# The impact of air quality regulations environmental sciences essay

Environment, Air

The main objective of this study is to determine the impact of air quality regulations on the frequency of childhood respiratory illnesses in countries around the world. Exposure to air with high particulate counts has been strongly linked to several negative health consequences, including the aggravation of asthma and other lung conditions as well as development of childhood cancer, and over 1. 3 million people are estimated to die annually from continued exposure to outdoor air pollution. 1 Of these, children are said to bear a large burden of the health problems due to their smaller lung surface area, the amount of time they spend outdoors, and their state of development in the midst of harmful agents. 2 This, combined with their predisposition towards respiratory problems3 and the potential of these problems to develop into long-term problems that may extend into adulthood, 4 means that stricter regulations with regards to air pollution control should have major implications from a public health standpoint. 5The main hypotheses of the study are: The presence of air quality regulations, and especially enforcement of these, will be negatively associated with the amount of air pollution present. The presence of air pollution is strongly associated with the frequency of respiratory conditions in children. To test these hypotheses we propose to monitor air quality through a machine that can be carried around and provide real-time data (through devices like those of Preemptive Media Project’s Area’s Immediate Reading, or AIR) and to determine the medical histories of students by using questionnaires and cross-examining these with medical histories in a multi-country cross-sectional survey conducted in 20 countries around the world. The specific aims of the study will be the following: To select 15 to 20 schools from

among 5 cities in each of 20 selected countries. The countries in the study will be representative of varying air quality regulations from all regions of the world. To assess the air quality at each school to assess the exposure and outcomes of children over varying levels of air pollution. To evaluate the impact of air quality on the frequency of childhood respiratory illness. To evaluate the impact of regulations regarding air quality control on the amount of air pollution in each of these locations. The data generated by this study should be immediately relevant for public health and government officials alike. This study will generate globally comparable figures that are sure to promote the development of more stringent air quality regulations in order to reduce air pollution and subsequently the frequency of respiratory illnesses in children. This study should also show the importance of regularly monitoring air quality in order to provide optimal environments for the habituation of children and adults alike.

# BACKGROUND AND SIGNIFICANCE

## B. 1 AIR POLLUTION

An air pollutant, by definition, is any substance in the air that can cause harm to any living creature, human or otherwise. 6 While there may be similarities between those pollutants that affect plants and animals more so than humans, there needs to be made a distinction between those pollutants that humans should be specifically watching for (ones that cause potential threats to health upon exposure) and those that do not pose any real threat. Common air pollutants can be grouped into 4 major categories based on chemical similarities, and each one poses slightly different health risks to the

human body. 6The first category is gaseous pollutants such as carbon monoxide, ozone, sulfur dioxide, nitrogen oxides, and carbon dioxide and other volatile organic compounds. These are abundant in the atmosphere primarily due to the production of energy from the process of burning fossil fuels. 6 For example, natural sulfur dioxide emissions typically come from volcanoes and oceans; however, these emissions comprise only 2% of the total sulfur dioxide in the atmosphere. 6The second category is made up of persistent organic pollutants. Man-made sources include pesticides, dioxins, and dioxin-like compounds. 6 Dioxins are formed both during incomplete combustion (the same way carbon dioxide is formed) and whenever materials containing chlorine, like plastics, are burned. 6 These tend to be emitted in the atmosphere only for a time, but they often settle on soil and water and accumulate as they move through a food chain due to them being water-insoluble and being able to bind to lipids. 6The third category is made up of heavy metals such as mercury and lead. These compounds enter the air as a pollutant through many different sources such as combustion or manufacturing facilities. 6 Some of these metals are known as trace elements because the human body needs a minute amount in order to regulate some metabolic processes, but larger amounts are especially toxic to the body and can accumulate and stay in the body for long periods of time. 6The last category, and one of the most dangerous components, is particulate matter. These are fine particles of matter suspended in the air that can be breathed into the lungs and originate from a wide variety of sources, including but not limited to manufacturing, power plants, motor vehicles, and naturally made dust. 6 These vary in size (PM2. 5 and PM10 are

the most common groups by which these particles are categorized, being less than 2. 5 µm and less than 10 µm respectively) and chemical composition and thus vary in both where they settle into the respiratory tract and the potential harm that they can cause. 6

## B. 2 ADVERSE HEALTH EFFECTS OF AIR POLLUTION

Air pollution has been consistently linked to increased mortality and hospital admissions in multiple studies. 6 More than 1. 3 million people, and more than half of them in developing nations, are estimated to die annually from outdoor air pollution. 1 In addition to increased mortality rates, air pollution lowers the quality of life in the general population. It has been linked to a wide range of other adverse health effects that vary depending on the nature of the pollutant and the duration of exposure. Some of these include nausea, difficulty breathing, skin irritation, reduced immune activity, and even more serious effects such as cancer, cardiovascular disease, birth defects, and developmental delays in children. 6 Because there are so many different pollutants in the air, we will briefly cover only the six common pollutants by which the EPA sets standards for clean air and some of the known health effects of each of these pollutants.

### Ozone

Ozone is one of the components of air pollution that poses the highest health risks, and it is one of the " criteria" pollutants that the EPA builds its standards around. 7 At the ground level, ozone is better known as " smog," and it is formed as the product of a chemical reaction between two other fossil-fuel derivatives, nitrogen oxides and volatile organic compounds. 7

Even low levels of ozone still pose significant adverse health risks, and they are especially potent on sunny days in urban areas. 7 Health effects ozone has been associated with include: a decrease in lung capacity, increased response to allergens, increased inflammation responses, increased airway resistance and symptoms, aggravated asthma, a decrease in respiratory frequency, and changes in lung function at high temperatures. 6, 8, 9, 10 Exercise is known to increase exposure to ozone. 10

## Carbon monoxide

Carbon monoxide is a very toxic gas, and because it is colorless and odorless, it is extremely difficult to identify without the proper laboratory equipment. 7 Carbon monoxide has a greater attraction to the hemoglobin in blood than oxygen does and so actually displaces oxygen in the blood7 and decreases the amount of oxygen sent to different organs, decreasing an individual’s reflexes and ability to concentrate, as well as causing confusion in some. 6 As an air pollutant, carbon monoxide has been linked to: increased cardiopulmonary mortality, increased respiratory and cardiovascular hospital admissions, and an increase in emergency admissions for heart attacks. 6, 8, 9, 10

## Nitrogen oxides

Nitrogen oxides are a highly reactive group of gases that have been linked to numerous adverse health effects, especially on the respiratory system. 7 With respect to air pollution, this group of gases includes nitrogen dioxide, nitrous acid, and nitric acid, with nitrogen dioxide being the main component of interest. 7 Nitrogen dioxide itself has been linked to: damage to the lung

parenchyma, increased inflammation response, changes in lung function, increases in cardiopulmonary mortality, increases in respiratory and cardiovascular hospital admissions, an increase in emergency admissions due to strokes and heart attacks, increased response to allergens, and increased asthma severity after respiratory viral infections. 6, 8, 9, 10 Nitrogen oxides in general also are associated with: increased risk of respiratory infection, nose and throat irritation, increased bronchoconstriction, and shortness of breath. 6, 8, 9, 10

## Sulfur dioxide

Like nitrogen dioxide, sulfur dioxide is also the main component of interest in a larger group of air pollutants. 7 Sulfur dioxide is known to be an irritant in gas form and highly reactive as well. 10 It arises from both fossil-fuel emissions and other varied industrial processes. 7 Sulfur dioxide has significant associations with: shortness of breath, nose and throat irritation, increased response to allergens, increased number of respiratory and cardiovascular hospital admissions, increased airway resistance, an increase in cardiopulmonary mortality, and a decrease in pulmonary function that is increased in asthma patients. 6, 8, 9, 10 Exercise has also been known to increase individual exposure to sulfur dioxide. 10

## Particulate matter

Particulate matter is one of the most dangerous components of general air pollution, as breathing it in often causes the matter to stay in an individual’s lungs for an undefined period of time. 7 As the origins of particulate matter vary widely, there are a wide range of effects. 7 However, because

particulate matter has been recognized for the danger it presents by the EPA, it also is one of the " criteria" pollution components by which the EPA sets standards around. 7 Particulate matter has been linked to: asthma, increases in coughing and wheezing in children with allergies, temporary changes in lung function and blood clotting, increased inflammation responses, exacerbating illness in sensitive subjects, increased risk of respiratory infection and increased responses to infection, and an increased hyperresponsiveness to methacholine (which causes bronchoconstriction). 6, 8, 9, 10

## Lead

In the past, lead air pollution was a major problem due to the use of leaded gasoline in transportation vehicles, especially in automobiles. 7 Today, most lead in the atmosphere is found solely due to metal processing and airplanes using leaded fuel. 7 The problem with lead is that it is difficult to eliminate, and so it accumulates in the body in an individual’s bones for most of their whole life. 7 Once exposed, lead is usually distributed through the bloodstream to other organs. 7 Lead has been shown to have adverse effects on the nervous system, cardiovascular system, immune system, reproductive system, and the developmental system. 7 Infants and children are particularly sensitive to even small amounts of lead because of lead’s effects on the developmental system. 7

## B. 3 ADVERSE HEALTH EFFECTS OF AIR POLLUTION ON CHILDREN

Air pollution has harmful effects for everyone, but especially for children. As detailed before, children spend more time outdoors and more time in physical activity while still having their bodies develop, 2 meaning that they have the most exposure to air pollution and its harmful effects at the time that its consequences are most serious. As such, children comprise a large portion of the respiratory illnesses caused by air pollution. 5 In developing nations, respiratory diseases are one of the highest contributors to child mortality, and even in industrialized nations, respiratory diseases continue to be one of the most common causes of incidences of child illness. 5More importantly, however, many adult respiratory problems are now being shown to have origins during childhood. 4 Because 80% of a person’s alveoli develop postnatally, and the lungs continue developing all the way through late adolescence for females and until early adulthood for males, 3 anything happening before the lungs finish developing risks affecting the lung’s function later on in life. 4 For example, the severity of several adult respiratory conditions has been shown to be associated with the severity of their childhood asthma. 4 Also, exposure to traffic-related air pollution does not only contribute to an onset of childhood respiratory illnesses, but in addition negatively affects the increase in lung function that comes with age. 5

## B. 4 HISTORY OF AIR POLLUTION REGULATION

Air pollutantGuideline ValuePM2. 510 µg/m3 annual mean25 µg/m3 24-hour meanPM1020 µg/m3 annual mean50 µg/m3 24-hour meanO3100 µg/m3 8-

hour meanNO240 µg/m3 annual mean200 µg/m3 1-hour meanSO220 µg/m3 24-hour mean500 µg/m3 10-minute meanAlthough air pollution has been around for centuries, only recently has there been the necessary attention brought to it. For instance, even during the Middle Ages, coal was burned for fuel so often that people took notice of its effects on the surrounding atmosphere. 11, 12 The Industrial Revolution was also powered primarily by coal, dramatically increasing air pollution levels in not only cities, but the surrounding towns and settlements as well. 11, 12 Once the presence of visible smog began to drive people out of cities, city officials began writing legislation to limit the amount of smoke that could be emitted. 12 However, it was not until the early 1900s, when there were multiple incidents of direct harm to humans around the world, that governmental bodies began moving to push through legislation for air pollution control. 12WHO 2005 Air Quality Guideline ValuesCurrently, most nations now have some sort of guideline for air quality, typically known as ambient air quality standards. 13 However, these guidelines vary widely from nation to nation, and a number of them are too relaxed, either in the standards themselves or their enforcement of them. 13 The World Health Organization (WHO) estimates that 15% of all air-quality related mortality cases could be eliminated if the standards it has advised for air quality were to be heeded. 1 The problem is worst in nations with rapidly developing economies where regulations have not yet been put into place, and the disproportionate percentage of the death burden due to air-quality related causes in these nations reflects this. 1

## B. 5 STUDY SIGNIFICANCE

Despite the significant effect of air pollution on childhood respiratory health, many countries still refuse to adopt appropriate standards and regulations by which air quality should be maintained. These are often developing countries where industrialization has just begun taking place and must now face the conflict of how to industrialize in order to develop their economy while still placing a priority on the safety of their people. Unfortunately, many seem to have opted on the side of negligence with regards to the effect of air pollution on their citizens, especially their youth. Information to the contrary should hopefully serve to motivate countries to develop higher standards for regulating air quality or adopt stricter regulations, especially with regards to enforcement of air quality legislationThis study should be useful on several levels. It will provide a rough estimate of the air quality of each country that will hopefully motivate countries to adopt policies closer in line with those of the guidelines set by the World Health Organization. This study should also add to the growing body of evidence surrounding the harmful effects of air pollution on the human body and especially on childhood respiratory health. Finally, this study should serve as notification to the necessity of continually monitoring air quality in order to provide the optimal environment for children to be raised in.

## PRELIMINARY STUDIES

In this section we describe the various papers that helped finalize the methods and procedures by which we will perform this study. The first three studies helped outline the main variables to measure and how to measure

them, particularly with regards to how to determine childhood respiratory health, and the last description discusses the Area’s Immediate Reading Project by Preemptive Media, especially its measurement of data. Air Pollution and Childhood Respiratory Health: Exposure to Sulfate and Ozone in 10 Canadian Rural Communities. 14 In this study, the authors wanted to know if there was any difference in pulmonary function between the two regions Saskatchewan, which had low exposure to sulfate and ozone pollution, and Ontario, which had moderate exposure to both sulfate and ozone due to polluted air masses coming into the region. For assessment of each child’s respiratory history, the child’s parent was given a questionnaire to be filled out, and then each child’s respiratory function was assessed by means of various measurements, the most important of which were forced vital capacity and forced expiratory volume. There were no significant differences in the levels of any other measurable pollutants. After possible confounders in the measurement results were accounted for, the authors found that the forced vital capacity and forced expiratory volume means were statistically significantly different between the two regions by 1. 7% and 1. 3% respectively. Air Pollution and Child Respiratory Health: A Case-Crossover Study in Australia and New Zealand. 15 This study was done with the purpose of defining the relationship between hospital admissions and outdoor air pollution, since the strength of the association between the two had never yet been determined. Researchers monitored both the pollution levels of various pollutants and hospital admissions for various respiratory conditions in order to determine not only the strength of association between air pollution and hospital admissions but also which pollutants, if any, had a

stronger correlation with hospital admissions. The pollutants in question were particulate matter, nephelometry, nitrogen dioxide, sulfur dioxide, carbon monoxide, and ozone. Health data was gathered in Australia by examining data held by state government health departments and in New Zealand from the New Zealand Ministry of Health. The results of this study showed a statistically significant association between air pollution and child respiratory health in Australia and New Zealand. Air Pollution and Respiratory Symptoms in Preschool Children. 16 This study was done through four locations in Switzerland in order to determine the association between air pollutions and respiratory health. A random sample of children up to age 5 was selected from each region, and the parents of each child would be asked to complete a questionnaire as well as fill out a diary of their child's symptoms. 20% of these diaries were selected to be validated by an attending physician in order to ensure quality control. Air pollution was measured with samplers located outside the apartments as well as the room in which the child in question resided in most frequently. The results of the study showed a statistically significant association between the suspended particulate concentration and the incidence and duration of any respiratory illnesses, and an association between the concentration of nitrogen dioxide and the duration of the illnesses as well. Area's Immediate Reading (AIR). 17 This project was conceived by Preemptive Media, which consists of Beatriz da Costa, Jamie Schulte, and Brooke Singer. The original concept for the AIR project, launched on September 14, 2006, was as a social experiment in order to explore local neighborhoods and urban settlements for areas that had high measurements for fossil-fuel derivatives so that individuals and

organizations could self-identify places outputting large amounts of pollution into the local environment. The measuring device itself is capable of measuring carbon monoxide, nitrous oxide, and ozone levels (which are all common fossil-fuel derivative particles) in the immediate surroundings where the machine is located. The device itself is extremely small, meant to be carried on the body at all times, and measures its data in real-time and transmits that data to a central database for the purpose of visualization on their viewing platform. Since its launch in NYC, the AIR project has expanded to multiple locations, including Long Beach, California; San Francisco, California; Pittsburgh, Pennsylvania; Belo Horizonte, Brazil; and Australia.

# RESEARCH DESIGN AND METHODS

## D. 1 OVERVIEW AND STUDY DESIGN

The study will select 20 countries that have the ability to record the medical histories of potential study subjects and that have a range of air pollution regulations. 20 students will be selected at random from 15 to 20 schools divided among 5 cities, with each school being measured as well for a rough estimate of the surrounding air quality. One of the cities must be the capital city of the country. Potential subjects will all answer the same questionnaire about previous respiratory illnesses and have their medical histories checked as well in order to obtain a comprehensive view of each subject’s past respiratory health.

## D. 2 STUDY POPULATION

Countries. Potential countries must have the ability to gather medical histories that are easily accessible to researchers. We would like to partner

with organizations in each of these countries that have the capability to access the necessary data and capacity to handle in a timely manner the work involving the questionnaires. Each organization will be briefed on how to collect the data in order to ensure continuity and comparability of the data across all countries. Cities. Each city in the study will be selected at random except for the capital city. Each city needs at least a minimum of 3 schools with children under the age of 14 in order to be eligible. If there is a range of regulations in air quality among cities, the appropriate protocol will be to divide the regulations into categorical groups and select one city per categorical group to perform the study in. Schools. In the event that a city has more than 4 schools, each school will be selected at random. , Preference will be given to those schools with children ages 11 and under. Students. Students will be selected at random and stratified into blocks according to income. Ideally, there would be 5 students for each income group. However, if there are not enough students for one block, the remainder of the spaces in that block will be divided among the remaining income groups. There should always be 20 students per school unless the school has less than 20 students.

## D. 3 DATA COLLECTION

Medical history. The organization in each country will be responsible for obtaining medical histories on past respiratory illnesses for each student, preferably through the health provider for each subject. It is possible for the subject to have no recorded medical history. A case of respiratory illness as derived from medical history will be defined as any visit to the doctor

concerning a respiratory issue. Questionnaire. Each student will be given a questionnaire to be filled out, with a parent’s help if necessary. The purpose of the questionnaire is primarily to make note of any respiratory conditions that may have been serious enough to make a note of but were not severe enough to warrant a trip to the hospital. Thus, a case of respiratory illness as derived from the questionnaire will be defined as any respiratory episode in which the parent would have preferred to seek the counsel of a doctor if cost were not an issue, regardless of whether or not the child was actually taken to see the doctor. Air quality. Air quality at each school will be taken through a device provided by the AIR Project. To estimate the air quality of each city, we will calculate the mean of each pollutant measure in order to obtain a rough estimate. An estimate of each country will also be obtained by averaging the measures for concentration of pollutants at each school; however, this might not be useful depending upon the randomization of cities and schools for the study as detailed above.

# D. 4 STRENGTHS AND LIMITATIONS

## Strengths

While there are many studies showing the association of air pollution with adverse respiratory effects in children, there are very few comprehensive global studies that show a concrete association between the two on a worldwide scale. Furthermore, there are still doubts as to the legitimacy of some of these results, and this study will serve as another body of evidence with which to show that this association between the two exists. One particular strength of this study is that by using two different methods to

obtain respiratory health histories, we will be able to obtain a more accurate depiction of medical histories overall and maybe even make known other concerns relevant to public health such as the frequency of doctor visits. Another strength of the study is that by obtaining data with a machine such as those from AIR that already have preexisting data, it increases the comparability of the data obtained and lends it credibility. The proposed methods as detailed above should serve as an efficient and objective method by which various countries around the globe can be compared in the stated areas of interest and have both relevant results for the countries involved as well as provide results that can guide future efforts and resources.

## Limitations

Several limitations should be considered. Because questionnaires are mainly dependent upon the parents' ability to recall previous health conditions, there could be bias introduced. Parents could be especially adept at remembering previous respiratory conditions based upon their severity, and because the study takes frequency of conditions into account without accounting for the severity of those conditions, the results of the study could be skewed. However, this should be a minimal problem as long as the questionnaires are written in a very specific manner in order to diminish this bias. The risk of the data obtained not being comparable should be nominal as long as detailed procedures are written out uniformly in order to obtain all possibly subjective data (mainly the questionnaires) in the same exact manner. Also, because we are selectively randomizing within categories for

geography and socioeconomic status, we should have data that is truly representative of the general population and can be extrapolated as such.

## TIME FRAME

The proposed study will be completed in approximately two years, from July 2013 to August 2015, as follows: Protocol development (questionnaires, codebooks, data collection forms, fieldwork manual): July 2013 – December 2013Database preparation: November 2013 – February 2014Country research approval: January 2014 – February 2014Field work in 20 countries: March 2014 – March 2015Data analysis and interpretation: March 2015 – July 2015Report writing and dissemination: May 2015 – August 2015