WRITTEN REPORT OF GEORGE D. THURSTON
REGARDING THE PUBLIC HEALTH BENEFITS OF EPA'S PROPOSED RULEMAKING REGARDING BEST AVAILABLE RETROFIT TECHNOLOGY FOR TEXAS SOURCES UNDER THE REGIONAL HAZE RULE

RE: ENVIRONMENTAL PROTECTION AGENCY,
Promulgation of Air Quality Implementation Plans; State of Texas; Regional Haze and Interstate Transport of Pollution Affecting Visibility Federal Implemntation Plan, 82 Fed. Reg. 912 (proposed Jan. 4, 2017)
EPA Docket No.: EPA–R06–OAR–2016–0611; FRL–9955–77-Region 6

May 4, 2017

PROFESSIONAL EXPERIENCE OF THE AUTHOR

I am Professor of Environmental Medicine at the New York University (NYU) School of Medicine.

I have a Bachelor of Science degree in Engineering from Brown University, and a Masters and Doctorate of Environmental Health Sciences from the Harvard University School of Public Health. I have over 30 years of subsequent experience in the evaluation of the human health effects of air pollution. I have served on the U.S. Environmental Protection Agency's Clean Air Scientific Committee (CASAC) that advises the EPA on the promulgation of ambient air quality standards from 2007 through 2010, and I have served on the National Academy of Science's Committee on the Health Effects of Incineration from 1995 through 1999. I have published extensively regarding the health effects of inhaled air pollutants on humans, particularly as it relates to asthma attacks, hospital admissions, and mortality, in prominent scientific journals, such as Science, Lancet, Thorax, and The Journal of the American Medical Association (JAMA). I have also been called upon by both the U.S. House of Representatives and the U.S. Senate on multiple occasions in recent decades to provide testimony before them regarding the human health effects of air pollution, most recently on October 10, 2010. A statement of my qualifications is attached to my affidavit as Exhibit T-1.

SUMMARY OF REPORT

The purpose of this report is to document the adverse human health effects that are associated with exposures to air pollutants from fossil fuel-fired utility power plants generally, and in particular, the adverse human health effects that will be avoided by the application of EPA's proposed sulfur dioxide (SO_2) emission limits for 18 individual electric generating units (EGU) at nine power plants in Texas.

This report documents how emissions from these 18 EGUs contribute to the serious and well-documented adverse human health effects known to be associated with exposure to air pollution from fossil fuel-fired power plants. The documentation I present confirms this conclusion, including both epidemiological and toxicological evidence that I and others have published in the medical and scientific literature. In this work, I also rely upon the expert report submitted by Dr. Gray. Applying this information to the U.S. EPA approved Environmental

Benefits Mapping and Analysis Program (BenMAP) model, I then provide calculations of the excess adverse human health impacts that would occur each year if EPA's proposed BART controls for these 18 Texas EGUs are not installed, as well as the annual economic valuation of those health impacts across 14 states.[1]

BACKGROUND

The adverse health consequences of breathing air pollution from sources such as fossil-fuel fired utility power plants are well documented in the published medical and scientific literature. During the past decades, medical research examining air pollution and public health has shown that air pollution is associated with a host of serious adverse human health effects. This documentation includes impacts revealed by observational epidemiology, and confirmed by controlled chamber exposures, showing consistent associations between air pollution and adverse impacts across a wide range of human health outcomes.

Observational epidemiology studies provide the most compelling and consistent evidence of the adverse effects of air pollution. "Epidemiology" is literally "the study of epidemics," but includes all statistical investigations of human health and potentially causal factors of good or ill health. In the case of air pollution, such studies follow people as they undergo varying real-life exposures to pollution over time, or from one place to another, and then statistically inter-compare the health impacts that occur in these populations when higher (versus lower) exposures to pollution are experienced. In such studies, risks are often reported in terms of a Relative Risk (RR) of illness, wherein a RR =1.0 is an indication of no change in risk after exposure, while a RR>1.0 indicates an increase in health problems after pollution exposure, and that air pollution is damaging to health.

These epidemiological investigations are of two types: 1) population-based studies, in which an entire city's population might be considered in the analysis; and 2) cohort studies, in which selected individuals, such as a group of asthmatics, are considered. Both of these types of

[1] In April 2015, I prepared a separate report documenting the human health benefits across ten states resulting from EPA's proposed sulfur dioxide emission reductions at 14 Texas EGUs. *See* U.S. Environmental Protection Agency, Approval and Promulgation of Implementation Plans; Texas and Oklahoma; Regional Haze State Implementation Plans; Interstate Transport State Implementation Plan To Address Pollution Affecting Visibility and Regional Haze; Federal Implementation Plan for Regional Haze and Interstate Transport of Pollution Affecting Visibility; Proposed Rule, 79 Fed. Reg. 74,818 (Dec. 16, 2014), EPA Docket No. EPA-R06-OAR-2014-0754-0070.

epidemiologic studies have shown confirmatory associations between air pollution exposures and increasing numbers of adverse impacts, including:

- decreased lung function (a measure of our ability to breathe freely);
- more frequent asthma symptoms;
- increased numbers of asthma and heart attacks;
- more frequent emergency department visits;
- additional hospital admissions; and
- increased numbers of deaths.

The fact that the effects of air pollution have been shown so consistently for so many health endpoints, and in so many locales, indicates these associations to be causal.

Fine Particulate Matter (PM) is among the key air pollutants emitted from power plants that have been revealed by research to adversely affect human health. These research studies have been conducted for a wide array of geographic areas, including eastern North America. $PM_{2.5}$ air pollution has been carefully studied in recent decades. PM is composed of two major components: "primary" particles, or soot, emitted directly into the atmosphere by pollution sources, and; "secondary" particulate matter, formed in the atmosphere from gaseous pollutants, such as the sulfur oxides (SOx) and nitrogen oxides (NOx) also emitted by coal-fired power plants. After formation in the atmosphere, this secondary PM largely condenses upon the smallest existing primary particles that, collectively, represent the greatest surface area for the secondary PM to condense upon. These particles are very small, commonly having an aerodynamic diameter of less that 1.0 micrometer (*u*m) – a fraction of the diameter of a human hair. For example, after it is released from a smokestack, gaseous SOx is chemically converted in the atmosphere to become sulfate PM.

In addition to lung damage, recent epidemiological and toxicological studies of PM air pollution have shown adverse effects on the heart, including an increased risk of heart attacks. For example, when PM stresses the lung (*e.g.*, by inducing edema), it places extra burden on the heart, which can induce fatal complications for persons with cardiac problems. Indeed, for example, Peters et al. (2001) found that elevated concentrations of fine particles in the air can elevate the risk of Myocardial Infarctions (MI's) within a few hours, and extending 1 day after PM exposure. The Harvard University team found that a 48 percent increase in the risk of MI was associated with an increase of 25 ug/m^3 $PM_{2.5}$ during a 2-hour period before the onset of MI, and a 69 percent increase in risk to be related to an increase of 20 ug/m^3 $PM_{2.5}$ in the 24-hour average 1 day before the MI onset (Peters et al., 2001). Numerous other U.S. studies have also shown qualitatively consistent acute cardiac effects, such as the Sullivan et al. (2005) study of acute myocardial infarctions in King County, Washington; the Zanobetti and Schwartz (2006) study of hospital admissions through emergency departments for myocardial infarction (ICD-9 code 410); and the Zanobetti et al. (2009) study that examined the relationship between daily $PM_{2.5}$ concentrations and emergency hospital admissions for cardiovascular causes, myocardial infarction, and congestive heart failure in 26 U.S. communities during 2000-2003.

Cardiac effects at the biological level have also been documented in both animal and human studies. Animal experiments at Harvard University by Godleski et al. (1996, 2000) indicate that exposures to elevated concentrations of ambient PM can result in cardiac related problems in dogs that had been pre-treated (in order to try to simulate sensitive individuals) to induce coronary occlusion (i.e., narrowed arteries in the heart) before exposing them to air pollution. The most biologically and clinically significant finding was that, in these dogs, the PM affected one of the major electrocardiogram (ECG) markers of heart attacks (myocardial ischemia) in humans, known as elevation of the ST segment. Cardiac effects at the biological level have been found in human studies, as well. For example, Pope et al. (1999) and Gold et al. (1999) found that PM exposure is associated with changes in human heart rate variability. Such changes in heart rate variability (HRV) may reflect changes in cardiac autonomic function and risk of sudden cardiac death. In the Pope et al. study, repeated ambulatory ECG monitoring was conducted on 7 subjects for a total of 29 person-days before, during, and after episodes of elevated pollution. After controlling for differences across patients, elevated particulate levels were found to be associated with (1) increased mean heart rate, (2) decreased SDNN, a measure of overall HRV, (3) decreased SDANN, a measure that corresponds to ultra-low frequency variability, and (4) increased r-MSSD, a measure that corresponds to high-frequency variability. This confirms, at the individual level, that biological changes do occur in heart function as a result of PM exposure, supporting the biological plausibility of the epidemiological associations between PM exposure and cardiac illnesses.

Epidemiologic research conducted on U.S. residents has indicated that acute exposure to PM air pollution is associated with increased risk of mortality. A nationwide time-series statistical analysis by the Health Effects Institute (HEI, 2003) of mortality and PM_{10} air pollution in 90 cities across the US indicates that, for each increase of 10 ug/m^3 in daily PM_{10} air pollution concentration, there is an associated increase of approximately 0.3% in the *daily* risk of death. While a 0.3 % change in the daily death risk may seem small, it is important to realize that such added risks apply to the entire population, and accumulate day after day, week after week, and year after year, until they account for thousands of needless daily deaths from air pollution in the U.S. each year. Indeed, I concur with the most recent U.S. EPA Particulate Matter Integrated Science Assessment (ISA) (USEPA, 2009), which unequivocally states that "Together, the collective evidence from epidemiologic, controlled human exposure, and toxicological studies is sufficient to conclude that *a causal relationship exists between short term exposures to* $PM_{2.5}$ *and cardiovascular effects . . . and mortality.*"[2]

In addition to the acute health effects associated with daily PM pollution, the long-term exposure to fine PM is also associated with increased lifetime risk of death and has been estimated to take years from the life expectancy of people living in the most polluted cities, relative to those living in cleaner cities. For example, in the Six-Cities Study (which was one key basis for the setting of the original $PM_{2.5}$ annual standard in 1997), Dockery et al. (1993) analyzed survival probabilities among 8,111 adults living in six cities in the central and eastern portions of the United States during the 1970's and 80's. The cities were: Portage, WI (P); Topeka, KS (T); a section of St. Louis, MO (L); Steubenville, OH (S); Watertown, MA (M); and Kingston-Harriman, TN (K). Air quality was averaged over the period of study in order to study long-term (chronic) effects. As shown in Figure 1, it was found that the long-term risk of death, relative to the cleanest city, increased with fine particle exposure, even after correcting for potentially confounding factors such as age, sex, race, smoking, etc.

In addition, a study that I wrote with co-authors, published in the Journal of the American Medical Association (JAMA), shows that long-term exposure to combustion-related fine particulate air pollution is an important environmental risk factor for cardiopulmonary and lung cancer mortality. Indeed, as shown in Figure 2, this study indicates that the increase in risk of lung cancer from long-term exposure to $PM_{2.5}$ in a city like New York was of roughly the same size as the increase in lung cancer risk of a non-smoker who breathes passive smoke while living with a smoker, or about a 20% increase in lung cancer risk. *See* Pope, CA, et al., 2002.

[2] U.S. Environmental Protection Agency (2009a) (emphasis added).

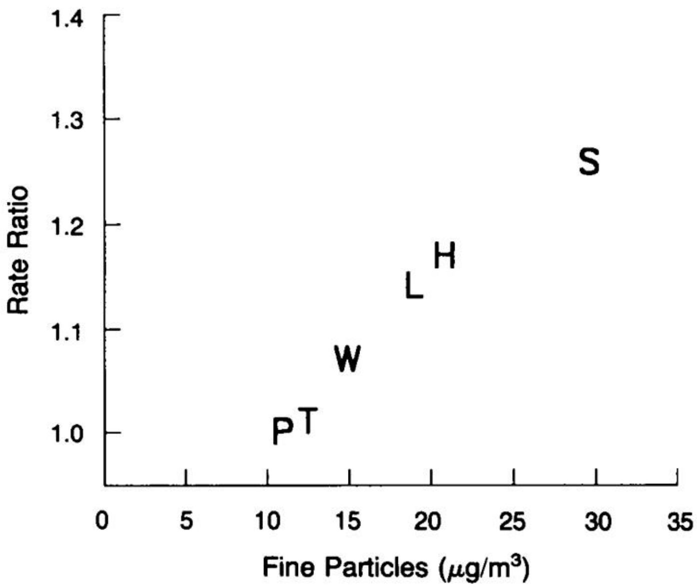

Figure 1. The Harvard Six-Cities Study showed that the lifetime risk of death increased across 6 U.S. cities as the average fine PM levels increased. (Source: Dockery et al., 1993).

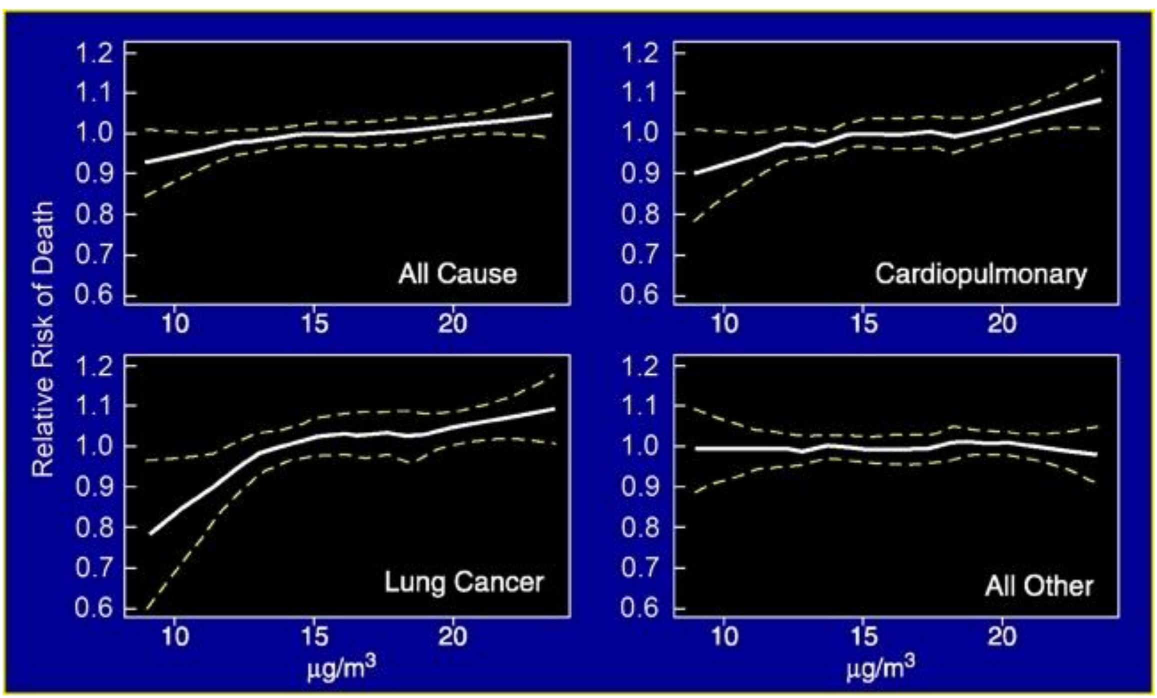

Figure 2. Cardiopulmonary and lung cancer mortality risks increase monotonically with exposure to long-term fine PM (adapted from: Pope, Burnett, Thun, Calle, Krewski, Ito, and Thurston, 2002)

Most studies evaluate whether rising air pollution levels worsen health, but it has also been shown that reducing pollution in the air can result in health benefits to the public. For example, Pope (1989) conducted a compelling study clearly showing that, when pollution levels diminish, the health of the general public improves. He investigated a period during the winter of 1986-87 when the Geneva Steel mill in the Utah Valley shut down during a strike. The PM levels dropped dramatically in that strike-year winter, as opposed to the winters preceding and following when the steel mill was in operation. As shown in Figure 3 below, hospital admissions in the valley showed the same pattern as the PM air pollution, decreasing dramatically during the strike. As a control, Pope also examined the pollution and hospital admissions records in nearby Cache Valley, where the mill's pollution was not a factor, and no such drop in respiratory admissions was seen, showing that the drop in admissions in the Utah Valley was not due to some cause other than the reduction in the air pollution levels.

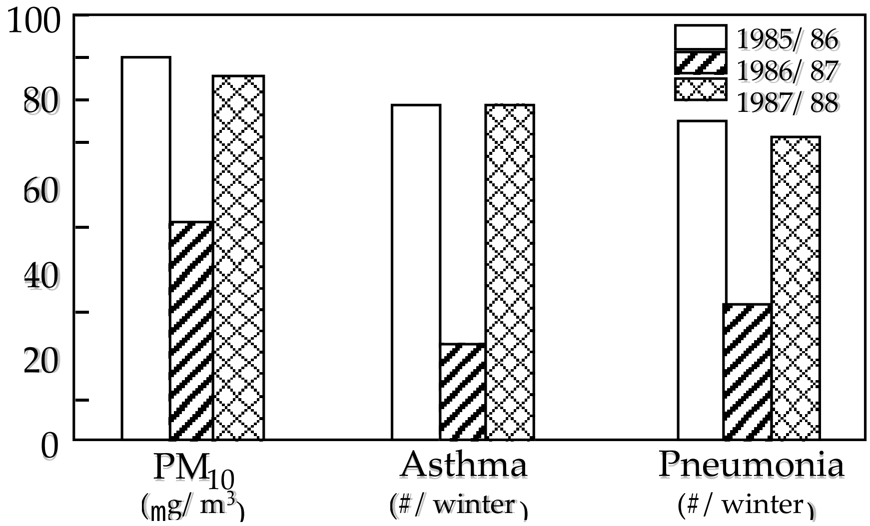

Figure 3. Decreasing PM pollution lowered the number of children's hospital admissions (Source: Pope, 1989).

These studies of the health improvements associated with decreases in $PM_{2.5}$ pollution show that any reduction can be expected to result in commensurate health benefits to the public at ambient levels, even where the National Ambient Air Quality Standards (NAAQS) are already met. A follow-up analysis of the Harvard Six-Cities Study cohort discussed earlier (Dockery et al., 1993), published in the March 15, 2006 issue of The American Journal of Respiratory and Critical Care Medicine (Laden et al., 2006), shows that mortality is decreased by lowering PM pollution. This study was carried out in the same six metropolitan areas evaluated in the earlier study, study participants' ages ranged from 25 to 74 at enrollment in 1974, and the scientists tracked both PM air pollution and mortality through 1998 in these populations. The Laden study found that improved overall mortality (i.e., a risk ratio significantly below 1.0) was associated with decreased mean $PM_{2.5}$ over the study follow-up time (RR = 0.73; 95% per 10 μg/m^3, CI = 0.57-0.95). In other words, for each decrease of 1 μg/m^3 of $PM_{2.5}$, the overall death rate from causes such as cardiovascular disease, respiratory illness and lung cancer decreased by nearly 3% (i.e., 10 μg/m^3 x 2.7% = 27% decrease, or RR=0.73). The study also found that people who are exposed to lower pollution live longer than they would if they were exposed to higher pollution. Francine Laden, the study's lead author, explained its key findings in the March 21, 2006 issue of the New York Times: "For the most part, pollution levels are lower in this country than they were in the 70's and 80's," and "the message here is that if you continue to decrease them, you will save more lives."[3] "Consistently," Dr. Laden said, "in the cities where there was the most cleanup, there was also the greatest decrease in risk of death."

Although the Laden study took place in urbanized areas, the same principle can be applied in more rural areas where the air is more pristine: higher concentrations of $PM_{2.5}$, even at very low overall levels, are associated with greater health risks. Indeed, a more recent Canadian national-level cohort study, Crouse et al. (2012), has shown that the adverse effects of air pollution extend down to very low levels of $PM_{2.5}$. These investigators calculated hazard ratios (i.e., risk ratios) and 95% confidence intervals (CIs), adjusted for available individual-level and contextual covariates, finding a relative risk (or hazard ratio) of 1.30 (95% CI: 1.18, 1.43) for cardiovascular mortality from Cox proportional hazards survival models with spatial random-effects. Figure 4, taken from the Crouse study, illustrates the finding that mortality risk decreases with decreasing levels of $PM_{2.5}$, even at ambient $PM_{2.5}$ levels down to 1 μg/m^3.

[3] Nicholas Bakalar, *Cleaner Air Brings Drop in Death Rate*, New York Times (Mar. 21, 2006), pg F7.

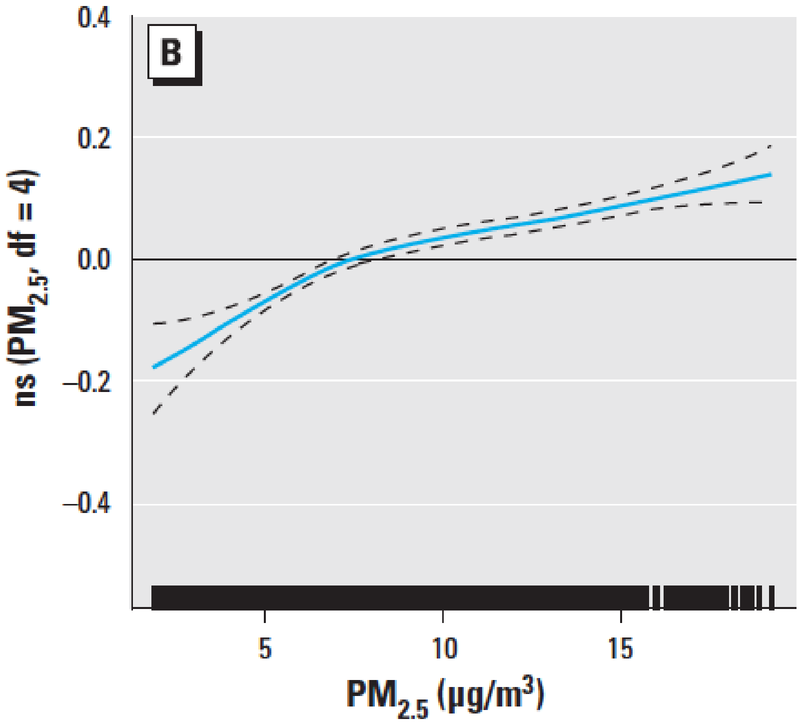

Figure 4. Cardiovascular Mortality Risk vs. $PM_{2.5}$ exposure (solid line) and 95% CIs (dashed lines), showing increasing risk of death with increasing $PM_{2.5}$, even at very low ambient levels of $PM_{2.5}$ air pollution (from Crouse et al., 2012).

Similarly, my own research has verified (as shown in Figure 5) that the association between $PM_{2.5}$ air pollution and cardiovascular mortality extends down to very low $PM_{2.5}$ concentration levels in the US as well (Thurston et al, 2016). Importantly, this study is highly regarded, as it was conducted in a well characterized and large US population: the National Institutes of Health – American Assoiation of Retired Persons (NIH-AARP) Diet and Health Study cohort. The NIH-AARP Study was initiated when members of the AARP, aged 50 to 71 years from 6 US states (California, Florida, Louisiana, New Jersey, North Carolina, and Pennsylvania) and 2 metropolitan areas (Atlanta, Georgia, and Detroit, Michigan), responded to a mailed questionnaire in 1995 and 1996. The NIH-AARP cohort questionnaires elicited information on demographic and anthropometric characteristics, dietary intake, and numerous health-related variables (e.g., marital status, body mass index, education, race, smoking status, physical activity, and alcohol consumption), that was used to control for these factors in the air pollution mortality impact assessment.

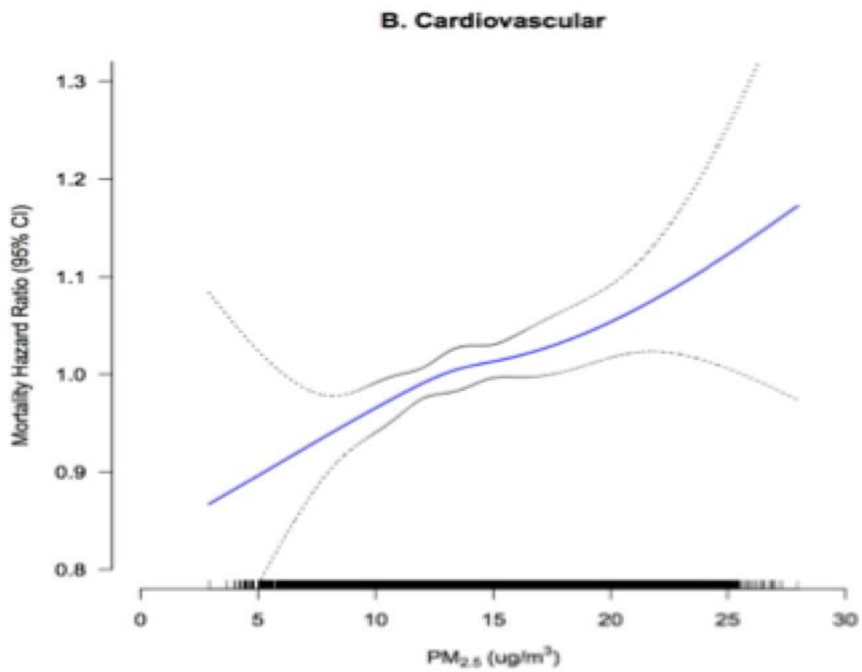

Figure 5. Mortality Risk from Cardiovascular Disease Increases with Rising PM2.5 Exposure, Even Well Below the Present US Ambient Air Quality Standard annual limit for PM2.5 (12 µg/m3). Thurston *et al*., 2016a.

Although published too late to be considered by the U.S. EPA in their 2013 standard setting process, the Crouse et al. (2012) and Thurston et al. (2016a) results indicate that the mortality effects of $PM_{2.5}$ air pollution can occur at even lower ambient air pollution levels than shown by Pope et al. 2002, and even lower levels than that at which the U.S. EPA assumed the effects of $PM_{2.5}$ to exist in its 2012 Regulatory Impact Assessment for the revised annual PM NAAQS (U.S. EPA, 2012). These results confirm that, even in places where background air is relatively clean, small changes in air pollution concentration can have population health impacts.

As these studies show, there is no convincing evidence to date showing that there is any threshold below which such adverse effects of PM air pollution will not occur. This lack of a threshold of effects indicates that any reduction in air pollution can be expected to result in commensurate health benefits to the public at ambient levels.

With respect to $PM_{2.5}$ from power plants, my recent studies, and those by others, have also found that long-term exposure to combustion-related fine particulate air pollution is a particularly important environmental risk factor for cardiopulmonary and lung cancer mortality. Air pollutants associated with fossil fuel combustion (e.g., from oil, coal, and natural-gas-fired power plants) have well-documented adverse human health effects. The health impact is particularly high for particulate matter from fossil-fuel-burning facilities, such as coal burning, which has been associated with an ischemic heart disease mortality risk that is roughly five times that of the average for $PM_{2.5}$ particles in general (Thurston *et al.*, 2016b), and more damaging per $\mu g/m^3$ than $PM_{2.5}$ from other common sources (Figure 6).

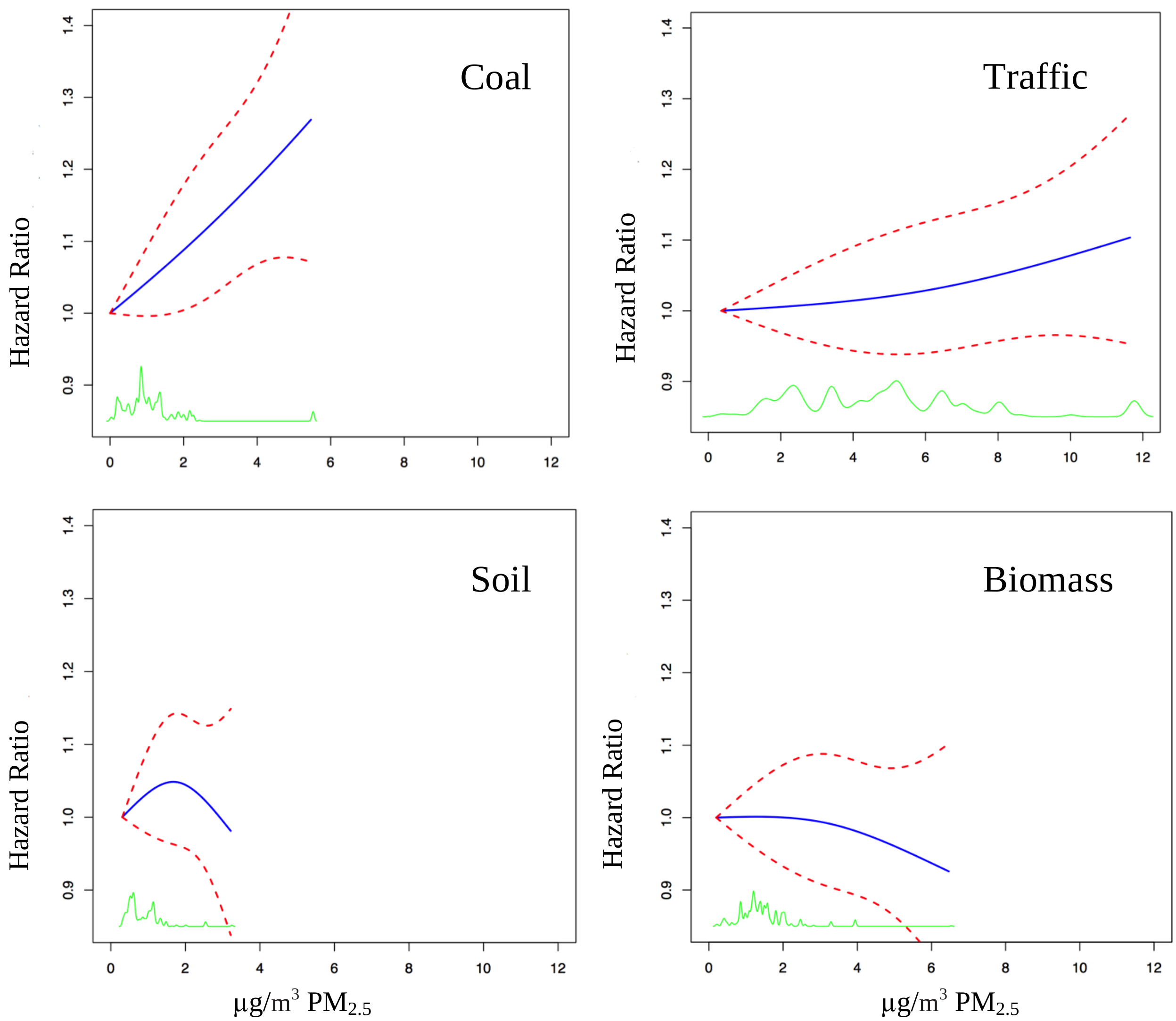

Figure 6. Concentration-response curve (solid lines) and 95% confidence intervals (dashed lines) for source-specific $PM_{2.5}$ mass in the US American Cancer Society (ACS) Cohort. (Thurston et al., 2016b).

Thus, this new study, combined with past studies of US mortality and source-specific $PM_{2.5}$ (e.g., Ozkaynak and Thurston, 1987) indicate that the estimates provided here are conservative underestimates of the health benefits that would result from these proposed emissions controls, because the particles resulting from coal-combustion that will be eliminated are apparently far more toxic to human health than the average $PM_{2.5}$ mass, when considered on per $\mu g/m^3$ mass basis. Thus, by assuming in this report that the toxicity of the particles controlled are the of same toxicity as other particles (including, for example, wind blown soil), the estimates provided for the numbers and monetary valuations of the human health benefits of the BART controls are very conservative.

Sulfur oxide (SOx) exposures have also been associated with adverse health effects, in addition to leading to the secondary formation of $PM_{2.5}$ in the atmosphere. As concluded in the most recent U.S. EPA Risk and Exposure Assessment Report for SO_2 (EPA-452/R-09-007), research studies have provided scientific evidence that is sufficient to infer a similar relationship to also exist between short-term (e.g., daily) SO_2 exposure and adverse effects on the respiratory system. This finding of a causal relationship between SO_2 exposure and increased respiratory morbidity is supported by a large body of recent epidemiologic evidence, as well as by findings from human and animal experimental studies. These epidemiologic and experimental studies encompass a number of endpoints, including ED visits and hospitalizations, respiratory symptoms, airway hyperresponsiveness, and lung function (U.S. EPA, 2009).

Overall, there is a consistency between the epidemiologic study associations and experimental study results, supporting the conclusion that 1) there is indeed a cause-effect relationship between air pollution and negative health effects; and, 2) there is no known threshold below which no effects are experienced. Thus, reductions in air pollution result in commensurate improvements in public health, as provided in this report.

METHODS

The U.S. EPA-approved Environmental Benefits Mapping and Analysis Program (BenMAP) is a Windows-based computer program that uses a Geographic Information System (GIS)-based method to estimate the health impacts and economic benefits occurring when populations experience changes in air quality (Abt Associates, 2010; U.S. EPA, 2015). Analysts have relied upon BenMAP to estimate the health impacts from air quality changes at the city and regional scale, both within and beyond the U.S. A copy of my BenMAP certification is attached as Exhibit T-2. Some of the purposes for which BenMAP has been used include the following:

- Generation of population/community level ambient pollution exposure maps;
- Comparison of benefits across multiple regulatory programs;
- Estimation of health impacts associated with exposure to existing air pollution concentrations;
- Estimation of health benefits of alternative ambient air quality standards.

BenMAP is primarily intended as a tool for estimating the health impacts, and associated economic values, associated with changes in ambient air pollution, as we apply it here. It accomplishes this by computing health impact functions that relate a change in the concentration of a pollutant with a change in the incidence of a health endpoint.

Inputs to health impact functions in this work included:

- The change in ambient air pollution level (as provided by Dr. Andrew Gray, of Gray Sky Solutions);
- Pollutant health effect estimates (based upon the scientific literature and present EPA practice);
- The exposed population, on a county basis, as provided in the BenMAP model; and,
- The baseline incidence rate of the health endpoint, on a county basis, as provided in the BenMAP model.

For example, in the case of a premature mortality health impact function, the BenMAP calculation can be represented, in a simplified form, as:

Mortality Change = (Air Pollution Change) * (Air Pollution Mortality Effect Estimate) * (Mortality Incidence)* (Exposed Population)

- **Air Pollution Change**. The air quality change is calculated as the difference between the starting air pollution level, also called the baseline, and the air pollution level after some change, such as that caused by a regulation. In the case of particulate matter, this is typically estimated in micrograms per meter cubed (µg/m^3). In this analysis, these concentrations were provided on a county-by-county population weighted centroid basis.

- **Mortality Effect Estimate**. The mortality effect estimate is an estimate of the percentage change in mortality due to a one unit change in ambient air pollution. Epidemiological studies provide a good source for effect estimates.[4] In this Report, since the choice of mortality effect study has such a large influence on the valuation of the adverse health impacts avoided by applying EPA's proposed emission limits, I have presented (in Table 1) several BenMAP estimates for the mortality effect estimate, ranging from the lower end of estimates (Krewski et al., 2009), the higher end (Laden et al, 2007), and an intermediate estimate (Lepeule et. al, 2012). However, for breakdowns in adverse effects, in order to show the distribution of the effects benefits of EPA's proposed BART controls (e.g., between states, power plants, or metropolitan areas, as in Tables 2-4), I present results using only the low mortality effect estimate (Krewski et al, 2009) to simplify comparisons. This conservative (lowest benefit estimate) choice of the ACS Cohort studies to evaluate mortality benefits of EPA's proposed emissions reductions is consistent with the estimate used by EPA in the agency's prior nationwide analysis of the health benefits of Best Available Retrofit Technology determinations under the Regional Haze Regulations.[5] This choice of a specific mortality study does not affect the *relative* comparisons between states, power plants, etc., which would remain the same irrespective of mortality effect estimate choice. It should be noted that, if I instead used the higher mortality per µg/m^3 $PM_{2.5}$ effect estimates from the other two studies in Table 1 (which are also scientifically supportable), the dollar valuation of health benefit estimates in Tables 2 thru 4 would be approximately 2.2 times higher using the Lepeul et al. study mortality effect estimate, or approximately 2.8 times higher using the Laden et al. study mortality effect estimate, across the board. However, the ratios of the *relative* impacts across categories would be unaffected by the choice of mortality

[4] When multiple epidemiological studies are available in BenMAP for a health outcome, multi-study pooled estimates have been made, following recent EPA practice (e.g., USEPA, 2012), and as delineated in Table 1.

[5] EPA, Regulatory Impact Analyis for Final Clean Air Visibility Rule of the Guidelines for Best Available Retrofit Technology (BART) Determinations Under the Regional Haze Regulations, EPA-452/R-05-004 (June 2005), *available at* http://www.epa.gov/oar/visibility/pdfs/bart_ria_2005_6_15.pdf.

impact study effect estimate.

• **Mortality Incidence**. The mortality incidence rate is an estimate of the average number of people that die in a given population over a given period of time, as provided in BenMAP. For example, the mortality incidence rate might be the probability that a person will die in a given year.

• **Exposed Population**. The exposed population is the number of people affected by the air pollution reductions required under EPA's BART proposal, based on Census data for each county within BenMAP.

For this work, population-weighted centroid $PM_{2.5}$ concentration impacts from each source in each county in the fourteen study states (Alabama, Arkansas, Colorado, Illinois, Indiana, Kansas, Kentucky, Louisiana, Mississippi, Missouri, New Mexico, Oklahoma, Tennessee, and Texas) were determined by Andrew Gray for the (1) existing emissions; and (2) controlled emissions scenarios based on EPA's BART Proposal, respectively. *See* Gray, Visibility and Health Modeling, Technical Support Document to Comments of Conservation Organizations (May 5, 2017), EPA Docket No. EPA-R06-OAR-2016-0611. The arithmetic difference between the two scenario results were calculated (on a plant-by-plant and county-by-county basis) as the concentration reduction associated with the BART controls, for each plant and county in the study area modeled by Dr. Gray. As outlined in more detail by Dr. Gray in his report, CALPUFF air dispersion modeling was used to estimate long-term (three-year modeled average) fine PM concentrations at the 837 county receptors within the CALPUFF modeling domain for both the 2001-2004 emissions baseline and for the proposed BART control emission scenario. Postprocessing of the CALPUFF results was performed to sum the modeled sulfate, nitrate, and PM2.5 at each receptor in order to estimate the total fine PM concentration at each receptor, as contributed by each source, under both baseline and the control scenarios.] These values were entered into BenMAP to estimate the health benefits, and their dollar valuations, associated with EPA's BART controls on a county-by-county basis for each of nine electrical generating power plant sources. The results for the nine power plants proposed for BART control by the EPA were then summed on a cumulative basis (Table 1, with both numbers and valuations, by cause). Furthermore, to allow an indication of the plant-by-plant and spatial distribution of the health and economic benefits from EPA's BART proposal, the health benefit valuations (summed over all causes, as dollars) were also calculated on a state-by-state (Table 2), plant-by-plant (Table 3), and metropolitan area-specific (Table 4) basis, providing insight into the relative health impacts by specific sources to specific areas benefitting from the pollution control FIP. The Appendix to this report provides a complete breakdown of the annual health benefits associated with the application of EPA's proposed emission limits by individual power plant and health effect.

RESULTS

Using the above-described EPA BenMAP methodology-based analysis, I conservatively estimate the total public health-based economic benefits associated with reductions in ambient $PM_{2.5}$ concentrations as a result of applying EPA's BART control determinations to the 18 individual Texas EGUs (as displayed in Table 1 for all nine electric generating stations, and all states considered, combined) to be between roughly $6.7 billion and nearly $17 billion per year, overall, primarily depending on the epidemiological study used to determine the $PM_{2.5}$ mortality impacts (*i.e.*, Krewski et al. (low), Lapieule et al. (mid), or Laden et al. (high)). These impacts reflect the range of potential mortality effects associated with the proposed EPA FIP, depending on the particular study used to estimate the effect per $\mu g/m^3$ $PM_{2.5}$ exposure. Further breakdowns of Table 1's estimates using only the Krewski et al. study (*i.e.*, the low mortality effect estimate) to estimate total mortality impacts are provided in Tables 2 through 4 of this report: *i*) by electric generating power plant (i.e., for each of the nine power plants over all areas modeled by Dr. Gray); *ii*) for all power plant generating unit impacts collectively by State of impact (i.e., in Alabama, Arkansas, Colorado, Illinois, Indiana, Kansas, Kentucky, Louisiana, Mississippi, Missouri, New Mexico, Oklahoma, Tennessee, and Texas); and, *iii*) for all power plant generating unit impacts collectively by major metropolitan impact area.

As seen in Table 1, the numbers of adverse health events avoided by application of EPA's proposed SO_2 emission limits are dominated by the morbidity events, such as respiratory symptoms, restricted activity days, and work loss days. In contrast, the dollar valuation of the adverse health events are largely dominated, as would be expected, by the more severe health outcomes, including myocardial infarctions (heart attacks), chronic bronchitis, and (especially) deaths. As shown in Table 2, on a state-by-state basis, the largest health benefits go to the state in which the power plants are operating (Texas), but, because this pollution can be carried so far downwind, nearly one half of the health benefits would accrue in other (downwind) states. On a power plant basis (Table 3), it is seen that large health benefits are derived from controlling each the nine plants EPA proposes to regulate under this FIP, with the greatest benefits being derived from controlling the Big Brown, Martin Lake, and Monticello plants. Table 4 makes clear that urban areas in Texas would receive the largest health benefits from the proposed BART emission controls at these generating stations, but that the benefits stretch long distances downwind, with still very large health benefits in cities as far away as Illinois.

Table 1. Annual Multi-State Human Health Effects and Monetary Valuations Associated With the $PM_{2.5}$ Air Pollution Avoided by Applying EPA's Proposed BART Controls for Texas Sources

Health Endpoint	**Expected Number Per Year Avoided***	**Total Dollar Valuation (2010$)****
Respiratory Hospital Admissions (Kloog et al., 2012; Zanobetti et al., 2009)	125[a]	$3,966,000
Cardiovascular Hospital Admissions (Bell et al., 2008; Peng et al., 2008; Peng et al., 2009; Zanobetti et al., 2009)	125[a]	$4,733,000
Acute Bronchitis (Dockery et al., 1996)	1317	$633,000
Acute Myocardial Infarction, Nonfatal (Pope et al., 2006; Sullivan et al., 2005; Zanobetti et al., 2009; Zanobetti & Schwartz, 2006)	80[b]	$10,094,000[a]
Emergency Room Visits (Glad et al., 2012; Mar et al., 2010; Slaughter et al., 2005)	381[b]	$162,000[a]
Asthma Exacerbation Symptoms (Mar et al., 2004; Ostro et al., 2001)	24,818[b]	$1,434,000
Upper Respiratory Symptoms (Pope et al., 1991)	23,915	$795,000
Lower Respiratory Symptoms (Schwartz and Neas, 2000)	16,767	$352,000
Minor Restricted Activity Days (Ostro & Rothschild, 1989)	625,525	$42,754,000
Work Days Lost (Ostro et al., 1987)	105,853	$15,803,000
Chronic Bronchitis (Abbey et al., 1995)	521	$147,152,000[c]
Mortality, All Causes (Krewski et. al, 2009)	678	$6,518,235,000
Mortality, All Causes (Lepeule et. al, 2012)	1541	$14,823,929,000
Mortality, All Causes (Laden et al., 2007)	1760	$16,921,843,000

* Rounded to nearest whole number.

** Rounded to nearest $1000.

a Pooled effects with averaging approach, as per EPA BenMAP default setting.

b Pooled effects with random/fixed effects approach, as per EPA BenMAP default setting.

c Pooled effects with summation approach, as per EPA BenMAP default setting.

Table 2. State-By State Total Valuation of Annual Health Benefits of EPA Proposed BART Controls Applied to the Nine Power Plants At Issue* (Applying Krewski et al., 2009 for mortality)

State	Total Dollar Valuation (2010$)**
AL	$57,080,000
AR	$522,356,000
CO	$5,564,000
IL	$46,516,000
IN	$12,432,000
KS	$152,556,000
KY	$35,415,000
LA	$492,830,000
MS	$241,108,000
MO	$324,832,000
NM	$38,796,000
OK	$771,304,000
TN	$149,283,000
TX	$3,896,042,000
Total	$6,746,113,000

* Big Brown, Coleto Creek, Fayette, Harrington, JT Deely, Martin Lake, Monticello, Parish, and Welsh.
** Rounded to nearest $1000.

Table 3. Plant-By Plant Total Valuation of Annual Health Benefits of EPA Proposed BART Controls (Applying Krewski et al., 2009 for mortality)

Electric Generating Station	Total Dollar Valuation (2010$)*
Big Brown	$1,617,952,000
Coleto Creek	$261,901,000
Fayette	$495,331,000
Harrington	$153,627,000
JT Deely	$508,409,021
Martin Lake	$1,135,234,000
Monticello	$1,553,080,000
Parish	$816,736,000
Welsh	$203,842,000
Total	$6,746,113,000

* Rounded to nearest $1000.

Table 4. Total Valuation of Annual Health Benefits of EPA Proposed BART Controls for Selected Metropolitan Areas (Applying Krewski et al., 2009 for mortality)

City (Counties)	**Total Dollar Valuation All 9 Plants (2010$)***
Austin, TX (Hayes, Travis, Williamson)	$182,849,000
Dallas, TX (Colin, Dallas, Ellis, Rockwall)	$623,296,000
Ft. Worth, TX (Johnson, Tarrant)	$369,004,000
Houston, TX (Brazoria, Chambers, Fort Bend, Galveston, Harris)	$606,467,000
San Antonio, TX (Bexar, Comal, Guadalupe)	$325,461,000
Little Rock, AR (Lonoke, Pulaski, Saline)	$90,863,000
Kansas City, KS (Johnson, Wyandotte, Cass, Clay, Jackson, Platte)	$6,670,000
New Orleans, LA (Jefferson, Orleans, Plaguemines, St. Bernard, St. Charles, St. John the Baptist)	$56,435,000
Jackson, MS (Hinds, Madison, Rankin)	$39,942000
Oklahoma City, OK (Canadian, Cleveland, Logan, Oklahoma)	$185,587,000
Tulsa, OK (Creek, Osage, Tulsa, Wagoner)	$156,516,000
Nashville, TN (Davidson, Fsumner, Williamson, Wilson	$2,911,000

* Rounded to nearest $1000.

In addition to reflecting a conservative (i.e., low) mortality effects estimate, these overall health impact counts and their dollar valuations are conservative estimates of the health benefits after the application of the proposed BART controls at the affected power plant units for a number of reasons, including: (a) additional health impacts not modeled in this analysis attributable to co-reductions in other pollutants (*e.g.*, gaseous SO_2) are not included here; (b) consideration of health impacts only for the ages of the exposed populations that were considered in the epidemiological studies on which these analyses were based; (c) there are either no health impact studies or no dollar valuation available for many health outcomes thought to be adversely affected by air pollution, such as effects of air pollution on birth outcomes; and (d) in Tables 2-4 we have applied the low estimate of the mortality benefits (whereas applying the other two studies noted would roughly double or triple the estimates in Tables 2-4, respectively) . Thus, while all air pollution control costs associated with application of EPA's proposed BART controls can be estimated, these estimates of the health benefits and their monetary valuations are only available for a subset of likely health impacts from air pollution. This, in addition to prior discussion of the likely higher toxicity of particles from coal-fired power plants, means that my analysis is very conservative, and likely underestimates the health and monetary benefits of applying EPA's BART emission limits to the affected Texas power plant units.

CONCLUSIONS

Even applying conservative estimates and assumptions, the health benefits and valuations derived from the application of EPA's BART control determination to the 9 Texas electric generating power plants at issue are substantial. Moreover, these benefits and their valuations accrue each and every year those controls are operational. Accordingly, ten years from the compliance date, the health benefits and valuations of proposed controls will be roughly ten times the values provided in Tables 1 through 4, before adjustment for a discount rate and future affected population growth, as appropriate. Similarly, these benefits and their valuations are lost (not accrued) each and every year that application of the EPA's BART controls are delayed. Thus, even a delay of just a few months carries the risk of substantial, and irreparable, harm to public health. As demonstrated above, those public health impacts have an associated and quantifiable adverse economic impact. Thus, it is reasonable to conclude that any delay implementing EPA's Regional Haze BART controls for Texas will only exacerbate the substantial, and irreparable, harms to public health that have already been incurred to date by the operation of these electric generating units.

LITERATURE CITED

Abbey, D.E., B.E. Ostro, F. Petersen and R.J. Burchette. (1995) Chronic Respiratory Symptoms Associated with Estimated Long-Term Ambient Concentrations of Fine Particulates Less Than 2.5 Microns in Aerodynamic Diameter (PM2.5) and Other Air Pollutants. J Expo Anal Environ Epidemiol. 1995 Apr-Jun;5(2):137-59.

Abt Associates (2010). BenMAP Environmental Benefits Mapping and Analysis Program User's Manual. Prepared for the U.S. EPA Office of Air Quality Planning and Standards, RTP, NC.

Bell, M. L., K. Ebisu, et al. (2008). "Seasonal and Regional Short-term Effects of Fine Particles on Hospital Admissions in 202 US Counties, 1999-2005." American Journal of Epidemiology 168 (11): 1301-1310.

Coffin, D. L., and D. E. Gardner. 1972. Interaction of biological agents and chemical air pollutants. *Ann. Occup. Hyg.* 15:219-35.

Crouse DL, Peters PA, van Donkelaar A, Goldberg MS, Villeneuve PJ, Brion O, Khan S, Atari DO, Jerrett M, Pope CA, Brauer M, Brook JR, Martin RV, Stieb D, Burnett RT. (2012). Risk of Nonaccidental and Cardiovascular Mortality in Relation to Long-term Exposure to Low Concentrations of Fine Particulate Matter: A Canadian National Level Cohort Study. Environ Health Perspect. 2012 May;120(5):708-14.

Dockery DW, Pope CA 3rd, Xu X, Spengler JD, Ware JH, Fay ME, Ferris BG Jr, Speizer FE. (1993). An association between air pollution and mortality in six U.S. cities. N Engl J Med. 1993 Dec 9;329(24):1753-9.

Dockery, D.W., J. Cunningham, A.I. Damokosh, L.M. Neas, J.D. Spengler, P. Koutrakis, J.H. Ware, M. Raizenne and F.E. Speizer. 1996. Health Effects of Acid Aerosols On North American Children - Respiratory Symptoms. Environ Health Perspect. 1996 May;104(5):500-5.

Glad JA, Brink LL, Talbott EO, Lee PC, Xu X, Saul M, Rager J. (2012) The relationship of ambient ozone and PM(2.5) levels and asthma emergency department visits: possible influence of gender and ethnicity. Arch Environ Occup Health. 2012;67(2):103-8.

Godleski, J.J.; Sioutas, C.; Katler, M.; Catalano, P.; and Koutrakis, P. (1996) Death from inhalation of concentrated ambient air particles in animal models of pulmonary disease. *Proceedings of the Second Colloquium on Particulate Air Pollution and Human Health*, May 1-3, 1996, Park City, Utah.

Godleski, JJ. (2000) Mechanisms of Morbidity and Mortality from Exposure to Ambient Air Particles. *Health Effects Institute Research Report 91*, 2000. Health Effects Institute. Cambridge, MA.

Gold DR, Litonjua A, Schwartz J, Lovett E, Larson A, Nearing B, Allen G, Verrier M, Cherry R, Verrier R. (2000). Ambient pollution and heart rate variability. Circulation. Mar 21;101(11): 1267-73.

Health Effects Institute (HEI) (2003). Revised Analyses of Time-Series Studies of Air Pollution and Health. Special Report.Health Effects Institute, Boston MA.

Kloog I, Nordio F, Zanobetti A, Coull BA, Koutrakis P, Schwartz JD. (2014). Short term effects of particle exposure on hospital admissions in the Mid-Atlantic states: a population estimate. PLoS One. 2014 Feb 7;9(2):e88578. doi: 10.1371/journal.pone.0088578. eCollection 2014.

Krewski, D. et al. (2000). Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality: Investigators' Report Part I: Replication and Validation. 2000. Health Effects Institute, Cambridge, MA.

Krewski D., Jerrett M, Burnett R, Ma R, Hughes E, Shi Y, Turner MC, Pope CA III, Thurston G, Calle E, and Thun MJ (2009). Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA

Laden F, Neas LM, Dockery DW, Schwartz J. (2000). Association of fine particulate matter from different sources with daily mortality in six U.S. cities. Environ Health Perspect. 2000 Oct;108(10):941-7.

Laden F, Schwartz J, Speizer FE, Dockery DW. Reduction in Fine Particulate Air Pollution and Mortality: Extended Follow-up of the Harvard Six Cities Study. Am J Respir Crit Care Med. 2006 Mar 15;173(6):667-72.

Lamm SH, Hall TA, Engel A, Rueter FH, White LD. (1994). PM_{10} Particulates: Are they the major determinant of pediatric respiratory admissions in Utah County, Utah (1985-1989) Ann. Occup. Hyg. 38: 969-972, 1994.

Lay JC, Bennett WD, Ghio AJ, Bromberg PA, Costa DL, Kim CS, Koren HS, Devlin RB. (1999). Cellular and biochemical response of the human lung after intrapulmonary instillation of ferric oxide particles. Am J Respir Cell Mol Biol. 1999 Apr;20(4):631-42.

Lepeule J, Laden F, Dockery D, Schwartz J. (2012). Chronic exposure to fine particles and mortality: an extended follow-up of the Harvard Six Cities study from 1974 to 2009. Environ Health Perspect. 2012 Jul;120(7):965-70.

Mar TF, Koenig JQ, and Primomo J. (2010). Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8.

Ministry of Health of Great Britain, (1954) Report on Pub. Health and Med. Subjects: Mortality and Morbidity During the London Fog of December 1952 (Her Majesty's Stationary Office, London).

Moolgavkar, S. H. 2000a. Air Pollution and Hospital Admissions for Chronic Obstructive Pulmonary Disease in Three Metropolitan Areas in the United States. Inhalation Toxicology. Vol. 12 (Supplement 4): 75-90.

Moolgavkar, S. H. 2000b. Air pollution and hospital admissions for diseases of the circulatory system in three U.S. metropolitan areas. J Air Waste Manag Assoc. Vol. 50 (7): 1199-206.

National Research Council (NRC) (1978) *Sulfur oxides.* Committee on Sulfur Oxides, Board on Toxicology and Environmental Health Hazards, Assembly of Life Sciences. Washington, D.C

National Research Council (NRC). (1977). *Airborne Particles*, National Academy of Sciences. Subcommittee on Airborne Particles, Committee on Medical and Biological Effects of Environmental Pollutants. University Park Press, Baltimore.

New York Times (2006). "Cleaner Air Brings Drop in Death Rate." March 21, 2006, pg F7.

Ostro, B.D. (1987). Air Pollution and Morbidity Revisited: A Specification Test. Journal of Environmental Economics and Management. 14: p. 87-98.

Ostro B, and Rothschild S. (1989). Air Pollution and Acute Respiratory Morbidity: An Observational Study of Multiple Pollutants, Environmental Research 50, 238-247.

Ostro, B, Lipsett M, Mann J, Braxton-Owens H, and White M. (2001). Air pollution and exacerbation of asthma in African-American children in Los Angeles. Epidemiology. Vol. 12 (2): 200-8.

Ozkaynak H, Thurston GD. (1987). Associations between 1980 U.S. mortality rates and alternative measures of airborne particle concentration. *Risk Anal.* 1987 Dec;7(4):449-61.

Peng, R. D., H. H. Chang, et al. (2008). "Coarse particulate matter air pollution and hospital admissions for cardiovascular and respiratory diseases among Medicare patients." JAMA 299 (18): 2172-9.

Peng, R. D., M. L. Bell, et al. (2009). "Emergency admissions for cardiovascular and respiratory diseases and the chemical composition of fine particle air pollution." Environ Health Perspect 117 (6): 957-63.

Peters A, Dockery DW, Muller JE, Mittleman MA. (2001). Increased particulate air pollution and the triggering of myocardial infarction. Circulation. 2001 Jun 12;103(23):2810-5.

Pope CA 3rd. (1989). Respiratory disease associated with community air pollution and a steel mill, Utah Valley.Am J Public Health. 1989 May;79(5):623-8.

Pope, C. A., D. W. Dockery, J. D. Spengler and M. E. Raizenne. 1991. Respiratory Health and PM10 Pollution - a Daily Time Series Analysis. American Review of Respiratory Disease. Vol. 144 (3): 668-674.

Pope CA 3rd, Thun MJ, Namboodiri MM, Dockery DW, Evans JS, Speizer FE, Heath CW Jr. (1995). Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. Am J Respir Crit Care Med. 1995 Mar; 151(3 Pt 1): 669-74.

Pope, CA (1996) Particulate pollution and health: A review of the Utah Valley Experience. J. Expos. And Env. Epi. Vol 6: 23-34.

Pope CA 3rd, Verrier RL, Lovett EG, Larson AC, Raizenne ME, Kanner RE, Schwartz J, Villegas GM, Gold DR, Dockery DW. (1999). Heart rate variability associated with particulate air pollution. Am Heart J. 1999 Nov; 138(5 Pt 1):890-9.

Pope, C.A. III, Burnett, R.T., Thun, M.J., Calle, E.E., Krewski, D., Ito, K., and Thurston, G.D. Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution. J. Am. Med. Assoc. (JAMA) 287(9):1132-1141 (2002).

Pope, C. A., 3rd, J. B. Muhlestein, et al. (2006). "Ischemic heart disease events triggered by short-term exposure to fine particulate air pollution." Circulation 114 (23): 2443-8.

Rodriguez, C, Tonkin R, Heyworth J, Kusel M, De Klerk N, Sly P, Franklin P, Runnion T, Blockley A, Landau L & A Hinwood (2007), The relationship between outdoor air quality and respiratory symptoms in young children, International Journal of Environmental Health Research, 17:5, 351-360.

Schwartz, J. and L.M. Neas. 2000. Fine particles are more strongly associated than coarse particles with acute respiratory health effects in schoolchildren. Epidemiology. Vol. 11 (1): 6-10.

Slaughter, J. C., E. Kim, et al. (2005). "Association between particulate matter and emergency room visits, hospital admissions and mortality in Spokane, Washington." J Expo Anal Environ Epidemiol 15(2): 153-9.

State of California (2003). Final Regulation Order for the Rulemaking To Consider Amendments to Regulations for the State Ambient Air Quality Standards for Suspended Particulate Matter and Sulfates. Sacramento, Ca.

Sullivan, J., L. Sheppard, et al. (2005). "Relation between short-term fine-particulate matter exposure and onset of myocardial infarction." Epidemiology 16 (1): 41-8

Thurston GD, Ito K, Kinney PL, Lippmann M. A multi-year study of air pollution and respiratory hospital admissions in three New York State metropolitan areas: results for 1988 and 1989 summers. J Expo Anal Environ Epidemiol. 1992 Oct-Dec;2(4):429-50.

Thurston GD, Lippmann M, Scott MB, Fine JM. (1997). Summertime haze air pollution and children with asthma. Am J Respir Crit Care Med. 1997 Feb;155(2):654-60.

Thurston GD, Ito K, Mar T, Christensen WF, Eatough DJ, Henry RC, Kim E, Laden F, Lall R, Larson TV, Liu H, Neas L, Pinto J, Stölzel M, Suh H, and Hopke, PK. (2005). Workshop on the Source Apportionment of Particulate Matter Health Effects: Inter-Comparison of Results and Implications. Env. Hlth. Perspect.: 113(12):1768-74.

Thurston GD, Ahn J, Cromar K, Shao Y, Reynolds H, Jerrett M, Lim C, Shanley R, Park Y, Hayes RB. (2016a). Ambient Particulate Matter Air Pollution Exposure and Mortality in the NIH-AARP Diet and Health Cohort. Env. Health Persp. 2016 Apr;124(4):484-90. doi: 10.1289/ehp.1509676.

Thurston GD, Burnett RT, Turner MC, Shi Y, Krewski D, Lall R, Ito K, Jerrett M, Gapstur SM, Diver WR, Pope CA. (2016b). Ischemic Heart Disease Mortality and Long-Term Exposure to Source-Related Components of U.S. Fine Particle Air Pollution. Environ Health Perspect. 2016 Jun;124(6):785-94. doi: 10.1289/ehp.1509777.

U.S. EPA (2001). AIR DATA. National Emissions Trends (NET) Database: http://www.epa.gov/air/data/net.html

U.S. EPA. (2004). Fourth External Review Draft of Air Quality Criteria for Particulate Matter (June, 2003). EPA/600/P-99/002aD, Office of Research and Development, Washington, DC.

U.S. EPA. (2004). Air Quality Criteria for Particulate Matter (October, 2004). Final. EPA/600/P-99/002aF, Office of Research and Development, Washington, DC.

U.S. EPA, (2005). Regulatory Impact Analysis for the Final Clean Air Visibility Rule or the Guidelines for Best Available Retrofit Technology (BART) Determinations Under the Regional Haze Regulations, Research Triangle Park, NC, available at: http://www.epa.gov/oar/visibility/pdfs/bart_ria_2005_6_15.pdf

U.S. Environmental Protection Agency (2009a). Integrated Science Assessment for Particulate Matter (Final Report), Washington, DC, EPA/600/R-08/139F, at 2-10, 2-11 (emphasis in original), available at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546

U.S. Environmental Protection Agency (2009b). Risk and Exposure Assessment to Support the Review of the SO2 Primary National Ambient Air Quality Standards. OAQPS. EPA-452/R-09-007. RTP, NC

U.S. Environmental Protection Agency (2012). Regulatory Impact Analysis for the Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter, OAQPS, EPA-452/R-12-003. RTP, NC.

U.S. EPA. (2015). BenMAP Environmental Benefits Mapping and Analysis Program – Community Edition: User's Manual Appendices. Prepared by RTI International. OAQPS, RTP, NC. http://www2.epa.gov/benmap/benmap-community-edition

Veronesi B, Oortgiesen M, Carter JD, Devlin RB. (1999). Particulate matter initiates inflammatory cytokine release by activation of capsaicin and acid receptors in a human bronchial epithelial cell line. Toxicol Appl Pharmacol. 1999 Jan 1;154(1):106-15.

Wilson WE, Mage DT, Grant LD. (2000). Estimating separately personal exposure to ambient and nonambient particulate matter for epidemiology and risk assessment: why and how. J Air Waste Manag. Assoc. Jul;50(7):1167-83.

Woodruff, T. J., J. Grillo and K. C. Schoendorf. 1997. The relationship between selected causes of postneonatal infant mortality and particulate air pollution in the United States. Environmental Health Perspectives. Vol. 105 (6): 608-612.

Zanobetti A, Schwartz J. Air pollution and emergency admissions in Boston, MA.. J Epidemiol Community Health. 2006 Oct;60(10):890-5.

Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.

DATED: May 4, 2017, at Chester, New York.

DR. GEORGE D. THURSTON

Curriculum Vitae

GEORGE D. THURSTON
3 Catherine Court
Chester, NY 10918
Hm: (845) 783-1978
Wk: (845) 731-3564
Fax: (845) 351-5472
Email: george.thurston@nyu.edu
http://www.med.nyu.edu/biosketch/gdt1

Education

Degree	**Field**	**Institution**
Diploma	Academic	Barrington High School, RI
Sc.B. (Honors)	Environmental Engineering	Brown University
A.B.	Environmental Studies	Brown University
S.M.	Environmental Health Sciences	Harvard Univ. Schl. of Public Health
Sc.D.	Environmental Health Sciences	Harvard Univ. Schl. of Public Health

Postdoctoral Training

Specialty	Mentor	Place of Training
Environ. Epidemiology	Dr. H. Ozkaynak	Harvard Univ., Kennedy Schl. of Gov., Camb., MA

Internships and Residencies N/A

Clinical and Research Fellowships N/A

Licensure and Certification: Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE) Training Certification (August 2014).

Academic Appointments

1987-1993	Assistant Professor, Dept. of Environmental Medicine, New York University School of Medicine, New York City, NY.
1993-2006	Associate Professor (Tenured), Dept. of Environmental Medicine, New York University School of Medicine, New York City, NY.
2007-present	Professor (Tenured), Dept. of Environmental Medicine, New York University School of Medicine, New York City, NY.
2007-present	Affiliated Faculty, Environmental Studies Program, College of Arts and Sciences, New York University, New York City, NY.
2012-present	Affiliated Faculty, Marron Institute on Cities and the Urban Environment, New York University, New York City, NY
2012-present	Faculty Mentoring Champion, Dept. of Environmental Medicine, New York University School of Medicine, New York City, NY.

Hospital Appointments: N/A

Other Professional Positions and Visiting Appointments:

Oak Ridge Institute for Science and Education (ORISE) Fellow (2008-2010)

Major Administrative Responsibilities

Year	*Title, Place of Responsibility*
1995-2004	Director, Community Outreach and Environmental Education Program, NYU-NIEHS Center of Excellence, Nelson Inst. of Environ. Med., NYU School of Medicine, Tuxedo, NY
2002-2012	Deputy Director, NYU Particulate Matter Research Center, Nelson Inst. of Environmental Medicine, NYU School of Medicine, Tuxedo, NY
2007-2008	Director, Environmental Epidemiology Core, NYU-NIEHS Center of Excellence, Department of Environmental Medicine, Tuxedo, NY
2010-2015	Co-Leader, Metals Research Focus Group, NYU-NIEHS Center of Excellence, Department of Environmental Medicine, Tuxedo, NY.
2012-2016	Chair, Appointments and Promotions Committee, Department of Environmental Medicine, NYU School of Medicine.
2014-2016	Co-Chair, Environmental Health Research Affinity Group, NYU Global Institute of Public Health (GIPH), New York University, Washington Square.
2012-present	Director, Program in Exposure Assessment and Human Health Effects, Department of Environmental Medicine, NYU School of Medicine.

Teaching Experience

Year	*Name of course*		*Type of Teaching*
1984-1994	Air Poll. Transport Modeling	(G48.2048)	Course Director
2006-present	Climate, Air Pollution, & Health	(G48.1010)	Course Director
1986-present	Aerosol Science	(G48.2033)	Course Director
1984-2010	Environmental Contamination	(G48.2305)	Lecturer
1984-present	Environ. Hygiene Measurements	(G48.2035)	Lecturer/Lab
1990-1998	Environmental Toxicology	(G48.1006)	Lecturer
1993-1995	Environmental Epidemiology I	(G48.2039)	Lecturer
2001-2003	NYU Summer Institute, Wagner School		Lecturer
2006-present	Environmental Epidemiology I	(G48.2039)	Lecturer
2006-present	Science, Health & Envir. Journalism	(G54.1017.0)	Lecturer
2009-2011	Global Environmental Health	(U10.2153.1)	Course Director
2009-2012	Global Issues in Environ. Health	(G48.1011)	Course Director
2009-present	Earth Systems Science (undergrad)	(V36.0200)	Lecturer
2011-present	Principles of Environmental Health	(G48.1004)	Course Director
2013-present	Environ. Hygiene Measurements	(G48.2035)	Course Co-Director

Awards and Honors

November 1999	Orange Environment Citizens Action Group, OE Award for Excellence in Translating Science to the Public
December 2000	NYU School of Medicine Dean's Research Incentive Award
October 2012	Recipient of the "Haagen Smit Prize" for Best Paper, Atmospheric Environment. http://geo.arc.nasa.gov/sgg/singh/winners12.html
March 2013	Recipient of the "Best Paper of the Year – Science" Award from ES&T http://pubs.acs.org/doi/full/10.1021/es400924t

Major Committee Assignments

New York University Committees

2007-present: University Sustainability Task Force
2010-2012: University Faculty Senate Alternate
2012-present: University Faculty Senator

NYU School of Medicine Departmental Committees

1992-1998: Sterling Forest Library Committee, Member, NYU SOM Dept of Environ. Medicine
1991-1994 Health & Safety Committee, Member, NYU SOM Dept. of Environ.. Medicine
1992-2004 Community Outreach and Education Comm., Chairman, NYSOM Dept. of Environ. Med.
1999-2004 Dept. Chairman's Internal Advisory Comm., Member, NYUSOM Dept. of Environ. Med.
2005-present Dept. Academic Steering Committee, Member, NYUSOM Dept. of Environ. Medicine
2007-2012 Dept. Appointments & Promotions Comm., Member, NYUSOM, Dept. of Environ. Medicine
2012-present Dept. Appointments & Promotions Comm., Chair, NYUSOM, Dept. of Environ. Medicine

Advisory Committees

Regional

1983-1984 Massachusetts Acid Rain Advisory Board, Member, Mass. Dept. of Env. Protection
1984-1986 Committee on Environ. And Occup. Health. , NY State American Lung Association
1991-1996 Air Management Advisory Comm., Member of Health Effects Subcom., NY State DEC
1995-1999 Engineering Advisory Board, Member, Tuxedo, NY
1997-1998 Advisory Committee to the Mayor on the Port of Newburgh, Member, Newburgh, NY
1996-1999 CUES Asthma Working Group, Member, New York Academy of Medicine
2008-2010 New York City Community Air Study (NYCCAS) Advisory Panel

National

1995-1999 Comm. on Health Effects of Waste Incineration, Member, National Academy of Sciences
1995-1999 National Air Conservation Commission, Member, American Lung Association
2000-2004 National Action Panel on Environment, Member, American Lung Association
2005-present National Clean Air Committee, Member, American Lung Association
2007-2010 U.S. EPA Clean Air Science Advisory Committee (CASAC) for SOx and NOx
Mar. 2012 EPA Panelist for "Kickoff Workshop to Inform EPA's Review of the Primary NO_2 NAAQS"

International

1996-1997 Sulfur in Gasoline Health and Environment Panel, Chairperson, Health Canada
Sept. 2007 Illness Cost of Air Pollution Expert Committee, Canadian Medical Association
2008-2012 Global Burden of Disease (GBD), Committee on the Human Health Effects of Outdoor Air Pollution, World Health Organization (WHO)

Grant Review Committees (National)

March 1989 EPA Air Chemistry and Physics Extramural Grants Review Panel (*ad hoc member*)
Oct. 1989 NIEHS P30 Center Special Review Panel (*ad hoc member*)
July 1992 NIH R01 Epidemiology & Disease Control Study Section (*ad hoc member*)
Nov. 1992 NIEHS P20 Center Development Grant Special Study Section, (*ad hoc member*)
June 1996 EPA Special Review Panel of the Health Effects Institute (HEI) (*ad hoc member*)
March 1997 EPA Office of Res. and Development External Grant Review Panel (*ad hoc member*)
April 1997 NIEHS Community-Based Participatory Res. R01 Special Study Sect. (*ad hoc member*)
July 1997 EPA National Environ. Research Lab Intramural Research Review Panel (*ad hoc member*)
June 1998 EPA Office of Res. and Development External Grant Review Panel (*ad hoc member*)
July 1998 EPA Climate Policy and Programs Division Grant Application Review (*ad hoc member*)
Oct. 1998 Mickey Leland Center for Air Toxics Grant Review Panel (*ad hoc member*)
April 2000 NIEHS P30 Center Special Review Panel (*ad hoc member*)
July 2001 NIEHS Community-Based Participatory Res. R01 Special Study Sect. (*ad hoc member*)
Dec. 2001 NIEHS Program Project P01 Site Visit Review Panel (*ad hoc member*)
April 2003 NIH R21 Fogarty Health, Env. and Economic Development Study Sect. (*ad hoc member*)
Nov. 2003 U.S. EPA STAR Grant Panel (Epidemiologic Research on Health Effects of Long-Term Exposure to Ambient Particulate Matter and Other Air Pollutants) (*member*)
October 2004 NIEHS Program Project P01 Review Panel (*ad hoc member*)
June 2005 NIH Special Emphasis Panel (ZRG1 HOP Q 90 S) (*ad hoc member*)
Nov. 2005 NIH Infectious Disease, Reproductive Health, Asthma/Allergy, and Pulmonary (IRAP) Conditions Study Section Review Panel (*ad hoc member*)

Feb. 2006	NIH Infectious Disease, Reproductive Health, Asthma/Allergy, and Pulmonary (IRAP) Conditions Study Section Review Panel (*ad hoc member*)
June 2006	NIH Infectious Disease, Reproductive Health, Asthma/Allergy, and Pulmonary (IRAP) Conditions Study Section Review Panel (*ad hoc member*)
Dec. 2006	NIEHS Special Emphasis Panel on Genetics, Air Pollution, and Respiratory Effects (ZES1 TN-E FG P) (*member*)
Nov. 2007	NIH Special Emphasis Panel on Community Participation in Research (ZRG1 HOP-S) (*member*)
June 2009	NIH Study Section Review Panel on Challenge Grants in Health & Science Research
March 2011	U.S. EPA Science to Achieve Results (STAR) Graduate Fellowship Review Panel – Clean Air Panel (*chair*)
Sept. 2011	NIH Special Epidemiology Study Section (ZRG1 PSE K 02 M) (*member*)
Oct. 2012	NIH Cardiac and Sleep Epidemiology (CASE) Study Section (*ad hoc member*)
June 2013	NIH Special NHLBI Dataset Study Section (ZRG1 PSEQ 56) (*member*)
July 2013	NIH "Career Awards" Study Section (ZES1 LWJ-D, K9) (*member*)
Sept. 2013-17	Appointed Permanent Member, NIH Cancer, Heart, and Sleep Epidemiology Study Section (CHSE) Study Section
Nov. 2016	NIEHS R13 Study Section (*member*)

<u>Memberships, Offices, And Committee Assignments in Professional Societies</u>

Year	*Society/Committees*
1980-1996	Air and Waste Management Association (Comm. on Health Effects and Exposure,)
1992-Present	American Thoracic Society (ATS): Environmental and Occup. Health (EOH) Assembly, 1995-1999, 2012-present: ATS EOH Long Range Planning Committee; 1993-1994, 2002-2004: ATS Program Committee 2006-2007 Chairman of the ATS-EOH Nominating Committee 2010-present: ATS Environmental Health Policy Committee, member 2012-2014: ATS Environmental Health Policy Committee, Vice-Chairman 2015-2017: ATS Environmental Health Policy Committee, Chairman
1990-present	International Society of Exposure Science
1992-present	International Society for Environmental Epidemiology (Annual Meeting Program Committee: 1998, 2000, 2003, 2004, 2006) (ISEE Conference Planning Committee: 2006-present)
2007-2009	New York Academy of Sciences (membership given in appreciation for a 1/23/07 NYAS forum presentation)
2017-present	American Public Health Association (APHA)

Editorial Positions

<u>Journal Board Membership</u>

Year	*Name of Board*
1993-2008	International Society of Exposure Analysis (J. of Exp. Anal. and Environ. Epid.)

<u>Ad Hoc Manuscript Reviewer</u>

Years	*Journal*
1996-1998	American Journal of Epidemiology
1994	Archives of Environmental Health
1995-present	Atmospheric Environment
1995-present	Environmental Health Perspectives
1994-present	Environmental Research
2004-present	Environmental Science and Technology
2011-present	Epidemiology
1993-present	Journal of Exposure Analysis and Environmental Epidemiology

1994-present	Journal of the Air and Waste Management Association
1996-present	Journal of the American Medical Association
1997-present	Journal of Occupational and Environmental Medicine
1997-present	Journal of Respiratory and Critical Care Medicine
2006-present	Thorax

Scientific Report Reviewer

August, 1986	Reviewer for the National Academy of Sciences, Board on Environmental Studies and Toxicology report "The Airliner Cabin Environment: Air Quality and Safety"
October, 2002	Reviewer for the NAS, Board on Environmental Studies and Toxicology report "Estimating the Public Health Benefits of Proposed Air Pollution Regulations"

Mentoring of Graduate Students, Residents, Post-Doctoral Fellows in Research

Under direct supervision:

Student Name	*Type of Position*	*Time Period*	*Present Position*
Mark Ostapczuk	Masters	1984-1986	Industrial Hyg., Barr Labs, Pomona, NJ
Kazuhiko Ito	Masters/Doctoral	1984-1990	Scientist, NYC Dept. of Health, NYC, NY
Peter Jaques	Masters/Doctoral	1988-1998	Assoc. Prof., Clarkson Univ., Potsdam, NY
R. Charon Gwynn	Masters/Doctoral	1992-1999	Epidemiologist, Columbia Univ., NY
Ramona Lall	Masters/Doctoral	2000-2007	Research Sci. IV, NYC Dept. of Health, NY
Ariel Spira-Cohen	Masters/Doctoral	2003-2009	Research Sci. III, NYC Dept. of Health, NY
Kevin Cromar	Masters/Doctoral	2008-2012	Assistant Professor, NYU School Of Medicine
Lital Yinon	Doctoral	2011-present	Doctoral Candidate, NYU School of Medicine
Chris Lim	Doctoral	2012-present	Doctoral Candidate, NYU School of Medicine

In advisory function (thesis committee):

Student Name	*Advisory Role*	*Time Period*	*Student's Supervisor*
Shao-Keng Liang	Doctoral Committee member	1990-1994	Dr. J. Waldman, UMDNJ, Rutgers
Jerry Formisano	Doctoral Committee member	1997-2000	Dr. M. Lippmann, NYU SOM
Yair Hazi	Doctoral Committee member	1993-2001	Dr. B. Cohen, NYU SOM
Samantha Deleon	Doctoral Committee member	1997-2003	Dr. K Ito, NYU SOM
Chun Yi Wu	Doctoral Committee member	2000-2004	Dr. L.C. Chen, NYU SOM
Carlos Restrepo	Doctoral Committee member	2002-2004	Dr. R. Zimmerman, Wagner, NYU
Shaou-I Hsu	Doctoral Committee member	2000-2009	Dr. M. Lippmann, NYU-SOM
Steven Schauer	Doctoral Committee member	2007-2009	Dr. B. Cohen, NYU-SOM
Christine Ekenga	Doctoral Committee Chair	2009-2011	Dr. G. Friedman-Jimenez, NYU-SOM
Rebecca Gluskin	Doctoral Committee Chair	2009-2012	Dr. Kazuhiko Ito, NYU SOM
Jiang Zhou	Doctoral Committee Chair	2008-2012	Dr. Kazuhiko Ito, NYU SOM
Eric Saunders	Doctoral Committee Chair	2012-present	Dr. Terry Gordon, NYU SOM

Teaching Awards Received

N/A

Major Research Interests

1) Air Pollution Epidemiology: Real-world air pollution exposures and human health effects in the general population and study cohorts of suspected susceptible individuals (e.g., children).

2) Aerosol Science: Ambient particulate matter aerosol exposures, including designing and implementing air monitoring equipment to collect human exposures to air pollution.

3) Environmental Exposure Assessment: Methods to assess human exposures and health effects from air pollution, especially the development of source apportionment models to separate human effects on the basis of pollution source. Design of epidemiological models/methods that better incorporate potential air pollution confounders/effect modifiers (e.g. weather and genetic influences).

Grants Received

Prior:

Agency	Title	Grant #	Period	Total Direct Costs	Role	% Effort
USEPA	Effects of Acute Exposure to Summertime Haze Episodes on the Health of Humans	R811563	05/01/84-09/30/87	$538,586	Co-I	50%
NIH	Acid Aerosol Exposure: Effect on Respiratory Morbidity	R01 ES04612	09/25/87-08/31/92	$846,966	PI	30%
USEPA	Acid Aerosol Chamber Experiments	OD2524AEX	7/2/90-7/31/90	$5,810	PI	9%
USEPA	Analysis of Acid Aerosol Experiments	00422248NAEX	8/1/90-9/30/90	$3,364	PI	5%
USEPA	Air Pollutants and Human Health	R814023	05/18/87-05/17/91	$690,921	CO-I	50%
USEPA	Development and Field Applic. of an Automated Sequential Weekly Average H+ Sampler	Subcontract to EPA Grant CR816740-03	6/1/92-2/28/93	$13,156.	PI	15%
NIH	Acid Aerosol Exposure: Effect on Respiratory Morbidity	R01 ES04612	09/01/92-08/31/95	$377,298.	PI	30%
HEI	Retrospective Characterization of Ozone Exposures	Health Effects Institute Grant	11/1/93-10/31/94	$98,238	CO-I	10%
NIH	Temperature and Air Pollution Effects on Human Mortality	R01 ES05711	6/1/92-5/31/95	$371,993	PI	30%
NYUSOM	Environmental Effects on Human Mortality and Morbidity	Bridge Grant	9/1/95-8/31/96	$48,400	PI	-
USEPA	Effects of Exposure to Ambient Air Pollutants on Human Healt	R808325	10/1/91-09/30/96	$870,565	CO-I	50%
USEPA	Investigation of Acid Aerosol Exposures in Metropolitan Settings	Subcontract to Grant No. CR822050	11/1/93-10/31/96	$200,499	PI	10%
USEPA	An Evaluation of Potential Confounders in PM10 Mortalit Associations	R825271	11/25/96-11/24/01	$219,410	CO-I	10%
USEPA	Acidic PM and Daily Human Mortality in Three U.S. Cities	#R825264	11/25/96-11/24/00	$232,671	PI	15%
NYS-ERDA	Environmental Monitoring, Evaluation, and Protection Program	6084-ERTER-ES00	12/01/99-11/30/02	$341,926	PI	20%
HEI	Children's Asthma Incidence and Personal Exposures to Diesel Particles and Traffic in NYC		01/01/02-12/31/02	$154,800	PI	30%
USEPA	Influence of Alternate	R827358	03/01/99-	$183,089	PI	30%

	Indicators of Exposure to PM and PM Components in Statistical Associations with Mortality and Hospital Admissions		02/28/03			
NIH	NIEHS Center Supplement: Health Issues Related to the World Trade Center Disaster, Outreach Project	ES00260-S1	04/01/02-03/31/03	Total=$ 936,487 Outreach=$172,031	Co-PI PI	10% 15%
NIH	Effects of Ambient Air Pollutants on Annual Mortality	RO1 ES09560	9/15/99-8/31/03	$471,408	PI	30%
USEPA	Particle Exposures of High-Risk Sub Populations	R827164	10/01/98-09/30/03	$1,327,240	Co-I	10%
USEPA	A Source Oriented Evaluation of the Combined Effects of Fine Particles and Co-pollutants	R827997	02/01/00-01/31/04	$291,407	Co-I	15%
NIH	NIEHS Center Grant: Outreach and Education Program	ES00260	04/01/00-03/31/05	Total=$5,000,000 Outreach=$240,365	Co-I PI	5% 5%
USEPA	EPA PM Health Effects Center Project 6: "A Prospective Study of Asthma Susceptibility to PM Epidemiologic Investigations o Key PM Components and Biomarkers of Effects & Community Outreach Project	R827351	06/01/99-05/31/05	Total=$6,000,000 Project 6=$134,923 Outreach=$77,779	Co-PI PI PI	15% 10% 10%
NIH	Genetic/Epigenetic Susceptibility to Superfund Chemicals: Outreach Project	ES010344	05/08/00-03/31/06	$156,812	Co-I	5%
USEPA	Env. Issues in the South Bronx. Thurston Project: S. Bronx Backpack Study	X1982152	08/01/00-09/30/06	Total=$921,922 Project=$307,131	CO-I PI	5% 15%
NIH	NIEHS Center Supplement: Health Issues Related to the World Trade Center Disaster, Source Attribution (Project 4) & Community Outreach	ES00260-S2	04/01/02-03/31/04	Total=$660,000 Project 4=$69,999 Outreach=$172,03	Co-PI PI PI	10% 10% 15%
USEPA	The role of traffic-related pollution in PM health effects associations among inner-city children with asthma	16511	09/01/06-08/31/09	$51,516	PI	-
California Air Resources Board (CARB)	Spatio-temporal Analysis of Air Pollution and Mortality in California Based Upon the ACS Cohort (Thurston: Consulting Project)		06/01/07-5/31/10	Project=$13,634	Co-I	4%
USEPA	Real time modeling of weather, air pollution, health outcome indicators in NYC.	RD-83362301-0	12/07-11/10	$130,496	Co-I	5%
NIH	Fine Particles and Out-of-Hospital Cardiac Arrest in New York City	R01ES014387-01A2	04/09-12/11	$200,000	Co-I	10%

Health Effects Institute (HEI)	Characteristics of PM Associated with Health Effects. *Thurston Project*: "Study Of PM Components and U.S. Human Mortality In The ACS Cohort.	4750	01/01/07-3/31/11	Total=$3,247,567 Project=$355,920	Co-I PI	5% 20%
NT State DOT	Mobile Source Air Toxics Mitigation Measures		09/01/10 06/31/13	SubProject=$89,062	Co-I	10%
Robert Wood Johnson Fndn.	The Effect of Peak-Shaving Regulations on the Activity, Toxic Emissions, and Health Impacts of Local Power Plants	Public Health Law Research	1/12-7/13	$151,500	Co-I	10%
NIH	Dietary Influence on Mortality from Air Pollution Exposure in the NIH-AARP Cohort (R21)	1R21ES021194-01	7/12-6/15	$150,000	MPI (Contact PI)	8%

Current:

Agency	Title	Grant #	Period	Total Direct Costs	Role	% Effort
NIH	Long-term Air Pollution Exposure and Mortality in the NIH-AARP Cohort.	R01ES019584-01A1	1/01/12-6/30/18	$1,221,253	MPI (Contact PI)	20%
The Public Health Research Institute of Abu Dhabi	Development of a Public Health Research Institute in Abu Dhabi. *Thurston Project*: "Air Pollution in Abu Dhabi".		3/2012-2/2018	$9,993,960	Co-I	5%

Patents

None

Boards and Community Organizations

1990-1995 St. Mary's Episcopal Church, Tuxedo, NY, Vestry member
1992-2008 Monroe-Woodbury Soccer Club, Coach (Board Member: 1999-2000)
1994-1999 Orange County Citizen's Foundation, Member
1999-2009 Y2CARE Monroe-Woodbury, NY School District Residents Action Group, Founder
2005-present St. Mary's Episcopal Church, Tuxedo, NY, Community Outreach Committee, Member
2006-present EPISCOBUILD-Newburgh, NY Habitat for Humanity Advisory Board, Member
2012-present St. Mary's Episcopal Church, Tuxedo, NY, Vestry member

Military Service

None

International Scientific Meetings Organized

May 28-30, 2003 "Workshop on the Source Apportionment of PM Health Effects." U.S. EPA PM Centers, Harriman, NY.

Aug. 1-4, 2004 "Sixteenth Conference of the International Society for Environmental Epidemiology," Kimmel Conference Center, Washington Square, New York University, New York City, NY.

Scientific Forums for the Public Organized

June 2001 "Science and Community Interaction Forum on the Environment." Held at Hostos Community College, Bronx, , New York City, NY.

October 2001 "Forum on Environmental Health Issues Related to the World Trade Center Disaster." Held at NYU Law School, Washington Square, New York City, NY.

October 2002 "2nd Annual Forum on the Environmental Health Issues Related to the World Trade Center Disaster." Held at Manhattan Borough Community College, New York City, NY.

October 2003 "3rd Annual Forum on the Environmental Health Issues Related to the World Trade Center Disaster." Held at NYU Lower Manhattan Campus, New York City, NY.

Invited U.S. House and Senate Congressional Testimony

Feb. 5, 1997 "Human Health Effects of Ambient Ozone Exposures" Statement before the Committee on Environment and Public Works, Subcommittee On Clean Air, Wetlands, Private Property, And Nuclear Safety, U.S. Senate, Washington, DC.
http://epw.senate.gov/105th/thurston.htm

April 16, 1997 "Human Health Effects of Ambient Ozone and Particulate Matter Exposures." Statement before the Government Reform and Oversight Committee of the U.S. House of Representatives, Washington, D.C.

May 8, 1997 "Human Health Effects of Ambient Ozone and Particulate Matter Exposures." Statement before the Subcommittee on Health and Environment, Committee on Commerce of U.S. House of Representatives, Washington,. D.C.

July 29, 1997, "The Human Health Effects of Ambient Ozone And Particulate Matter Air Pollution." Statement before the Subcommittee on Commercial and Administrative Law of the Judiciary Committee of the U.S. House of Representatives, Washington,. D.C.
http://judiciary.house.gov/legacy/commercial.htm

October 22, 1997 "Ozone and Particulate Matter Air Pollution Health Effects." Statement before the U.S. Senate Committee on Environment and Public Works Subcommittee on Clean Air, Wetlands, Private Property, and Nuclear Safety. Washington, DC.
http://epw.senate.gov/105th/thursto2.htm

July 15, 1999: "The Mandated Release of Government-Funded Research Data." Statement before the Committee On Government Reform, Subcommittee on Government Management, Information And Technology, U.S. House of Representatives

July 26, 2001 "The Human Health Effects Of Air Pollution From Utility Power Plants." Statement before the Committee on Environment and Public Works, U.S. Senate, Washington, D.C.
http://www.c-spanvideo.org/program/PlantE

Feb 11, 2002: "The Air Pollution Effects of The World Trade Center Disaster." Statement before the Committee On Environment And Public Works, Subcommittee On Clean Air, Wetlands, And Climate Change. United States Senate, New York, NY.
http://www.c-spanvideo.org/program/Qualitya

March 5, 2002	"The Use of the Nationwide Registries to Assess Environmental Health Effects." Statement before the Committee On Health, Education, Labor, And Pensions, Subcommittee On Public Health, U.S. Senate, Washington, DC.
Sept. 3, 2002	"The Clean Air Act and The Human Health Effects of Air Pollution from Utility Power Plants." Statement before the U.S. Senate Committee on Health, Education, Labor, and Pensions, Subcommittee on Public Health, Washington, D.C. http://www.c-spanvideo.org/program/AirStand
April 1, 2004	"The Human Health Benefits Of Meeting the Ambient Ozone And Particulate Matter Air Quality Standards." Statement before the Committee on Environment and Public Works, Subcommittee on Clean Air, Climate Change, and Nuclear Safety, U.S. Senate, Washington, D.C. http://epw.senate.gov/epwmultimedia/epw040104.ram
July 19, 2006	"The Science And Risk Assessment Of Particulate Matter (PM) Air Pollution Health Effects." Statement before the Committee on Environment and Public Works, U.S. Senate, Washington, D.C. *http://epw.senate.gov/hearingstatements.cfm?id=258766*
May 7, 2008	"Science And Environmental Regulatory Decisions." Statement before the Committee On Environment And Public Works of The U.S. Senate, Subcommittee on Public Sector Solutions to Global Warming, Oversight, and Children's Health Protection, U.S. Senate, Washington, D.C. http://www.c-spanvideo.org/program/RegulatoryD http://epw.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&HearingID=a1954f70-802a-23ad-4192-fc2995dda7f4
October 4, 2011	"The Science of Air Pollution Health Effects and the Role of CASAC in EPA Standard Setting" Statement before the Subcommittee on Energy and the Environment, Committee on Science, Space and Technology, U.S. House Of Representatives, Washington, DC. http://science.house.gov/hearing/energy-and-environment-subcommittee-—-hearing-quality-science-quality-air

Other Invited Presentations

Regional Presentations

April 21, 1993	"Summertime Smog and Hospital Admissions for Respiratory Illness", Environmental and Occupational Health Sciences Institute Seminar Series Lecture, UMDNJ-Robert Wood Johnson Medical School, Piscataway, NJ.
Dec .14, 1995	"Health Effects of Acidic Aerosols", NY State Dept. of Health, Wadsworth Center Seminar, Albany, NY
Jan. 18, 1996	"Outdoor Air Pollution and Asthma in Children " American Lung Association Press Briefing, New York, NY.
June 1, 1996	"Asthma and Urban Air Pollution", WHEACT, Harlem Hospital, New York, NY.
July17, 1996	"Asthma and Outdoor Air Pollution", Making the Connection: Urban Air Toxics & Public Health. Northeast States for Coordinated Air Use Management (NESCAUM), Roxbury, MA
Feb. 11, 1997	"Outdoor Air Pollution and Asthma", Bellevue Hospital Asthma Clinic *Grand Rounds*. New York City, NY.
Feb. 26, 1998	"Scientific Research for Ozone and Fine Particulate Standards ", Pace University School of Law, White Plains, NY
Nov. 30, 1998	"Outdoor Air Pollution and Asthma", Center for Urban and Environmental Studies (CUES), NY Academy of Medicine,, New York, NY
Feb. 22, 1999	"Asthma and Air Pollution", Cornell University, Ithaca, NY

April 28, 2001	"Asthma and Air Pollution in New York City", NYC Council Environmental Candidate School, NY League of Conservation Voters, New York, NY.
Nov. 1, 2001	"Air Quality and Environmental Impacts Due to the World Trade Center Disaster", Testimony before the Comm. on Environ. Protection, NYC Council, New York, NY.
Nov. 13, 2001	"WTC Pollution Impacts in Lower Manhattan", Stuyvesant High School Parents Association General Meeting, Stuyvesant High School, New York, NY
Feb. 28, 2002	"Lung Cancer Effects of Long-Term Exposure to Ambient Fine Particulate Matter", Mailman School of Public Health, Columbia University, New York, NY.
April 5, 2002	"Air Pollution Impacts of the WTC Disaster", 23rd Annual Scientific Conference of the NY/NJ Education and Research Center: "Worker Health and Safety: Lessons Learned in the Aftermath of Sept. 11, 2001," Mt. Sinai School of Medicine, NYC, NY
April 21, 2002	"Adverse Health Effects of Power Plant Air Pollution on Children" Earth Day 2002, 14th Street Y, New York City, NY.
May 23, 2002	"Human Health Effects of Power Plant Pollution", Rockland County Conservation Association, Suffern, NY
May 31, 2002	"Environmental Health Impacts of the World Trade Center Disaster", University of Rochester Medical School, Rochester, NY.
Sept. 19, 2002	"Community Air Pollution Related to the World Trade Center Disaster". NYC Council Forum: The Environmental Health Consequences of 9/11: Where Do We Stand One Year Later? Borough of Manhattan Community College, New York City, NY.
Oct. 3, 2002	"Community Exposures to Particulate Matter Air Pollution from the World Trade Center Disaster", Mount Sinai School of Medicine *Grand Rounds*, New York City, NY.
April 11, 2003	"Environmental Impacts of the World Trade Center Disaster", NIEHS Public Interest Liaison Group, New York City, NY.
April 21, 2003	"Asthma and Air Pollution", Airborne Threats to Human Health, NIEHS Town Hall Meeting, Syracuse, NY.
May 7, 2003	"Asthma and Air Pollution in NY City" Environmental Candidate School for New York City Council Candidates, Wagner School, NYU, New York City, NY.
July 21, 2003	"Health Effects of Particulate Matter Air Pollution", Ozone Transport Commission, Philadelphia, PA.
Nov. 18, 2004	"Ambient Air Pollution Particulate Matter (PM): Sources and Health Impacts". U.S. Environmental Protection Agency, Region 2, New York City, NY.
Feb. 17, 2005	"Community Air Pollution Aspects Of The Demolition Of 9-11 Contaminated Buildings". Testimony before the Committee On Lower Manhattan Redevelopment, New York City Council, New York City, NY.
Oct. 19, 2005	Air Pollution Health Effects: Consideration of Mixtures. Fall Meeting of the Mid-Atlantic Chapter of the Society of Toxicology (MASOT), East Brunswick, NJ.
Dec.7, 2006	Asthma and Air Pollution Effects in the South Bronx. New York City Child Health Forum, The Children's health Fund, Harlem, NYC, NY.
Jan. 18, 2007	Air Pollution Effects in New York City. NYU Environmental Sciences Seminar Lecture, Washington Square, NYC, NY.
Jan. 23, 2007	The South Bronx Backpack Study: Asthma and Air Pollution in NYC. Presented at the forum "High Asthma Rates in the Bronx: What Science Now Knows and Needs to Learn." New York Academy of Sciences, 7 World Trade Center, NYC, NY.
Oct. 2, 2009	"Diesel Air Pollution and Asthma in New York City". Brown Superfund Research Program, Brown University, Providence, RI.
June 19, 2012	"The Backpack Study of Asthma and Diesel Air Pollution in the South Bronx". Region 1 U.S. EPA, Citizen Science Workshop, New York City, NY.

National Presentations

Oct. 20, 1987.	NIEHS Symposium on the Health Effects of Acid Aerosols: "Re-examination of London, England, Mortality in Relation to Exposure to Acidic Aerosols During 1963-1972 Winters" RTP, NC.
Aug. 13, 1991	"Kuwait Mortality Risks from SO_2 and Particles: Insights from the London Fogs"' The Kuwait Oil Fires Conf., American Academy of Arts and Sciences, Cambridge, MA.
Jan. 24, 1994	"Air Pollution Epidemiology: Is the Model the Message?" The First Colloquium on Particulate Air Pollution and Human Morbidity and Mortality". Beckman Center of the NAS, Irvine, CA.
May 23, 1994	" Ozone Epidemiological and Field Studies". American Thoracic Society Annual Meeting, Boston, MA.
May 25, 1994	"Epidemiological Evidence Linking Outdoor Air Pollution and Increased Hospital Admissions for Respiratory Ailments" American Thoracic Society Annual Meeting, Boston, MA.
May 6, 1996	"Associations Between PM_{10} & Mortality in Multiple US Cities". Second Colloquium on Particulate Air Pollution and Health. Park City, Utah.
Sept. 5, 1996	"Particulate Matter Exposure Issues for Epidemiology" U.S. EPA Particulate Matter Workshop, RTP, NC
April 3, 1997	"Health Effects of Ambient Ozone & Particulate Matter" Air and Waste Assoc. Regional Conference On Impacts of EPA's Proposed Changes to Ozone and PM Standards, Oak Brook, IL
April 22, 1998	"The New EPA Standards for Ambient PM and Ozone" American Lung Association Annual Meeting, Chicago, IL.
Dec. 21, 1999	"Global Overview of Human Death and Illness due to Air Pollution". California Air Resources, Sacramento, CA.
March 24, 2000	"Estimating Ancillary Impacts, Benefits and Costs Of Proposed GHG Mitigation Policies For Public Health" Resources for the Future, Wash., DC.
June 24, 2002	"Investigations Into the Environmental Health Impacts Related to the WTC Disaster" Air And Waste Management Annual Meeting, Baltimore, MD.
July 15, 2002	"Air Pollution and Human Health" NIEHS Built Environment Conference, RTP, NC
July 26, 2002	"The Human Health Effects of Power Plant Emissions and Associated Air Pollution", The Environment & Health Forum, Physicians for Social Responsibility, Washington, DC.
October 7, 2002	"Community Exposures to Particulate Matter Air Pollution from the World Trade Center Disaster" Plenary Speaker at the American Association for Aerosol Research, Charlottesville, North Carolina.
Nov. 11, 2002	"Characterization of Community Exposures to World Trade Center Disaster Airborne and Settled Dust Particulate Matter Air Pollution", American Public Health Association Annual Meeting, Philadelphia, PA.
Dec. 5, 2002	"Susceptibility of Older Adults to Air Pollution", EPA Workshop on Differential Susceptibility of Older People to Environmental Hazards. National Academy of Sciences, Washington, DC.
Feb. 3, 2003	"Health Effects of Particulate Matter Air Pollution", National Air Quality Conference, U.S. EPA, San Antonio, Texas
May 17, 2003	"Assessing the Influence of Particle Sources and Characteristics on Adverse Health Effects of PM", PG18 - New Tools to Evaluate the Health Effects of Air Pollution in Epidemiologic Studies. American Thoracic Society Annual Meeting, Seattle, WA.
Sep. 10, 2003	"Nature and impact of World Trade Center Disaster fine particulate matter air pollution at a site in Lower Manhattan after September 11." Annual Meeting of the American Chemical Society, New York, NY.

October 20, 2003	"Translating Air Pollution Risks to the Community" Annual Meeting of the NIEHS Center Directors, Baltimore, MD.
May 18, 2004	"The Health Imperative for Implementation of the Clean Air Act" State and Territorial Air Pollution Program Administrators/ Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) National Conference, Point Clear, Alabama.
Oct. 18, 2004	"NIEHS Centers' Investigations of the World Trade Center Collapse Pollution Exposures and Effects: A Public Health Collaboration" National Institute of Environmental Health Sciences Center Directors' Meeting, Research Triangle Park, NC.
May 25, 2005	"Human Health Effects Associated with Sulfate Aerosols", American Thoracic Society Annual Meeting, San Diego, CA
Oct. 24, 2005	"The Science Behind the Particulate Matter (PM) Standards" State and Territorial Air Pollution Program Administrators/ Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) National Conference, Alexandria, Virginia.
Oct. 14, 2008	"Diesel Air Pollution and Asthma Exacerbations in a Group of Children with Asthma" Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Pasadena, California.
Feb. 26, 2010	"What studies are appropriate to use to estimate health impacts from specific sources such as diesel PM?" CARB Symposium: "*Estimating Premature Deaths from Long-term Exposure to* $PM_{2.5}$*"*. Sacramento, CA.
May 6, 2011	"Lung Cancer Risks from Exposure to Fine Particle Air Pollution" NYU Cancer Institute Symposium: "Cancer and the Environment", NYC, NY.
May 16, 2012	"The Human Health Effects of Air Pollution" The Air We Breathe: Regional Summit on Asthma and Environment at Allegheny General Hospital, Pittsburgh, PA.
June 20, 2013	"Particles in our Air: A Global Health Risk", Northeastern University, Research Seminar. Boston, MA.
Mar 5, 2015	"Air Pollution, Climate Change and Health". Stegner Institute Air Quality Symposium, Salt Lake City, Utah.

International Presentations

May 1, 1987	"Acid Aerosols: Their Origins, Occurrence, and Possible Health Effects", Canadian Environmental Health Directorate Seminar, Health and Welfare Canada, Ottawa, Canada
July 2, 1987	"Health Effects of Air Pollution in the US", University of Sao Paulo, Sao Paulo, Brasil
Feb. 5, 1991	"Results from the Analysis of Toronto Summer Sulfate and Aerosol and Acidity Data", Workshop on Current Use and Future Directions of Hospital-Based Data in the Assessment of the Effects of Ambient Air Pollution on Human Health. Health and Welfare Canada, Ottawa, Canada.
April 23, 1997	"An Evaluation of the Role of Acid Aerosols in Particulate Matter Health Effects", Conference on the Health Effects of Particulate Matter in Ambient Air. Air & Waste Management Association, Prague, Czech Republic.
May 12, 1998	"The Health Effects of PM and Ozone Air Pollution", Air Pollution: Effects on Ontario's Health and Environment. Ontario Medical Association, Toronto, Canada
Nov. 1, 1999	"Climate Change and the Health Impacts of Air Pollution". The Public Health Opportunities and Hazards of Global Warming Workshop at the U.N. Framework Convention on Climate Change, Conference of Parties (COP5), Bonn, Germany.
August 31, 2000	"Particulate Matter Air Pollution and Health in three Northeastern Cities", World Congress on Lung Health, Florence, Italy
January 29, 2001	"PM Exposure Assessment and Epidemiology", NERAM International Colloquia: Health and Air Quality: Interpreting Science for Decision Makers. Ottawa, Canada.
Feb. 4-5, 2002:	"Air Pollution Exposure Assessment Approaches in U.S. Long-Term Health Studies", Workshop on Exposure Assessment in Studies on the Chronic Effects of Long-term Exposure to Air Pollution, World Health Organization, Bonn, Germany

May 2, 2002	"Health Effects of Sulfate Air Pollution" Air Pollution as a Climate Forcing Workshop, East-West Center, Honolulu, Hawaii
Sept. 24, 2003	"Identification and Characterization of World Trade Center Disaster Fine Particulate Matter Air Pollution at a Site in Lower Manhattan Following September 11." Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Perth, Australia.
Dec. 1, 2003	"Terrorism and the Pulmonary Effects of the World Trade Center Disaster Particulate Matter Air Pollution", British Thoracic Society, London, England.
Sept 14, 2005	"Results And Implications of The Workshop on the Source Apportionment of PM Health Effects", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Johannesburg, South Africa.
Sept. 4, 2006	"A Source Apportionment of U.S. Fine Particulate Matter Pollution for Health Effects Analysis", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Paris, France.
Sept. 4, 2007	"Applying Attributable Risk Methods to Identify Susceptible Subpopulations", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Mexico City, Mexico.
Aug. 27, 2009	"Ischemic Heart Disease Mortality Associations with Long-Term Exposure to $PM_{2.5}$ Components", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Dublin, Ireland.
Dec. 1, 2010	"The Hidden Air Quality Health Benefits of Climate Change Mitigation". The Energy and Resources Institute (TERI), Lodhi Road, New Delhi, India.
July 17, 2012	"Recent Findings on the Mechanisms and Health Risks of Particulate Matter Air Pollution", European Centre for Environment & Human Health, Truro, England.
Aug. 29, 2012	"Health Effects of PM Components: NYU NPACT Epidemiology Results and their Integration with Toxicology Results", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Columbia, SC.
May 20, 2013	"Long-term $PM_{2.5}$ Exposure and Mortality in the NIH-AARP Cohort", Annual Meeting of the American Thoracic Society (ATS). Philadelphia, PA.
Oct. 27, 2013	"Human Health Effects and Global Implications of Particle Air Pollution", Center of Excellence in Exposure Science and Environ. Health, Technion University, Haifa, Israel.
May 17, 2015	"Human Health Co-Benefits of Climate Change Mitigation Measures" in the Environment, Global Climate Change And Cardiopulmonary Health session of the American Thoracic Society (ATS) Annual Meeting in Denver, CO, USA.
Jan. 21, 2016	"Particle Air Pollution: Its Adverse Human Health Effects and Potential Climate Mitigation Health Co-Benefits". Imperial College. London, England.
Sep. 1, 2016	"Air Quality Health Co-benefits from Climate Change Mitigation Measures". 2016 Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Rome, Italy.
Apr. 22, 2017	"Clean Air Health Benefits from Climate Change Mitigation Action". Global Health & Innovation Conference. Yale University, New Haven, CT.

Scientific Meeting Sessions Chaired

May 1, 1996	"Epidemiological Findings", 2nd Colloquium on Particulate Air Pollution & Health. Park City, UT.
May 14, 1996	"Particulate Toxicity", American Thoracic Society Annual Meeting, New Orleans, LA.
Jan. 30, 1998	"Evaluation of PM Measurement Methods". $PM_{2.5}$: A Fine Particulate Standard Specialty Conference. Los Angeles, CA.
August 18, 1998	"Communities and Airports: How to Co-Exist?", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Boston, MA.
April 28, 1998	"Clean Air Act Update", American Thoracic Society Annual Meeting, Chicago, IL.

Oct. 21, 1998	"Health Effects and Regulatory Issues in PM", Particulate Methodology Workshop,. U.S. EPA Center, for Statistics and the Env., Univ. of Washington, Seattle, WA.
April 26, 1999	"Pulmonary Smoking and Air Pollution Epidemiology." American Thoracic Society Annual Meeting, San Diego, CA
Sept. 6, 1999	"Personal exposures to Gases and Particles", Annual Conference of the International Society for Environmental Epidemiology (ISEE), Athens, Greece.
March 31, 2000	"Epidemiology: Particles, Co-pollutants & Morbidity and Mortality", Workshop on Inhaled Environmental/Occupational Irritants and Allergens: Mechanisms of Cardiovascular Responses, American Thoracic Society, Scottsdale, AZ
Jan. 26, 2000	"Epidemiology of Particulate Matter Air Pollution", PM2000 Specialty Conference, Air & Waste Management Assoc., Charleston, SC
May 8, 2000	"Outdoor Air Pollution: Epidemiologic Studies", American Thoracic Society Annual Meeting, Toronto, Canada
Sept. 5, 2001	"Mortality Epidemiology Studies", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Garmisch, Germany.
May 20, 2002	"After September 11: Bio-terrorism and The Environmental Health Aftermath of The World Trade Center Disaster", Plenary Session. American Thoracic Society Annual Meeting, Atlanta, GA.
April 1, 2003	"Epidemiology: Short-Term and Long-Term Health Effects", Conference on Particulate Matter: Atmospheric Sciences, Exposure, and the Fourth Colloquium on PM and Human Health, Pittsburgh, PA
May 19, 2003	"Particulate Air Pollution and Diseases in Adults", American Thoracic Society Annual Meeting, Seattle, WA.
May 21, 2003	"Air Pollution as a Cause of Childhood Asthma and Chronic Airway Disease", American Thoracic Society Annual Meeting, Seattle, WA.
Sept. 2003	"Unexplained Medical Symptoms", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Perth, Australia.
Sept. 25, 2005	"Technology and Health", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Johannesburg, South Africa.
June 22, 2006	"Characteristics of PM and Related Considerations", Annual Meeting of the Air and Waste Management Association, New Orleans, LA.
Sept. 3, 2006	"Air Pollution Mechanisms", Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Paris, France.
Sept. 20, 2006	"Linkage and Analysis of Air Quality and Health Data", EPA & CDC Symposium on Air Pollution Exposure and Health, RTP, NC
Sept. 5, 2007	"Radiation Exposures and Health Risks", 2007 Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Mexico City, Mexico
Aug. 26, 2009	"Exploring the Range of Methodological Approaches Available for Environmental Epidemiology." 2009 Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Dublin, Ireland
March 23, 2010	"Exposure to and Health Effects of Traffic Pollution", 2010 American Association for Aerosol Research Conference on Air Pollution and Health, San Diego, CA.
Sept. 16, 2011	"Susceptibility to Air Pollution", 2011 Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Barcelona, Spain.
Aug. 27, 2012	"Source Apportionment Of Outdoor Air Pollution: Searching For Culprits". 2012 Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Columbia, SC.
Aug. 21, 2013	"Source-specific health effects of air pollution". 2013 Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Basel, Switzerland.

May 19, 2015	"Indoor and outdoor pollution: epidemiology and mechanisms". 2015 Annual Meeting of the American Thoracic Society (ATS). Denver, CO, USA.
Sep. 1, 2016	"Climate Change, Mitigation Measures and Co-Benefits". 2016 Annual Meeting of the International Society for Environmental Epidemiology (ISEE). Rome, Italy.
Feb. 12, 2017	"Human Health Effects and Global Implications of Particle Air Pollution". MASDAR Institute. Abu Dhabi, United Arab Republic.

Bibliography

Invited Journal Editorials

Thurston GD and Bates DM. (2003). Air Pollution as an Underappreciated Cause of Asthma Symptoms, 2003. JAMA, 290:14, pp. 1915-1916.

Thurston G.D. (2006). Hospital admissions and fine particulate air pollution. JAMA. Oct 25; 296(16):1966.

Thurston G. (2007). Air pollution, human health, climate change and you. Thorax. 2007 Sep; 62 (9): 748-9.

Thurston GD, Balmes JR. (2012). Particulate matter and the environmental protection agency: setting the right standard. Environmental Health Policy Committee of the American Thoracic Society. Am J Respir Cell Mol Biol. Dec;47(6):727-8. doi: 10.1165/rcmb.2012-0414ED.

Thurston GD. (2013). Mitigation Policy: Health Co-Benefits. Nature Climate Change. Oct. (3) 863-864.

Thurston GD, Balmes JR. (2017). "We need to "Think Different" about PM. Am. J Resp. & Crit. Care Med. (In Press)

Book Chapters

Thurston, G.D. and Leber, M. The relationship between asthma and air pollution. In: *Emergency Asthma* (ed.: B. Brenner), pp. 127-144. Marcel-Dekker, New York, NY (1999).

Thurston, G.D. and Ito, K. Epidemiological studies of ozone exposure effects. In: *Air Pollution and Health* (ed.: S. Holgate and H. Koren). Academic Press. London. pp. 485-510 (1999).

Chen, LC, Thurston, G, and Schlesinger, RB. Acid Aerosols as a Health Hazard. In: *Air Pollution and Health* (ed.: J. Ayres, R. Maynard, and R. Richards). Air Pollution reviews: Vol. 3. Imperial College Press. London. pp. 111-161 (2006).

Thurston, G.D. and Wallace, L. Air Pollution: Outdoor and Indoor Sources. In: *Environmental and Occupational Medicine*, 4^{th} Edition (Eds.: W. Rom and S. Markowitz). Lippincott, Williams, and Wilkins, Philadelphia (2006).

Thurston, G.D. Outdoor Air Pollution. In: *Encyclopedia of Public Health* (ed. K. Heggenhougen) Elsevier Press. (2008).

Thurston, G.D and Bell, M. Aerosols, global climate, and the human health co-benefits of climate change mitigation. In *Aerosol Handbook* (2^{nd} edition) (eds.: Lev S. Ruzer and Naomi H. Harley). CRC Press (2012).

Thurston, G. and Bell, M. The Human Health Co-benefits of Air Quality Improvements Associated with Climate Change Mitigation. In. Global Climate Change and Public Health (eds. Kent E. Pinkerton and William N. Rom). Humana Press (2013).

National Academy Committee Books Co-Authored

National Research Council (NRC), *Waste Incineration & Public Health.* Committee on Health Effects of Waste Incineration. Board on Environmental Studies and Toxicology. National Academy Press, Washington, DC (2000).

International Reports Co-Authored

Health Canada, *Health and Environmental Impact Assessment Panel Report*, "Joint Industry/Government Study: Sulfur in Gasoline and Diesel Fuels". Ottawa, Canada. (1997).

World Health Organization (WHO), *Exposure assessment in studies on the chronic effects of long-term exposure to air pollution.* Report EUR/03/5039759. Geneva, Switzerland (2003).

Peer Reviewed Journal Articles/Letters

Thurston, G.D. General Discussion: Atmospheric dispersion modeling - A critical review. J. Air Pollut. Control Assoc. 29: 939 (1979).

Thurston, G.D. Discussion of multivariate analysis of particulate sulfate and other air quality variables by principal components - part I. Annual data from Los Angeles and New York. Atmos. Environ. 15: 424-425 (1981).

Thurston, G.D., J.D. Spengler and P.J. Samson. An assessment of the relationship between regional pollution transport and trace elements using wind trajectory analysis. Receptor Models Applied to Contemporary Pollution Problems, Ed. E. Frederick, Air Pollution Control Association, Pittsburgh, PA (1982).

Spengler, J.D. and G.D. Thurston. Mass and elemental composition of fine and coarse particles in six U.S. cities. J. Air Poll. Control Assoc. 33: 1162-1171 (1983).

Currie, L., R. Gerlach, C. Lewis, W.D. Balfour, J. Cooper, S. Dattner, R. DeCesar, G. Gordon, S. Heisler, P. Hopke, J. Shah and G. Thurston. Inter-laboratory comparison of source apportionment procedures: Results for simulated data sets. Atmos. Environ. 18: 1517-1537 (1984).

Thurston, G.D. and J.D. Spengler. A quantitative assessment of source contributions to inhalable particulate matter in metropolitan Boston, Massachusetts. Atmos. Environ. 19: 9-25 (1985).

Thurston, G.D. and N.M. Laird. Letters: Tracing aerosol pollution. Science 227: 1406-1407 (1985).

Thurston, G.D. and J.D. Spengler. A multivariate assessment of meteorological influences on inhalable particle source impacts. J. Clim. and Appl. Met. 24: 1245-1256 (1985).

Ozkaynak, H., J.D. Spengler, A. Garsd and G.D. Thurston. Assessment of population health risks resulting from exposures to airborne particles. Aerosols: Second U.S.-Dutch International Symposium, Lewis Publishing Co., December 1985 (Peer Reviewed).

Ozkaynak, H., A.D. Schatz, G.D. Thurston, R.G. Isaacs and R.B. Husar. Relationships between aerosol extinction coefficients derived from airport visual range observations and alternative measures of airborne particle mass. J. Air Pollut. Control Assoc. 35: 1176-1185 (1985).

Thurston, G.D. and P.J. Lioy. Receptor modeling and aerosol transport. Atmos. Environ. 21: 687-698 (1987).

Ozkaynak, H., and G.D. Thurston. Associations between 1980 U.S. mortality rates and alternative measures of airborne particle concentration. Risk Analysis 7: 449-460 (1987).

Lioy, P.J., D. Spektor, G. Thurston, N. Bock, F. Speizer, C. Hayes and M. Lippmann. The design considerations for ozone and acid aerosol exposure and health investigation: The Fairview Lake Summer Camp-Photochemical Smog Case Study. Environ. Int'l. 13: 27-83 (1987).

Spektor, D.M., M. Lippmann, P.J. Lioy, G.D. Thurston, K. Citak, D.J. James, N. Bock, F.E. Speizer and C. Hayes. Effects of ambient ozone on respiratory function in active normal children. Am. Rev. Resp. Dis. 137: 313-320 (1988).

Lippmann, M. and G.D. Thurston. Exposure Assessment - Input into risk assessment. Arch. Environ. Health 43: 113-123 (1988).

Spektor, D.M., M. Lippmann, G.D. Thurston, P.J. Lioy, J. Stecko, G. O'Connor, E. Garshick, F.E. Speizer, and C. Hayes. Effects of ambient ozone on respiratory function in healthy adults exercising outdoors. Am. Rev. Resp. Dis. 138: 821-828 (1988).

Ito, K. and G.D. Thurston. Characterization and reconstruction of historical London England acidic aerosol concentrations. Environ. Health Presp. 79: 35-42 (1989).

Thurston, G.D., K. Ito, M. Lippmann, and C. Hayes. Re-examination of London mortality in relation to exposure to acidic aerosols during 1962-1973 winters. Environ. Health Persp. 79: 73-82 (1989).

Waldman, J.M., P.J. Lioy, G.D. Thurston and M. Lippmann. Spatial and temporal patterns in summertime sulfate aerosol acidity and neutralization within a metropolitan area. Atmos. Environ. 24B: 115-126 (1990).

Echalar, E., P. Artaxo and G.D. Thurston. Source apportionment of aerosols in the industrial area of Cubatao, Brazil. In: Aerosols: Science, Industry, Health and Environment (S. Masuda and K. Takahashi, Eds.), pp. 942-945, Pergamon Press (1990).

Spektor, D.M., V.A. Hofmeister, P. Artaxo, J. Brague, F. Echelar, D.P. Nogueria, C. Hayes, G.D. Thurston and M. Lippmann. Effects of heavy industrial pollution on respiratory function in the children of Cubatao, Brazil: A preliminary report. Environ. Health Persp. 94: 51-54 (1991).

Waldman, J.M., S.K.C. Liang, P.J. Lioy, G.D. Thurston, and M. Lippmann. Measurements of sulfate aerosol and its acidity in the SO_2 source region of Chestnut Ridge, PA. Atmos. Environ. 25A: 1327-1333 (1991).

Spektor, D.M., G.D. Thurston, J. Mao, D. He, C. Hayes, and M. Lippmann. Effects of single and multiday ozone exposures on respiratory function in active normal children. Environ. Res. 55: 107-122 (1991).

Thurston, G.D. and H. Ozkaynak. Letters: Air pollution and mortality. Science 225: 382-383 (1992).

Thurston, G.D., J.F. Gorczynski Jr., P. Jaques, J. Currie and D. He. An automated sequential sampling system for particulate acid aerosols: Description, characterization and field sampling results. J. Exposure Anal. Environ. Epidemiol. 2: 415-428 (1992).

Thurston, G.D., K. Ito, P. Kinney and M. Lippmann. A multi-year study of air pollution and respiratory hospital admissions in three New York State metropolitan areas: Results for 1988 and 1989 summers. J. Exposure Anal. and Environ. Epidemiol. 2: 429-450 (1992).

Jaques, P.A., G.D. Thurston, P.L. Kinney, and J.E. Gorczynski, Jr. Precision of an ambient sequential acid aerosol sampling system. Appl. Occup. Environ. Hyg. 8: 313-316 (1993).

Kinney, P.L. and G.D. Thurston. Field evaluation of instrument performance: Statistical considerations. Appl. Occup. Environ. Hyg. 8: 267-271 (1993).

Ito, K., G.D. Thurston, C. Hayes, and M. Lippmann. Associations of London, England daily mortality with particulate matter, sulfur dioxide, and acidic aerosol pollution. Arch. Environ. Health 48: 213-220 (1993).

Thurston, G.D., K. Ito, M. Lippmann and D.V. Bates. Respiratory hospital admissions and summertime haze air pollution in Toronto, Ontario: Consideration of the role of acid aerosols. Environ. Res. 65: 271-290 (1994).

Thurston, G.D., J.E. Gorczynski, J.H. Currie, D. He, K. Ito, M. Lippmann, J. Waldman and P. Lioy. The nature and origins of acid aerosol pollution measured in Metropolitan Toronto, Ontario. Environ. Res. 65:254-270 (1994).

Kinney, P.L., Ito, K., and Thurston, G.D. A sensitivity analysis of mortality/PM10 associations in Los Angeles. Inhal. Toxicol. 7:59-69 (1995).

Thurston, G.D. and Kinney, P.L. Air pollution epidemiology: Considerations in time-series modeling. Inhal. Toxicol. 7:71-83 (1995).

Ito, K., Kinney, P., Christie, E., and Thurston, G.D. Variations in PM10 concentrations within two metropolitan areas and their implications to health effects analyses. Inhal. Toxicol. 7:735-745 (1995).

Waldman, J. M., Koutrakis, P., Allen, G.A., Thurston, G.D., Burton, R.M., and Wilson, W.E. Human Exposures to Particle Strong Acidity. Inhal. Toxicol. 7:657-670 (1995).

Thurston, G. Measurement methods to determine compliance with ambient air quality standards for suspended particles: Discussant. J. Air & Waste Manage. Assoc. 45:667-668 (1995).

Kinney, P.L., Thurston, G.D., and Raizenne, M. (1996) The effects of ambient ozone on lung function in children: a reanalysis of six summer camp studies. Environ. Health Perspect. 104:170-174.

Thurston, G.D. A critical review of PM10-mortality time-series studies. J. Exposure Anal. and Environ. Epidemiol. 6:3-22 (1996).

Ozkaynak, H., Xue, J., Zhou, H., Spengler, J.D., and Thurston, G.D. Intercommunity Differences in Acid Aerosol (H^+)/Sulfate (SO_4^+) Ratios. J. Exposure Anal. and Environ. Epidemiol. 6:57-78 (1996).

Ito, K. and Thurston, G.D. Daily PM10/mortality associations: An investigation of at-risk subpopulations. J. Exposure Anal. and Environ. Epidemiol. 6:79-96 (1996).

Lippmann, M. and Thurston, G.D. Sulfate concentrations as an indicator of ambient particulate matter air pollution for health risk evaluations. J. Exposure Anal. and Environ. Epidemiol. 6:123-146 (1996).

Thurston, G. D., Lippmann, M., Scott, M.B., and; Fine, J.M. Summertime haze air pollution and children with asthma. Am. J. Respir. and Crit. Care Med. 155:654-660 (1997).

Thurston, G.D. Mandating the release of health research data: issues and implications. *Tulane Environmental Law Journal.* 11(2):331-354 (1998).

Thurston, G.D. The health benefits of the U.S. EPA clean air standards. *Pace Environmental Law Review*. 16:1 (1998)

Cassino, C., Ito, K., Bader, I., Ciotoli, C., Thurston, G., and Reibman, J. Cigarette smoking and ozone-associated emergency department use for asthma by adults in New York City. *Am. J. Respir. Crit. Care Med.*. 159:1773-1779 (1999).

Gwynn, R.C., Burnett, R.T., and Thurston, G.D. A time-series analysis of acidic particulate matter and daily mortality and morbidity in the Buffalo, New York, region. Environ. Health Perspect. 108(2):125-133 (2000).

Cifuentes, L., Borja-Aburto, V., Gouveia, N., Thurston, G., and Davis, D. Assessment of the urban air pollution benefits of global warming mitigation: Santiago, São Paulo, Mexico City, and New York City. Environ. Health Perspect. 109, Supplement 3:419-425 (2001).

Thurston, G.D. and Ito K. Epidemiological studies of acute ozone exposures and mortality. J. Expo. Anal. Environ. Epidemiol. 11(4):286-294 (2001).

Gwynn, R.C. and Thurston, G.D. The burden of air pollution: Impacts in racial minorities. Environ. Health Perspect. 109 Suppl 4:501-506 (2001).

Cifuentes, L., Borja-Aburto, V.H., Gouveia, N., Thurston, G., and Davis, D.L. Climate change. Hidden health benefits of greenhouse gas mitigation. Science 293(5533):1257-1259 (2001).

Pope, C.A. III, Burnett, R.T., Thun, M.J., Calle, E.E., Krewski, D., Ito, K., and Thurston, G.D. Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution. J. Am. Med. Assoc. (JAMA) 287(9):1132-1141 (2002). PMID: 11879110.

Chen LC, Thurston G. World Trade Center Cough. Lancet. 2002 Dec;360 Suppl:s37-38.

Thurston GD, Chen LC. Risk communication in the aftermath of the World Trade Center disaster. Am J Ind. Med. Dec;42(6):543-4 (2002).

De Leon SF, Thurston GD, Ito K. Contribution of respiratory disease to nonrespiratory mortality associations with air pollution. Am J Respir Crit Care Med. Apr 15;167(8):1117-23 (2003).

Pope CA, Burnett R, Thurston, GD, Thun M, Calle E, Krewski, D, Godleski, J. Cardiovascular Mortality and Long-Term Exposure to Particulate Air Pollution: Epidemiological Evidence of General Pathophysiological Pathways of Disease. Circulation Jan 6;109 (1):71-7 (2004).

Landrigan PJ, Lioy PJ, Thurston G, Berkowitz G, Chen LC, Chillrud SN, Gavett SH, Georgopoulos PG, Geyh AS, Levin S, Perera F, Rappaport SM, Small C; NIEHS World Trade Center Working Group. Health and environmental consequences of the World Trade Center disaster. Environ Health Perspect. May;112(6):731-9 (2004).

Ito K, De Leon S, Thurston GD, Nadas A, Lippmann M. Monitor-to-monitor temporal correlation of air pollution in the contiguous US. J Expo Anal Environ Epidemiol. Jun:16 (2004).

Ito K , Xue N, Thurston G. (2004). Spatial variation of $PM_{2.5}$ chemical species and source-apportioned mass concentrations in New York City. Atmos. Environ. 38: 5269–5282.

Lall R, Kendall M, Ito K, Thurston G. Estimation of historical annual $PM_{2.5}$ exposures for health effects assessment. Atmos. Environ. V38:31, pp. 5217-5226 (2004).

Maciejczyk, PB, Offenberg, JH, Clemente J, Blaustein M, Thurston G., Chen LC. Ambient pollutant concentrations measured by a mobile laboratory in South Bronx, NY. Atmospheric Environment. V38:31, pp. 5295-5304 (2004).

Restrepo C, Zimmerman R, Thurston G, Clemente J, Gorczynski J, Zhong M, Blaustein M, and Chen LC. A comparison of ground-level air quality data with New York State Department of Environmental Conservation monitoring stations data in South Bronx, New York. Atmospheric Environment. V38:31, pp. 5283-5294 (2004).

Trasande L, and Thurston, GD. The role of air pollution in asthma and other pediatric morbidity. J. of Allergy & Clinical Immunol. Apr;115(4):689-99 (2005).

Krewski D, Burnett R, Jerrett M, Pope CA, Rainham D, Calle E, Thurston G, Thun M. Mortality and long-term exposure to ambient air pollution: ongoing analyses based on the American Cancer Society cohort. J Toxicol. Environ Health A. Jul 9-23;68(13-14):1093-109 (2005).

Jerrett M, Burnett RT, Ma R, Pope CA 3rd, Krewski D, Newbold KB, Thurston G, Shi Y, Finkelstein N, Calle EE, Thun MJ. Spatial analysis of air pollution and mortality in Los Angeles. Epidemiology. 2005 Nov;16(6):727-36.

Krewski D, Jerrett M, Burnett RT, Ma R, Hughes E, Shi Y, Turner MC, Pope CA 3rd, Thurston G, Calle EE, Thun MJ, Beckerman B, DeLuca P, Finkelstein N, Ito K, Moore DK, Newbold KB, Ramsay T, Ross Z, Shin H, Tempalski B. Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. Res Rep Health Eff Inst. 2009 May;(140):5-114

Thurston GD, Ito K, Mar T, Christensen WF, Eatough DJ, Henry RC, Kim E, Laden F, Lall R, Larson TV, Liu H, Neas L, Pinto J, Stolzel M, Suh H, Hopke PK. Workgroup report: workshop on source apportionment of particulate matter health effects--intercomparison of results and implications. Environ Health Perspect. 2005 Dec;113(12):1768-74.

Ito K, Christensen WF, Eatough DJ, Henry RC, Kim E, Laden F, Lall R, Larson TV, Neas L, Hopke PK, Thurston GD. PM source apportionment and health effects: 2. An investigation of intermethod variability in associations between source-apportioned fine particle mass and daily mortality in Washington, DC. J Expo Sci Environ Epidemiol. 2006 Jul;16(4):300-10.

Mar TF, Ito K, Koenig JQ, Larson TV, Eatough DJ, Henry RC, Kim E, Laden F, Lall R, Neas L, Stolzel M, Paatero P, Hopke PK, Thurston GD. PM source apportionment and health effects. 3. Investigation of inter-method variations in associations between estimated source contributions of PM(2.5) and daily mortality in Phoenix, AZ. J Expo Sci Environ Epidemiol. 2006. Jul;16(4):311-20.

Hopke PK, Ito K, Mar T, Christensen WF, Eatough DJ, Henry RC, Kim E, Laden F, Lall R, Larson TV, Liu H, Neas L, Pinto J, Stolzel M, Suh H, Paatero P, Thurston GD., PM source apportionment and health effects: 1. Intercomparison of source apportionment results. J Expo Sci Environ Epidemiol. 2006 May;16(3):275-86.

Lall R and Thurston G. (2006). Identifying and quantifying transported vs. local sources of New York City $PM_{2.5}$ fine particulate matter air pollution. Atmospheric Environment, 40: S333–S346.

Ito K, Thurston GD, Silverman RA. Characterization of PM2.5, gaseous pollutants, and meteorological interactions in the context of time-series health effects models. J Expo Sci Environ Epidemiol. 2007 Dec;17 Suppl 2:S45-60.

Kim JY, Burnett RT, Neas L, Thurston, G.D., Schwartz J, Tolbert PE, Brunekreef B, Goldberg MS, Romieu I. Panel discussion review: session two--interpretation of observed associations between multiple ambient air pollutants and health effects in epidemiologic analyses. J Expo Sci Environ Epidemiol. 2007 Dec;17 Suppl 2:S83-9.

Ross Z, Jerrett M, Ito K, Tempalski, Thurston G. A land use regression for predicting fine particulate matter concentrations in the New York City region. 2007. Atmospheric Environment. 41: 2255-2269.

Jerrett M, Newbold KB, Burnett RT, Thurston G., Lall R., Pope C. A. III, Ma R, De Luca P, Thun M., Calle J, Krewski D. Stoch. Environ. Res. Risk Assess. Geographies of uncertainty in the health benefits of air quality improvements. 2007. Volume 21, No. 5: 511-522.

Ito K, Thurston GD, Silverman RA. Characterization of $PM_{2.5}$, gaseous pollutants, and meteorological interactions in the context of time-series health effects models. J Expo Sci Environ Epidemiol. 2007 Dec;17 Suppl 2:S45-60.

Bell ML, Davis DL, Cifuentes LA, Krupnick AJ, Morgenstern RD, Thurston GD. Ancillary human health benefits of improved air quality resulting from climate change mitigation. Environ Health. 2008 Jul 31;7:41.

Thurston GD, Bekkedal MY, Roberts EM, Ito K, Arden Pope C 3rd, Glenn BS, Ozkaynak H, Utell MJ. (2009). Use of health information in air pollution health research: Past successes and emerging needs. J Expo Sci Environ Epidemiol. 2009 Jan;19(1):45-58. Epub 2008 Sep 10.

Jerrett M, Burnett RT, Pope C. A. III, Ito K, Thurston G., Krewski D., Shi Y., Calle J, Thun M., The Contribution of Long-Term Ozone Exposure to Mortality. NEJM. 360;11 March 12, 2009. PMID: 19279340.

Ying Z, Kampfrath T, Thurston G, Farrar B, Lippmann M, Wang A, Sun Q, Chen LC, Rajagopalan S. Ambient particulates alter vascular function through induction of reactive oxygen and nitrogen species. Toxicol Sci. 2009 Sep;111(1):80-8. Epub 2009 Jan 30.

McKean-Cowdin R, Calle EE, Peters JM, Henley J, Hannan L, Thurston GD, Thun MJ, Preston-Martin S. Ambient air pollution and brain cancer mortality. Cancer Causes Control. 2009 Nov;20(9):1645-51. Epub 2009 Aug 15.

Smith KR, Jerrett M, Anderson HR, Burnett RT, Stone V, Derwent R, Atkinson RW, Cohen A, Shonkoff SB, Krewski D, Pope CA 3rd, Thun MJ, Thurston G. Public health benefits of strategies to reduce greenhouse-gas emissions: health implications of short-lived greenhouse pollutants. Lancet. 2009 Dec 19;374(9707):2091-103. PMID: 19942276.

Chen L; Hwang J; Lall, R; Thurston, G; Lippmann, M. Alteration of cardiac function in ApoE-/- mice by subchronic urban and regional inhalation exposure to concentrated ambient PM 2.5. Inhalation toxicology. 2010 Jun;22(7):580-92.

Spira-Cohen A, Chen LC, Kendall M, Sheesley R, Thurston GD. (2010). Personal exposures to traffic-related particle pollution among children with asthma in the South Bronx, NY. J Expo Sci Environ Epidemiol. 2010 Jul;20(5):446-56. Epub 2009 Oct 28.

Ito K, Mathes R, Ross Z, NádasA, Thurston G, and Matte T. Fine Particulate Matter Constituents Associated with Cardiovascular Hospitalizations and Mortality in New York City Environmental Health Perspectives (EHP). 2011 Apr; 119(4):467-73. [Epub Dec. 2010 ahead of print]

Lall R, Ito K, Thurston G. Distributed Lag Analyses of Daily Hospital Admissions and Source-Apportioned Fine Particle Air Pollution. Environmental Health Perspectives (EHP). 2011 Apr; 119(4):455-60. PMC3080925.

Zhou J, Ito K, Lall R, Lippmann M, Thurston G. Time-series Analysis of Mortality Effects of Fine Particulate Matter Components in Detroit and Seattle. Environ Health Perspect. 2011 Apr;119(4):461-6. PMCID: PMC3080926.

Spira-Cohen A, Chen LC, Kendall M, Lall R, Thurston GD. Personal Exposures to Traffic-Related Air Pollution and Acute Respiratory Health Among Bronx School Children with Asthma. Environ Health Perspect. 2011 Apr;119(4):559-65. PMCID: PMC3080941.

Thurston G., Ito K, and Lall R. A Source Apportionment of U.S. Fine Particulate Matter Air Pollution. Atmospheric Environment. 2011Aug. 45(24): 3924-3936. PMCID: PMC3951912.

Brauer M, Amann M, Burnett RT, Cohen A, Dentener F, Ezzati M, Henderson SB, Krzyzanowski M, Martin RV, Van Dingenen R, van Donkelaar A, Thurston GD. (2012). Exposure Assessment for Estimation of the Global Burden of Disease Attributable to Outdoor Air Pollution. Environ. Sci. Technol. 2012 Jan 17;46(2):652-60. PMID: 22148428.

Restrepo CE, Simonoff JS, Thurston GD, Zimmerman R (2012) Asthma Hospital Admissions and Ambient Air Pollutant Concentrations in New York City. Journal of Environmental Protection, Vol. 3 No. 9, 2012, pp. 1102-1116.

Murray CJ, Vos T, Lozano R, et al. (2012) Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. Dec 15; 380(9859):2197-223.

Lim S, Vos T, Flaxman A, et al. (2012) A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. Dec 15;380(9859):2224-60.

Vos T, Flaxman AD, Naghavi M, Lozano R et al. (2012). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet Dec 15; 380(9859): 2163-96.

Trasande L, Wong K, Roy A; Savitz D, and Thurston, G (2013) Exploring prenatal outdoor air pollution, birth outcomes and neonatal health care utilization in a nationally representative sample". J Expo Sci Environ Epidemiol. 2013 May-Jun;23(3):315-21. doi: 10.1038/jes.2012.124. Epub 2013 Jan 23.

Jerrett M, Burnett RT, Beckerman BS, Turner MC, Krewski D, Thurston G, Martin R, von Donkelaar A, Hughes E, Shi Y, Gapstur SM, Thun MJ, Pope CA 3rd. (2013) Spatial Analysis of Air Pollution and Mortality in California. Am J Respir Crit Care Med. Sep 1;188(5):593-9. PMID: 23805824

Murray CJ, Abraham J, Ali MK, Alvarado M, et al. (2013) US Burden of Disease Collaborators. The State of US Health, 1990-2010: Burden of Diseases, Injuries, and Risk Factors. JAMA. 2013 Aug 14;310(6):591-608. PMID: 23842577.

Lippmann M, Chen LC, Gordon T, Ito K, Thurston GD. (2013) National Particle Component Toxicity (NPACT) Initiative: Integrated epidemiologic and toxicologic studies of the health effects of particulate matter components. Res Rep Health Eff Inst. 2013 Oct;(177): 5-13.

Rice MB, Thurston GD, Balmes JR, Pinkerton KE. Climate Change: A Global Threat to Cardiopulmonary Health. Am J Respir Crit Care Med. 2014 Mar 1;189(5):512-9.

Vilcassim MJ, Thurston GD, Peltier RE, Gordon T. Black Carbon and Particulate Matter (PM2.5) Concentrations in New York City's Subway Stations. Environ Sci Technol. 2014 Dec 16;48(24):14738-45.

Solenkova NV, Newman JD, Berger JS, Thurston G, Hochman JS, Lamas GA. Metal pollutants and cardiovascular disease: mechanisms and consequences of exposure. Am Heart J. 2014 Dec;168(6):812-22.

Sarfaty M, Bloodhart B, Ewart G, Thurston GD, Balmes JR, Guidotti TL, Maibach EW. American Thoracic Society Member Survey on Climate Change and Health. Ann Am Thorac Soc. 2014 Dec 23.

Newman JD, Thurston GD; Cromar K; Guo, Yu; Rockman, Caron B; Fisher, Edward A; Berger, Jeffrey S. Particulate Air Pollution and Carotid Artery Stenosis. Journal of the American College of Cardiology. 2015:1-5.

Naghavi M; Wang H; Lozano R, et al., Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2015:385(9963):117-171.

Mirowsky J. E., Jin L; Thurston G, Lighthall D, Tyner T, Horton L, Galdanes K, Chillrud S, Ross J, Pinkerton K, Chen LC, Lippmann M, Gordon T. In vitro and in vivo toxicity of urban and rural particulate matter from California. 2015-04-10; 1352-2310, Atmospheric Environment (Oxford) - id: 1522182.

Thurston G, Lippmann M. Ambient particulate matter air pollution and cardiopulmonary diseases. Semin Respir Crit Care Med. 2015 Jun;36(3):422-32.

Thurston GD, Ahn J, Cromar K, Shao Y, Reynolds H, Jerrett M, Lim C, Shanley R, Park Y, Hayes RB, Ambient Particulate Matter Air Pollution Exposure and Mortality in the NIH-AARP Diet and Health Cohort. Env. Health Persp. 2016 Apr;124(4):484-90. doi: 10.1289/ehp.1509676. Epub 2015 Sep 15

Gany F, Bari S, Prasad L, Leng J, Lee T, Thurston GD, Gordon T, Acharya S, Zelikoff JT. Perception and reality of particulate matter exposure in New York City taxi drivers. J Expo Sci Environ Epidemiol. 2016 May 11. doi: 10.1038/jes.2016.23. [Epub ahead of print]

Thurston GD, Burnett RT, Turner MC, Shi Y, Krewski D, Lall R, Ito K, Jerrett M, Gapstur SM, Diver WR, Pope CA. Ischemic Heart Disease Mortality and Long-Term Exposure to Source-Related Components of U.S. Fine Particle Air Pollution. Environ Health Perspect. 2016 Jun;124(6):785-94. doi: 10.1289/ehp.1509777. Epub 2015 Dec 2.

Thurston GD, Kipen H, Annesi-Maesano I, Balmes J, Brook RD, Cromar K, De Matteis S, Forastiere F, Forsberg B, Frampton MW, Grigg J, Heederik D, Kelly FJ, Kuenzli N, Laumbach R, Peters A, Rajagopalan ST, Rich D, Ritz B, Samet JM, Sandstrom T, Sigsgaard T, Sunyer J, Brunekreef B. A Joint ERS/ATS Policy Statement: What Constitutes An Adverse Health Effect Of Air Pollution? An Analytical Framework. *European Respiratory Journal.* 2017 Jan 11; 49(1).

Bayram H; Bauer AK; Abdalati W; Carlsten C; Pinkerton KE; Thurston GD; Balmes JR; Takaro TK. Environment, Global Climate Change, And Cardiopulmonary Health. American Journal of Respiratory & Critical Care Medicine. 2017 Mar 15; 195(6):718-724

Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE) Training

George Thurston

NYU School of Medicine

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