The troposphere, the layer we associate with weather, is closest to Earth. Most of the visible clouds in the sky are in the troposphere. Extending up to 10 miles above Earth's surface, the troposphere contains a variety of gases: water vapor, carbon dioxide, methane, nitrous oxide, and others. These gases help retain heat, a portion of which warms the surface of Earth (greenhouse effect). Changes in the composition of these atmospheric gases have a dramatic impact on Earth’s climate.

Above the troposphere is the stratosphere, which extends from about 10 to 30 miles above the Earth’s surface. It includes the ozone layer. Ozone molecules absorb ultraviolet radiation from the Sun, protecting us from its harmful effects.

Thirty to 50 miles above the surface is the mesosphere, the coldest part of the atmosphere. Above the mesosphere is a layer called the ionosphere (also called the thermosphere). Temperatures in the ionosphere, which extends about 50 to 180 miles from the surface of Earth, can reach up to several thousand degrees Fahrenheit. Beyond the ionosphere is the exosphere, which extends about 500 miles above the surface of Earth. This is the outermost layer of earth’s atmosphere, the transition zone into space.

What are temperature and precipitation extremes?
Extreme temperatures are unusually high, such as extreme heat and heat waves; or unusually low, such as extreme, bitter cold. Precipitation extremes occur when there is excess rain, snow, hail, sleet, or ice, which can cause flooding; or when there are prolonged dry periods, causing droughts.

How do temperature extremes impact health?
Extreme cold impacts the homeless and vulnerable populations such as the elderly, those with disabilities, and children, without protective clothing and shelter. Extreme cold weather is a dangerous situation that can bring on health emergencies in susceptible people, such as those without shelter, outdoor workers, and those who work in an area that is poorly insulated or without heat. What constitutes cold stress and its effects can vary across different areas of the country. Whenever temperatures drop decidedly below normal and as wind speed increases, heat can more rapidly leave your body. These weather-related conditions may lead to serious health problems.

Extreme heat events cause hospitalizations and death from heat stroke, cardiovascular disease, respiratory disease, and cerebrovascular disease. Greater numbers of hospital admissions for cardiovascular, kidney, and respiratory disorders occur during heat waves. The elderly, those with disabilities, and people with chronic health issues such as cardiovascular and respiratory diseases, are at risk for health problems caused by temperature extremes. If these groups live in urban areas, they are at increased risk of suffering from urban heat islands. The term "heat island" describes built up areas that are hotter than nearby rural areas.

Fortunately, some illness and death risks have diminished in recent years due to better forecasting, early warning systems, and greater access to air conditioning during periods of extreme heat and warmth during extreme cold conditions.

How do precipitation extremes impact health?
Extreme precipitation and tropical storms cause severe flooding and flash floods. In these situations, public health measures are to help provide emergency shelters. Following a storm, standing and polluted water can cause waterborne disease outbreaks. Mold can grow in damp indoor environments, causing coughing, wheezing, an increase in asthma, and lower respiratory tract infections such as pneumonia, respiratory syncytial virus (RSV), and RSV pneumonia.

Sources:

http://www.eo.ucar.edu/basics/

http://www.cdc.gov/niosh/topics/coldstress/

http://climate.nasa.gov/

DELAWARE HEALTH AND SOCIAL SERVICES
Division of Public Health

Public Information

CLIMATE CHANGE: PUBLIC HEALTH IMPACTS

Climate change is projected to create new, unprecedented health problems and health threats, as well as more severe and frequent health problems that are already affected by the climate and weather. Human vulnerability to these health effects depends on three factors: *exposure* to climate and weather threats; *sensitivity*, or tendency to be affected by a given amount of exposure; and *adaptive* capacity, or the ability to avoid or reduce exposure.

The National Climate Assessment, produced by the U.S. Global Change Research Program, reports that U.S. residents will face more health issues. Increased ground-level ozone and particulate matter will impact air quality, causing some U.S. residents to experience respiratory stress, more asthma attacks and cases, weakened lung function, and more premature deaths. Plants will flourish in warmer temperatures and produce more allergens, resulting in more frequent allergic sensitizations and asthma occurrences. Rising temperatures and more extreme rainfall will foster indoor air quality problems, including the growth of molds.

Climate change will cause more extreme weather events, such as hurricanes, heavy snowfall, and flooding. Extreme weather events lead to fatalities and increases in behavioral health issues: anxiety, substance abuse, suicide, and post-traumatic stress disorder. The leading weather-related cause of death in the U.S. is extreme heat events, and these will increase. Extreme heat causes increases in heat stroke, cardiovascular disease, respiratory disease, cerebrovascular disease, and kidney disorders.

Scientists expect a greater number of disease outbreaks caused by mosquitoes, ticks, and fleas. Climate change will influence the geographic and seasonal distribution of these vector populations and the outbreak potential for Lyme disease, dengue fever, West Nile virus, Rocky Mountain spotted fever, plague, and tularemia. Vector-borne pathogens not currently found in the U.S., such as chikungunya, Chagas disease, and Rift Valley fever viruses, may impact U.S. residents as a result of travel and trade.

Climate change will most impact people whose health is already at risk and who have the fewest resources to address or adapt to changes in climate. Children are physiologically and behaviorally more vulnerable to heat waves, extreme weather events, asthma, and many infectious diseases. Seniors are susceptible to extreme heat waves and may have underlying diseases that increase health risks and illness. Low-income and minority communities often experience higher rates of asthma, diabetes, and other chronic diseases that place them at higher risk of complications from extreme weather, especially extreme heat.

Extreme weather events can affect mental health in several ways. Following disasters, mental health problems increase among people with no history of mental illness as well individuals with mental illness. Reactions may be short-lived or persist for years after experiencing the loss of homes, livelihoods, and community resources. Anyone can experience mental health impacts due to the stress of environmental changes, drought, or severe weather or disasters.

24/7 Emergency Contact Number: 1-888-295-5156

Individuals at increased risk of mental health impacts from climate change are persons with pre-existing mental illness, persons and responders who experienced disaster, and those who live in disaster-prone areas near waterways and urban "heat islands." Other vulnerable populations are pregnant women, the elderly, persons on low incomes or impaired mobility, and farmers and watermen whose livelihoods depend on stable climate conditions. Polluted air, which causes asthma, is associated with higher rates of anxiety, depression, and schizophrenia.

Flash floods, storm surge, and damaging winds destroy infrastructure, displacing people and disrupt the normal rhythms of families and communities for months and years. Prolonged droughts, heavy rains that run off quickly, and less snowfall can contaminate or diminish water supplies, severely limiting farming and food production, and cause damaging flash floods that contribute to stress, anxiety, and depression. As sea level rise displaces coastal residents or requires the construction of barrier walls to protect communities and drinking water, it will create inordinate stress, depression, grief, and post-traumatic stress.

Symptoms of stress are anxiety, post-traumatic stress, depression, interpersonal and/or societal conflict, family stress, persistent grief, and child behavioral and developmental problems and academic decline. Stress resulting from climate change may result in behavioral health outcomes of stress disorders and increased substance abuse, as well as personal and interpersonal violence.

Sources:

The National Climate Assessment, 2014, http://nca2014.globalchange.gov/

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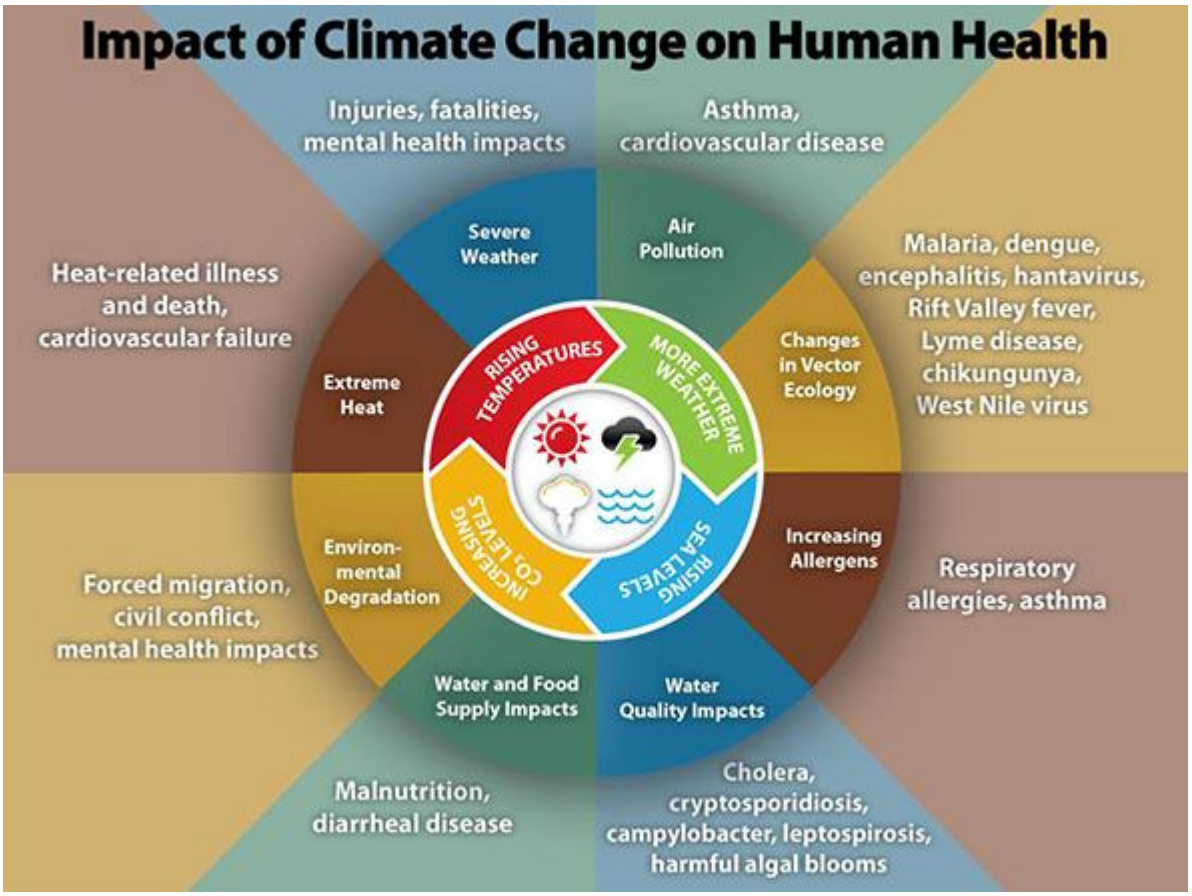

Source: Climate and Health Program, CDC, 2014

CLIMATE CHANGE: AIR POLLUTION AND ALLERGENS

Climate change is projected to impact human health by increasing ground-level ozone and particulate matter air pollution. Also, more frost-free days and warmer seasonal air temperatures are contributing to a greater prevalence of allergy.

Ground-level ozone, a key component of smog, causes many health problems, such as diminished lung function, more hospital admissions and emergency room visits for asthma, and increases in premature deaths.

Ozone is produced when temperatures are over 80°F and when it is sunny with few or no clouds, or only high transparent clouds. Sunlight (ultraviolet radiation) stimulates volatile organic compounds VOCs and nitrogen oxides NOx to have photochemical reactions. When there is little cloud cover, sunlight penetrates to ground level, enabling the photochemistry that generates ground-level ozone. When cloud cover increases, the likelihood of elevated ozone levels decreases. The higher the temperature, the more likely elevated levels of ozone will occur.

Particulate matter air pollution is caused by wildfire emissions or another direct source, and stagnant air incidents. Secondary contributors are three pollutants: nitrates, sulfates, and organic carbon. Meteorological conditions and atmospheric chemistry for high particulate matter days vary seasonally.

Climate change also causes more airborne allergens. Higher temperatures change the botanical landscape, increasing the distribution of allergenic plants across a wider geographic area. More frost-free days, warmer seasonal air temperatures, and higher levels of carbon dioxide (CO_2) contribute to changes in flowering time and longer and more intense plant pollination cycles from allergenic plant species. Under these conditions, allergenic plants such as grasses and weeds to grow faster and produce more allergens. Higher pollen concentrations and longer pollen seasons can increase allergic sensitizations and asthma episodes, diminishing productive work and school days. Individuals prone to seasonal allergies may have greater difficulty when they are simultaneously exposed to toxic air pollutants.

Extreme rainfall and rising temperatures can also contribute to indoor air quality problems such as indoor molds, with increases in respiratory and asthma-related conditions.

Allergenic insects such as roaches, wasps, bees, and fire ants are coming out earlier and staying out longer, increasing the chances that allergic patients will encounter them. Of special mention is the distribution of fire ants, which are currently limited to the southern U.S. due to frozen ground in the northern states. As the country gradually warms, fire ants may expand northward.

Health data for Delaware:

the path towards creating Delaware's Environmental Public Health Tracking Network

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ABSTRACT

The environment impacts health and contributes to factors that not only protect us from disease but also increase our risk for certain negative health outcomes. The Delaware Division of Public Health (DPH) embarked on an endeavor in 2014 to provide its communities with timely, high-quality data on the environment, risk and protective factors, and health outcomes through a data sharing platform. Through strong partnerships with the Department of Natural Resources and Environmental Control and key opportunities, these efforts coalesced into the development of Delaware's Environmental Public Health Tracking Network. We share our analyses and presentation of asthma hospitalization and air quality data and describe our path towards creating Delaware's Environmental Tracking Network.

INTRODUCTION

Health and the environment in which we live are inherently connected (World Health Organization, 2015). Recent events such as those in Flint, Michigan

underscore the impacts of the environment on the health status of our population (Kennedy et al., 2016). Whether it is contamination of a population's drinking water supply or changing temperatures and their impact on vectors (e.g., mosquitoes) that cause vector-borne diseases (e.g., Zika, West Nile Virus), there is an emergent need for communities to have access to relevant, timely data about the environment in which they live. Furthermore, across the country, there is an increasing demand for public health agencies to share data with their communities for data-informed decision making intended to affect change. Through the development and implementation of interventions, programs, and policies that are informed by data, public health and its partners can make positive impacts on the lives of the people who reside in our communities (van Panhuis et al., 2014).

To support efforts for data sharing and exchange, the Delaware Division of Public Health (DPH) embarked on an endeavor to build a Web-based interactive data portal that shares environmental, health, and other related data with our communities. This article describes the division's collaborative effort to develop Delaware's Environmental Public Health Tracking Network.

BACKGROUND

Delaware's Environmental Public Health Tracking Network is part of a national effort to provide communities and key stakeholders with data to inform the development, implementation, and evaluation of population health activities (Centers for Disease Control and Prevention, 2017a). The National Environmental Public Health Tracking Program is a surveillance network of systems, resources, and programs focused on the compilation, presentation, and sharing of environmental hazard, exposure, and health outcome data and information (Centers for Disease Control and Prevention, 2017a). Twenty-six state and local health departments are currently funded by the Centers for Disease Control and Prevention (CDC) to develop local tracking networks. Experts in the field worked collaboratively to develop indicators and nationally consistent data measures that were implemented by participating jurisdictions (Centers for Disease Control and Prevention, 2017b). Additionally, state and local health departments participating in the national tracking network share locally derived measures that are meaningful to their geography and population-specific health priorities (Centers for Disease Control and Prevention, 2017c). While the national tracking network shares data at the state and county levels, local tracking networks have the ability to share data at smaller geographic areas. Delaware recognized the significant benefits of participating in the national tracking network and invested resources to create a local tracking network.

METHODS

Over a period of three years, DPH's Epidemiology, Health Data, and Informatics Section led efforts to build DPH's data sharing platform. The team recognized early on that the process would require commitment and determination. Discussions led the DPH team to conceptualize the framework for data sharing. Opportunities became available that supported efforts that would actualize their vision.

Conceptual framework for data sharing

In December 2014, DPH drafted an internal proposal entitled, Health Data for Delaware, with a vision that "Delawareans have access to usable, meaningful, timely, and high-quality data about…the health of the communities in which they live" (Offutt-Powell, Codes-Johnson, Silverman, & Rattay, 2014). The proposal outlined three overarching areas related to data exchange and sharing for Delaware to be positioned to identify health priorities, measure health indicators, monitor trends, and catalyze change. As outlined in the proposal, Delawareans must have (1) access to their own health data; (2) access to data about the community in which they live; and (3) the tools to make the necessary changes that positively impact individual and population health factors and outcomes. Public health is by definition focused on population health and population-based approaches for addressing the factors that influence and mediate health outcomes through prevention (primary, secondary, and tertiary) and response measures. As such, the aforementioned proposal focused on addressing the second priority area, access to data about the community in which they live.

Planning and evaluating current processes and data sharing platforms available in the state was a necessity. During the conceptual phase of the project, DPH conducted an initial assessment of public health's data sharing platforms. The results of the assessment identified two areas that needed to be addressed including (1) requests for DPH data are submitted by both internal and external stakeholders through either

direct contact with DPH staff or online through the Delaware Health Statistics Center for vital records data (e.g., birth, death, etc.), and (2) data are made available to the public through non-query based tools such as downloadable document files (e.g., portable document format, Microsoft® Excel table, etc.). As a result of the first finding, DPH initiated a quality improvement project to centralize and standardize DPH's data request process. To address the second finding, DPH submitted an application to the CDC's National Environmental Public Health Tracking Network funding opportunity and drafted the Health Data for Delaware proposal (Offutt-Powell et al., 2014).

Opportunities

Two funding announcements and a state-to-state peer fellowship provided key opportunities for DPH to begin the internal process of conceptualizing and describing the design of a data sharing platform that reflected DPH's vision to make health risk/protective factor and outcome data available to its communities. The first funding announcement posted in 2014 was the CDC's Implementation of the Environmental Public Health Tracking Network (CDC-RFA-EH14-1405). The funding announcement gave jurisdictions (state or local health departments) an opportunity to submit proposals that would support the development of a local tracking network and participate in, by sending data to, the National Environmental Public Health Tracking Network. DPH collaborated with the Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Air Quality and internal DPH sections including Health Systems Protection to submit a proposal. Figure 1 illustrates the resources, inputs, strategies (activities), outputs, short- and mid-term outcomes, and long-term outcomes in the Delaware EPHTN's logic model. Although DPH was not selected as an award recipient, DPH's application laid the groundwork for the development of the Delaware EPHTN.

In June 2016, DNREC released a funding opportunity, the Strategic Opportunity Fund for Adaptation (SOFA) that provided state agencies with an opportunity to use funding to implement adaptation recommendations outlined in the Climate Framework for Delaware (Executive Order 41, Governor Jack Markell). DPH submitted a proposal and was awarded funding to evaluate the feasibility of and implement an environmental public health tracking network in Delaware. An already strong DPH – DNREC collaboration was reaffirmed with the commitment of both agencies to work on the project.

Congruently, Delaware submitted an application to participate in the Association of State and Territorial Health Officials' (ASTHO) 2016 Environmental Public Health Tracking, State-to-State Peer Fellowship Program. Although the ASTHO fellowship did not provide monetary support for the pilot project, the additional guidance and expertise of the CDC, ASTHO, and Kentucky, as Delaware's state tracking network mentor, ensured that DPH's approach and activities were grounded in best practices and with a support network of experts. Furthermore, DPH wanted to ensure that the project funded through DNREC resulted in a viable sustainable platform for data transmission and sharing with CDC's EPHTN. The continued support and guidance of the Kentucky tracking network team enhanced DPH's understanding of the information technology requirements, processes for ensuring continued support and engagement of stakeholders, and communication and outreach components of the tracking network to ensure appropriate and effective use of the data by the community (Offutt-Powell, 2017).

Systematic approach to develop the Delaware EPHTN

The development of the Delaware EPHTN focused primarily on the data portal aspect of the tracking network. As a result of participating in the ASTHO fellowship program, many resources became available to the Delaware tracking network team. We reviewed the technical specifications and identified the "best parts" of each states' environmental public health tracking networks. We also assessed DPH's current data needs using the framework described in the Heath Data for Delaware proposal. We involved the Delaware Department of Technology and Information (DTI) in discussions regarding the design and development of the data sharing platform to assess the utility of using existing data platforms and resources. It was also important that the data sharing platform was configured for expansion to include additional datasets and present sub-county data. And to ensure sustainability of the project, DPH devised a plan that included resource allocation (funding and staff).

A larger vision – beyond the data portal

As mentioned previously, the National EPHTN is a surveillance system and network of programs, resources, and people that come together to use data to catalyze action and respond to environmental hazards and their impacts on health. State and local health departments have shared many success stories using tracking data to inform policy, target prevention activities, identify communities at risk, impact city or state planning, improve surveillance, support epidemiologic studies, and educate communities (Centers for Disease Control and Prevention, 2014). DPH focused initially on the data sharing platform with a larger vision to expand its efforts into a fully functioning tracking network. Figure 2 illustrates the conceptual framework for the Web-based data portal. DPH outlined specific requirements for the design of the data portal that included the ability to: (1) present data in community profiles; (2) query, overlay, analyze, and readily export data; (3) upload data and add or edit content in a DPH-managed technical solution; (4) allow users to create charts, graphs, maps, filter(s), conditionally format data; and (5) include the CDC nationally consistent data measures with the functionality to include additional measures and data on demand. Figure 3 illustrates the data content areas that are included in the national tracking network.

Data analysis

We analyzed data from the Delaware Hospital Discharge dataset (years 2000-2014) to calculate and present time trends of age-adjusted inpatient hospitalization rates per 100,000 population using the 2000 U.S. standard population and corresponding 95% confidence intervals (CI). Rates were stratified by sex and age group. Hospital discharges were defined as a principal diagnosis codes beginning with 493 (ICD-9 for asthma) following the National Environmental Public Health Tracking Network's nationally consistent data measures. Graphs presenting county-level data are available upon request and will be available as part of the Delaware EPHTN once the data portal is operational. Using DNREC's Air Monitoring program data, we presented air quality data available from monitoring stations across the state stratified by county that measure 8-hour average ozone concentrations, number of days of Particulate Matter (PM) 2.5, and annual concentrations of PM 2.5 that exceeded the National Ambient Air Quality Standard (NAAQS). National standards for air quality were used to establish acceptable levels of ozone concentration and particulate matter and identify geographic areas that exceeded standard levels. Data requests were submitted to both DNREC and DPH for access to these data for purposes of the Delaware EPHTN. Although not completed for the initial phase of the project, future activities include presenting data geospatially by census-derived geographic aggregations (when permissible) with the additional ability to overlay environmental and health data simultaneously.

RESULTS

Development of Delaware's EPHTN

DPH continues to make steady, incremental progress towards building Delaware's EPHTN. The results that we documented thus far reflect the establishment of a strong, viable, and sustainable infrastructure. The data sharing platform will be self-sustained and housed with

> *Optimizing the use of science, practice, and technology, the Epidemiology, Health Data, and Informatics Section will serve as the coordinating unit within the Division of Public Health to lead, support, and facilitate the compilation and analysis of public health data for the generation of epidemiologic evidence and translation of findings into practical and actionable information for internal and external partners.*

DPH's cross-cutting section; the Epidemiology, Health Data, and Informatics (EHDIS). Because this project builds upon DPH's vision of healthy people in healthy communities and the mission of EHDIS, which states

successful completion of this project is a priority. To ensure sustainability of the project, DPH will submit an application to participate in the National EPHTN during the next available funding cycle. Dedicated staff in EHDIS will ensure that existing data on the portal are updated according to a predefined schedule. Furthermore, the state of Delaware has recently engaged in an open data initiative, which may support updates of the data in the portal.

Working with the state's information technology team (DTI), DPH completed the required technical documents necessary to build an outward facing data sharing platform. Specifications for the design of the system were defined by the DPH team to meet the national EPHTN requirements and reflect the additional components described in Delaware's health data proposal.

Data presentation

An important outcome of this project was the compilation and presentation of both asthma and air quality data that meet the requirements of the National EPHTN's nationally consistent data measures.

Asthma

Figure 4 illustrates fluctuations in hospitalization rates for asthma among females and males living in Delaware between 2000 and 2014. Statewide age-adjusted hospitalization rates for asthma were highest among females compared to males. In 2014, females continued to have higher hospitalization rates for asthma diagnoses as compared to males (female= 14.4 hospitalizations per 10,000 population; male= 10.4 hospitalizations per 10,000 population).

County-specific rates are not presented here but are available upon request. Rates varied considerably across the three counties. The highest hospitalization rates occurred in 2014 among Kent County and New Castle County females (Kent= 16.9, 95% CL: 14.2, 19.6 per 10,000 population; New Castle= 15.7, 95% CL: 14.2, 17.2 per 10,000 population). Age-adjusted hospitalization rates for asthma were most often higher for females compared to males across the three counties. Overall, hospitalization rates were lowest across the state among females and males living in Sussex County (females= 9.2 per 10,000 population; males= 5.6 per 10,000 population), although there was more variability in the Sussex County rates compared to Kent and New Castle counties given the smaller number of hospital discharges.

Figure 5 illustrates the age-specific inpatient hospitalization rates per 10,000 population for asthma by 5-year age groups for the state from 2010-2014. Hospitalization rates for asthma diagnoses were highest among the very young; in particular children under 10 years of age. Rates were disproportionately higher among males than females in children under 15 years of age; however, rates among females surpassed those of males in children older than 14 years of age and among adult populations. Rates were lowest among males in the 20 to 39 year age group. Most notably, the highest reported hospitalization rates across the state occurred among males younger than 5 years of age living in New Castle County (Age 0-5 years= 62.3 hospitalizations for asthma per 10,000 population).

Air Quality

Figure 6 illustrates the number of days with maximum 8-hour average ozone concentration in exceedance of the NAAQS that varied considerably from year to year and were relatively similar across the three counties. New Castle County air monitors recorded the highest number of days exceeding the NAAQS measured in 2016 at 10 days compared to Sussex County (3 days) and Kent County (2 days). Figure 7 presents the number of days with PM 2.5 levels that exceeded the NAAQS level of 35.0 micro-grams per cubic meter in Delaware from 2000-2016. New Castle County air monitors recorded one day each in 2010, 2011, and 2013 that measured PM 2.5 above the national standard level. For the past three years, no counties in Delaware recorded days in which PM 2.5 levels exceeded the national standard. Figure 8 presents the annual average concentration of PM 2.5 by county from 2000 to 2016. Annual average concentrations in all three counties remained below the NAAQS over the 17-year period. Highest concentrations were reported in 2000 or 2001 (New Castle= 17.6 mg/m3; Sussex= 14.4 mg/m3; Kent= 13.2 mg/m3).

Interpretation and use of data

DPH understands that the display of tracking data in the absence of context or statistical associations does not infer causality (e.g., environmental hazard X caused health outcome Y). However, tracking data can be used to describe trends and patterns and to determine whether further investigation is needed. These data may also assist with generating and/or screening hypotheses to elucidate reasons for correlations or statistical associations of environmental and health factors. Analytic studies can be designed to more fully understand the causal relations between environmental exposures and health outcomes.

CONCLUSION

DPH continues to make progress on its path towards creating the Delaware's EPHTN. With support from DNREC, DPH Leadership, and the many partners that have contributed to our successes thus far, we are achieving our vision of "Delawareans having access to usable, meaningful, timely, and high-quality data about… the health of the communities in which they live."

Figure 1. Delaware Environmental Public Health Tracking Network Logic Model

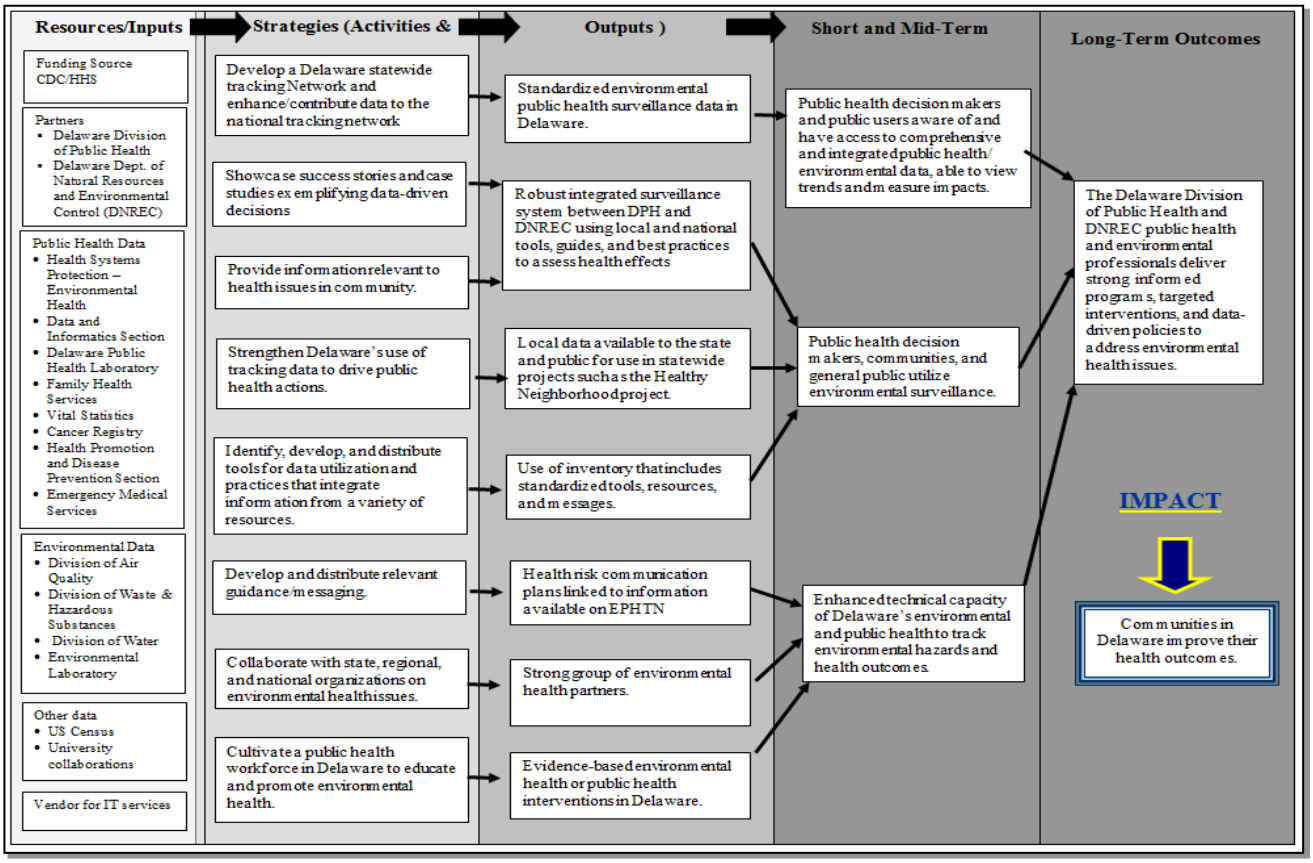
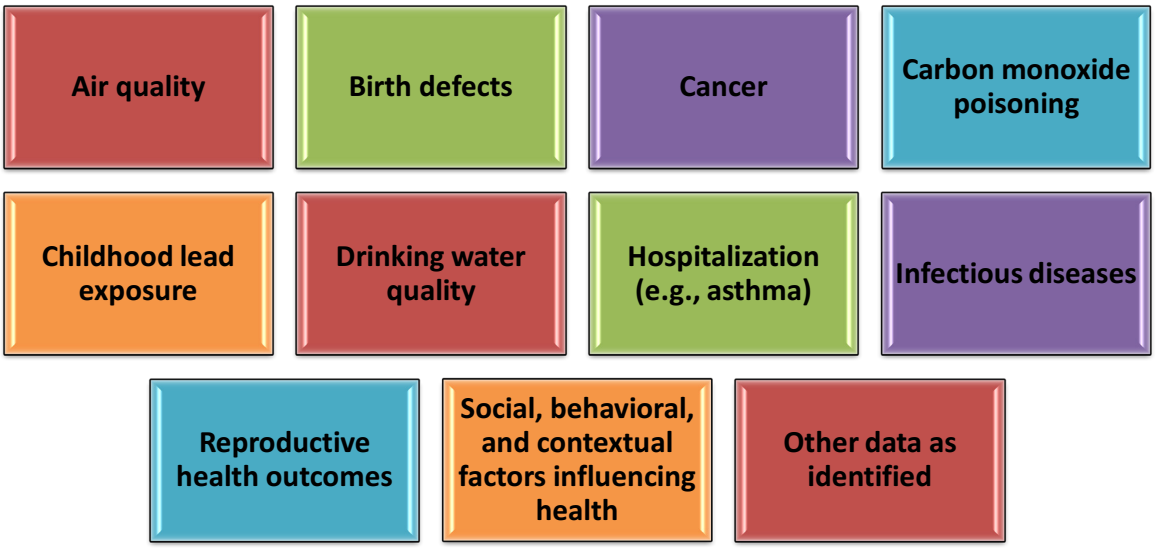


Figure 2. Conceptualization and illustration of an interactive Web-based data portal for Delaware communities.

Left picture: Connecticut Health Equity Index: https://www.sdoh.org/ Permission granted to use screen capture; Right picture: Florida Charts: http://www.floridacharts.com/charts/default.aspx, infant mortality.

Figure 3. Proposed Delaware Environmental Public Health Tracking Network Data Content Areas[1]



[1]Content areas include the Nationally Consistent Data Measures required to participate in the Centers for Disease Control and Prevention's National Environmental Public Health Tracking Network. Additional content areas were included to address the intent of the *Health Data for Delaware proposal* (Offutt-Powell et al., 2014).

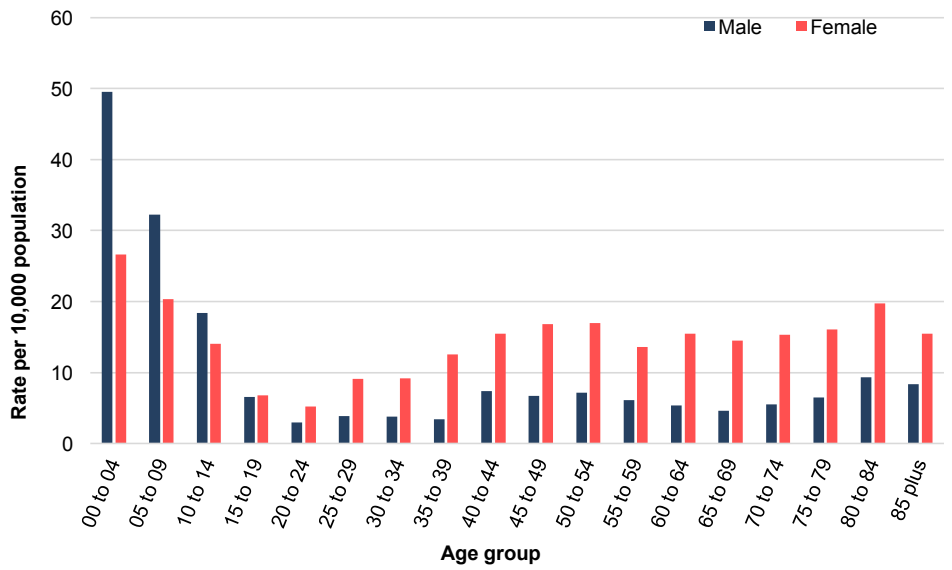
Figure 4. Age-adjusted[1] inpatient hospitalization rates[2] for asthma[3] by sex, Delaware, 2000-2014

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Female	17.3	18.6	16.6	19.5	17.2	18.3	19.3	17.7	15.5	17.9	15.2	13.7	14.4	13.6	14.4
Male	12.4	14.1	13.4	15.5	14.5	15	16.9	15.7	14.2	17.6	14.7	9.8	10.9	11.3	10.4

1. Rates are age-adjusted to the 2000 U.S. standard population.
2. Rates are based on counts of hospitalizations of Delaware residents.
3. Hospital discharges were defined as a principal diagnosis code beginning with 493 (ICD-9 for asthma) following the National Environmental Public Health Tracking Network's Nationally Consistent Data Measures.

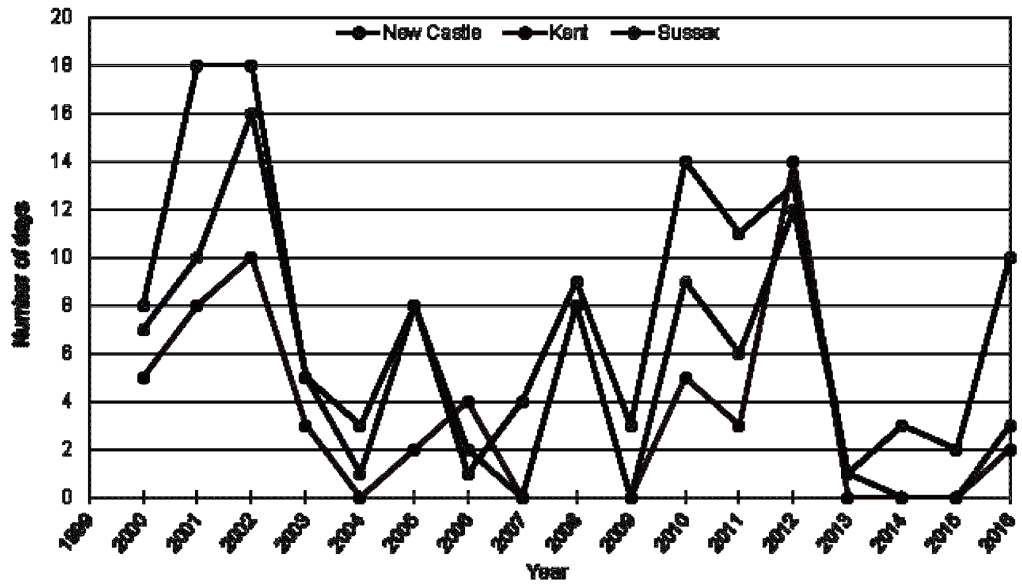
Source: Delaware Health and Social Services, Division of Public Health, Hospital Discharge dataset

Figure 5. Inpatient hospitalization rates[2] for asthma[3] by age group, Delaware, 2010-2014



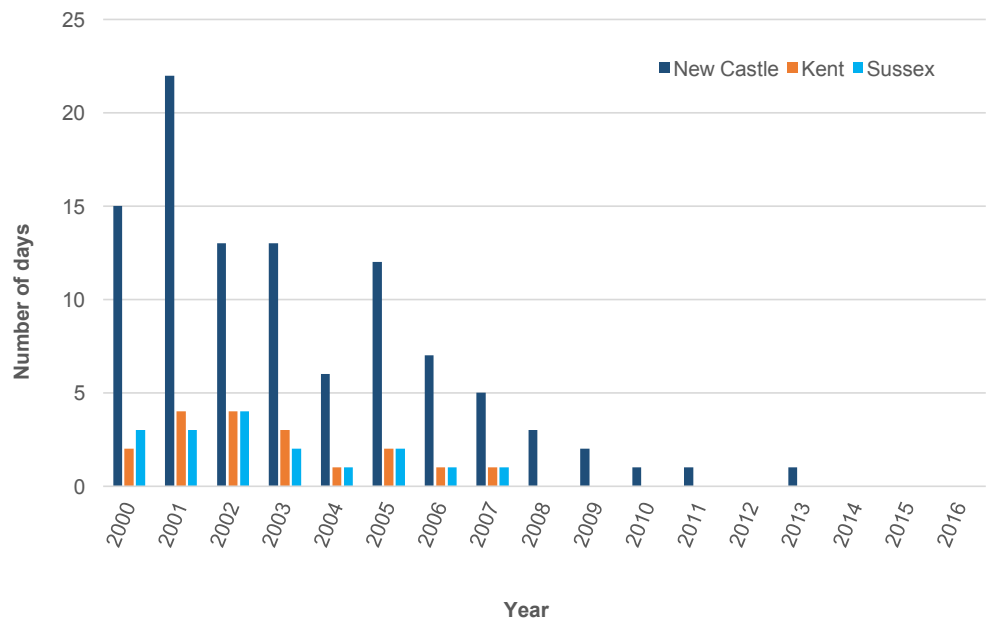
1. Rates are based on counts of hospitalizations of Delaware residents.
2. Hospital discharges with a principal diagnosis code beginning with 493 (ICD-9 for asthma) were used as defined by the National Environmental Public Health Tracking Network's Nationally Consistent Data Measures.
Source: Delaware Health and Social Services, Division of Public Health, Hospital Discharge dataset

Figure 6. Number of days with maximum 8-hour average ozone concentration in exceedance of the National Ambient Air Quality Standard[1] by county, Delaware, 2000-2016



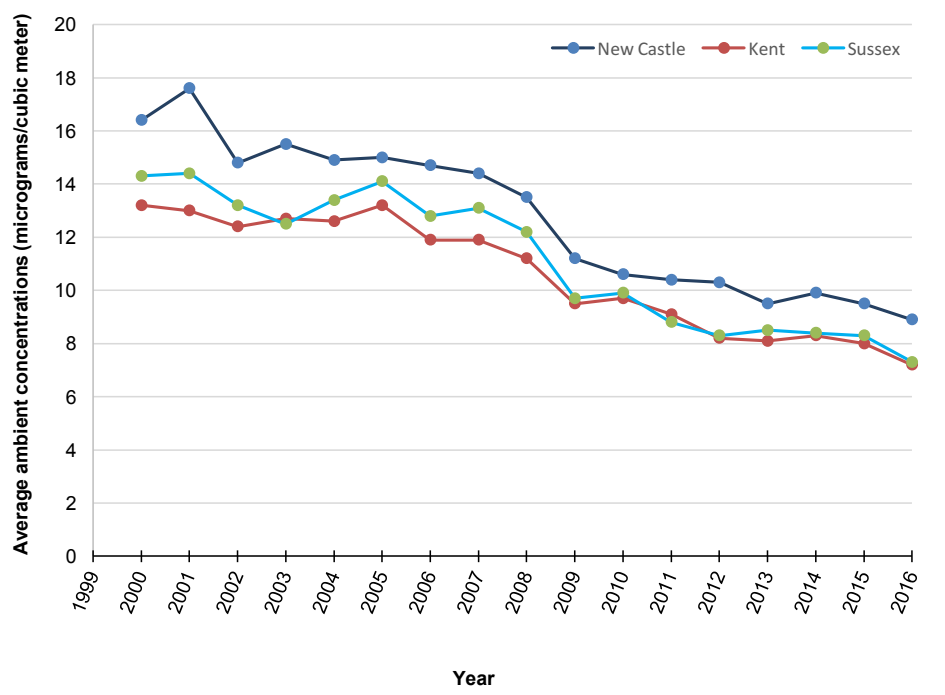
1. National Ambient Air Quality Standard for ozone for the specified time periods is: 2000-2007= 0.080 ppm; 2008-2015= 0.075 ppm; and 2016-present= 0.070. Please note that the number of days above the standard will be affected by this change.
Source: Delaware Department of Natural Resources and Environmental Control, Division of Air Quality, Air Quality Monitoring dataset.

Figure 7. Number of days with Particulate Matter (PM) 2.5 levels in exceedance of the of the National Ambient Air Quality Standard[1] by county, Delaware, 2000-2016



1. National Ambient Air Quality Standard for PM 2.5 is 35.0 micrograms per cubic meter.
Source: Delaware Department of Natural Resources and Environmental Control, Division of Air Quality, Air Quality Monitoring dataset.

Figure 8. Annual average concentration of Particulate Matter (PM) 2.5 by county, Delaware, 2000-2016



1. National Ambient Air Quality Standard for PM 2.5 is 35.0 micrograms per cubic meter.
Source: Delaware Department of Natural Resources and Environmental Control, Division of Air Quality, Air Quality Monitoring dataset.

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Dr. Rick Perkins is an Environmental Scientist with the Delaware Division of Public Health's Office the Preparedness. He has both industrial and governmental work experience where he has expertise in environmental toxicology, human health risk assessment, and radiological emergency planning.

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Save the Date: Thursday, October 26, 2017| 6 – 8:30 p.m.

Embracing Palliative Care: A Physician's Role

The Helen F. Graham Cancer Center & Research Institute presents the 2017 Cancer Symposium on Thursday, October 26. This year's symposium and dinner program Embracing Palliative Care: A Physician's Role will help to advance the knowledge and practice of healthcare professionals who impact the quality of life for their patients and families who are experiencing life threatening illnesses. A panel discussion local experts will follow.

You will receive an invitation via e-mail in the near future. In the meantime, please mark your calendar for October 26.

We look forward to seeing you at this year's Cancer Symposium.

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October 2017

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Climate and Health in Maryland:

The Maryland Climate Change Health Adaptation Program

Allison Gost[1, 2], Rachel Hess-Mutinda[1], Clifford Mitchell[1] & Amir Sapkota[2]
[1]Maryland Department of Health; [2]Maryland Institute for Applied Environmental Health, School of Public Health University of Maryland College Park

Abstract

Maryland's response to climate change has included creation of the Maryland Commission on Climate Change in 2007, and initiatives across many State agencies. The Commission coordinates these initiatives through the State Climate Action Plan. The Maryland Department of Health has partnered with the School of Public Health at the University of Maryland College Park to develop the 2016 Climate and Health Profile report, which estimates the health impacts of climate change in Maryland. Using historical health data and climate model projections, the report found that climate change will have a disproportionate impact on certain populations across the state. For example, extreme heat and extreme precipitation events during summer months increased the risk of hospitalization for asthma in Maryland by 22% and 11% respectively. But the extreme heat related risk for asthma hospitalization was more pronounced among non-Hispanic whites (33%) than non-Hispanic blacks (20%). Based on these findings, the Department and School have begun to engage with community organizations and various stakeholders to develop interventions and adaptations aimed at increasing resilience and mitigating some of the health impacts. Through these partnerships and projects, Maryland is using health data, climate projections, and the State Climate Action Plan to assist local communities and regional partners in climate adaptation activities.

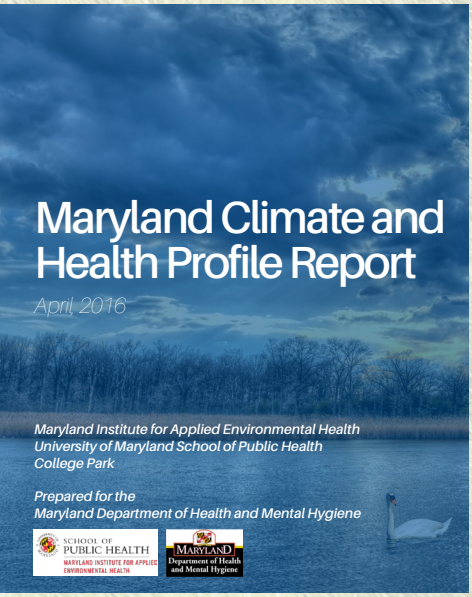
Background

In 2007, Executive Order 01.01.007.07 established the Maryland Commission on Climate Change (MCCC). The Commission was tasked with developing a "Plan of Action to address the drivers and causes of climate change, to prepare for the likely consequences and impacts of climate change to Maryland and to establish firm benchmarks and timetables for implementing the Plan of Action." Executive Order No. EO01.01.007.07 (2007). Initially, the MCCC included representatives from several State agencies, and established three working groups: the Adaptation and Response Working Group (ARWG), Greenhouse Gas and Carbon Mitigation Working Group (MWG), and the Scientific and Technical Working Group (STWG). In 2014 Executive Order 01.01.2014.14 reaffirmed the state's commitment to responding to climate change, expanding the membership and the scope of the MCCC's activities. A fourth workgroup was created, focused on Education, Communication and Outreach (ECO).

Under a cooperative agreement with the U.S. Centers for Disease Control and Prevention (CDC), the Maryland Department of Health (MDH) established the Maryland Climate Change Health Adaptation Program (MCCHAP), which is housed in MDH and operates in partnership with the School of Public Health at the

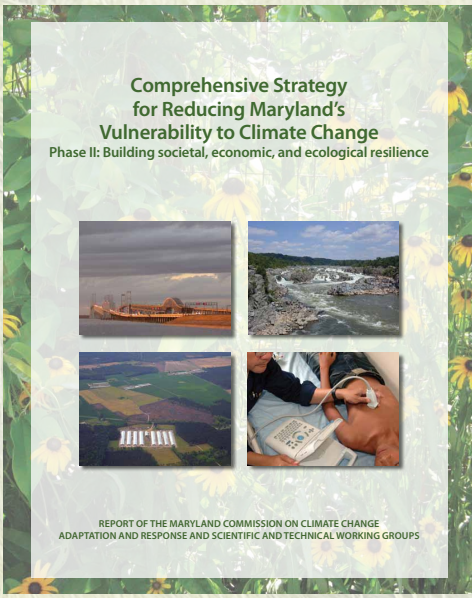
University of Maryland in College Park (UMD-SPH). MCCHAP builds on the previous Maryland Public Health Strategy for Climate Change, which was funded by the CDC from 2012 to 2016. In 2017, MCCHAP participated in each of the following work groups: ARWG, STWG and ECO. Through engagement with the work groups, MCCHAP is supporting climate and health adaptation activities in Maryland that have been initiated by other State agencies, local communities, and non-governmental organizations (NGOs). These activities are in alignment with the State Climate Action Plan, and the activities supported by the CDC Climate-Ready States and Cities Initiative (CRSCI).

The CRSCI aims to use "prevention expertise to help state and city health departments investigate, prepare for, and respond to the health effects that climate change may have on people" (CDC's Climate-Ready States, 2014). In the latest round, CDC has funded 16 states and two cities to focus on the impacts of climate and health in their jurisdiction. To assist states and cities, CDC developed and implemented the Building Resilience Against Climate Effects (BRACE) framework (Figure 1) which provides guidance to grantees to develop strategies and programs designed to minimize the health impacts of climate change (CDC's Building Resilience Against Climate Effects, 2015).



Beginning with the Maryland Public Health Strategy for Climate Change in 2012, MDH has utilized CDC support to integrate a public health focus into the State Climate Action Plan and incorporate public health considerations into Maryland's ongoing climate change-related activities. MDH and UMD-SPH produced the 2016 Maryland Climate and Health Profile Report, www.bit.ly/MDCHPR (University of Maryland School of Public Health, 2016) and integrated priority recommendations for human health into the Maryland Climate Plan Phase II Adaptation Report, www.bit.ly/phase2climateadaptationMD (Maryland Commission On Climate Change, 2011).

Since the release of the Climate and Health Profile Report and the conclusion of first CDC funding period in 2016, MDH has transitioned from an emphasis on quantifying the baseline climate and health impacts in Maryland, to implementation of adaptation activities consistent with the State Climate Action Plan. MDH and UMD-SPH are now focusing on interventions and adaptations tailored to specific community needs and aimed at reducing the identified climate impacts in Maryland. The new MCCHAP, which began in the fall of 2016 (Figure 2), is using partnerships with other agencies, the Climate Commission's working groups, and communities, to identify and support adaptation activities through technical assistance and other approaches.



Introduction

The Climate and Health Profile Report identified vulnerable populations that are disproportionately impacted by two climate change related exposure metrics: extreme heat and extreme precipitation events. These exposure metrics were chosen because of the increasing body of literature including the most recent National Climate Assessment which concluded that not only are such extreme events becoming more frequent, more intense, and longer lasting, but this trend will continue into the future decades in response to ongoing climate change. The report also illustrated how the projected increases in the frequency of extreme heat and precipitation events will adversely affect the health of Marylanders in future decades (2040). For full methodology see the full report available online via www.bit.ly/MDCHPR.The CHPR analyzed exposure metrics and health data both for the state overall and locally in four pilot jurisdictions: Wicomico County, Washington County, Prince George's County and Baltimore City.

Using hospitalization data from 2002-2012, the report identified how extreme weather related risk

of hospitalization for asthma, and heart attack as well as motor vehicle accidents and food-borne/waterborne diseases, differ across geographic location and population subgroups. For example, extreme heat and extreme precipitation events during summer months increased the risk of hospitalization for asthma in Maryland by 22% and 11% respectively. But the extreme heat related risk of asthma hospitalization was more pronounced among non-Hispanic whites (33%) than non-Hispanic blacks (20%) (Soneja et al., 2016). However, risk of hospitalization for heart attack following exposure to extreme heat event was considerably higher among non-Hispanic blacks (27%) compared to non-Hispanic whites (9%) (Fisher et al., 2017). One of the more striking disparities is related to geography and distance to the coast. Both extreme heat and extreme precipitation were found to increase risk of Salmonella infection in Maryland with the coastal communities experiencing considerably higher risk (7.1%) compared to non-coastal communities (3.6%) (Jiang et al., 2015).

These findings from historical data were combined with climate projections to estimate disease burdens in future decades (2040), to inform community-specific adaptation strategies designed to protect public health. These projections were then used to qualitatively rank the impacts of these diseases in the future: large impacts (asthma), moderate impacts (heart attack), and small impacts (salmonellosis) (University of Maryland School of Public Health, 2016).

The Climate and Health Profile Report provided an understanding of where vulnerable populations exist within Maryland that are either currently experiencing higher health burdens or are expected to experience higher burdens under projected environmental changes in the state. The report provided the first step to addressing climate change and the subsequent health impacts in Maryland, showing who is likely to be affected, and where adaptive interventions are needed to increase community resilience.

The report also demonstrated that as the impacts from climate change vary across populations, time of year and geographic region, so too must the programming and community engagement be individualized and tailored to be effective. Recognizing this, the MCCHAP team has enlisted a range of partners to help in the development and implementation. The team continually seeks to establish new and strengthen existing partners as a continuous activity under the current programming cycle.

Since the start of CDC CRSCI funding in Maryland, the MDH MCCHAP team has recognized the importance of inter-agency relationships between MDH and other state agencies. These partners include state agencies like Maryland Department of the Environment, Maryland Department of Natural Resources, Maryland Department of Planning, and the MDH Office of Minority Health and Health Disparities, among others. MCCHAP also continues to maintain a strong partnership with UMD-SPH, and has also developed a new relationship with the University of Maryland Extension program. Through its active involvement in MCCC workgroups, MCCHAP has also established formal and informal working relationships with organizations and partners such as the Baltimore Aquarium, the University Of Maryland Center for Environmental Science, Washington College Center for Environment and Society, and the Eastern Shore Land Conservancy. Partnerships with other NGOs have also been explored to establish connections to stakeholders and activities at a local level. One of the most successful mechanisms to engage directly with stakeholders was a one day forum on Building Resilient Communities,

which took place in December, 2016. MCCHAP plans to conduct a series of similar forums across the state in 2017 and 2018.

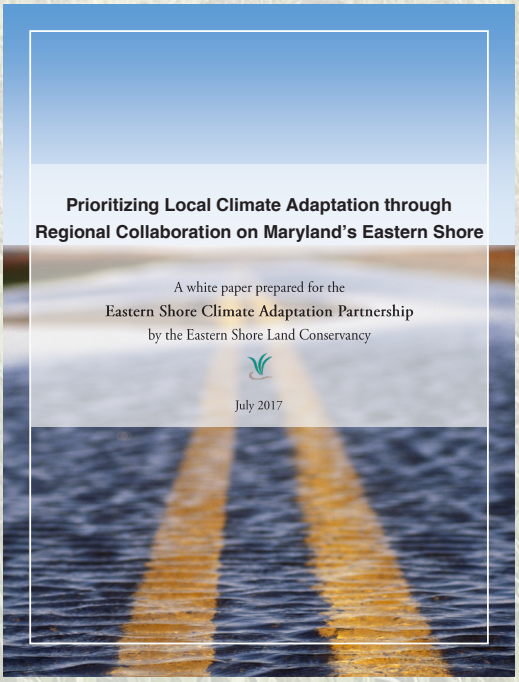
The growing network of partners has allowed the MCCHAP program to support climate and health projects in multiple communities across the state. The projects, some of which are described in greater detail below, include a number of locally initiated and state-wide projects focused on different age groups and populations. They range from an educational program for school aged children in Somerset County on the Eastern Shore of Maryland, to a program to develop leadership opportunities around climate change for high school students in Prince George's County, to a state wide extension programming that reaches extension educators and community health workers (CHW) who work directly with individuals at the local level. The section that follows contains a more detailed description of some of the projects. More information about all of the projects and their progress is available at www.bit.ly/mdclimatehealth.

Projects

Along with other states supported by CDC's CRSCI program, MCCHAP is developing an Implementation Monitoring Strategy (IMS), a document and framework that describes the adaptive interventions supported by MCCHAP in terms of their location, target populations, evidence base for intervention, progress and impact. Currently in development, the Maryland IMS has a tentative public release date of mid- to late-2018. Central to the development of both the IMS and the projects it describes is stakeholder feedback and suggestions. Stakeholders are active partners in all stages of the program, and will be critical to the dissemination and updates around climate and health work to the larger Maryland community. The IMS considers project development, implementation strategies and evaluation metrics within both the guidelines of the CDC CRSCI framework and the Maryland State Climate Action Plan. The goal of this dual framework is to ensure that the projects meet both the needs of the communities where they are initiated and the State Climate Action Plan. Because resources limit the number of projects that can be funded or supported, the IMS seeks to identify the resources, evidence base, and models required for climate and health adaptations to be replicated in other communities, regions, or states seeking to protect human health in the face of climate change. To ensure the evidence base created is accessible to others, once established, the IMS will be displayed online through the Climate Change and Public Health website on the Maryland Department of Health's website, www.bit.ly/mdclimatehealth.

On December 9, 2016, the first of the 'Building Resilient Community Stakeholder Forums' was held at the University of Maryland. More than 80 attendees from state agencies, community organizations, NGOs, universities and the faith based community came together to share their experiences. The forum offered a space for community members to share what a path to resiliency means to them, and what difficulties they faced in achieving their goals. The forum provided a two-way exchange of information and perspectives.

The day started with presentations highlighting the work MDH, UMD-SPH and partners completed, including the Climate and Health Profile Report. Following morning presentations, the floor was opened to attendees for discussion around multiple topics. One of the key questions, "Who is not in the room?" sought to better understand the communities that have not previously been a part of conversations regarding climate change. The day also included a session to allow participants to share personal experience during "stories from communities" and "planning for the changing environment – local perspective." The feedback by and large from the forum was this: continue to identify missing partners and bring them to the table in a meaningful way, increase opportunities for individuals to speak for and represent themselves at all levels of programming and governance, work to continue the discussion and planning towards resilience, and involve everyone from young people, to working age, and senior populations. Following the success of the 2016 forum



and at the request of attendees, the MCCHAP is in the process of planning two additional Building Resilient Communities forums in 2017. The 2017 forums will have a more regional focus, with one forum taking place in Western Maryland and the other on the Eastern Shore.

The MCCHAP team has partnered with a local community hub in Suitland Park, Prince George's County, Maryland. Prince George's county is a jurisdiction that was identified in the Climate and Health Profile Report as at risk of significant health impacts from climate change. Following the 2016 forum, the community hub approached the MCCHAP team to begin discussion around formalizing a partnership. The conversation led to the decision to develop and implement a Student Climate Ambassador program. This program will empower student leaders to serve as Climate Ambassadors in their classes, schools, and community while educating students on the interconnections between the environment, social and health factors. Ultimately, it is hoped that change will happen under the leadership of the Student Climate Ambassadors. Planning and structuring of the program will occur with input from MCCHAP, school administrators, and students themselves. The programming is planned in three phases: brainstorming, planning & development, and finally implementation. During brainstorming, the MCCHAP and community hub will develop the Student Climate Ambassador program and ensure the goals and outcomes align with the priorities for the schools, the community and aligns with the CRSCI framework and overall programming goals. Development will include the formalizing of the materials, timeline, evaluation components and implementation plan. Finally, implementation will take place, at the beginning of a semester in both a local middle and a local high school as a pilot semester. For this particular program, distinct phases were necessary to establish and ensure continued progress towards a mutually agreed upon path to meeting the community needs.

MCCHAP has also partnered with the Maryland Department of Natural Resources to support the Shoring Up Resiliency Through Education (SURE) program. This project addresses regional vulnerabilities on the Eastern Shore to climate change and community resilience. The goals of the project will be achieved through partnership with a local public school system and engage elementary, middle and high school students in the experience, study and understanding of local condition trends related to weather and water quality. Currently in the beginning stages of program development, this project provides an opportunity to work with a vulnerable population and educate school age youth around connections between the environment and their health.

While the previous projects are primarily local in scope, MCCHAP's partnership with the University of Maryland Extension (UME) Program is designed to develop and implement climate change training for extension educators and community health workers state-wide. The partnership with UME piggybacks on the community work and established networks of community partnership. UME and MCCHAP have developed content specific to UME educators around climate, health and how it relates to their content topics in their day to day work. Programming has been completed and offered to extension educators during a full day training session in September 2017. Evaluation on the content and method of delivery will be used by team members to improve the program and offer training to more extension educators. A continuous cycle of iteration and refinement will continue with additional trainings offered to achieve training and programmatic goals around climate change content integration into extension programming across the state.

There is strong integration and collaboration between the MCCHAP and other environmental health programs, including the MDH Environmental Public Health Tracking program (MD-EPHT). MD-EPHT originally started in 2003, and provides online environmental and health data, as well as tools and resources for data presentation and analysis. (Maryland Environmental Public Health Tracking, 2017). MD-EPHT is a key tool for community members to access baseline health and environmental data and

visualization of their community for environment and health intersections. The tracking portal currently hosts air pollution data associated with PM2.5 and Ozone concentrations in Maryland and is in the process of adding precipitation and heat events. Many of the health impacts presented in the Climate and Health Profile Report are currently on the MD-EPHT portal, including asthma hospitalizations and myocardial infarction. Others, like salmonella infection and car accidents, are not currently displayed. The current programming provides support to the partnership to display climate indicators such as extreme heat and extreme precipitation events. The MD-EPHT and MCCHAP partnership continues to tackle the intersection of health and environment to provide the most up to date and useful data visualizations to communities to allow programming to be effective.

The ECO workgroup of the Commission identified a gap in communication between climate change activities across the state. Without a central location for climate change events to exist, efforts were being duplicated and experiencing underwhelming attendance. The MCCHAP team, in an effort to address this gap, created and maintains a public calendar: Climate Change, Public and Environmental Health Events in Maryland. This online calendar has become a central resource utilized statewide by MCCHAP and the greater climate change community to track climate and health-related events and activities.

Looking Forward

The discussion of climate change and health has matured in Maryland with the release of the Maryland Climate and Health Profile Report. There is now a recognition of the significant role public health plays in climate change adaptation in the state. MCCHAP, and the strong partnership between MDH, UMD-SPH, and Federal partners, has enabled the state to create tools and resources for local communities in a variety of ways. While there are challenges such as capacity constraints and the diverse array of stakeholders, the strength and success of the program comes from the continued engagement of partners such as individual community members, school leadership and state agency leadership to address these difficulties as they arise in individual projects. MCCHAP utilizes existing partner networks and calls on trusted messengers to participate in all stages of the program. From initial brainstorming, through program development and implementation, to evaluation and program improvement, stakeholders are involved throughout the process for individual smaller scale projects and the overall climate and health endeavor in Maryland. This allows the MCCHAP team to identify, address, and resolve challenges as they occur. It is this collaborative approach that allows climate and health work in Maryland to succeed, and continues to increase community resilience to climate change.

Acknowledgment

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Figure 1: Building Resilience Against Climate Effects framework developed by the Centers for Disease Control and Prevention

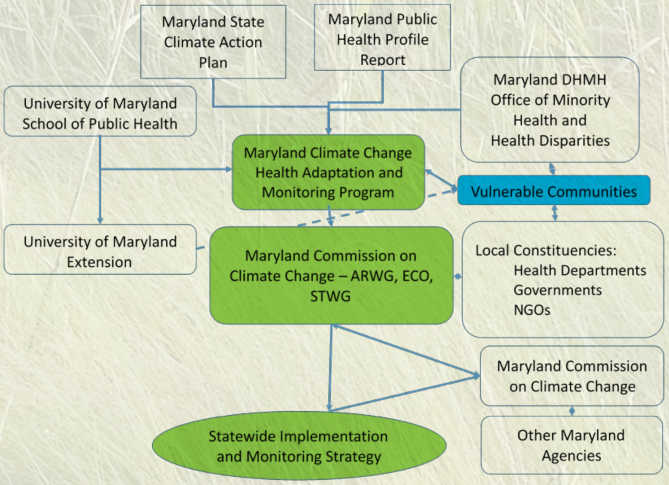

Figure 2: Maryland Climate Change Health Adaptation Program partnership framework

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from 9:00 AM to 12:00 PM
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Keyote Presentation
Secretary of the Department of Health and Social Services,
Dr. Kara Odom Walker

Coffee and snacks during
Brown bag lunch at conclusion

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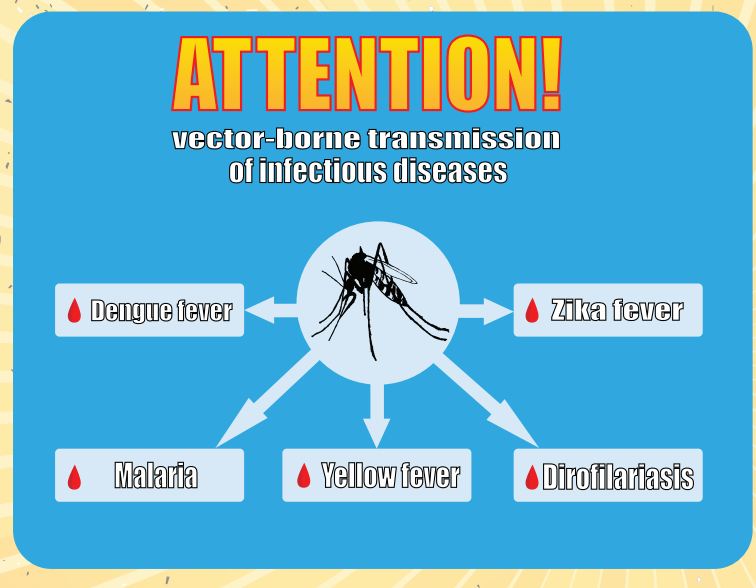
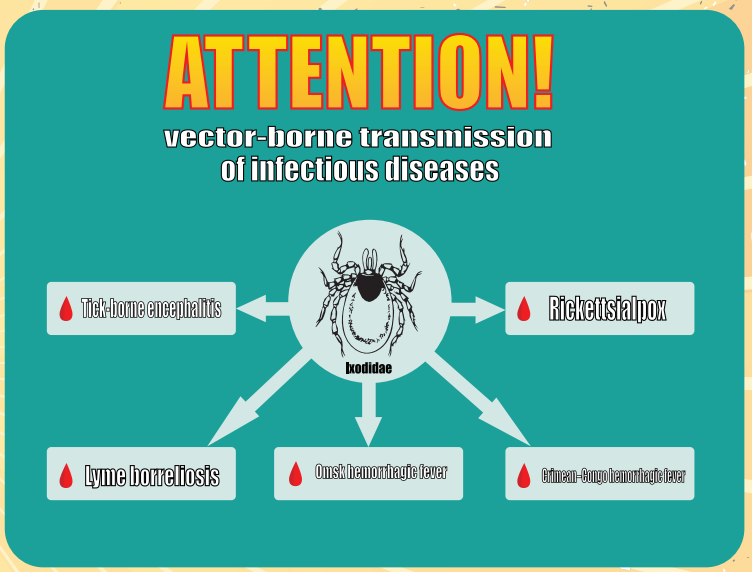
- **Staphylococcus aureus**

Climate Change:
Vector-Borne Diseases and Their Control; Mosquitoes and Ticks





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Whoever would study medicine aright must learn of the following subjects. First he must consider the effect of the seasons of the year and the differences between them. Secondly he must study the warm and the cold winds, both those which are in common to every country and those peculiar to a particular locality. Lastly, the effect of water on the health must not be forgotten. - Hippocrates

Human infectious diseases are sensitive to weather and climate in a variety of ways: impact on vector-borne disease transmission, pathogen survival outside the host, environmental contamination, food and water-borne infection, and disruptions of public health systems by disasters such as hurricanes and floods. One needs only consider the recent disasters on the United States mainland and in Puerto Rico as examples. In the continental United States during modern times, the most common mosquito-transmitted diseases are West Nile virus and several other encephalitis viruses. In southernmost areas of Florida and Texas, dengue and Zika viruses are found sporadically, usually resulting from travel to out-of-country endemic areas, although local transmissions can also occur. In the U.S. the most common diseases transmitted by ticks are Lyme disease, Rocky Mountain Spotted Fever, anaplasmosis and ehrlichiosis.

Vector-borne diseases affecting humans can vary in frequency and intensity depending upon population abundances of the vectors transmitting disease pathogens. In turn, vector population abundances can be influenced by environmental and ecological factors such as temperature, precipitation, humidity, photoperiod, food availability, habitat type, predation, inter-species competition and other parameters. Among these factors, climate change and particularly warming temperature regimes can cause some vector populations to become more abundant in given regions or areas, or to be more prevalent longer throughout the year, and in happening can lead to more disease problems for humans. This paper examines such phenomena for mosquitoes and ticks, which are major arthropod vectors for several kinds of diseases affecting people.

Mosquitoes

Aedes aegypti
(Yellow fever mosquito)

Aedes albopictus
(Asian tiger mosquito)

Warmer, longer, possibly wetter mosquito-production seasons can be an effect of warming climates. The present mosquito season in Delaware typically starts around mid-March and ends around mid-November, making for about an 8-month production period, having about a 5-1/2 month core or peak period from early May into mid-October. But what might happen if Delaware's climate warms over the next several decades and perhaps becomes more like what's experienced in South Carolina, Georgia or even northern Florida, which is a possibility that some climate change models indicate could happen? Under such conditions, the mosquito-production season might then start in mid-February and end around mid-December, making for a 10-month season, with a 7-1/2 month core or peak period from early April into mid-November. The need to control mosquitoes in Delaware would then last about 2 months longer than at present, being about 25% longer.

Indications of larger mosquito populations that might result from warming climates could turn-up in the 4 types of operational indicators that most all modern mosquito control programs use:

- Higher larval dipper counts
- Higher adult light trap counts
- Higher landing/biting rate counts
- More public complaints and requests for mosquito relief

Operational indicators of mosquito-borne arbovirus presence that might increase with warming climates include:

- Presence of viral antibodies in sentinel chicken blood samples
- Presence of virus in wild bird brain tissues
- Presence of virus in mosquito collections ("mosquito pools")
- And unfortunately, human and equine arbovirus cases

Mosquitoes are notorious for transmitting many types of diseases adversely affecting humans. In Delaware, we're primarily concerned with West Nile virus (WNV) and eastern equine encephalitis (EEE), with both arboviruses endemic in wild bird populations, and can be transmitted from birds to humans by certain types of mosquito species that serve as "bridge" vectors. There are also some lesser concerns in Delaware for dengue fever and now more recently for chikungunya and Zika too, which can all be brought into Delaware as imported cases by people who've become infected elsewhere in tropical or sub-tropical regions. This could then cause some of our local mosquitoes (e.g. the Asian tiger mosquito, Aedes albopictus) to contract these pathogens when they bite an infected traveler who's now in Delaware, and in turn via these infected mosquitoes biting other people could cause local disease transmissions or even set-off a larger outbreak.

Historically up until the early 1900s and the advent of modern medicine, appearance of organized mosquito control, and improved habitation and sanitary conditions, malaria was endemic in Delaware, and native mosquito vectors for this disease are still quite abundant in our state. Up until the mid- to late 1880s, yellow fever occasionally occurred in Delaware and other eastern seaboard locations during late summer, primarily associated with sailing ship commerce in coastal seaports. Problems caused by these two diseases were most evident during the warmest time of year.

Warmer temperatures as found with warming climates can exacerbate the potential for mosquito-borne disease transmissions in several ways besides just having more mosquitoes around for longer periods of time. Higher pathogen amplification can occur within individual mosquitoes, making for higher viremia levels and thereby increase their infectious nature. Faster pathogen replication rates can also occur in mosquitoes, perhaps reducing the cycle time for when a mosquito first picks-up a pathogen to when it's then capable of transmitting it to people from what was maybe 5-6 days to then become only 3-4 days. The more pathogen-infected mosquitoes there might be around (whether in terms of absolute numbers or percentages) that might then also have higher viremia levels, then the greater the potential for disease transmissions to humans.

A major concern that we have in Delaware for impacts of warming climate on mosquito-borne diseases is northward expansion of geographic ranges for mosquito species that can be very competent vectors for

disease transmission. First and foremost for this concern is with the yellow fever mosquito, Aedes aegypti, which is the primary vector not only for its namesake yellow fever, but is also a primary vector in tropical, sub-tropical, and even more southerly temperate areas for dengue fever, chikungunya and Zika. It's a peri-domestic species that does very well in high-density human population locations, essentially having evolved to be with and around people. At present along the eastern seaboard, Ae. aegypti is common only as far north as about central South Carolina, but can infrequently be found in quite low numbers as far north as southwestern Connecticut. This species in recent times in Delaware has been found in a single adult light trap collection in the Seaford area in 2012, and similarly in a single adult light trap collection in the Milford area in 2015. We are now carefully monitoring to see if this very troublesome species might become more abundant in our state with time, as our climate continues to slowly warm. If such happens, then the potential for transmission of these arboviral diseases will increase. It should be noted that in recent years Ae. aegypti has been found year-around in the Washington, D.C. area (at about the same latitude as southern Delaware), where it now successfully overwinters in the capital's subway system.

The Asian tiger mosquito (Aedes albopictus) is a non-native, invasive species that first came into the United States in the Houston area in 1985 via imported used tires from Japan, and has since become the #1 pest mosquito problem in urban and suburban locations throughout Delaware, as well as other locations as far north as northern New Jersey and New York City. It's also a secondary vector in Delaware for West Nile virus (the primary vector for WNV in Delaware is the

common house mosquito, Culex pipiens), and is a known vector in warmer climates for dengue fever, chikungunya and Zika. There is now concern that with warming climate this species will spread farther north into upstate New York and New England, bringing both its pestiferous nature and disease transmitting potential with it.

Aedes aegypti (the yellow fever mosquito) is a superb vector for mosquito-borne diseases, in that it feeds almost exclusively on people; the female in order to meet its ovipositioning-driven protein needs will take quick blood meals, flitting about from person-to-person potentially biting several people during a single feeding period; it can be very common in backyards; and will readily enter houses to feed on sleeping people within and to rest. Aedes albopictus (the Asian tiger mosquito) is not quite as competent a vector as Ae. aegypti, but nonetheless it's still a concern for disease transmission. Besides feeding on people, it will also feed on other mammals and birds, which helps to lessen demands for resorting to people for blood meals; will usually meet its egg-producing protein needs by taking longer blood meals from a single source (person or otherwise); and while also quite common in backyards is not as likely to enter houses to feed. These are both container-breeding species common in urban and suburban settings and other developed locations too, but fortunately have flight ranges not much more than about 500 feet away from their natal origins [unlike other species such as the common saltmarsh mosquito, Aedes sollicitans, that typically can fly 3-5 miles inland from its coastal wetland origins in search of blood meals, and at times up to 5-15 miles away]. But even with a relatively short flight range, anything that might increase the abundance or seasonal duration of these two problematic peri-domestic species, such as warming climate, is a most unwelcomed development.

Climate change can also affect and cause shifts in local mosquito production locations at smaller scales than latitudinal effects. For example, relative sea-level rise associated with warming climate can cause a landward transgression of salt marshes into formerly upland areas, creating new production sites and habitats for larval saltmarsh mosquitoes in manner at least temporarily unknown to our field inspectors, causing treatment response problems for us. We have now seen this type of change within a period of only a few decades. Additionally, our Open Marsh Water Management (OMWM) systems, which are networks of small ponds and shallow ditches (constructed at some effort and

expense to the State) that are installed in high marsh areas to help control saltmarsh mosquitoes via non-insecticidal means (relying heavily upon promotion of mosquito larvae consumption by native larvivorous killifishes), can be altered and rendered somewhat ineffective or prematurely aged by relative sea-level rise induced by warming climates.

It's also interesting to note that warming climate and mosquito-borne disease potential not only can manifest itself by latitude, but also by altitude. While altitudinal differences are of very little concern in a low-lying area such as Delaware, warming climate can cause mosquito-borne disease to occur at higher altitudes than before, essentially creeping-up mountainsides. For example, malaria is now being found in higher altitude areas of east Africa than ever before.

A changing and warming climate has tangible impacts on mosquito control operations, causing more need and more demands for our mosquito prevention or treatment services. If due to climate change our control program in future years has to become more like what now occurs in locations farther to the south, we might then be looking at a 25-50% increase in our annual program costs, including the need for more staff and operating resources. The annual budget for the Mosquito Control Section might then have to increase from its present level of about $2 million/year up to perhaps $2.5-3.0 million/year. Additionally, this would also result in our needing to use more insecticides to control the burgeoning mosquito populations and their problems, both for larvicides and adulticides -- environmentally this certainly would not be a good development.

But as a caveat to all of this, increases in the frequencies or abundances of mosquitoes, and for changes in their geographic ranges, shouldn't all be attributed to warming environments driven by climate change. Myriad types of human activities and their impacts on local ecology can also be major driving forces, as shown in the past for malaria, yellow fever and dengue.

Ticks

Similar as with mosquitoes, a warming climate can lead to more ticks in any given area, along with geographic range expansions northward for some species, causing more tick bites and more tick-borne diseases. With warming temperatures, everything becomes more intense and of longer duration within a year.

Ixodes scapularis (Deer tick) | *Dermacentor variabilis* (American Dog tick) | *Amblyomma americanum* (Lone Star tick)

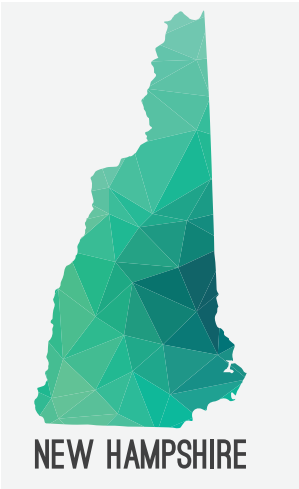
There can be some important corollary effects from a warming climate conducive to disease problems, in then having higher populations of white-footed mice (Peromyscus leucopus) in woodland areas, which are a primary host reservoir for the Lyme Disease pathogen, a spirochete bacterium known as Borrelia burgdorferi. Black-legged or "deer" ticks (Ixodes scapularis) are the primary vectors for Lyme Disease, with their larval stage (after hatching-out from eggs) feeding on white-footed mice and other rodents, and as such the larvae can pick-up the pathogen from infected small mammals. The tick's later nymphal stage will feed on humans and other larger mammals such as white-tail deer (Odocoilues virginianus), and in so doing infected nymphs can pass the pathogen onto people and other mammals. The adult tick stage can also take blood meals from people or other larger mammals, and in so doing if the tick is infected then pass the Lyme Disease pathogen onto their victims. Adult ticks can also initially acquire the pathogen when feeding on infected larger mammals, but are less likely to pick it up this way than in their larval or nymphal stages.

White-tail deer are the preferred source of an adult tick's final blood meal for both male and female ticks, and then also serve as mating sites for the adults, with mated females then falling off the deer to subsequently lay their eggs in forest floor soil and leaf litter. Fortunately, passage of the Lyme Disease pathogen onto tick eggs is thought to be extremely rare.

Primary concerns for tick-borne diseases in Delaware are as follows, involving 3 primary tick vectors:

- Black-legged or Deer tick (Ixodes scapularis) – Lyme Disease, anaplasmosis, babesiosis, ehrlichiosis, Powassan.
- American Dog tick (Dermacentor variabilis) – Rocky Mountain spotted fever, tularemia, tick paralysis.
- Lone Star tick (Amblyomma americanum) – ehrlichiosis, tularemia, STARI, Alpha-gal red meat allergy.

Anything that might increase the population abundances of these tick species, or extend or prolong their active periods throughout the year, would be of concern for human health and safety in terms of disease transmission potential. Unfortunately, a warming climate can be conducive to both greater tick abundances and their longer active presence.



An excellent example of climate change impacts on tick populations comes not from tick species that adversely affect humans, but rather this time from the animal world involving winter tick (Dermacentor albipictus) and moose (Alces alces) populations. Warming climate over the past 20 years or so is now being manifested in New Hampshire by much greater winter tick abundance, along with winter ticks being active both later into the fall and then earlier in the spring. Adult winter ticks feed upon moose, but in the past during colder climates many winter ticks would drop-off during the winter from their moose hosts or otherwise die. Unfortunately now during increasingly warmer, more mild winters, they will remain on moose throughout the winter in often very high densities adversely affecting their hosts, at times even fatally from excessive exsanguination that can greatly weaken adult moose during an already stressful cold time of year.

Better tick survival and longer periods of their contact with moose (due to milder, shorter winters) are now occurring, attributed to warmer winter temperatures. These tick-weakened moose appear quite gaunt and lightly discolored from their loss of hair, often manifested as clear patches of skin, and have now been named "ghost moose." Newborn moose calves in late winter and early spring can be even more adversely affected by their harboring huge densities of winter ticks.

Moose populations in New Hampshire have rapidly declined over the past 10 years by about 50% due to tick-caused mortalities, going from an estimated 8000-10,000 animals in the state down to only about 4000-5000 moose. This downward crash caused by winter ticks has also been noticed in nearby Maine and Vermont, as well as in other areas to the west near southern limits of the moose's geographic range. This is a quite striking example of a warming climate favoring tick population increases, which comes at expense of their moose host populations. It's expected that moose population declines will eventually level-off at some point dictated by a newly established tick-moose population equilibrium, but the end result might be a permanently lowered moose population in southern portions of their present geographic range (which will then also have some adverse consequences for ecotourism-based economies, along with ecological impacts too).

Delaware is one of the states with a significant increase in cases of Lyme disease over the years. The Environmental Protection Agency (EPA) is concerned that climate change is playing a role. Climate is just one of many important factors that influence the transmission, distribution, and incidence of Lyme disease. That said, the life cycle and prevalence of deer ticks are strongly influenced by temperature. Deer ticks are most active when temperatures are above 45˚F, and they thrive in areas with at least 85 percent humidity. Thus, warming temperatures associated with climate change are projected to increase the range of suitable tick habitat and are therefore one of multiple factors driving the observed spread of Lyme disease.

Personal Protection Measures

All told whether dealing with mosquitoes or ticks during an era of warming climate, populations of these disease-transmitting vectors will increase and benefit from warmer climes. This will come at the health expense of the species they feed upon, which of course includes people too. In addition to the measures taken by the state to control vector-borne diseases, Delawareans should protect themselves from these diseases by:

Avoidance of the vectors

For mosquitoes

- Emptying standing water from containers (to reduce opportunity for breeding)
- Installing or repairing screens on windows/doors
- Using air conditioning if available
- Mosquito netting if camping or traveling to certain areas

For ticks

- Light colored clothes
- Hat, long sleeves, long pants
- Tuck pants into socks
- Tick checks and tick removal

Use of repellents (applied in accordance with all product label instructions)

For mosquitoes

- Apply DEET (15-30%), picaridin (20%), or oil of lemon eucalyptus (30%) to skin

For ticks

- Apply DEET to skin (may be toxic in young children)
- Apply DEET or permethrin to clothing
- Use other repellents that are EPA-registered

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HOW WILL CLIMATE CHANGE AFFECT MY HEALTH?

Below are examples of how climate change can affect your health at different stages of your life.

RISING TEMPERATURES

Increasing temperatures mean heat waves are more frequent, more intense, and last longer. **Health risks: dehydration, heat stroke, worsened heart and lung disease, death.**

REDUCED AIR QUALITY

Rising temperatures, changes in rain patterns, and increasing wildfires lead to more smog, plant allergens, and other air pollutants. **Health risks: increased episodes of asthma and chronic lung disease, heart disease, death.**

PREGNANT WOMEN who experience extreme weather, like floods and heat waves, can experience mental health effects, injuries, and other health risks that affect their pregnancies and newborn infants.

INFANTS AND TODDLERS have developing immune systems that make them sensitive to heat, allergens, diseases carried by ticks and mosquitoes, and food and water-related illness.

INCREASING EXTREME WEATHER

Hurricanes, severe storms, flooding, droughts, and wildfires are already increasing in frequency, intensity, or length. **Health risks: water and food-related illnesses, respiratory illness, injuries, mental health problems.**

SPREADING DISEASES FROM MOSQUITOES AND TICKS

Changes in temperatures and precipitation patterns affect when and where diseases carried by mosquitoes and ticks occur. **Health risks: Lyme disease, West Nile virus.**

CHILDREN are sensitive to heat, poor air quality, water and food-related illnesses. They are often exposed to mosquitoes and ticks during outdoor play.

ADOLESCENTS can suffer heat-related illness, asthma or allergies while playing outdoors or competing in sports.

ADULTS who work in active or outdoor jobs have increased exposure to heat, allergens, poor air quality, and ticks or mosquitoes. They may have greater sensitivity to heat stress if taking certain medications.

EXPANDING WATER-RELATED ILLNESS

Increasing water and air temperatures, heavy rainfall, flooding, and sea level rise can expose people to contaminated waters. **Health risks: diarrhea, skin and eye infections.**

DECREASED FOOD SAFETY

Increasing air and water temperatures and extreme weather lead to food contamination, spoilage, and disrupted food distribution. **Health risks: food poisoning, diarrhea, reduced access to food.**

OLDER ADULTS are sensitive to heat because they are less able to regulate body temperatures. They are less able to respond to extreme weather due to normal aging processes that affect physical or mental ability.

Read more in the *Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* at **https://health2016.globalchange.gov.**

Climate Change and Population Health

Alan Greenglass, M.D.

Everyone - whether they are a health system executive in Delaware, a clinician participating in an Accountable Care Organization (ACO), a primary care provider for children and adults, or someone who just needs to breathe - should be concerned about the quality of the air around us.

There are over 204,000 children in Delaware, and over 18,000 of them suffer from pediatric asthma (American Lung Association, 2016). Of the 153,000 Delawareans over the age of 65, many are affected by adult onset asthma and/or Chronic Obstructive Pulmonary Disease

(COPD). These children and adults may be in managed Medicaid panels, or in a Medicare ACO.

Childhood asthma increased nationally from 8.7 to 9.3% from 2001-2010, and asthma in the 65+ population increased from 6.0 to 8.1% (Crimmins, et al., 2016). Physicians are aware of this, as more and more patients are visiting the doctor, or are being seen at the Emergency Department complaining of wheezing. Prescription sprays and pills can help control symptoms, but are not stopping the increase in disease prevalence.

There are many possible reasons for this increase in asthma prevalence in our populations. Bad health habits are often indicated as an indicator of poor health, but in this case, there may be another factor: the air we breathe. For asthma, chronic lung disease, and even heart disease and diabetes, the evidence is strong that air quality has an impact on preventing illness and maintaining health.

Many may assume that poor air quality is a problem to be dealt with far in the future, or as a part of the existential threat of climate change. To millions of people in the United States, however, the consequences of poor air quality are a daily reality.

Higher sea levels, more frequent shore-line flooding and erosion, more powerful rain and wind events, and increased mosquito and tick populations facilitated by warmer, wetter weather are not issues that everyone may be facing on a day-to-day basis. Many do not believe that these issues are caused by climate change at all, but rather by the innate weather patterns of the Earth itself.

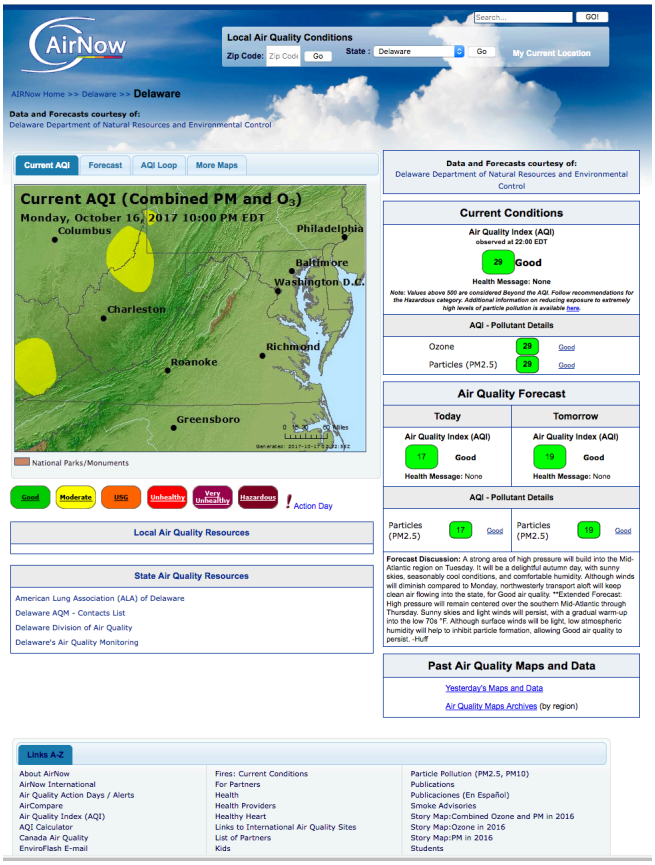
Whatever the cause, planetary temperatures, as well as the presence of carbon dioxide (CO2) and other greenhouse gases (GHG) in the air have increased since the beginning of the Industrial Revolution, and these increases have accelerated in the last few decades. Correlations between these increases in temperature and air quality leading to respiratory and cardiovascular illnesses have been studied.

But how does climate change affect respiratory and cardiac health? What does this mean for Delaware? And most importantly, what can we do to affect change?

The Air We Breathe

The water we drink and the air we breathe have been around since the beginning of time on Earth. The water molecules we drink may have sailed across the Atlantic with the Vikings; the oxygen we inhale may have been part of the carbon dioxide exhaled by Caesar.

The air in Delaware comes in great part from our surrounding states. Due to our prevailing winds (generally from the south and west), our air quality is determined by policies and economics in Maryland, Pennsylvania, West Virginia, Ohio, and occasionally even further. Industry, energy, and vehicle emissions here in Delaware also play a major part in what we breathe on any given day.



In April, 2017, the Environmental America Research and Policy Center released a report based on 2015 Federal Environmental Protection Agency (EPA) data. This data, collected by the states, found that the air quality in Delaware has improved over the years, in part due to decreased ozone pollution. Unfortunately, the Wilmington-Philadelphia metropolitan area ranks second in the Northeast for days with elevated ozone and soot (Ridlington & Madsen, 2017). Table 1 illustrates some of the data given by the report.

Table 1. Elevated Ozone and Soot in the State of Delaware, 2015

County	High Ground Level Ozone (Smog) Days	Elevated Soot Days
New Castle/ Wilmington	97	212
Kent/Dover	40	52
Sussex	49	60

"We know that future weather in Delaware will be warmer in all seasons, especially in the summer, when heat waves will be more frequent, more intense, and last longer due to climate change. Ozone levels already exceed national air quality standards in Delaware, and will exacerbate with rising temperatures." – Dr. Cristina Archer (University of Delaware) (Ridlington & Madsen, 2017)

Yes, Delaware has made progress, but as more GHGs enter the atmosphere, we have to work hard, just to maintain the air quality we have now.

What is Changing in our Air?

Carbon dioxide (CO2) is an essential part of life on earth. It is a small part of the air we breathe, but without it we would have no carbon to build the tissues in our bodies, no stored energy to use for walks in the park, and no way to break down the food we eat. Additionally, oxygen cannot exist without carbon dioxide – about half of the air we breathe is due to plants and trees excreting oxygen during photosynthesis (the other half is due to photosynthesis by marine phytoplankton).

Over the eons, the amount of CO2 in the atmosphere has varied from 180 to 280 parts per million (ppm), as determined by glacial ice core sampling (NASA, 2017). The current rise in CO2 began with the onset of the Industrial Revolution. In 1950, the CO2 level was measured at 300 ppm; in 2013 it was over 400 ppm. It is now rising at 2 ppm/year.

Early in the 19th century, Joseph Fourier first described the greenhouse effect: oxygen is converted to ozone high in the atmosphere. This ozone protects us from harmful ultra-violet solar rays, and traps gases in the atmosphere. Those gases retain the heat from the sun, and make our planet warm enough to sustain life.

At the beginning of the 20th century, the Swedish scientist Svante Arrhenius postulated that a rise in GHGs would bring on global warming. In the 1960s Charles Keeling was able to measure atmospheric CO2 and found it rising rapidly (most of our data about years previous comes from ice core samples).

The increase in CO2 is due to the burning of fossil fuels. Mining and burning natural gases – like methane – has been suggested as a good alternative to fossil fuels, and both methane and CO2 are accumulating in the atmosphere. Although there is less methane than CO2, it is better at trapping heat, and thus creates its own problems.

The ozone layer – the high atmosphere layer of oxygen particles that protects the earth from solar radiation and makes the planet habitable – is "good" ozone. This ozone layer is made by sunlight striking oxygen particles, and was being depleted by hydrocarbons from industrial and commercial processes in the last century. Many governments and scientists got together to reduce the use of these chemicals to save the ozone layer.

When that ozone is present closer to the ground, it becomes a detriment to health. This ground-level ozone is formed by heat and sunlight acting on dangerous chemicals like sulfur dioxide, nitrogen oxide, and volatile organic compounds (VOCs) that are created when fossil fuels are burned in power plants and in vehicles.

What can we take away from this brief view of climate change and health?

Without CO2, and without high atmospheric ozone (O3), we could not have carbon-based life on earth.

As GHGs have increased (including CO2, methane, and others) more heat has been trapped in our atmosphere, causing weather changes.

The increase in GHGs and in global temperature corresponds to the beginning of the Industrial Revolution, and to the increased burning of fossil fuels.

Fossil fuel waste (exhaust) is the cause of ground-level ozone (smog) and particulates (soot) in the air we breathe.

The Impact on Health

In 2009 the Regional Greenhouse Gas Initiative (RGGI) began in the Northeast and Mid-Atlantic. The RGGI operates through a "cap and invest" strategy: limits are placed on power plant emissions, utility companies can sell excess credits or buy needed credits from cleaner utilities, and the sponsoring States gain revenues which are re-invested in energy efficiency and clean energy projects.

In 2017, the Natural Resources Defense Council (NRDC) published a report on the RGGI program (Abt Associates, 2017). Not only did the report find a significant decrease in carbon emissions - as well as sulfur dioxide and nitrogen oxides - from power plants, it also estimated the health and economic benefits throughout the region (including the non-RGGI States) of the program.

Table 2. Selected Findings of the RGGI Program

	Delaware	Northeast/ Mid-Atlantic Region
Asthma Attacks	↓ 290	↓ 9,000
Restricted Activity Days	↓ 8,171	
Lost Work Days	↓ 1,364	↓ 40,000
Health-Related Savings	$115 – 274 million	$3.0 – 8.3 billion

What is it about worsening air quality that impacts our bodies and results in the findings in this report?

Air Quality and Respiratory Conditions

Allergens. As the weather becomes wetter and warmer, plants will be impacted. While some cooler climate plants will suffer under the increase in temperatures, others – including ragweed – will benefit. The Environmental Protection Agency (EPA) reported that from 1995-2011, the ragweed season has lengthened by 11-27 days (Crimmins, et al., 2016). In addition, higher CO2 and increased temperature results in earlier flowering, greater floral numbers, greater pollen production, and increased antigenicity in common ragweed. Temperature and moisture has an impact on tree pollen, and on leaf and indoor mold, thus increasing allergy symptoms in the population.

Ozone and Particulates. Ozone (smog) is a direct irritant to the lungs, causing airway hyper-reactivity and inflammation. Ozone levels are related to both immediate and long-term respiratory exacerbations. The immediate risks of high ozone days, especially for those already vulnerable or who are physically exerting themselves, are shortness of breath, cough, wheezing, asthma attacks, and increased respiratory infections. Long-term exposure to excessive ozone is now shown to result in a higher risk of death from respiratory illness, a higher incidence of asthma, and also decreased lung function - especially in children (Uysal & Schapira, 2003). Ozone and allergens have also been shown to work together to create even more negative impacts.

Particulate pollutants (soot) are the physical evidence of smoke stack exhaust and diesel exhaust. Our noses and upper respiratory passages provide natural defenses against larger particles, but not for particles smaller than 10 microns. These can pass into the lungs, through the alveoli, and into the blood stream. The types of particles in the air vary by region, and are related to the types of fossil fuel burned. In the Northeast and Mid-Atlantic, where 40% of power comes from coal, we have more sulfate particles than in other parts of the country.

As with ozone, particulates pose short-term and long-term health risks. In the short-term, an increased risk of severe asthma attacks, more lung inflammation (even in healthy, young adults), more Emergency Department visits due to breathing problems, and a higher incidence of respiratory related deaths are likely with increased particulate exposure (American Lung Association, 2016).

Long-term exposure to particulates is correlated to slowed lung function growth in children and teens, the development of childhood asthma, small airway damage, and more Emergency and inpatient care (American Lung Association, 2016).

Air Quality and Heart Disease

Just as ozone and inhaled particles cause inflammation in the airways, their passage into the blood stream can cause vascular inflammatory responses and can have an effect on cardiovascular health.

Carbon monoxide (CO) is another gas produced by the burning of fossil fuels. When CO is inhaled and enters the blood stream, it replaces oxygen in the red blood cells. This replacement cannot be reversed, and can lead to suffocation. Malfunctioning indoor space heaters and poorly ventilated work spaces are often the cause of CO poisoning. Smokers have been shown to have higher levels of CO in their blood than non-smokers (Aronow W. S., 1973).

Ozone and particle pollution both have direct effects on cardiac arrhythmias, angina, heart attacks, and strokes. In 1972, Aronow, et al. demonstrated that there was

an increased risk of angina with increased exposure to freeway air. The study showed that one or two days of increased ozone exposure resulted in an increase in heart attacks in otherwise healthy middle-aged men (Aronow, Harris, Isbell, Rokaw, & Imparato, 1972). A 2007 study by Metzger, et al., showed a correlation between particle pollution and cardiovascular Emergency visits (Metzger, et al., 2004).

Other Air Quality Concerns

Diabetes. About 80,000 (8.5%) Delawareans have diabetes mellitus (American Lung Association, 2016). Many of these are in the older population groups, and many of the most severe are in lower socio-economic groups. There are extra risks posed by air quality on the pulmonary and cardiac health of diabetics. New research suggests that long-term exposure to particle pollution may increase the risk of Type 2 diabetes (Zanobetti & Schwartz, 2001).

Low Income Groups. Lower socio-economic status is associated with greater harm from poor air quality (American Lung Association, 2016). People living in poverty (especially certain racial and ethnic groups) often face higher exposure and greater responses to pollution. Between 30-45% of the urban population lives near busy roads, and there is a proven relationship between traffic pollution and childhood asthma. There is likely a relationship between pulmonary and cardiovascular morbidity and traffic pollution in adults. Lower socio-economic status among Medicare recipients correlates with excess risk of premature death due to fine particle pollution.

Conclusion

Our air is warmer and wetter, and there is more CO2 in it. There is no evidence to suggest this situation will get better on its own. In fact, geologic history has shown that the response to less extreme changes in the past has been cataclysmic (Alley, 2014). The oceans may have absorbed as much CO2 as they can and the resultant increase in their acidity is harming marine life. The ice caps are melting and that influx of water onto our shores and into our air makes our climate change even more.

The populations we care for, and the individuals in those populations, are at risk. Pills and sprays can mitigate some symptoms, but the incidence of disease - especially respiratory disease - is increasing. The fossil fuel and climate risks to respiratory and heart disease are synergistic.

What is to be done? Clearly, we need to treat the needs of each individual, especially those with a high degree of risk and poor access to care. We need to understand the impact of poor air quality well enough to communicate how to avoid situations that could worsen health.

On a public health level, we can advocate for fewer diesel buses and trucks in communities with large populations of the elderly and the poor. We can lobby for the use of air conditioners as a means to improve indoor air quality. We can ask our health systems and communities to take steps to reduce GHGs.

On a regional level, we can advocate for our neighboring states to be part of the RGGI. We can encourage our elected officials in Delaware to go beyond our current commitment to the RGGI and to reduce the fossil fuel mix in our power generation.

On a national level, we need to arm ourselves with facts, and set good examples. We can help others understand that it is not just air: it feeds our bodies and keeps us alive.

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Delaware

Table 3. Avoided Health Effects in DE due to RGGI

Health Endpoint	Cases Avoided due to RGGI						
	2009	2010	2011	2012	2013	2014	Total
Acute Bronchitis	7	1	<1	2	3	2	**15**
Adult Mortality	5 - 12	1 - 2	0 - 1	1 - 3	2 - 5	1 - 3	**12 - 26**
Asthma ER Visits	2	<1	<1	1	1	1	**5**
Asthma Exacerbations	138	21	7	32	55	38	**290**
Cardiovascular Hospital Admissions	2	<1	<1	1	1	1	**4**
Infant Mortality	<1	<1	<1	<1	<1	<1	**<1**
Lower Respiratory Symptoms	89	14	4	21	37	26	**192**
Minor Restricted Activity Days	3,812	606	192	904	1,583	1,073	**8,171**
Non-fatal Heart Attacks	0.59 - 6	0 - 1	0 - 0	0 - 1	0 - 3	0 - 2	**1 - 12**
Respiratory Hospital Admissions	1	<1	<1	<1	<1	<1	**3**
Upper Respiratory Symptoms	127	20	6	30	53	37	**274**
Work Loss Days	638	101	32	151	264	179	**1,364**

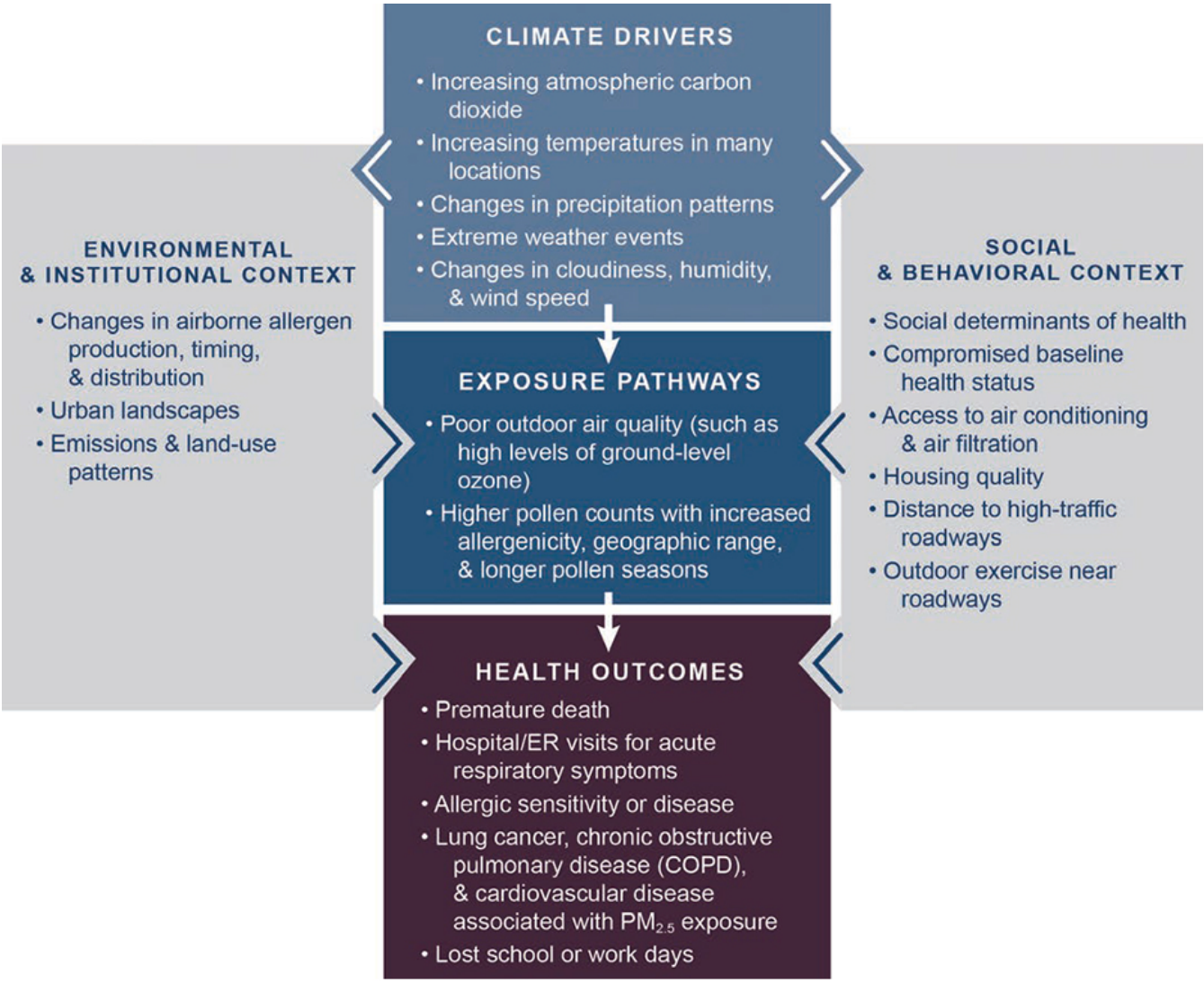
Delaware

Table 4. Valuation of Avoided Health Effects in DE due to RGGI

Health Endpoint	Million 2015 dollars, 3% discount rate						
	2009	2010	2011	2012	2013	2014	Total
Acute Bronchitis	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.01**
Adult Mortality	$54 - $122	$9 - $20	$3 - $6	$13 - $28	$22 - $49	$14 - $31	**$114 - $257**
Asthma ER Visits	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.00**
Asthma Exacerbations	$0.01	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.02**
Cardiovascular Hospital Admissions	$0.1	$0.02	$0.01	$0.02	$0.04	$0.03	**$0.22**
Infant Mortality	$0.15	$0.02	$0.01	$0.03	$0.05	$0.03	**$0.29**
Lower Respiratory Symptoms	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.00**
Minor Restricted Activity Days	$0.33	$0.05	$0.02	$0.07	$0.12	$0.08	**$0.67**
Non-fatal Heart Attacks	$0.1 - $0.92	$0.02 - $0.15	$0 - $0.05	$0.02 - $0.22	$0.04 - $0.37	$0.03 - $0.23	**$0.21 - $1.95**
Respiratory Hospital Admissions	$0.05	$0.01	$0.00	$0.01	$0.02	$0.01	**$0.12**
Upper Respiratory Symptoms	$0.01	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.01**
Work Loss Days	$0.14	$0.02	$0.01	$0.03	$0.05	$0.03	**$0.28**
Total	**$55 - $124**	**$9 - $21**	**$3 - $6**	**$13 - $29**	**$22 - $50**	**$14 - $31**	**$115 - $261**
Health Endpoint	**Million 2015 dollars, 7% discount rate**						
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
Acute Bronchitis	$0.01	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.01**
Adult Mortality	$60 - $137	$10 - $22	$3 - $6	$13 - $28	$21 - $47	$13 - $29	**$119 - $270**
Asthma ER Visits	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.00**
Asthma Exacerbations	$0.01	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.02**
Cardiovascular Hospital Admissions	$0.13	$0.02	$0.01	$0.03	$0.05	$0.03	**$0.26**
Infant Mortality	$0.18	$0.03	$0.01	$0.03	$0.06	$0.04	**$0.35**
Lower Respiratory Symptoms	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.01**
Minor Restricted Activity Days	$0.41	$0.06	$0.02	$0.08	$0.13	$0.08	**$0.79**
Non-fatal Heart Attacks	$0.12 - $1.13	$0.02 - $0.18	$0.01 - $0.05	$0.03 - $0.24	$0.04 - $0.39	$0.03 - $0.24	**$0.24 - $2.23**
Respiratory Hospital Admissions	$0.07	$0.01	$0.00	$0.01	$0.02	$0.01	**$0.14**
Upper Respiratory Symptoms	$0.01	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.01**
Work Loss Days	$0.17	$0.02	$0.01	$0.03	$0.05	$0.04	**$0.33**
Total	**$61 - $139**	**$10 - $22**	**$3 - $6**	**$13 - $29**	**$21 - $48**	**$13 - $29**	**$121 - $274**

Appendix

Climate Change and Health – Outdoor Air Quality



Dr. Alan Greenglass came to Delaware in 2005 as senior vice president for the employed Medical Group at Christiana Care. He later oversaw the creation and development for Christiana Care of a state-wide Accountable Care Organization. Prior roles were as a primary care physician, and as a Medical Director, for Kaiser Permanente, and at Yale University. More recently he has served on the Advisory Council of the Wood Hole Research Center, and also is working with Physicians for Social Responsibility in Pennsylvania on climate change issues.

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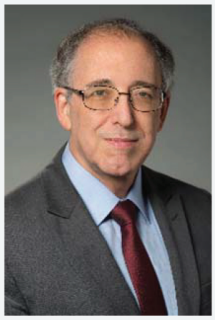

James M. Ellison, M.D., MPH, researcher, educator & renowned clinical practitioner

Jane Meier Hamilton, MSN, RN, educator, author, and national caregiving expert

2. There will be a collection of breakout sessions customized just for you, like:
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   - Equipping Faith Communities for Caregiver Ministry
   - When Dementia Isn't Alzheimer's
   - Caregiver Resilience
   - Mindfulness & Clinical Applications
   - Behaviors
   - Traveling with Someone Who has Alzheimer's
   - Changing the Conversation
   - Research
3. Professional attendees can earn continuing education credits!

THE FLU

DELAWARE HEALTH AND SOCIAL SERVICES
Division of Public Health

Vaccination is your best protection. Get vaccinated today!

Flu vaccines can both prevent the disease, and make it milder if you do get the flu. That means fewer hospitalizations and fewer sick days.

Vaccinations are offered through physician offices, and many pharmacies and grocery stores. For information on the flu or where to get vaccinated, visit **www.flu.delaware.gov** or call 1-800-282-8672.

Delawareans are also encouraged to prevent infection by:

- **Washing hands with soap** frequently or using alcohol-based hand sanitizers, especially after coughing, sneezing, or touching your face.
- **Covering coughs and sneezes** with a tissue and disposing of the tissue immediately. If a tissue is not available, cough or sneeze into your sleeve. Droplets from a sneeze can travel up to six feet.
- **Staying home when sick** and not returning to school or work until 24 hours after a fever.

Five steps to take if you get the flu:

- **Stay at home and rest.**
- **Avoid close contact** with well people in your house so you won't make them sick.
- **Drink plenty of water** and other clear liquids to prevent fluid loss (dehydration).
- **Treat fever and cough** with medicines you can buy at the store.
- If you get very sick or are pregnant or have a medical condition (like asthma) that puts you at higher risk of flu complications, **call your doctor**. You may need antiviral medication.

When should you seek medical attention?

IN CHILDREN	IN ADULTS
Fast breathing or trouble breathing	Difficulty breathing or shortness of breath
Bluish skin color	Pain or pressure in the chest or abdomen
Not drinking enough fluids	Sudden dizziness
Not waking up or not interacting	Confusion
Being so irritable that the child doesn't want to be held	Severe or persistent vomiting
Flu-like symptoms improve but return with fever and worse cough	Flu-like symptoms that improve but return with fever and worse cough
Fever with a rash	

In addition to the signs above, get medical help right away for any infant who has any of these symptoms:
Inability to eat
Trouble breathing
No tears when crying
Significantly fewer wet diapers than normal

Vaccination: protecting each other.

09/15/2017

THE FLU

DELAWARE HEALTH AND SOCIAL SERVICES
Division of Public Health

PROTECTING ELDERLY AND OTHERS WHO ARE VULNERABLE

The flu can be a particularly hard on the elderly and other vulnerable people, so extra precautions are important. Flu vaccines can both prevent the disease, and make it milder if you do get the flu. That means fewer hospitalizations and fewer sick days.

Vaccinations are offered through physician offices, and many pharmacies and grocery stores. For information on the flu or where to get vaccinated, visit **www.flu.delaware.gov** or call 1-800-282-8672.

To Protect Seniors And Vulnerable Populations

- **Ensure all your loved ones are vaccinated against the illness.** Vaccines are available from DPH clinics, physicians, pharmacies, and many grocery stores.
- **If you are receiving treatment in a long-term care facility or in-home care**, ask if the staff is vaccinated against the flu and, if not, the staff person should be wearing a mask at all times.
- **Visits at home or in a facility should be limited if the visitor is under age 16**, or has the flu or is at risk of exposure to the flu. The illness can be transmitted prior to someone showing symptoms.
- **If living with a senior and a family member contracts the flu**, keep the two separate as much as possible and ensure everyone in the home follows sanitary precautions.
- **Wash hands frequently with soap** or use alcohol-based hand sanitizers, especially after you cough, sneeze or touch your face.
- **Cover coughs and sneezes with a tissue** and dispose of the tissue immediately. If a tissue is not available, cough or sneeze into your inner elbow. Droplets from a sneeze can travel up to six feet.
- **Stay home when sick** and do not return to work or school until 24 hours after a fever is gone.
- **Contact a medical provider immediately** if flu symptoms appear.
- **Anti-virals may need to be prescribed** to help lessen the severity and length of the illness, but are most effective if taken early.

In addition to seniors, others who are most vulnerable are the very young, pregnant women and those who recently gave birth, and people with underlying medical conditions, such as cancer, lung disease, heart disease, diabetes, and individuals with weak immune systems. These precautions should be applied to these groups as well.

Flu symptoms can include fever, cough, sore throat, runny or stuffy nose, body aches, headache, chills, and fatigue.

Vaccination: protecting each other.

09/15/2017

Climate and Health Resources

LOCAL AND NATIONAL ORGANIZATIONS

American Public Health Association
https://www.apha.org/

Center for Disease Control
https://www.cdc.gov/

College of Earth, Ocean, and Environment – University of Delaware
http://www.ceoe.udel.edu/

Delaware Department of Natural Resources and Environmental Control
http://www.dnrec.delaware.gov/Pages/Portal.aspx

Delaware Department of Health and Social Services
http://dhss.delaware.gov/dhss/

National Institute of Environmental Health Sciences
https://www.niehs.nih.gov/

National Oceanic and Atmospheric Administration
http://www.noaa.gov/

National Centers for Environmental Information
https://www.ncei.noaa.gov/

NOAA Climate
www.climate.gov

National Weather Service
http://www.weather.gov/

US Global Change Research Program
https://health2016.globalchange.gov/

World Health Organization
http://www.who.int/en/

University of Delaware Climate Variability and Change
http://extension.udel.edu/ag/climate-variability-and-change/

US Environmental Protection Agency
https://www.epa.gov/

PROGRAMS, PLANS, REPORTS, ASSESSMENTS

APHA Adaption in Action:
https://www.cdc.gov/climateandhealth/pubs/adaptation-in-action.pdf

CDC Assessing Health Vulnerability to Climate Change
https://www.cdc.gov/climateandhealth/pubs/assessinghealthvulnerabilitytoclimatechange.pdf

Climate Framework for Delaware
http://www.dnrec.delaware.gov/energy/Documents/The%20Climate%20Framework%20for%20Delaware%20PDF.pdf

Delaware Climate + Health Conference Summary Report
http://www.dnrec.delaware.gov/energy/Documents/Climate%20Health%20Conference/DE%20Climate%20+%20Health%20Report.pdf

Delaware Climate Action Progress Report
http://www.dnrec.delaware.gov/energy/Documents/2016%20Climate%20Action%20Progress%20Report/Climate%20Action%20in%20Delaware%202016%20Progress%20Report.pdf

Delaware Climate Change Impact Assessment
http://www.dnrec.delaware.gov/energy/Pages/The-Delaware-Climate-Impact-Assessment.aspx

Delaware's Sea Level Adaption Plan
http://www.dnrec.delaware.gov/coastal/Pages/SLR/DelawareSLRAdaptation.aspx

Environmental Health Perspectives and the National Institute of Environmental Health Sciences: A Human Health Perspective on Climate Change
https://www.cdc.gov/climatechange/pubs/hhcc_final_508.pdf

NOAA State Summary
https://statesummaries.ncics.org/sites/default/files/downloads/DE-screen-hi.pdf

USGCRP The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment
https://health2016.globalchange.gov/

WHO Protecting Health from Climate Change: Vulnerability and Adaptation Assessment
http://apps.who.int/iris/bitstream/10665/104200/1/9789241564687_eng.pdf?ua=1

CLIMATE AND HEALTH LEXICON
OF TERMS

Adaptive Capacity – the ability of communities and people to adjust to potential hazards, to take advantage of opportunities, or to respond to consequences

Air Pollution – a mixture of solid particles and gasses in the air created by car emissions, chemicals, dust, pollen, mold, ozone, and more. Air pollution can cause allergies, diseases, and in extreme cases, even death.

Air Quality Index (AQI) – A number used by government agencies to project to the public the current measure of pollution in the air, and/or the projected pollution forecast. As the AQI in a given area increases, a larger percentage of people are at risk for developing or experiencing adverse health effects.

Allergens – substance that causes the immune system to react abnormally

Asthma – a condition in which a person's airways become swollen, inflamed, and narrow, and they have difficulty breathing. Climate change can exacerbate asthma by affecting weather patterns and the duration of seasons.

Climate – The average weather within a certain region.

Climate Change – changes in the average weather within a region. Climate changes in a region could include average rainfall or average temperatures, for example

Environmental Health – an aspect of public health focusing on how the built and natural environment affect human health. Elements within Environmental Health affecting health outcomes include outdoor air quality, hazardous waste, communities and homes, infrastructure, and surface and ground water.

Global Surface Temperature – The average temperature of Earth above ground and at sea-surface level. This value is found through the average temperature of water a few meters below the surface, and the average temperature of land and 1.5 meters above.

Global Warming – The increase in surface temperatures globally. Global warming occurs when carbon dioxide and other air pollutants collect in the atmosphere and trap solar radiation and sunlight, heating the Earth's temperature.

Greenhouse Gas Emissions – gases that trap heat in the atmosphere. The largest source of greenhouse gas emissions in the United States is the burning of fossil fuels by humans. Fossil fuels are burned for heat, electricity, and transportation.

Natural Resources – the basis of life on Earth consisting of water, minerals, air, living organisms, fossil fuels, soil, vegetation, and land. Climate change can affect natural resources particularly through extreme temperature changes and weather events such as floods, droughts, and hurricanes.

Ozone – A major component of air pollution in cities across the US. Ozone is created by chemical reactions between oxides of nitrogen and volatile organic compounds. Reducing ozone levels helps make breathing easier for individuals in the community.

Smog – A 20th century term describing a type of air pollutant. The term combines the words "smoke" and "fog". Modern-day smog can be created by coal emissions, vehicular emissions, and burning of agricultural areas.

Vector-borne diseases – Diseases carried by living organisms, which transmit infectious diseases to both humans and animals. Many vectors are blood-sucking agents such as mosquitos, ticks, and fleas. Examples of vector-borne illnesses include Zika, Malaria, and Yellow Fever.

Waterborne Diseases – Illnesses caused by contaminated or untreated water, caused by microorganisms. Infection usually occurs during activities such as bathing, cooking, washing, or drinking contaminated water. Some examples of these diseases include Cholera, Typhoid, and Dracunculiasis.

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Questions? Contact us at Sarahfaye.F.Dolman@ChristianaCare.org or 302-733-5868.

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Index of Advertisers

From the history and archives collection

American gynecologist Howard Atwood Kelly's 1906 biography of Walter Reed emphasizes the Army physician's role in tracing the source of yellow fever. Five years earlier, Reed and his colleagues had determined that a certain species of mosquito was responsible for transmitting the disease. While most prevalent in the hot, humid environments where mosquitoes thrived, epidemics of yellow fever had also swept through the urban centers of the northern United States. One of the most notable epidemics occurred during the 1790s in Philadelphia, with the devastation extending into Wilmington later in the decade.

Prior to Reed's findings, the accepted theory attributed the spread of yellow fever to fomites, or objects that had come into contact with infected patients. A minority of dissenters, including Cuban physician Carlos Finlay, argued instead that mosquitos were the transmitters. Without firm proof, however, the medical community largely ignored this claim.

Following an outbreak of yellow fever in Havana at the turn of the 20th century, the U.S. Army assigned Reed to head a commission to study the disease. Combining the research of Finlay and other predecessors with their own, Reed and his colleagues proved conclusively that a certain species of mosquito was responsible for transmitting the disease.

The identification of yellow fever as a vector-borne disease, as we call it today, made it possible to take steps to limit its spread. Efforts like draining sources of standing water, fumigating areas with high mosquito populations, and using nets for protection have all helped to combat yellow fever and reduce its devastating effects.

Information used in this article courtesy of Harvard University Library, Encyclopedia Britannica, the National Institute of Health, and the New York Times.