Module 3: Activity 1

Scientific Literacy: Health Problems and Air Pollution

IT'S OUR AIR

SUMMARY

To learn about some of the health effects of ozone and particulate matter, students will read a variety of articles and scientific papers. While doing so, they will learn how to evaluate both general-interest articles and scientific papers. They will also learn how scientists discover, document, and communicate the health effects of air pollution. This activity is differentiated for classes of different abilities.

ESSENTIAL QUESTIONS

- What are some of the ways that ozone pollution and particle pollution affect human health?
- How do scientists discover ways that ozone and particle pollution affect human health?
- What are some strategies for reading, understanding, and analyzing an article about science in a newspaper, magazine or peer-reviewed science journal?
- How does the author of a general-interest article or scientific paper influence the credibility of the article or paper?

TIME NEEDED

90 minutes if articles are read in class. 45 minutes if articles are assigned as homework.

North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

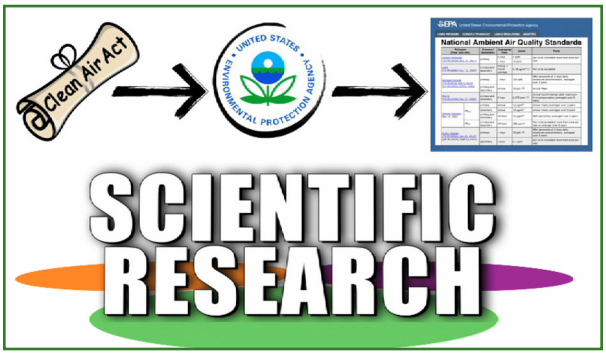
- EEn.2.5.5 Explain how human activities affect air quality.
- EEn.2.7.3 Explain how human activities impact the biosphere.
- HS.SI.1 Evaluate resources needed to solve a given problem.

A product of the NC Air Awareness Program 2016.

MAKING CONNECTIONS

Scientific literacy is a key focus of the North Carolina Essential Standards for Science. Although students will be reading about air pollution in this activity, the skills they learn will help them understand and analyze articles about any kind of science that they read in newspapers, or on the internet, or in peer-reviewed scientific journals. It's important to bring an analytical and questioning mind to the task. Do the data support the conclusions? Are there other conclusions that could explain the data? How large was the sample size? Have the findings been repeated by other scientists? Can the findings be applied to real-world situations? Science has much to tell us about our world, but we have a responsibility to think creatively and to ask questions as we read about scientific investigations.

BACKGROUND



Air pollution affects human health in many ways, some temporary and some long-term. It also affects crop yields, the environment, buildings, and other structures. How do we know? Scientific research. Scientific studies help legislators and regulatory agencies set environmental policies and give people information they need to protect their health. Furthermore, scientific studies form the basis of knowledge that scientists use to recommend changes to Environmental Protection Agency (EPA) air pollution standards. Scientific research into air pollution is ongoing, and EPA air pollution standards may change in the future based on new information.

OZONE POLLUTION AND HEALTH

Ground-level ozone pollution occurs as a result of nitrogen oxides (NO_x) reacting with volatile organic compounds (VOCs) in the presence of heat and sunlight. For more information about ozone formation, see "The Criteria Pollutants and a Closer Look at Ozone" (Module 1, Activity 4). For more information about ozone forecasting and ozone trends in North Carolina, see "Making a Simple Predictive Model for Ground-Level Ozone" (Module 2, Activity 2).

Ozone affects human health in many ways. High levels of ozone can cause chest pain, coughing, and throat irritation. Ozone can inflame lung tissue and cause reduced lung function, which leads to an increased breathing rate and decreased lung capacity. Ozone can aggravate existing lung conditions such as bronchitis, emphysema, and asthma. Increasingly, scientists are discovering that ozone can cause decreased lung function and inflammation in healthy people. Ozone is associated with mortality, particularly among older adults and especially during warm weather. Ozone can also affect other living things, reducing crop yields and forest growth.

PARTICULATE MATTER AND HEALTH

Particulate matter, or particle pollution, consists of liquid and solid particles, including dust and soot. It's classified according to size as PM2.5 (particles smaller than 2.5 microns in diameter) and PM10 (particles smaller than 10 microns in diameter). For other activities about particulate matter, see "Local Sources of Air Pollution" (Module 1, Activity 5) and "Sampling Particulate Matter" (Module 1, Activity 7).

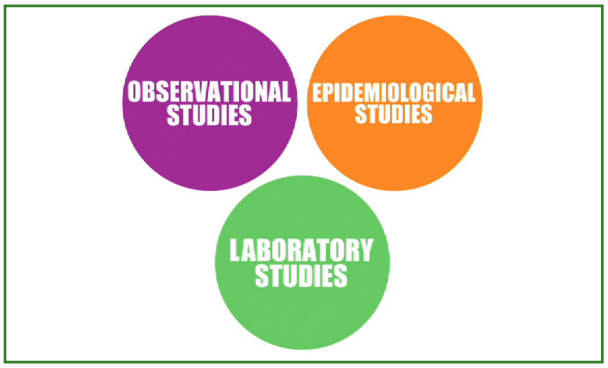
Particle pollution causes some of the same symptoms as ozone, such as airway irritation, coughing, difficulty breathing, decreased lung function, aggravation of asthma and bronchitis. In addition, particle pollution may be absorbed into the bloodstream, where it may cause cardiovascular problems such as irregular heartbeat, inflammation, constriction of blood vessels, high blood pressure, heart attacks and strokes. Studies show an increased risk of premature death due to particle pollution.

TYPES OF AIR POLLUTION STUDIES ON HUMAN HEALTH

Before we talk about studies involving humans, it's important to know that scientists also use laboratory animals as surrogates for humans to learn more about how exposure to air pollution affects biological functioning (called laboratory animal studies). These studies are less expensive and have the advantage of being able to follow the entire lifetime, and even multiple generations, in the case of short-lived animals such as mice or rats.

To investigate the effects of air pollution on humans, scientists sometimes bring a small number of volunteers into the lab and closely monitor their physiological response as they breathe polluted air in a controlled setting (called controlled human exposure studies). Other times, scientists use statistical methods to analyze health records of large numbers of people and environmental databases to try to

uncover the effects of air pollution on human health (called epidemiological studies). In this case, the people being studied are simply living their daily lives. Each type of study has pros and cons. Ultimately, society needs both types



of studies to continue to learn about the health effects of air pollution.

STUDIES BASED ON HUMAN EXPOSURE IN THE LAB

Some of the scientific papers in this activity are based on studies in which human volunteers came into a laboratory and underwent physiological measurements while breathing air (in a special chamber or through a face mask) that contained specific quantities of various pollutants. An advantage of laboratory studies is that all the variables can be carefully and precisely controlled. For example, a volunteer may be breathing in special air containing a small amount of only one type of pollution. In real life, we often breathe in multiple pollutants at once, making it difficult to sort out what pollutant is causing which health problem.

One disadvantage of human laboratory studies is that the sample size is usually relative small because of the time and money it takes to run a series of exposures on individuals. Also, conditions in a lab are not representative of human exposure in daily life. For example, in the lab people breathe in pollutant concentrations that remain constant over the course of a long period of time – often more than 6 hours. In daily life, the amount of pollution in the air varies over the course of the day and many people move back and forth from indoors to outdoors.

EPIDEMIOLOGICAL STUDIES

In an epidemiological study, scientists use data to study and compare various populations. For example, scientists can compare the rate of asthma among children who live in cities with higher levels of ozone to rates of asthma among children who live in cities with lower levels of ozone. These studies usually involve large numbers of people – hundreds, thousands or even millions.

The value of epidemiological studies is that the data comes from real people living their daily lives rather than volunteers following a laboratory protocol. The drawback is that it can be very difficult to draw conclusions because there are so many different variables involved. For example, if you find that children living in cities with more ozone do have higher rates of asthma, it can be difficult to figure out the true cause – is it the ozone, some other type of pollution, the climate, or the socioeconomic status of the population? Or maybe the cities with higher levels of ozone just happen to have bigger and better medical facilities, leading families with asthmatic children to move there for better healthcare.

There are several types of epidemiological studies. Some studies ask people to look back on their lives and report their behavior (diet or exercise, for example) and/or exposures (living near a highway or factory, for example). Other studies enroll participants and ask them to keep track of their behavior and/or exposures until some point in the future. Some studies don't ask individuals for self-reported data at all, but use large datasets about, for example, emergency room visits for asthma and archived air quality data. Some studies (longitudinal studies) last for years or even decades, whereas others are a "snapshot" in time. Each type of study has its own benefits and drawbacks.

HOW TO READ A GENERAL-AUDIENCE ARTICLE ABOUT SCIENCE

It's important to consider the author and the publication. Does the author have experience writing about science? Does the author appear to have a bias? Is the publication well-edited? Does it have a particular point of view or a particular goal? Publications or blogs online can be tricky to evaluate. A one-person blog may be quite accurate and well-supported, or it may be full of bias and half-truths. A blog or online publication associated with a well-known publication can generally be considered just as trustworthy as the print version. If you aren't sure, look for the "About Us" tab. On the *Scientific American* blog network, if you click "About the SA blog network," you'll learn that the in-house blogs are edited, while the independent blogs are typically not. No matter where you read an article, if it mentions the title and the authors of the scientific paper, you can look it up yourself to see whether you think it was accurately summarized.

HOW TO READ A SCIENTIFIC PAPER

Scientific research is usually published in peer-reviewed scientific journals. If you're not a scientist, reading these papers is challenging because of the jargon, abbreviations, acronyms, and frequent references to advanced statistical techniques. However, you can often get a general over-

view of the study by reading two or three sections of the article: the Abstract, the Results, and the Conclusion and/or Discussion.

SOME KEY TERMS AND CONCEPTS IN SCIENTIFIC PAPERS

Correlation vs. Cause and Effect

If an epidemiological study shows a correlation between two characteristics, remember not to jump to the conclusion that one causes the other. Just because two characteristics tend to occur together – say blond hair and blue eyes – doesn't mean that blond hair causes blue eyes. If A and B tend to occur together, it may be that A causes B, or that B causes A, or that some other factor C causes both A and B.

For example, imagine you read about a scientific study demonstrating that people who drink calorie-free soft drinks gain more weight over the course of a year than people who drink soda with sugar. You might think that calorie-free soft drinks cause weight gain. On the other hand, perhaps people who have a history of weight gain are more likely to choose diet soft drinks. Or maybe people who choose a diet drink believe it's okay to have a second helping of pie.

If one factor really does cause another (for example, regular exercise increases fitness), then the two characteristics can be said to be linked by cause and effect – in this case, exercise is the cause, and fitness is the effect.

Keep in mind that there's more than one way to refer to the relationships we've been discussing. Another word for correlation is association. Another word for cause and effect is causation.

Biomarkers

Some of the research papers in this activity use biomarkers, sometimes referred to as markers. Biomarkers are easily measured characteristics that are indicative of disease or a particular health impact. You and your students may already be familiar with these simple examples: temperature as a biomarker for fever, and resting pulse rate as a biomarker for fitness.

Using examples from some of the scientific papers, an elevated level of triglycerides can be used as a biomarker for risk of developing heart disease, and an elevated level of a protein called CRP (C-reactive protein) can be used a biomarker for inflammation. Note that in these examples, the presence of heart disease or inflammation has not been measured or observed directly.

Biomarkers are useful in clinical care because they can alert the physician and patient of a potential problem and/or they can provide a way to monitor an ongoing condition. Biomarkers are useful in scientific studies because they can be more easily measured than the disease or health condition itself. However, it's important that the relationship between the biomarker and the health condition be fully understood to ensure that the biomarker really does indicate the presence of the condition and is not just associated with it.

Blind Study

Imagine a study comparing a new drug to an existing drug. Half the volunteers receive the new drug and half receive the existing one. If the volunteers don't know which drug they are receiving, the study is single-blind. If the researchers who are monitoring the volunteers also don't know which drug each patient is receiving, it's a double-blind study. The advantage of blind studies is that they reduce the possibility of volunteers experiencing results or side effects due to the placebo effect. Sometimes it's not possible to make all parts of a study blind. For example, in a laboratory study comparing how ozone pollution affects people at room temperature versus hot temperatures, obviously volunteers would be able to tell which condition they were experiencing.

Crossover Study

In a crossover study, each participant is exposed to each condition at different times. For example, in this activity, one of the scientific papers describes an experiment in which each participant is tested on two occasions: once while breathing clean air and once while breathing air containing ozone. That is a crossover study. It would not be a crossover study if half the participants were tested with clean air only, and half with polluted air only. The benefit of a crossover study is that it reduces the potential impact of intrinsic differences in the health or physiology of the participants, because each group (e.g., clean air/dirty air) contains exactly the same population. Furthermore, each of the volunteers serves as his or her own control.

MATERIALS

ARTICLES

ARTICLE 1: "Duke Scientists Report Air Pollution Controls Linked to Lower NC Death Rates" by S. Wheeler

ARTICLE 2: "Take-Home Message is Clear" by T. Lucas

ARTICLE 3: "Air Pollution, Climate and Heart Disease" by D.R. Gold and J.M. Samet

ARTICLE 4: "FAQ Regarding Public Health and Wildfires by the North Carolina Department of Public Health"

SCIENTIFIC PAPERS

PAPER 1: "Long-term Dynamics of Death Rates of Emphysema, Asthma, and Pneumonia and Improving Air Quality" by J. Kravchenko et al.

PAPER 2: "Coarse Particulate Matter (PM 2.5-10) Affects Heart Rate Variability, Blood Lipids, and Circulating Eosinophils in Adults with Asthma" by K. Yeatts et al.

PAPER 3: "Controlled Exposure of Healthy Young Volunteers to Ozone Causes Cardiovascular Effects" by R.B. Devlin et al.

PAPER 4: "Forecast-Based Interventions Can Reduce the Health and Economic Burden of Wildfires" by A.G. Rappold et al.

SCIENTIFIC RESEARCH & AIR QUALITY VIDEO

- Introduces importance of scientific research in understanding the effect of air pollution on human health and in setting national air quality standards.
- Introduces the concepts of correlation, cause-and-effect, and coincidence in scientific research.
- Highlights various types of air quality studies (laboratory, observational, epidemiological) through interviews and video footage.
- Explains importance of reading scientific information critically.

Video Length: 14:00 minutes
Key Elements: animation, interviews, video footage

Teacher Tips

If the scientific papers seem too challenging for your class, rather than assigning each group a separate article or scientific paper, have all the groups read the newspaper article, "Duke Scientists Report Air Pollution Controls Linked to Lower NC Death Rates," and the scientific paper upon which it is based, "Long-term Dynamics of Death Rates of Emphysema, Asthma, and Pneumonia and Improving Air Quality." Have them answer the questions for each article, providing them with the "hints" given for the scientific paper. Review the two articles together as a class after the groups have finished their work.

If you use this latter option, use the last two pages of the Student Pages. Otherwise, use the first nine pages of the Student Pages.

– Mark Townley

WARM UP

Your students may not have any experience reading papers in peer-reviewed journals and may need a guided tour of the format and intended audience of such articles.

Show the video, "Scientific Research and Air Quality." If practical, you could have the students watch the video at home the day before you do the activity in class.

Discuss the following topics as a class:

- **What are some differences between an article about science for a general audience and a peer-reviewed paper published in a scientific journal?** Journalists writing for a general audience usually avoid scientific jargon and try to be compelling, relevant, and/or entertaining. Journalists can sometimes make mistakes about the science because they may not have a science background and/or may be rushing to meet a tight deadline. Furthermore, most newspaper articles aren't reviewed by scientists. A peer-reviewed article in a scientific journal is written by a scientist or team of scientists and it reports the results of a particular study. The article has been reviewed by two or more scientists not involved in the study to ensure that the science is rigorous and does not contain errors. These articles are usually full of technical language that may be difficult to decipher for laypeople – or even for scientists in a different field. They also follow a traditional format, and are not intended to be written in an entertaining or clever or literary way.
- **What are some useful skills when reading a peer-reviewed scientific paper?** To get the main idea, first read the abstract – which is a short summary – and then the conclusion. As you read the article, ask yourself questions. Are there other explanations that would explain the results besides the conclusions drawn by the scientists? How many people were studied (in other words, what was the "sample size")? Are two or more groups of people being compared, or does the study look at just one group of people? Does the data seem accurate and precise? What are potential factors that could influence the results in unintended ways? Do the results make sense? Are there other studies that support the conclusions from this one? How strong is the references section and are the articles in it easy to find?

THE ACTIVITY

This activity includes four general-audience articles and four scientific papers. Divide the class into eight groups. Assign each group a different article or paper. Have each group answer the questions about their assigned article/paper, then make a short presentation to the class summarizing what they read. Next, pair up each group that read a general audience article with a group that read the related scientific paper. Have them exchange papers and add to the answers given by the first group. (Pair Article 1 with the Paper 1, and so forth.)

ARTICLES FOR A GENERAL AUDIENCE

ARTICLE 1: "Duke Scientists Report Air Pollution Controls Linked to Lower NC Death Rates" by S. Wheeler

This is a newspaper article from the *Charlotte Observer* about an epidemiological study. It found a correlation between improved air quality in North Carolina and reduced death rates from respiratory diseases such as asthma and emphysema.

Read the article and answer these questions:

1. Who is the audience for this article? [**Answer**: newspaper readers, the general public]
2. What two pieces of air quality legislation are mentioned in the article as having contributed to the improvement of air quality in North Carolina? [**Answer**: Clean Air Act and North Carolina's Clean Smokestacks Act of 2002]
3. The study analyzed air quality data over the course of many years in North Carolina. What was the range of years? [**Answer:** 1993-2010]
4. What happened to the rates of death due to asthma and emphysema in North Carolina during that time period? [**Answer**: declined]
5. What happened to the air quality in North Carolina during that time period? [**Answer**: improved]
6. According to the article, did the study prove that the air quality legislation saved lives? Why or why not? [**Answer**: no, because the reduction in death rates could have been caused by factors not included in the study]
7. Why is it unlikely that medical advances in general accounted for the declining death rates from asthma and emphysema? [**Answer**: The rates of death from these conditions vary according to the season – too short a time-frame to be attributed to medical advances.]
8. What do you think? Have air quality regulations saved lives in North Carolina? Support your answer.
9. Write a one-paragraph summary of the paper or give a summary of the paper to the class.

ARTICLE 2: "Take-Home Message is Clear" by T. Lucas

This article is a profile of Duke scientist Jim Zhang and some of his work on the health effects of air pollution. The article appeared in a magazine called *Dukenvironment Magazine,* which is published by the Office of Marketing and Communication at the Nicholas School of the Environment at Duke University.

Read the article and answer these questions:

1. Who is the audience for this article? [**Answer**: general audience, especially people interested in the environment or people connected to Duke or Duke's Nicholas School of the Environment]
2. Would you expect articles in a magazine published by the Office of Marketing and Communication at Duke's Nicholas School to be accurate? Explain. Would you expect the articles to be critical of Duke scientists? Explain. [**Answer**: The articles would likely be accurate because the magazine wants to have a good reputation for accuracy – otherwise, it's not worth much. On the other hand, the articles would probably not be critical of Duke scientists because one of the goals of a publication coming out of the Office of Marketing and Communications is to promote the Nicholas School and the work of scientists there.]
3. Why did Zhang decide to do air pollution studies during the Beijing Olympics? [**Answer**: because China instituted air pollution controls during and before the Olympics to clean up the air]
4. In his study that was published in the *Journal of the American Medical Association*, describe the people Zhang studied, including the total number, healthy/unhealthy, smokers/non-smokers, and relative age. [**Answer**: 125 healthy non-smoking young adults]
5. What did Zhang find in that study? [**Answer**: During the Olympics when air pollution controls were in place, biomarkers of cardiovascular problems decreased compared to before the controls were put in place. The biomarkers increased again after the air pollution controls were relaxed.]
6. Describe Zhang's study of pregnancy and birth weight, as related to the Beijing Olympics. [**Answer**: He found higher birth weights (a biomarker of newborn health) in babies born to women whose eighth month of pregnancy was during the six weeks of cleaner air during and leading up to the Beijing Olympics.]
7. The article describes many research projects that Zhang has worked on. Choose one to briefly describe.
8. Zhang conducts both lab studies and studies of real-world exposure. Do you think he would be more or less effective if he focused on only lab work or only real-world exposure? Support your answer.
9. Write a one-paragraph summary of the paper or give a summary of the paper to the class.

ARTICLE 3: "Air Pollution, Climate and Heart Disease" by D.R. Gold and J.M. Samet

This article was published in the medical journal *Circulation*. It's intended for doctors to share with their patients. It summarizes what's known about the effects of air pollution on heart health, and how people can protect themselves.

Read the article and answer these questions:

1. Was this article written by journalists or by scientists (including medical doctors)? [**Answer**: scientists/doctors]
2. Who is the audience for this article? [**Answer**: people with cardiovascular disease and/or people at risk for it]
3. Air pollution can increase the risk of what three cardiovascular problems? [Answer: heart attack, stroke, irregular heart rhythm]
4. What groups of people have a higher risk for a heart attack, stroke, or irregular heartbeat caused by air pollution? [**Answer**: people who've had a heart attack, angioplasty, or heart rhythm problem before; people with diabetes; people with other risk factors for heart disease such as smoking, a family history of heart disease, being older than 65, and/or having high blood pressure or high cholesterol]
5. Name three things a person at risk for cardiovascular disease can do, with respect to air pollution, to protect their health. [**Answer**: keep track of air quality forecasts and reports; when exercising outdoors, choose times and places where air pollution is low; reduce your level of exertion if you are outdoors during times when air pollution is higher]
6. Name three things a person can do to help others protect their health when air pollution is elevated. [**Answer**: let neighbors know when levels of air pollution are elevated; offer shelter to your neighbors who don't have air conditioning; stay informed about efforts to improve air quality in your neighborhood, town, or state]
7. What parts of the world are experiencing rapidly increasing air pollution levels? Why? [**Answer**: mega-cities in Africa, Asia, and Latin America; due to rapid industrialization and growth in numbers of vehicles]
8. Do you think this article would have more or less credibility among patients if it were published without the authors' names and medical degrees? Explain your answer.
9. Write a one-paragraph summary of the paper or give a summary of the paper to the class.

ARTICLE 4: FAQ Regarding Public Health and Wildfires by the North Carolina Department of Public Health

This brochure is from the North Carolina Division of Public Health. It provides information to citizens about the health effects of wildfire smoke, as well as ways to stay safe when wildfire smoke is present.

Read the article and answer these questions:

1. Who is the audience for this brochure? [**Answer**: North Carolina citizens in an area with smoke from wildfires]
2. Would you expect a brochure from the North Carolina Division of Public Health to be accurate and reliable? Explain your answer. [**Answer**: yes, because a government agency is responsible for disseminating accurate information to help citizens]
3. What are some of the ingredients in smoke from wildfires? [**Answer**: a mixture of gases and particles]
4. What are some of the health effects that wildfire smoke can cause? [**Answer**: coughing, scratchy throat, irritated sinuses, shortness of breath, chest pain, headaches, stinging eyes, runny nose; worsening of symptoms in those with chronic lung conditions; symptoms such as rapid heart beat and chest pain in those with heart disease]
5. The best way to protect yourself from wildfire smoke is to limit your exposure. What are some ways of limiting your exposure? [**Answer**: stay inside and use air conditioner rather than leaving windows open; use mechanical air cleaners; keep windows closed while riding in the car; minimize other sources of indoor air pollution like smoking, burning candles, using the fireplace, or vacuuming]
6. What are some of the downsides to wearing a dust mask or N95 face mask? [**Answer**: They don't filter out toxic gases; they usually don't fit well especially on people with facial hair; they give a false sense of security; they may make it harder to breathe increasing the risk of rapid heart rate and/or heat stress.]
7. What should you do if you don't have an air conditioner and it's too hot to stay in the house with the windows shut? [**Answer**: seek alternative shelter with family or friends, or seek relief in air conditioned spaces such as malls]
8. Where can you find air quality updates? [**Answer**: ncair.org]
9. During a wildfire event, what do you think would be the most effective way to communicate this type of safety information to people living in areas affected by the smoke?
10. Write a one-paragraph summary of the paper or give a summary of the paper to the class.

PEER-REVIEWED PAPERS FOR A SCHOLARLY AUDIENCE

PAPER 1: "Long-Term Dynamics of Death Rates of Emphysema, Asthma, and Pneumonia and Improving Air Quality" by J. Kravchenko et al.

In this epidemiological study, scientists compared monthly averages of five of the six criteria pollutants with death rates from asthma, emphysema, and pneumonia in North Carolina. They found that decreasing rates of air pollution were associated with decreasing rates of death from these diseases. This paper was published in the International Journal of COPD.

Read the article and answer these questions:

1. Who is the audience for this paper? [**Answer**: other scientists]
2. These scientists measured rates of death of which three respiratory diseases? [**Hint**: See the Abstract. **Answer**: asthma, emphysema, and pneumonia]
3. Which air pollutants did the scientists track? [**Hint:** See the Abstract. **Answer**: carbon monoxide, sulfur dioxide, ozone, PM2.5, PM 10, and nitrogen dioxide]
4. The study population was the entire state of North Carolina. What years did the mortality data cover? [**Hint**: See Materials and Methods: Data. **Answer**: 1983-2010]
5. Where did the scientists get the air quality data they used, and what years did that data cover? [**Hint**: See Materials and Methods: Data. **Answer**: Air monitoring stations in North Carolina collected the data. Scientists downloaded data from 1993-2010 from the EPA website (1993 was the first year that monitoring data was available).]
6. Why was the time range for the air quality data different than for the mortality data? [**Hint**: See Materials and Methods: Data. **Answer:** Mortality data was available throughout the entire range of time (1983-2010) but monitoring data did not become available until 1993]
7. In the Conclusion, the authors state, "Since other factors (in addition to the studied pollutants) might also account for improved health outcomes, ultimately caution should be exercised in inferring cause-effect relations." In other words, they are not suggesting the air quality regulations *definitely* caused the decline in mortality associated with the respiratory diseases they studied. What are some of these "other factors"? [**Hint**: See Methodological Aspects and Study Limitations. **Answer**: improvements in medical treatment, changes in socioeconomic status, changes in diagnostic criteria over the last two decades]
8. What do you think? Have air quality regulations saved lives in North Carolina? Support your answer.
9. Write a one-paragraph summary of the paper or give a summary of the paper to the class.

PAPER 2: "Coarse Particulate Matter (PM 2.5-10) Affects Heart Rate Variability, Blood Lipids, and Circulating Eosinophils in Adults with Asthma" by K. Yeatts et al.

This paper was published in the scientific journal *Environmental Health Perspectives*. It combines techniques from laboratory and epidemiological studies. The research volunteers underwent testing for lung functioning in the lab 9 times over the course of 12 weeks. In addition, other tests (including blood tests) were performed to measure biomarkers that correlate with conditions such as inflammation. Yeatts correlated the results of the tests with daily outdoor levels of particulate matter. (Notes on some of the biomarkers used in the study: Eosinophils indicate inflammation and are often associated with airway or systemic inflammation in asthma; decreased heart rate variability indicates potential problems with cardiac function; high levels of a lipid called triglycerides are a risk factor for cardiac disease.)

Read the article and answer these questions:

1. Who is the audience for this paper? [**Answer:** other scientists]
2. How many people participated in this study, and what disease did they all have? [**Hint**: See Abstract. **Answer**: 12, asthma]
3. What are the drawbacks to having such a small number of volunteers? [**Answer**: Harder to draw legitimate statistical conclusions from such a small group]
4. What would be the pros and cons of having a larger group of volunteers? [**Answer**: It's expensive to recruit and to test each volunteer – it makes more sense to test an idea on a small group first and then if it holds up, do a second study with a larger group to confirm. On the other hand, if money and time were no object, you might get more reliable results from a larger group to start with.]
5. What was the range of ambient PM2.5 levels reported during the study? [**Hint**: See Results, Environmental Measures. **Answer**: 0.6-37 $\mu g/m^3$]
6. What was the range of ambient PM10 levels reported during the study? [**Hint**: See Results, Environmental Measures. **Answer**: 0-14.6 $\mu g/m^3$]
7. What about the results surprised the researchers? [**Hint**: See second paragraph of the Discussion. **Answer**: that they found no relationship between PM2.5 or PM10 levels and airway inflammation biomarkers in sputum, use of rescue inhaler, asthma symptoms, or lung function.]
8. What possible explanations of the surprise did the authors offer? [**Hint**: See second paragraph of the Discussion. **Answer**: 10 of 12 subjects used anti-inflammatory medicines, which may have reduced the response.]
9. What did the researchers find with respect to cardiovascular effects? [**Hint**: See last paragraph of the Discussion. **Answer**: An increase in ambient coarse particle pollution was associated with decreased HRV (heart rate variability), increased eosinophils in the blood, increase in serum triglycerides (type of cholesterol). This indicates that coarse particle pollution may play a role in cardiovascular problems, even among asthmatics using anti-inflammation therapy.]
10. If the authors of the paper were to repeat this experiment with 12 different subjects with asthma, do you think they would get the same results? Support your answer.
11. Write a one-paragraph summary of the paper or give a summary of the paper to the class.

PAPER 3: "Controlled Exposure of Healthy Young Volunteers to Ozone Causes Cardiovascular Effects" by R.B. Devlin et al.

This paper was published in the medical journal *Circulation*. It describes a crossover study designed to investigate the pulmonary, cardiovascular, and inflammatory effects of ozone. Each participant visited the laboratory twice and spent 2 hours each time alternately exercising and resting. During one of the visits, they breathed clean air. During the other visit, they breathed air with ozone in it (0.3 ppm, or 300 ppb).

Researchers measured lung function (with spirometry and bronchoscopy), the electrical properties of the heart (with a portable ECG or EKG machine called a Holter monitor), and drew blood to measure biomarkers relating to inflammation and the body's clot-busting process, called fibrinolysis. By helping to prevent and break up blood clots, fibrinolysis helps prevent strokes and heart attacks; it's a good thing.

Read the article and answer these questions:

1. Who is the audience for this paper? [**Answer**: other scientists]
2. How many people participated in this study? [**Hint**: See the Abstract. **Answer**: 23]
3. What are the drawbacks to having such a small number of volunteers? [**Answer**: Harder to draw legitimate statistical conclusions from such a small group]
4. What would be the pros and cons of having a larger group of volunteers? [**Answer:** It's expensive to recruit and to test each volunteer so it makes more sense to test an idea on a small group first and then if it holds up, do a second study with a larger group to confirm. On the other hand, if money and time were no object, you might get more reliable results from a larger group to start with.]
5. Did exposure to ozone decrease lung function? [**Hint**: See the Abstract. **Answer**: yes.]

6. Did exposure to ozone increase pulmonary inflammation (swelling in the lungs)? [**Hint:** See the Abstract. **Answer**: yes]
7. Why is it hard to separate the effects of ozone pollution and PM pollution in epidemiological studies? [**Hint**: See Introduction. **Answer**: because the two types of pollution often occur together]
8. What three cardiovascular effects did the researchers find? [**Hint**: See conclusion. **Answer**: vascular inflammation, changes in biomarkers that indicated decreased fibrinolysis, changes in heart rhythm]
9. How might those three changes affect someone? [**Hint**: See Conclusion. **Answer**: put them at risk for an adverse cardiovascular event]
10. What are the benefits of doing a crossover study instead of measuring only the effects of exercising in the polluted air? [**Answer**: comparing each subject's measurements in clean air and in polluted air allows you to conclude that the effects are truly from the pollution and not from exercise or something unique about that individual's physiology]
11. Write a one-paragraph summary of the paper or give a summary of the paper to the class.

PAPER 4: "Forecast-Based Interventions Can Reduce the Health and Economic Burden of Wildfires" by A. Rappold et al.

Wildfires are often located in rural areas not routinely covered by air quality forecasts. The study used smoke data and emergency room data from the 2008 Evans Road wildfire in eastern North Carolina to simulate whether daily air quality forecasts for each county would have resulted in fewer health problems. The study simulated nine scenarios, which are summarized in the table under the questions; refer to it if you need help understanding the study set-up. The study used the Smoke Forecasting System (SFS) developed by the National Oceanographic and Atmospheric Administration (NOAA) both *prospectively*, to make simulated forecasts for the following day or two, and *retrospectively*, to estimate the actual smoke for a particular day and place. When used retrospectively, more inputs could be used, such as satellite images for that day and acreage burned. This paper was published in *Environmental Science & Technology*.

Maximum Exposure to Smoke-Related PM2.5 for June 1, 2008-July 14, 2008 in 9 Scenarios – 3 different levels of intervention and 3 different levels of adherence

	Low Smoke Intervention (Most Responsive/ Aggressive): Alerts given on days when PM2.5 due to smoke is forecast to EXCEED 5 $\mu g/m^3$	**Intermediate Smoke Intervention**: Alerts given on days when PM2.5 due to smoke is forecast to EXCEED 20 $\mu g/m^3$	**High Smoke Intervention** (Least Aggressive/ Responsive): Alerts given on days when PM2.5 due to smoke is forecast to EXCEED 50 $\mu g/m^3$
Good Adherence: in response to intervention, population is able to reduce exposure to smoke-related PM2.5 to 5 $\mu g/m^3$	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 5 $\mu g/m^3$ (many alert days)	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 5 $\mu g/m^3$ (moderate number of alert days)	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 5 $\mu g/m^3$ (few alert days)
Moderate Adherence: in response to intervention, population is able to reduce exposure to smoke-related PM2.5 to 20 $\mu g/m^3$	*All days*: Actual smoke-related PM2.5	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 20 $\mu g/m^3$ (moderate number of alert days)	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 20 $\mu g/m^3$ (few alert days)
Poor Adherence: in response to intervention, population reduces exposure to smoke-related PM2.5 to 50 $\mu g/m^3$	*All days*: Actual smoke-related PM2.5	*All days*: Actual smoke-related PM2.5	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 50 $\mu g/m^3$ (few alert days)

Note: Each day also has background levels of PM2.5 not related to smoke. The NC average in warm season from 2006-08 was 13.2 $\mu g/m^3$
Note also: On alert days, the maximum exposure is given. Exposure could be less if the forecast was off and the actual smoke-related PM2.5 was less than expected.

Read the article and answer these questions:

1. Who is the audience for this paper? [**Answer**: other scientists]
2. Are wildfires in the United States increasing or decreasing in number and intensity? [**Hint**: See Introduction. **Answer**: increasing in number and intensity]
3. What was the study period? [**Hint**: See Methods, Affected Population. **Answer**: June 1, 2008-July 14, 2008]
4. How many counties did the study encompass and how many adults did those counties include? [**Hint**: See Methods, Affected Population. **Answer**: 31 counties, 1.2 million adults]
5. What two health conditions were included in the study, and how were these conditions counted? [**Hint**: See Methods, Health Data. **Answer**: asthma and congestive heart failure; counted using medical codes related to asthma and congestive heart failure in emergency room visits during the study period]
6. In the Methods, Statistical Analysis, the authors state, "The primary goal of the analysis was to estimate the relative risk (RR) of adverse health outcomes associated with SFS-estimated smoke-PM2.5 and to contrast it against the RR estimated under simulated forecast-based intervention programs." (SFS is Smoke Forecasting System.) Restate this in your own words. [**Answer**: The main goal of the study was to find out whether smoke from the fire created health problems and to see whether different types of air quality forecasts could have reduced the amount of health problems.]
7. The circles at the top of Figure 3A (asthma) show that without any intervention, there was a 4-5% increased risk for asthma-related visits to the emergency department during the time of the wildfire. Which two scenarios lowered that risk the most? [**Answer**: good adherence to low-smoke intervention, and good adherence to intermediate-smoke intervention]
8. The circles at the top of Figure 3B (congestive heart failure) show that without any intervention, there was a 1.9-3.5% increased risk for emergency department visits for congestive heart failure during the time of the wildfire. Which two scenarios lowered that risk the most? [**Answer**: good adherence to low-smoke intervention, and good adherence to intermediate-smoke intervention]
9. In Figure 3A and 3B, good adherence to the high-smoke intervention does not reduce risk much. Why might this be? [**Answer**: There are fewer alert days in the high-smoke intervention, so on all the other days (with low and moderate smoke) people aren't modifying their behavior at all.]
10. Write a one-paragraph summary of the paper or give a summary of the paper to the class.

WRAP UP AND ACTION

In a class discussion, consider the following questions:

- Compare the articles written for a general audience to the articles written for scientific journals in terms of vocabulary, breadth, ease of comprehension, level of detail, types of information display (charts and graphs), intended audience, etc.
- Discuss the issue of trust and credibility with respect to the different articles. Do you believe everything you read in newspapers or in magazines or on the internet? Why or why not? What about articles in scientific journals? How can you check out the reliability of a newspaper article or a scientific paper? How about blogs? Is a blog on the *Scientific American* website more reliable than the blog of an individual? Why or why not?
- How can you tell you're reading a peer-reviewed scientific paper? [**Answer**: it's published in a peer-reviewed journal; it follows a certain organization – Abstract, Introduction, Materials and Methods, etc.; the authors have PhDs, MDs or other advanced degrees]

For each peer-reviewed scientific paper, discuss these questions:

- Can you think of any problems with the way the study was designed? Consider factors such as the size of t he sample (how many people were studied), the consideration of possible confounding factors, and whether the design reflects real-world conditions. If money were no object, how might you improve the design of the study?
- Does the paper say whether these or similar findings have been replicated by other scientists? Why is that important?
- Are there other possible interpretations of the data? Consider whether A caused B, or whether A happens to be correlated to B for other reasons. Did the scientists address other possible interpretations?
- Discuss the advantages and disadvantages of epidemiological studies vs. laboratory studies. Is one type better than the other?
- Why is it important for volunteers in a laboratory study to sign an informed consent form before participating?
- Scientific papers usually report where the funding for the study came from, and whether the authors have any competing interests. How would it affect the credibility of a paper about the effectiveness of a new pharmaceutical if the study was funded by the company that designed the drug? Or if a paper about the health effects of diesel exhaust were funded by a company that produces diesel engines?

ASSESSMENT

HAVE STUDENTS:

- Make a list of some of the health effects of ozone and particulate matter.
- Describe the differences between a general-interest article and a peer-reviewed article.
- Describe the differences between an epidemiological study and a laboratory study.

EXTENSIONS

- Have each small group produce a poster outlining the study set-up and chief findings of the paper they read.
- Students can try their hand at writing a newspaper article or blog post based on one of the scientific papers they read.
- If the class has questions about one of the scientific papers, the class could compose an email and send it to the corresponding author.
- Have students produce a brochure outlining some of the health effects of air pollution, including a properly cited bibliography of some of the articles/papers in this activity.
- Ask students to bring in articles about air pollution written for a general audience from newspapers, magazines, or news websites. As a class, critique the article and the research it is based on.
- Have students investigate the ranking of the nearest metro area according to the website Asthma Capitals, which annually ranks metro areas in the U.S., to identify the most challenging places to live if you have asthma. The ranking takes into account air quality, pollen, public smoking laws, socioeconomic status, number of specialists, and other factors. Ask students to analyze the factors for the nearest metro area to identify which have a large impact on the ranking and which could be improved most easily. www.asthmacapitals.com/

RESOURCES

Center for Environmental Medicine, Asthma, and Lung Biology at UNC: www.med.unc.edu/cemalb/

Information from the EPA on the health effects of ozone: www.epa.gov/ozone-pollution/health-effects-ozone-pollution

Information from the EPA on the health effects of particle pollution: www.epa.gov/pm/health.html

More information on living near roadways: www.epa.gov/otaq/nearroadway.htm

WHO report on air pollution (indoor and outdoor) worldwide, 2014: www.who.int/phe/health_topics/outdoorair/databases/en/

WHO report on health effects of outdoor air pollution worldwide, 2014: www.who.int/mediacentre/factsheets/fs313/en/

ARTICLE 1: "Duke Scientists Report Air Pollution Controls Linked to Lower NC Death Rates" by S. Wheeler

This is a newspaper article from the *Charlotte Observer* about an epidemiological study. It found a correlation between improved air quality in North Carolina and reduced death rates from respiratory diseases such as asthma and emphysema.

Read the article and answer these questions:

1. Who is the audience for this article?

2. What two pieces of air quality legislation are mentioned in the article as having contributed to the improvement of air quality in North Carolina?

3. The study analyzed air quality data over the course of many years in North Carolina. What was the range of years?

4. What happened to the rates of death due to asthma and emphysema in North Carolina during that time period?

5. What happened to the air quality in North Carolina during that time period?

6. According to the article, did the study prove that the air quality legislation saved lives? Why or why not?

7. Why is it unlikely that medical advances in general accounted for the declining death rates from asthma and emphysema?

8. What do you think? Have air quality regulations saved lives in North Carolina? Support your answer.

9. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

ARTICLE 2: "Take-Home Message is Clear" by T. Lucas

This article is a profile of Duke scientist Jim Zhang and some of his work on the health effects of air pollution. The article appeared in a magazine called *Dukenvironment Magazine*, which is published by the Office of Marketing and Communication at the Nicholas School of the Environment at Duke University.

Read the article and answer these questions:

1. Who is the audience for this article?

2. Would you expect articles in a magazine published by the Office of Marketing and Communication at Duke's Nicholas School to be accurate? Explain. Would you expect the articles to be critical of Duke scientists? Explain.

3. Why did Zhang decide to do air pollution studies during the Beijing Olympics?

4. In his study that was published in the *Journal of the American Medical Association*, describe the people Zhang studied, including the total number, healthy/unhealthy, smokers/non-smokers, and relative age.

5. What did Zhang find in that study?

6. Describe Zhang's study of pregnancy and birth weight, as related to the Beijing Olympics.

7. The article describes many research projects that Zhang has worked on. Choose one to briefly describe.

8. Zhang conducts both lab studies and studies of real-world exposure. Do you think he would be more or less effective if he focused on only lab work or only real-world exposure? Support your answer.

9. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

ARTICLE 3: "Air Pollution, Climate and Heart Disease" by D.R. Gold and J.M. Samet

This article was published in the medical journal *Circulation*. It's intended for doctors to share with their patients. It summarizes what's known about the effects of air pollution on heart health, and how people can protect themselves.

Read the article and answer these questions:

1. Was this article written by journalists or by scientists (including medical doctors)?

2. Who is the audience for this article?

3. Air pollution can increase the risk of what three cardiovascular problems?

4. What groups of people have a higher risk for a heart attack, stroke, or irregular heartbeat caused by air pollution?

5. Name three things a person at risk for cardiovascular disease can do, with respect to air pollution, to protect their health.

6. Name three things a person can do to help others protect their health when air pollution is elevated.

7. What parts of the world are experiencing rapidly increasing air pollution levels? Why?

8. Do you think this article would have more or less credibility among patients if it were published without the authors' names and medical degrees? Explain your answer.

9. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

ARTICLE 4: FAQ Regarding Public Health and Wildfires by the North Carolina Department of Public Health

This brochure is from the North Carolina Division of Public Health. It provides information to citizens about the health effects of wildfire smoke, as well as ways to stay safe when wildfire smoke is present.

Read the article and answer these questions:

1. Who is the audience for this brochure?

2. Would you expect a brochure from the North Carolina Division of Public Health to be accurate and reliable? Explain your answer.

3. What are some of the ingredients in smoke from wildfires?

4. What are some of the health effects that wildfire smoke can cause?

5. The best way to protect yourself from wildfire smoke is to limit your exposure. What are some ways of limiting your exposure?

6. What are some of the downsides to wearing a dust mask or N95 face mask?

7. What should you do if you don't have an air conditioner and it's too hot to stay in the house with the windows shut?

8. Where can you find air quality updates?

9. During a wildfire event, what do you think would be the most effective way to communicate this type of safety information to people living in areas affected by the smoke?

10. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

PAPER 1: "Long-Term Dynamics of Death Rates of Emphysema, Asthma, and Pneumonia and Improving Air Quality" by J. Kravchenko et al.

In this epidemiological study, scientists compared monthly averages of five of the six criteria pollutants with death rates from asthma, emphysema, and pneumonia in North Carolina. They found that decreasing rates of air pollution were associated with decreasing rates of death from these diseases. This paper was published in the International Journal of COPD.

Read the article and answer these questions:

1. Who is the audience for this paper?

2. These scientists measured rates of death of which three respiratory diseases?

3. Which air pollutants did the scientists track?

4. The study population was the entire state of North Carolina. What years did the mortality data cover?

5. Where did the scientists get the air quality data they used, and what years did that data cover?

6. Why was the time range for the air quality data different than for the mortality data?

7. In the Conclusion, the authors state, "Since other factors (in addition to the studied pollutants) might also account for improved health outcomes, ultimately caution should be exercised in inferring cause-effect relations." In other words, they are not suggesting the air quality regulations definitely caused the decline in mortality associated with the respiratory diseases they studied. What are some of these "other factors"?

8. What do you think? Have air quality regulations saved lives in North Carolina? Support your answer.

9. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

PAPER 2: "Coarse Particulate Matter (PM 2.5-10) Affects Heart Rate Variability, Blood Lipids, and Circulating Eosinophils in Adults with Asthma" by K. Yeatts et al.

This paper was published in the scientific journal *Environmental Health Perspectives*. It combines techniques from laboratory and epidemiological studies. The research volunteers underwent testing for lung functioning in the lab 9 times over the course of 12 weeks. In addition, other tests (including blood tests) were performed to measure biomarkers that correlate with conditions such as inflammation. Yeatts correlated the results of the tests with daily outdoor levels of particulate matter. (Notes on some of the biomarkers used in the study: Eosinophils indicate inflammation and are often associated with airway or systemic inflammation in asthma; decreased heart rate variability indicates potential problems with cardiac function; high levels of a lipid called triglycerides are a risk factor for cardiac disease.)

Read the article and answer these questions:

1. Who is the audience for this paper?

2. How many people participated in this study, and what disease did they all have?

3. What are the drawbacks to having such a small number of volunteers?

4. What would be the pros and cons of having a larger group of volunteers?

5. What was the range of ambient PM2.5 levels reported during the study?

6. What was the range of ambient PM10 levels reported during the study?

7. What about the results surprised the researchers?

8. What possible explanations of the surprise did the authors offer?

9. What did the researchers find with respect to cardiovascular effects?

10. If the authors of the paper were to repeat this experiment with 12 different subjects with asthma, do you think they would get the same results? Support your answer.

11. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

PAPER 3: "Controlled Exposure of Healthy Young Volunteers to Ozone Causes Cardiovascular Effects" by R.B. Devlin et al.

This paper was published in the medical journal *Circulation*. It describes a crossover study designed to investigate the pulmonary, cardiovascular, and inflammatory effects of ozone. Each participant visited the laboratory twice and spent 2 hours each time alternately exercising and resting. During one of the visits, they breathed clean air. During the other visit, they breathed air with ozone in it (0.3 ppm, or 300 ppb). Researchers measured lung function (with spirometry and bronchoscopy), the electrical properties of the heart (with a portable ECG or EKG machine called a Holter monitor), and drew blood to measure biomarkers relating to inflammation and the body's clot-busting process, called fibrinolysis. By helping to prevent and break up blood clots, fibrinolysis helps prevent strokes and heart attacks; it's a good thing.

Read the article and answer these questions:

1. Who is the audience for this paper?

2. How many people participated in this study?

3. What are the drawbacks to having such a small number of volunteers?

4. What would be the pros and cons of having a larger group of volunteers?

5. Did exposure to ozone decrease lung function?

6. Did exposure to ozone increase pulmonary inflammation (swelling in the lungs)?

7. Why is it hard to separate the effects of ozone pollution and PM pollution in epidemiological studies?

8. What three cardiovascular effects did the researchers find?

9. How might those three changes affect someone?

10. What are the benefits of doing a crossover study instead of measuring only the effects of exercising in the polluted air?

11. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

PAPER 4: "Forecast-Based Interventions Can Reduce the Health and Economic Burden of Wildfires" by A. Rappold et al.

Wildfires are often located in rural areas not routinely covered by air quality forecasts. The study used smoke data and emergency room data from the 2008 Evans Road wildfire in eastern North Carolina to simulate whether daily air quality forecasts for each county would have resulted in fewer health problems. The study simulated nine scenarios, which are summarized in the table under the questions; refer to it if you need help understanding the study set-up. The study used the Smoke Forecasting System (SFS) developed by the National Oceanographic and Atmospheric Administration (NOAA) both *prospectively*, to make simulated forecasts for the following day or two, and retrospectively, to estimate the actual smoke for a particular day and place. When used *retrospectively*, more inputs could be used, such as satellite images for that day and acreage burned. This paper was published in *Environmental Science & Technology*.

Maximum Exposure to Smoke-Related PM2.5 for June 1, 2008-July 14, 2008 in 9 Scenarios – 3 different levels of intervention and 3 different levels of adherence

	Low Smoke Intervention (Most Responsive/ Aggressive): Alerts given on days when PM2.5 due to smoke is forecast to EXCEED 5 $\mu g/m^3$	**Intermediate Smoke Intervention**: Alerts given on days when PM2.5 due to smoke is forecast to EXCEED 20 $\mu g/m^3$	**High Smoke Intervention** (Least Aggressive/ Responsive): Alerts given on days when PM2.5 due to smoke is forecast to EXCEED 50 $\mu g/m^3$
Good Adherence: in response to intervention, population is able to reduce exposure to smoke-related PM2.5 to 5 $\mu g/m^3$	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 5 $\mu g/m^3$ (many alert days)	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 5 $\mu g/m^3$ (moderate number of alert days)	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 5 $\mu g/m^3$ (few alert days)
Moderate Adherence: in response to intervention, population is able to reduce exposure to smoke-related PM2.5 to 20 $\mu g/m^3$	*All days*: Actual smoke-related PM2.5	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 20 $\mu g/m^3$ (moderate number of alert days)	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 20 $\mu g/m^3$ (few alert days)
Poor Adherence: in response to intervention, population reduces exposure to smoke-related PM2.5 to 50 $\mu g/m^3$	*All days*: Actual smoke-related PM2.5	*All days*: Actual smoke-related PM2.5	*No-alert days*: Actual smoke-related PM2.5 *Alert days*: 50 $\mu g/m^3$ (few alert days)

Note: Each day also has background levels of PM2.5 not related to smoke. The NC average in warm season from 2006-08 was 13.2 $\mu g/m^3$
Note also: On alert days, the maximum exposure is given. Exposure could be less if the forecast was off and the actual smoke-related PM2.5 was less than expected.

PAPER 4: "Forecast-Based Interventions Can Reduce the Health and Economic Burden of Wildfires" by A. Rappold et al.

Read the article and answer these questions:

1. Who is the audience for this paper?

2. Are wildfires in the United States increasing or decreasing in number and intensity?

3. What was the study period?

4. How many counties did the study encompass and how many adults did those counties include?

5. What two health conditions were included in the study, and how were these conditions counted?

6. In the Methods, Statistical Analysis, the authors state, "The primary goal of the analysis was to estimate the relative risk (RR) of adverse health outcomes associated with SFS-estimated smoke-PM2.5 and to contrast it against the RR estimated under simulated forecast-based intervention programs." (SFS is Smoke Forecasting System.) Restate this in your own words.

7. The circles at the top of Figure 3A (asthma) show that without any intervention, there was a 4-5% increased risk for asthma-related visits to the emergency department during the time of the wildfire. Which two scenarios lowered that risk the most?

8. The circles at the top of Figure 3B (congestive heart failure) show that without any intervention, there was a 1.9-3.5% increased risk for emergency department visits for congestive heart failure during the time of the wildfire. Which two scenarios lowered that risk the most?

9. In Figure 3A and 3B, good adherence to the high-smoke intervention does not reduce risk much. Why might this be?

10. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

NEWSPAPER ARTICLE: "Duke Scientists Report Air Pollution Controls Linked to Lower NC Death Rates" by S. Wheeler

This is a newspaper article from the *Charlotte Observer* about an epidemiological study. It found a correlation between improved air quality in North Carolina and reduced death rates from respiratory diseases such as asthma and emphysema.

Read the article and answer these questions:

1. Who is the audience for this article?

2. What two pieces of air quality legislation are mentioned in the article as having contributed to the improvement of air quality in North Carolina?

3. The study analyzed air quality data over the course of many years in North Carolina. What was the range of years?

4. What happened to the rates of death due to asthma and emphysema in North Carolina during that time period?

5. What happened to the air quality in North Carolina during that time period?

6. According to the article, did the study prove that the air quality legislation saved lives? Why or why not?

7. Why is it unlikely that medical advances in general accounted for the declining death rates from asthma and emphysema?

8. What do you think? Have air quality regulations saved lives in North Carolina? Support your answer.

9. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.

SCIENTIFIC PAPER: "Long-Term Dynamics of Death Rates of Emphysema, Asthma, and Pneumonia and Improving Air Quality" by J. Kravchenko et al.

In this epidemiological study, scientists compared monthly averages of five of the six criteria pollutants with death rates from asthma, emphysema, and pneumonia in North Carolina. They found that decreasing rates of air pollution were associated with decreasing rates of death from these diseases. This paper was published in the International Journal of COPD.

Read the article and answer these questions:

1. Who is the audience for this paper?

2. These scientists measured rates of death of which three respiratory diseases? [**Hint**: See the Abstract.]

3. Which air pollutants did the scientists track? [**Hint**: See the Abstract.]

4. The study population was the entire state of North Carolina. What years did the mortality data cover? [**Hint**: See Materials and Methods.]

5. Where did the scientists get the air quality data they used, and what years did that data cover? [**Hint**: See Materials and Methods: Data.]

6. Why was the time range for the air quality data different than for the mortality data? [**Hint**: See Materials and Methods: Data.]

7. In the Conclusion, the authors state, "Since other factors (in addition to the studied pollutants) might also account for improved health outcomes, ultimately caution should be exercised in inferring cause-effect relations." In other words, they are not suggesting the air quality regulations definitely caused the decline in mortality associated with the respiratory diseases they studied. What are some of these "other factors"? [**Hint**: See Methodological Aspects and Study Limitations.]

8. What do you think? Have air quality regulations saved lives in North Carolina? Support your answer.

9. Write a one-paragraph summary of the paper (on back of sheet) and/or give a summary of the paper to the class.