Final Technical Report

Date of Final Report: August 1, 2006
EPA Grant Number: R827351C014
Center Name: NYU-EPA PM Center: Health Risks of PM Components
Center Director: Morton Lippmann
Title: PM Components and NYC Respiratory and Cardiovascular Morbidity
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Project Period: June 1, 1999–May 31, 2005 (no-cost extension to May 31, 2006)
Period Covered by the Report: June 1, 1999–May 31, 2006
RFA: Airborne Particulate Matter (PM) Centers (1999)
Research Category: Particulate Matter

Objective(s) of the Research Project: This project took advantage of the continuous PM_{10} and $PM_{2.5}$ data, as well as the newly available $PM_{2.5}$ chemical speciation data, collected in New York City (NYC). The project aimed to identify key PM components and source types that are associated with respiratory and cardiovascular morbidity, and to provide excess risk estimates for sub-populations that are characterized by age group, diagnoses, and sub-areas within NYC.

Summary of Findings: We retrieved all the relevant air pollution variables: particulate matter less than 2.5 µm, ($PM_{2.5}$) collected by the 24-hr filter samples using Federal Reference Method (FRM), $PM_{2.5}$ chemical speciation data, $PM_{2.5}$ and PM_{10} data measured by the Tapered Element Oscillating Microbalance (TEOM), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO). $PM_{2.5}$ data were available from 1999, and we therefore evaluated the influence of $PM_{2.5}$ and other co-pollutants for the years 1999-2002. All the pollution data were retrieved from the U.S. Environmental Protection Agency's (EPA) Air Quality System (AQS). Hourly readings were available for the gaseous pollutants and the TEOM PM data. Past studies have used O_3 exposure indices with varying averaging time (e.g., daily maximum of 1-hr averages, daily 24-hr average, and daily maximum of 8-hr averages). Since the current O_3 standard is set for the daily 8-hr maximum (the average of the fourth highest of which over three years is not to exceed 80 ppb), to facilitate easier interpretation, we focus on the daily 8-hr maximum values but also examined the 1-hr maximum and the 24-hr average values. For other pollutants, we also used the exposure indices that were used for the air quality standards (i.e., 24-hr average for $PM_{2.5}$ and SO_2; daily maximum of 1-hr average for CO). There is no daily standard for NO_2, and we used the 24-hr average values. The data from all the air quality monitors within a 20-mile radius from the geographic center of NYC were obtained, and the averages for multiple monitors were computed for each day. There were 17 O_3 monitors with this inclusion criterion, but the data from a monitor at the top of the World Trade Center was excluded because of its height (it read higher readings than the nearby monitors on the ground level). There were 33 monitors for the FRM $PM_{2.5}$; 18 monitors for CO; 15 monitors for NO_2; and 19 monitors for SO_2. There were five sites where both $PM_{2.5}$ and PM_{10} were measured by co-located TEOM monitors. Therefore, to estimate the coarse mass fraction, $PM_{10\text{-}2.5}$ we subtracted the $PM_{2.5}$ from PM_{10} for each site, and averaged across the five sites. $PM_{2.5}$ chemical

speciation data were available from three sites: 1) New York Botanical Gardens (NYBG) in Bronx; 2) I.S. 52 in Bronx; and 3) Queens College (QC) in Queens. The data are available starting from 2000 for NYBG and from 2001 for I.S. 52 and QC. Available PM components were: 1) $PM_{2.5}$ particulate mass; 2) anions (sulfate, nitrate) and cations (particulate ammonium, sodium, and potassium) by ion chromatograph; 3) trace elements (about 20 key elements from sodium through lead on the periodic table) by energy dispersive X-ray fluorescence (EDXRF); and 4) total carbon including organic, elemental, and carbonate carbon by thermal optical analysis. To adjust for weather effects on morbidity outcomes, we considered daily 24-hr average temperature and daily maximum relative humidity from La Guardia airport.

First, we examined the associations between each of the size-fractionated PM indices and asthma emergency department (ED) visits from the 11 NYC municipal hospitals for the years 1999-2002. The data were analyzed for the full-year period (excluding September and October to avoid the influence of the fall peaks in asthma ED visits), as well as for warm (April-August) and cold (November-March) season subsets. A total of 167,900 asthma ED visits were analyzed for the four-year period. A Poisson Generalized Linear Model (GLM) was used to estimate the impact of the average of 0- and 1-day lags of $PM_{2.5}$ and $PM_{10-2.5}$ on the asthma ED visits, adjusting for weather effects, temporal trends, and day-of-week. We modeled immediate and potentially non-linear temperature effects by including a smooth function (natural spline) of same-day temperature with three degrees of freedom. Likewise, we included a smooth function of the average of past 2- and 3-day temperatures with three degrees of freedom to adjust for any delayed and possibly non-linear effects of temperature. To model the effects of interaction of heat and humidity effects, an indicator variable was included for hot (temperature > 78°F) and humid (relative humidity > 80%) days. Relative risks were computed per 5th-to-95th percentile increments of concentration (i.e., representing “low” to “high” levels) of O_3 or $PM_{2.5}$. Both $PM_{2.5}$ (RR = 1.11; 95% CI: 1.04, 1.18, per 5th-to-95th percentile increment) and $PM_{10-2.5}$ (RR = 1.12; 95% CI: 1.06, 1.18) were associated with asthma ED visits in the full-year data. In the warm season, the risk estimate for $PM_{10-2.5}$ (RR = 1.25; 95% CI: 1.15, 1.36) was somewhat higher than that for $PM_{2.5}$ (RR = 1.15; 95% CI: 1.03, 1.27). In the cold season, $PM_{10-2.5}$ was not associated with asthma ED visits, and $PM_{2.5}$ was only weakly associated. We concluded that coarse summertime PM may be an important component that exacerbates asthma in NYC.

We also conducted regression analysis using the source-apportioned $PM_{2.5}$ that we constructed in Ito, et al. (2004). Two sets of source-apportioned $PM_{2.5}$ data were available, one using Absolute Principal Component Analysis (APCA) and the other using Positive Matrix Factorization (PMF). As described in Ito, et al. (2004), four major source types were identified using both methods: secondary sulfate, traffic-related particles, residual oil combustion/incineration effluents, and re-suspended soil. For each set, we averaged the source-apportioned $PM_{2.5}$ across the three monitors. The same Poisson GLM model described above was employed, except that 0- and 1-day lagged PM component variables were examined separately because of the every-3rd-day sampling frequency. Unfortunately, because of this sampling frequency, the total available number of days (< 180 days) for the study period did not provide sufficient statistical power for the expected magnitude of risk estimates. Most of the source-apportioned $PM_{2.5}$’s risk estimates were positive, but none were statistically significant. Generally, the risk estimates were larger for warm season than for year-round or cold season. For example, the relative risks per 5^{th}-to-95th percentile of source-apportioned $PM_{2.5}$ at lag 0 day using the APCA set were: 1.15 (95%

CI: 0.83, 1.59); 1.03 (95% CI: 0.88, 1.22); 1.02 (95% CI: 0.92, 1.14); and, 1.00 (95% CI: 0.94, 1.067) for residual oil combustion/incineration, secondary sulfate, soil, and traffic, respectively.

Gaseous pollutants were also analyzed using the same regression models. In the warm season, O_3 (RR=1.13; 95% CI: 1.03, 1.23]), NO_2 (RR=1.17; 95% CI: 1.08, 1.25), and CO (RR=1.12; 95% CI: 1.02, 1.22) were each associated with asthma ED visits, and O_3 and NO_2 associations appeared to be independent of $PM_{2.5}$. In the cold season, gaseous pollutants' associations with asthma ED visits were generally weaker.

While we had a sufficient number of observations to examine the effects of size-fractionated PM, the sample size for the $PM_{2.5}$ speciation data was less than desirable.

Conclusion

We found that both $PM_{2.5}$ and $PM_{10\text{-}2.5}$ were associated with asthma ED visits in this data set. $PM_{10\text{-}2.5}$ in warm season may be an important component that exacerbates asthma in NYC. NO_2 and O_3 also appear to independently contribute to excess asthma ED visits in warm months. An examination of specific PM chemical component(s) responsible for the observed associations requires a larger sample size (more days).

References:

Ito K, Xue N, Thurston GD. Spatial variation of PM2.5 chemical species and source-apportioned mass concentrations in New York City. *Atmospheric Environment* 2004;38:5269-5282.

Supplemental Keywords: NA

Relevant Web Sites: http://www.med.nyu.edu/environmental/
http://es.epa.gov/ncer/science/pm/centers.html