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Abstract

The Reduction of Asthma Emergency Room Visits From A Reduced Tropospheric Ozone Standard in Atlanta, GA

By Tameika N. Kastner

Being that the Environmental Protection Agency (EPA) analysis of asthma-related emergency room (ER) visits due to a proposed ozone (O_3) standard reduction was done only at the national level, it was useful to conduct an ozone standard reduction benefit analysis of asthma-related ER visits in the Atlanta area to see how an ozone standard reduction can benefit the public at the local level. Utilizing a random effects pooled estimate of the concentration-response functions from three epidemiologic studies (Jaffe, Singer, & Rimm, 2003; Peel et al., 2005; Wilson, Wake, Kelly, & Salloway, 2005) that EPA used to conduct a benefit analysis at the national level, in Atlanta there would be; 757 (233-1301) less asthma ER visits if O_3 was reduced from 100ppb to 70ppb. Also, there would be 631, 884, and 1010 less asthma-related ER visits annually if Atlanta's O_3 level was reduced from 100ppb to 75ppb, 65ppm and 60ppb respectively.

In addition to estimating asthma-related ER visit reductions using the random effects pooled estimate, analysis was also conducted using only concentration-response data from an Atlanta study (Peel, et al., 2005). Using only the Peel et al. study results, if the O_3 levels were reduced from 100ppb to the proposed standard of 70ppb, there would be 505(194-1145) less asthma-related ER visits in the Atlanta area annually. Similarly, there would be 421, 588, and 674 less asthma-related ER visits annually if the ozone levels were reduced from Atlanta's current level of 100ppb to 75ppb, 65ppb, and 60ppb respectively.

With an alarming number of 19,418 estimated asthma ER visits occurring yearly in Atlanta, it is important to estimate the reduction in asthma due to a reduction in O_3. O_3 forms when oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) are in the air and sunlight is present. A benefit analysis impact of asthma ER visits due to an O_3 reduction will also be useful to conduct future benefit-cost analysis.

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I. Introduction

With the increased presence of motor vehicles on the road and limited alternative sources of transportation in metro-Atlanta, ozone (O_3) (a colorless gas) reaches significantly high and dangerous levels (EPD, 2008). For example, the 3-year average of 4^{th} maximum value for 8-hr ozone concentrations (the metric used to assess compliance to National Ambient Air Quality Standards by the U.S. Environmental Protection Agency) reached as high as 120 ppb in the year 2000 in the Atlanta metro area (Figure 1). It is also known to be the major cause of smog which results in severe health symptoms including cough, chest pain, and throat irritation. These symptoms are a major health problem in individuals with sensitive respiratory systems, especially in children with asthma (EPD, 2008; Georgia Env. Protection Div., 2008). Asthma is a major concern in children because they are disproportionately affected with asthma. For Georgia alone, more than 100,000 (10%) children ages 0-10, approximately 56,000 (15%) middle school students, and approximately 70,000 (16%) high school students were diagnosed with asthma in 2005 (*Georgia Asthma Surveillance Report* 2007). In comparison to children, only 7% (480,000) adults in Georgia were diagnosed with asthma in 2005 (*Georgia Asthma Surveillance Report* 2007).

Nationally, asthma is also a major public health issue because nearly 22 million Americans are currently diagnosed with the disease. Significantly, in 2004 asthma was responsible for over 2 million ER visits, 500,000 hospitalization, and nearly 5,000 deaths nationwide (*Georgia Asthma Surveillance Report* 2007). As a result, the economic burden of asthma annually costs the nation over $16 billion dollars (*Georgia Asthma Surveillance Report* 2007). For Georgia alone, asthma accounted for approximately 47,000 ER visits, 11,000 hospitalizations, and 117 deaths per year in 2007.

Asthma is also known to be exacerbated by increased O_3. In Atlanta, this has been evidenced by several studies that show a positive association between increased emergency room visits of pediatric asthma and O_3 during the summers of 1993-1995 (Tolbert et al., 2000) ; an association between ozone and pediatric emergency room visits for asthma during the warm seasons and temperate cold summer months (November, March, and April) for 1993-2004 (Strickland et al., 2010); and an association between maximum daily 8-hour average ozone level and emergency room (ER) visits for asthma for the 1993-2000 time period (Peel, et al., 2005).

Since asthma is also a public health concern and an economic burden in the Atlanta metro area, the goal of this paper is to focus on an asthma stressor that could reduce this concern. This paper will concentrate on an impact benefit analysis, which describes the effects an improved environmental quality has on human welfare (U.S. EPA, 1999), of asthma ER visit reductions in the Atlanta area that could occur if Atlanta ozone levels were reduced from the current 8-hour maximum ozone level of 100 (parts per billion) ppb to levels set by the current and proposed National Ambient Air Quality Standard for ozone (i.e., within the 60-75ppb range). The impact of reduced ozone levels is important to address because ozone is responsible for nearly 19,418 asthma ER visits for the Atlanta metro area alone (Peel, et al., 2005). Basically, the question of concern is:

How many asthma ER visits in the Atlanta area would be eliminated if the ozone levels were reduced from the current levels of 100ppb to comply with the current and proposed standards of 75ppb, 70ppb, 65ppb, and 60ppb?

To conduct a benefit analysis, the U.S. Environmental Protection Agency (EPA) report, *"National Ambient Air Quality Standards for Ozone*", describes several steps that are necessary to conduct an effective and useful benefit analysis; which may be transferred to the Atlanta area. The process that should be used to conduct a benefit analysis for the Atlanta metro is: (1) to gather air quality information of O_3 from ambient monitors in the Atlanta area; (2) estimate the baseline number of asthma-related ER visits for the Atlanta metro and ; (3) estimate the relative risk-based concentration-response (CR) functions to quantify the relationship between the number of ER visits in Atlanta area and ambient O_3 concentration (Ostro, Tran, & Levy, 2006; U.S. EPA, 2010a). Without compliance to any of these steps, it is challenging to make clear assumptions about the value of benefits embedded in different policy choices (U.S. EPA, 2000), specifically mandating a reduction in the ozone standard level.

Due to time constraints and lack of resources to gather all of the pertinent data needed to conduct a full benefit analysis for the Atlanta area, essential data (i.e., concentration-response functions) gathered from U.S. EPA's benefit analysis will be used to conduct a benefit analysis for the Atlanta area. Because U.S EPA's benefit analysis was conducted at the national level, there are concerns and limitations regarding its transferability to the local level, which will be addressed.

In addition to concerns with basing metro-area data from national level data, there are uncertainties and limitations within EPA's data that EPA even addresses. Concerns EPA addresses from the epidemiological studies they used are; the small size of the effect estimates between O_3 and emergency room visits, exposure errors due to variations within a community/people and confounders; inconsistency among multiple studies used to conduct the analysis; and differences in biological thresholds for each person (U.S. EPA, 2010a). In addition, EPA addresses concerns surrounding their estimates of the O_3 coefficients for the CR relationships used in their assessment: uncertainties (1) surrounding the estimates of the O3 coefficients; (2) involving the shape of the CR relationship and whether or not there is a linear or non-linear within the range of concentrations; (3) related to when and where the CR relationships were derived and; (4) pertaining to the possible role of co-pollutants (U.S. EPA, 2010a). In addition to the concerns EPA addresses in their report, other concerns that may be relevant are; future climate change impacts, mandated future requirements to adapt to climate change; future advanced technology in ozone control and; other possible emerging exposures that can exacerbate ozone exposure in the future. But despite all the uncertainties that are taken into consideration, there are some advantages in using CR functions for multicity studies: (1) it provides more precise effect estimates due to the use of larger data sets instead of focusing on one single study that is based on one city and; (2) it has greater uniformity in data handling and model requirements due to its study design which eliminates city-to-city variation (U.S. EPA, 2010a).

Overall, the format that will be used to address impacts of ozone and its relevance to ER visits in the Atlanta using U.S. EPA criteria, is to; first, summarize EPA's benefit analysis of asthma ER visits from reduced trospospheric O_3 levels within 75ppb and 65ppb by specifying the results EPA gathered; provide estimates of asthma ER visits from reduced trospospheric O_3 levels of 75ppb, 70ppb, 65ppb, 60ppb for the Atlanta metro; discuss limitations in EPA's benefit analysis of reduced O_3 levels criteria and estimates; discuss limitations in the asthma ER visit estimates for the Atlanta metro and; in conclusion, describe the significance of the results and the implications in gathering the information for the benefit analysis for Atlanta metro.

II. Summary of EPA's Asthma Emergency Room (ER) Visits Benefit Analysis' Methods and Results at the National Level

Because of the major concerns of O_3 and air quality in general, EPA is currently proposing that the 75ppb standard, which was set in EPA's National Ambient Air Quality Standards for Ozone (NAAQS); Final Rule 2008, be further reduced to a lower level within the range of 70ppb to 60ppb. Specifically, within EPA, the Office of Air Quality Planning and Standards (OAQPS) Innovative Strategies Group has the authority to set the NAAQS for ozone; which is a criteria pollutant (U.S. EPA, 1999). The legitimacy is that children and other "at risk" populations will have increased protection against many O_3 related adverse health effects including respiratory morbidity, cardiovascular-related morbidity, and cardiovascular morbidity (U.S. EPA, 2010a). In addition, EPA indicates that lowering the ozone standard will benefit the nation in general.

To conduct a national benefit analysis, U.S. EPA, took several steps. As a first step, U.S. EPA gathered air quality information of O_3 taken from ambient monitors to bring together estimates of background of O_3 concentrations appropriate for the location of interest and used a method to adjust the recent data to reflect patterns of air quality estimated to occur when the area just meets a specified O_3 standard (U.S. EPA, 2010a).

In this case, the median nationwide 95th percentile value of daily maximum 8-h O_3 concentrations for May to September 2000 to 2004 was 73 ppb with 5% of the values being above 85 ppb (U.S. EPA, 2007).

The next step EPA did to conduct national benefit analysis on O_3 reduction was to estimate the number of people exposed to these O_3 concentration changes to obtain the national baseline incidence rate; which are the number of health events per year per unit population (Ostro, et al., 2006). To perform this method, EPA estimated the seasonal baseline incidence of health effects for the nation before there were any changes in the O_3 air quality by gathering the population estimate and the current O_3 provided in the prior step (Ostro, et al., 2006; U.S. EPA, 2010a). To gather the national population estimate, EPA used epidemiological studies from the 2000 National Hospital Ambulatory Medical Care Survey (NHAMCS) (ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Datasets/NHAMCS/) and the 1999 National Hospital Discharge Survey (NHDS) (ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Datasets/NHDS) public use data files (U.S. EPA, 2008) which were then used with the O_3 rate to estimate the health effect baseline incidence rates which were age-specific. After the age-specific baseline incidence rates were generated, EPA multiplied the baseline incidence rate by the corresponding population number to estimate the total baseline incidence per year (U.S. EPA, 2008). Overall, baseline incidence rates are important because they were needed to gather the estimated number of cases; where the relative change (rate) is converted into a number of cases (U.S. EPA, 2008) and that it was also useful for obtaining the effect estimates. Table 1, taken from EPA's "Final Ozone NAAQS Regulatory Impact Analysis, 2008" provides a summary of the average baseline incidence, age-specific national rates for asthma ER visits. In this case, estimates for the baseline number of cases that would have been analyzed from the baseline incidence are not specified. This is an area that could be further analyzed.

For the last step, EPA gathered relative risk-based concentration-response (CR) functions in order to relate the changes in the national population to changes in the O_3 concentration for the population (Ostro, et al., 2006). The CR effects gathered from each study for a 30 ppb increase in 8-hr maximum O_3 concentrations were; relative risk (RR) of 1.09 (95% CI: 1.00,1.19) for a 30 ppb in Jaffe's study; 1.026 (0.1,1.059) in Peel's study; and 1.094 (1.032 ,1.160) for Portland, ME and 0.970 (0.863, 1.092) for Manchester, NH in Wilson's study (U.S. EPA, 2006). After obtaining the CR functions for each study, EPA calculated a pooled estimate using a random effects pooling technique. Since

EPA's pooled estimate for the three studies combined could not be located in the published studies available, a pooled RR estimate of 1.039 (1.012, 1.067) found in Table 3 was calculated using the same method.

Overall, according to EPA's benefit analysis summarized in Table 2, at the national full attainment level if the national ozone standard was reduced from 80ppb to75ppb there would be 280 (-18 to 830) less asthma related ER visits annually by the year 2020. If the national ozone standard was reduced from 80ppb to 70ppb, there would be 1,000 (-82 to 3,000) less emergency department visits annually at the national rolled back full attainment level. If the national ozone standard was reduced from 80ppb to 65ppb, there would be 1,900 (-130 to 5,500) less emergency department visits annually at the national rolled back full attainment level (U.S. EPA, 2008). Furthermore, EPA concludes that school loss days, infant hospital admissions, acute respiratory symptoms, adult hospital admissions, and minor restricted activity days would also be reduced by 2020 (U.S. EPA, 2010b).

III. Asthma Emergency Room (ER) visits Benefit Analysis' Methods and Estimated Results for Atlanta, GA metro

Similar to EPA's methods in conducting a benefit analysis of asthma-related emergency visits due to O_3 at the national level, there are several steps that are necessary to conduct a similar benefit analysis for the Atlanta area. The methods that are useful are: (1) gather air quality information of O_3 from ambient monitors in the Atlanta area; (2) estimate the baseline number of asthma-related ER visits for the Atlanta metro and; (3) estimate the relative risk-based concentration-response (CR) function that provides an estimate of the relationship between the number of ER visits in Atlanta area and ambient O_3 concentration (Ostro, et al., 2006; U.S. EPA, 2010a).

Being that the current Atlanta benefit analysis is done at the local level versus the national level in which EPA's benefit analysis is based on, it was useful to first to focus Atlanta's benefit analysis on a specific study that was conducted on the Atlanta metro area. Out of the three studies EPA used (Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005), it was preferable to base the Atlanta benefit analysis on the Peel et al. (2005) study because the other two studies were based on locations in Ohio and the New England area. Specifically, Peel's study utilized computerized asthma-related ER data from 31 hospitals in the Atlanta metro between 1 January 1993 and 31 August 2000 (Peel, et al., 2005).

To get started, the first method required was to gather the latest air quality information regarding O_3 concentrations in the Atlanta area. The 3-year average of the 4^{th} maximum for 8-hr ozone concentration for the Atlanta area was 100 ppb in 2007 (Figure 1). The next method was to estimate the baseline number of people in the Atlanta area who had an asthma-related ER visit; which is slightly different from the method EPA. Using Peel's data, there are approximately 19,418 asthma-related ER visits annually in the Atlanta metro area. This number was estimated from the observed daily counts of 53.2 +/- 15.2 (mean, standard-deviation) of ER visits at 31 participating hospitals between 1 August 1998 and

31 August 2000 (Peel, et al., 2005). Multiplying the daily count of 53.2 visits by 365 to estimate the annual visits, the baseline came out to be 19,418 visits.

The last step was to estimate the relative risk-based concentration-response (CR) function that provides an estimate of the relationship between the number of ER visits in Atlanta area and ambient O_3 concentration. Based on the information in Peel's study, the CR function was RR 1.026 (0.1, 1.059) for a 30 ppb increase in 8-hour maximum O_3 for the Atlanta area (Peel, et al., 2005). Using the CR function of RR 1.026, if O_3 levels were reduced from 100ppb (the 3-year average of 4^{th} maximum for 8-hr ozone in the year 2007) to 70ppb (in the range of the currently proposed reduced ozone standard) the number of asthma ER visits would be reduced by 2.6% (1.0% to 5.9%); resulting in 505 (194-1145) less asthma ER. In addition, if the O_3 level was reduced from 100ppb to the 2008 ozone standard of 75ppb, the number of asthma-related ER visits would be reduced by 2.17% resulting in 421 less asthma-related ER visits annually. If the O_3 standard was reduced to 65ppb and compliance was attained, the number of asthma-related ER visits would be reduced by 3.03% resulting in 588 less asthma-related ER visits annually. Last, if the O_3 standard was reduced to 60ppb and compliance was attained, the number of asthma-related ER visits would be reduced by 3.47% resulting in 674 less asthma-related ER visits annually (Table 4 and Table 6).

Despite the usefulness in estimating asthma-related ER visits for the Atlanta metro area due to O_3 standard reductions using only Peel's study, it was also beneficial to project the number of asthma-related ER visits based on the random effects pooled estimate from the same studies (Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005) EPA used. Benefit analysis Results using the random pooled CR estimate are shown in Table 3. Overall, the weighted average RR is estimated to be 1.039 (1.012, 1.067) (Shown in Table 3), which indicates a 3.9 % increase in asthma ER visits per 30ppb increase in daily 8-hour maximum O_3. As a result, If the O_3 standard was reduced to 70ppb and compliance was attained, the number of asthma-related ER visits would be reduced by 3.9% (1.2% to 6.7%) resulting in 757 (233-1301) less asthma-related ER visits annually. Additionally, if the O_3 levels were reduced from 100ppb to 75ppb (compliance with the 2008 ozone standard), the number of asthma-related ER visits would be reduced by 3.25% resulting in 631 less asthma-related ER visits annually. If the O_3 standard was reduced to 65ppb and compliance was attained, the number of asthma-related ER visits would be reduced by 4.55% resulting in 884 less asthma-related ER visits annually. Last, if the O_3 standard was reduced to 60ppb and compliance was attained, the number of asthma-related ER visits would be reduced by 5.2% resulting in 1010 less asthma related ER visits annually (Table 5 and Table 6).

IV. Discussion of EPA's Benefit Analysis Criteria at the National Level and Atlanta, GA's metro Benefit Analysis Results for Asthma ER visits

Assessing evidence from the epidemiological studies (Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005), one concern EPA addresses is the weak, small size of the effect estimates between O_3 and ER visits, which increases the potential for confounders (daily variation of exposure to co pollutants, temperature, genetics, diet, and lifestyle) to negatively impact the results (U.S. EPA, 2010a). This is a concern because the effect estimates for one of the three epidemiological studies (Peel's et. al.) have a small size effect because its estimates ranges between 0.5 and 5% (U.S. EPA, 2010a) increases per 25ppb in 8-hour maximum O_3. Peel's et al. study gives a RR of 1.022 per 25ppb; which means there is only a 2.2% increase in the 8-hour maximum O_3 per 25ppb (U.S. EPA, 2006).

Another concern is exposure errors due to variations within a community. Basically, the relationship between ozone concentrations measurements and individual exposures can be influenced by various factors related to building ventilation practices (building filters) and personal behaviors. In this case, a personal behavior that would be critical in assessing the effect estimates would be time spent outdoors because children tend to spend more time outdoors in the warm season while the elderly tend to spend less time outdoors (U.S. EPA, 2010a).

Despite the lack of specific information on building ventilation practices for each study, building ventilation practices will always be a major factor because they will always vary among buildings, cities, states, and regions. But what can be addressed specifically from the studies is the seasonal range of the three studies (Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005) where all of the studies were specifically limited to the spring-summer months (April through September) (U.S. EPA, 2008). Then within this range, based on the national baseline incidence rate shown in Table 1, there was an increased rate of

1.1% per 100 asthma ER visits for pediatrics <18 years of age and an increased rate of 8.7% per 100 asthma ER visits for young adults ages 18-24 years of age. Unlike the estimates for pediatrics and young adults, the baseline incidences rates were protected (decreased rate per 100 asthma ER visits) for the other age ranges; 25-34, 35-44, 45-54, 66-64 and 65+ age ranges. Also, as these age ranges increased the protective effect increased (U.S. EPA, 2008).

In addition, in regards to epidemiological studies, inconsistency among multiple studies used to conduct the analysis is another major concern. This is an uncertainty because there may be variations in the effects because of differences in relative personal exposure to O_3 as well as changing concentrations and structure of co pollutants that are present at different locations (U.S. EPA, 2010a). In Peel's et al. study, there were numerous co pollutants that were considered. These co pollutants included NO_2, SO_2,CO, $PM_{2.5}$,$PM_{10-2.5}$, ultrafine PM count, SO_4^{-2}, H^+, EC, OC, metals, and oxygenated hydrocarbons for the Atlanta metro. In Jaffe's et. al. study, the co pollutants considered were PM_{10}, NO_2, and SO_2 for three cities in Ohio (Cincinnati, Cleveland, and Columbus). Last, in Wilson's et. al. study, the only co pollutant considered was SO_2 for both Portland, ME and Manchester, NH (U.S. EPA, 2006).

A last concern relating to the effects estimates taken from the epidemiological studies is the differences in biological thresholds for each person. Basically, individual thresholds will vary from person to person because of individual differences in genetic susceptibility, pre-existing conditions, diet levels and exercise levels. As a result, it would be challenging to identify a specific threshold at the population level below which no individual would experience a given effect. Overall, based on the epidemiological studies, no clear conclusions can be reached about possible threshold levels for O_3 related to asthma induced ER visits (U.S. EPA, 2010a).

In addition, EPA addresses concerns surrounding the estimates of the O_3 coefficients for the CR relationships used in their assessment. One uncertainty is the estimates of the O_3 coefficients used to determine the CR function (U.S. EPA, 2010a). As mentioned before, the estimates taken from the studies (Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005) may be affected by potential confounders and variations within the communities and people. Another uncertainty involves the shape of the CR relationship and whether or not there is a linear or non-linear relationship within the range of the concentrations (U.S. EPA, 2010a). This is a difficult area to address because the studies do not provide a basis for concluding whether or not there is a population effect threshold (Ostro, et al., 2006).

When and where the CR relationships were derived is another uncertainty (U.S. EPA, 2010a) because benefit estimates can vary from study to study. For there may be differences related to study location, study population, study size and duration (Ostro, et al., 2006). For example, Jaffe's et. al. study was conducted in three Ohio cities (Cincinnati, Cleveland, and Columbus) among Medicaid recipients aged 5-34 years of age from June-August 1991-1996. But unlike Jaffe's et al. study, Peel's et. al. study was conducted in Atlanta metro for all the age groups from 1993-2000. Last, Wilson's et.al. study was conducted in Portland, ME and Manchester, NH among all age groups from 1996-2000 (U.S. EPA, 2006).

Last, the role of co-pollutants and weather may be a major factor in assessing the CR function (Ostro, et al., 2006; U.S. EPA, 2010a). This is an important consideration because even though daily variations in O_3 is not highly correlated with most criteria pollutants (CO, NO_2, SO_2, and coarse PM), they are highly correlated with secondary fine $PM_{2.5}$ measured during summer (Ostro, et al., 2006). In this case, the only study that reported effect estimates of PM2.5 was Peel's et. al study. In contrast, the other two studies, (Jaffe, et al., 2003; Wilson, et al., 2005) did not report effect estimates of $PM_{2.5}$ but address $PM_{2.5}$ as a potential confounder in their estimates for O_3 correlation with asthma ER visits.

There are also uncertainties in the O_3 standard reduction benefit analysis results. The overall estimates for 0.075ppm, 0.070ppm and 0.065ppm were obtained using full-attainment of all areas in the country. This is a limitation because of relatively higher ozone levels in several large urban areas (Southern California, Chicago, Houston, and the Northeastern urban corridor) and lack of information on currently known emission technologies that would either be insufficient to bring some areas in attainment to the 0.075ppm or have more stringent ozone standards. So a part of the analysis is considered to be highly exploratory because it is based on estimating emission reductions and air quality improvements without any of the information on the emission technologies that would be useful (U.S. EPA, 2008). Not only were the estimates a full-attainment analysis, it is also a rolled back attainment analysis making the benefit analysis a national rolled back full attainment analysis. A rolled back attainment analysis is a process used to plan and execute strategies to control for O_3 producing compounds. This type of process was designed to reduce O_3 episodes during the worst-case weather conditions and, using base-line strategies, focus on O_3 concentrations at the highest designed site at each air basin. However, the planned and executed strategies used would affect sites during different episodes creating uncertainty. This prevalence is highly observed in different episodes that are marked differently for different months during the overall O_3 season. But in contrast, trends for multiple sites within a air basin would be similar to each other (Ostro, et al., 2006).

In comparing the RR estimates of only Peel's et. al. study and the RR estimates of all three of the studies (Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005) pooled together, there are advantages in using only Peel's et al. study. One, using only Peel's et. al. study to estimate asthma ER visit reductions due to O_3 for Atlanta metro, there is an advantage for having locally observed associations. Another benefit includes limiting the data to a specific age range and the ability to have more control of the other air pollutants (Ostro, et al., 2006). In contrast, using a pooled estimate from all three of the studies (Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005) to estimate reductions in asthma ER visits Atlanta metro have limitations. Limitations are due to differences in study locations, personal exposure in the populations, study size and duration, and analytical methods (Ostro, et al., 2006). As a result, it is more beneficial to use only Peel's et. at. study for Atlanta metro benefit analysis.

Despite the limitations and uncertainties in using a pooled technique for Atlanta metro estimates, it is still beneficial to use for national benefit analysis. One, the pooled technique can be useful because it allows the possibility for the estimates from the different studies to have estimates from different parameters (Abt Associates Inc., 2008; U.S. EPA, 2008). It can combine the results of the studies to provide estimates that are more reliable. Combining the results instead of the original data is important because of data confidentiality and the impracticality of combining the original data sets (Abt Associates Inc., 2008). For example, all three of the studies were done at different locations and at different time frames. In differentiating the studies; Jaffe's study examined the relationship between ER visits and air pollution for ages 5-34 for the Ohio cities of Cleveland, Columbus, and Cincinnati that were pooled together from 1991-1996 (Jaffe, et al., 2003); Peel's study estimated asthma-related ER visits for all ages in Atlanta from 1993 to 2000 (Peel, et al., 2005); last, Wilson's study examined the relationship between ER visits for asthma for all people living in Portland, Maine form 1998-2000 and Manchester, New Hampshire from 1996-2000 (Wilson, et al., 2005) . Despite the variation in locations and time frames for the studies, as mentioned before, time of the year was similar for all the studies because the ozone data was restricted to spring-summer months (April through September) (U.S. EPA, 2008).

In addition, there are some advantages in using CR functions for multicity studies: (1) it provides more precise effect estimates due to the use of larger data sets instead of focusing on one single study that is based on one city and; (2) it has greater uniformity in data handling and model requirements due to its study design which eliminates city-to-city variation and (U.S. EPA, 2010a).

Comparing Atlanta's benefit analysis results to those from EPA was difficult because EPA based its estimates on a maintained ozone level of 80ppb; which does not provide benefit analysis estimates based on current 8-hour maximum O_3 levels that are higher. Using current O_3 levels may not have been easy because O_3 levels vary across the nation. For example, O_3 levels are more likely to be much higher in California than many other states. Unlike EPA's analysis, the current analysis for Atlanta analysis was based on the observed 3-year average of 4th maximum for 8-hr ozone level of 100ppb. Also, since baseline estimates of asthma ER visits due to O_3 were not specified for EPA's benefit analysis, the results cannot be compared.

Other reasons for the difficulty in comparing EPA's results with Atlanta's results are the lack of gathered results for EPA's baseline number estimate of asthma ER visits and not able to recover EPA's CR function estimate for the nation. Even though estimates for EPA's baseline incidence rates by age-group were retrievable, shown in Table 1, it was difficult to arrive at information on the baseline number EPA used to conduct a benefit analysis at the national level. Despite knowing that there were over 22 million asthma ER visits annually nationwide based on other resources ("2008 Georgia Data Summary: Asthma," 2008), having a baseline estimate would have been useful for comparative analysis. Regardless of not knowing EPA's CR estimate, they did use a random effects pooled method (U.S. EPA, 2008). As a result, knowing how to perform a random effects pooled calculation was beneficial for estimating what EPA's CR estimate could have been and what Atlanta's CR estimate would be. Since a visual of look of EPA's calculations are not attained, there is some level of uncertainty.

Last, there other issues that are also important to address regarding the benefit analysis of asthma ER visits due to O_3, that are not as publicized. One of these concerns is future climate change impacts evidenced by rising sea levels and melting ice caps. Due to the possible mandated future requirements to adapt to climate change; future advanced technology in ozone control can alter the type of O3 exposure that can occur. Ozone levels can sharply decrease if aggressive renewable energy alternative sources are implemented reduced.

V. Conclusion

With over O_3 associated 19,418 annual asthma ER visits in the Atlanta metro it is important to further address O_3. The first step by just by reducing the ozone levels from current observed levels of 100ppb to levels within 75ppb and 60ppb.

VI. References

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VII. Tables

Table 1

Table 1: National Average Baseline Incidence Rates for Asthma ER visits								
		[a]Rate per 100 people per year by Age Group						
Source	**Notes**	**<18**	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
2000 NHAMCS public use data files; 1999 NHDS public use data files	incidence	1.011	1.087	0.751	0.438	0.352	0.425	0.232

[a] Rates reported as population –weighted incidence rates per 100 people per year (U.S. EPA, 2008)

Table 2

Table 2: EPA's Estimated Annual Reductions in the Incidence of Asthma ER Visits Associated with O_3 Exposure in 2020 If O_3 levels were Reduced From 80ppb to 75ppb, 70ppb or 65ppb		
Reduced Level	**Attainment**	**[a,c]Estimate (95% Confidence Interval)**
75ppb	[b]National Full Attainment	280 (-18--830)
70ppb	[b]National Rolled Back Full Attainment	1000 (-82--3,000)
65ppb	[b]National Rolled Back Full Attainment	1900 (-130--5,500)

[a]All estimates are rounded to two significant figures.
[b]Reflects full attainment at all locations of the U.S. except two areas of California (San Joaquin and South Coast Air Basins) that have high levels of ozone.
[c]With a negative 5th percental incidence, due to weak statistical power, it should be inferred that a decrease O_3 exposre may cause and increase in asthma ER visits.
(U.S. EPA, 2008)

Table 3

Table 3: Random Effects, Pooled Estimates for 8-hour O_3 pollutant Used to Estimate Asthma ER Visits in Atlanta								
Study	[a]**RR**	[t]**LCL**	[t]**UCL**	[a]**ln RR**	[a]**ln LCL**	[a]**ln UCL**	[a]**Weight= 1/(var lnRR+ var betwn)**	**Weight x lnRR**
[b]**Jaffe**	1.09	1	1.19	0.086	0	0.174	190.215	16.392
[c]**Peel**	1.026	0.100	1.059	0.023	-0.000	0.057	3833.224	98.390
[b]**Wilson1**	1.094	1.032	1.16	0.089	0.032	0.148	1119.502	100.576
[b]**Wilson2**	0.97	0.863	1.092	-0.03	-0.147	0.088	273.716	-8.337
			Average lnRR=	0.043		Sum=	5416.658	207.022

Study (continue)	[a]**SE lnRR**	[a]**Var lnRR**	[a]**w*w*var lnRR**	[a]**sq dev var**	**Unit**	[f]**Date Range**
[b]**Jaffe**	0.045	0.002	72.565	0.002	30ppb	1991-1996
[c]**Peel**	0.016	0.000	3833.228	0.000	30ppb	1993-2000
[d]**Wilson1**	0.030	0.001	1119.506	0.002	30ppb	1998-2000
[d]**Wilson2**	0.060	0.004	273.719	0.005	30ppb	1996-2000
		Sum=	5299.017	0.003	30ppb	1991-1996
Weighted Average lnRR=				0.038		
[e]**Weighted Average RR=**				***1.039***		
[a]**Var Weighted Average lnRR=**				0.000		
[a]**SE Weighted Average lnRR=**				0.014		
UCL Weighted Average lnRR=				0.065		
LCL Weighted Average lnRR=				0.011		
UCL Weighted Average RR=				1.067		
LCL Weighted Average RR=				1.012		

[t]95% CI range = Lower Confidence Level (LCL), Upper Confidence Level (UCL) for 8-hour O_3 pollutant
[a]RR=Relative Risk, ln=natural logarithm, betwn=between, SE=Standard Deviation, Var= Variance
w=weight, sq dev=squared deviation, [b](Jaffe, et al., 2003), [c](Peel, et al., 2005),
[d](Wilson, et al., 2005), Wilson1(location) Portland, ME, Wilson2 (location) Manchester, NH
[e]Weighted Average RR is the Concentration Response Estimate, [f]Restriction of data to spring-summer months (April-September) for the years given
All estimates were rounded to three decimal places after the calculations were completed.
(Steenland,Kyle, PhD Emory University 2010)

Table 4

Description of Obtaining Annual Reduction Estimates of Asthma ER Visits Associated with O_3 From Using Only Peel's et. al. Study	
CR Function Estimate: 1.026 for 30ppb 8-Hour Ozone Maximum	
Reduced Ozone Level from 100ppb to:	**Calculation**
75ppb	2.6% = X% Estimate: 2.17% Reduction 30 25 (.0217 * 19,418 =421) [a]
70ppb	2.6% = X% Estimate: 2.6% Reduction 30 30 (.026 *19,418= 505) [a]
65ppb	2.6%= X% Estimate: 3.03% Reduction 30 35 (.0303 * 19,418= 588) [a]
60ppb	2.6%= X% Estimate: 3.47% Reduction 30 40 (.0347 * 19,418= 647) [a]

[a] Each of the estimated values were multiplied by the baseline number of 19,418 to obtain the number of reduced asthma ER visits.

Table 5

Description of Obtaining Annual Reduction Estimates of Asthma ER Visits Associated with O_3 From Using a Random Pooled Estimate of the [a]Three Studies Combined	
Pooled CR Function Estimate: 1.039 for 30ppb 8-Hour Ozone Maximum	
Reduced Ozone Level from 100ppb to:	**Calculation**
75ppb	3.9% = X% Estimate: 3.25% Reduction 30 25 (.0325 * 19,418 =631) [b]
70ppb	3.9% = X% Estimate: 3.9% Reduction 30 30 (.039 *19,418= 757) [b]
65ppb	3.9%= X% Estimate: 4.55% Reduction 30 35 (.0455 * 19,418= 884) [b]
60ppb	3.9%= X% Estimate: 5.2% Reduction 30 40 (.052 * 19,418= 1010) [b]

[a](Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005)
[b]Each of the estimated values were multiplied by the baseline number of 19,418 to obtain the number of reduced asthma ER visits.

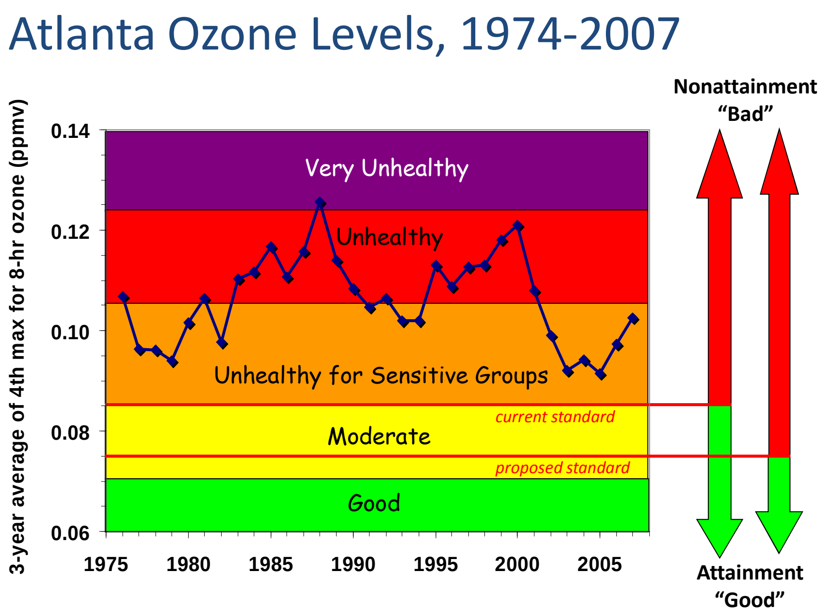
Table 6

Summary of Estimated Annual Reductions in the Incidence of Asthma ER Visits Associated with O_3 Exposure for Atlanta Metro at 30ppb for 8-hour Maximum O_3 Pollutant		
Reduced Ozone Level From 100ppb to:	**Only Peel's et. al. Study (% Reduction)**	**Random Pooled Estimate From All Three Studies[a] (% Reduction)**
75ppb	421(2.17%)	631 (3.25%)
70ppb	505 (2.60%)	757 (3.90%)
65ppb	588 (3.03%)	884 (4.55%)
60ppb	647(3.47%)	1010 (5.20%)

[a](Jaffe, et al., 2003; Peel, et al., 2005; Wilson, et al., 2005)

VIII. Figures

Figure 1



Courtesy of Emory University, School of Public Health, EOH Department, 2010