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Climate Change and Population Health

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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.[1] 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%.[2] 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

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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.[3] 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)[3]

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.[4] 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

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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 (see Table 2).[5] 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

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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.[2] 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.[6] 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.[1]

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.[1]

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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.[7]

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.[8] A 2007 study by Metzger, et al., showed a correlation between particle pollution and cardiovascular Emergency visits.[9]

Other Air Quality Concerns

Diabetes. About 80,000 (8.5%) Delawareans have diabetes mellitus.[1] 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.[10]

Low Income Groups. Lower socio-economic status is associated with greater harm from poor air quality.[1] 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.[11] 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.

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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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