

10047-Fine Particle Concentration, Composition and Sources in the Salt Lake City, Utah Area  
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EPA is sponsoring studies at BYU, under the Science To Achieve Results (STAR) Program and the Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program, to evaluate factors which influence the effect of fine particulate matter on human health using continuous measurement of PM<sub>2.5</sub> mass, including the semi-volatile components. Included in the program is an evaluation of the effect of changes in exposure on heart rate variability and markers of blood inflammation in elderly subjects. Ammonium nitrate and semi-volatile organic material are significant components of fine PM in most urban atmospheres. These species are not properly identified during sampling with conventional systems because they are lost from the collected particles during sampling. The joint STAR/EMPACT study is exploring the hypothesis that fine PM mass, including semi-volatile PM, is associated with acute changes in cardiac rhythm and markers of inflammation. Techniques have been developed and tested for the continuous measurement of total PM<sub>2.5</sub> mass and composition. The two year field research program, completed under the EPA STAR and EMPACT studies in Salt Lake City, Bountiful and Lindon Utah, has (1) Demonstrated the usefulness of a newly-developed, real-time, continuous monitor (RAMS) for total (nonvolatile plus semi-volatile) PM<sub>2.5</sub> mass, particularly the time- and health-relevance of this method, as compared to other measurements of PM<sub>2.5</sub> parameters. (2) Compared a variety of batch (24-hour) and continuous (one-hour) PM<sub>2.5</sub> measurement methods, including equilibrated mass (FRM), nonvolatile mass (TEOM), total mass (RAMS, the new method), particulate carbon (R&P monitor), soot (Anderson Aethalometer) and particle number (TSI DMPS). The sum of 24 1-h mass measurements have also been being compared to mass measured by 24-h filter collections and by the PC-BOSS (a diffusion denuder sampler designed to measure semi-volatile organic and nitrate material in fine particles). (3) Identified the combustion sources (mobile, refinery, steel mill and wood smoke, both from home combustion and mountain wild fires) associated with 1-h PM<sub>2.5</sub> measurements and demonstrated that the secondary aerosol is essentially all associated with the semi-volatile material that is not measured with a TEOM monitor and only partially detected with conventional single filter samplers. These data are now being used to examine which components may be associated with the exacerbation of cardiovascular health problems. The various aspects of and results from the field sampling program will be presented.

## 10082- USING SULFUR AS A TRACER OF OUTDOOR FINE PARTICULATE MATTER

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Introduction: Numerous epidemiologic studies have reported associations between ambient fine particle (PM<sub>2.5</sub>) concentrations and adverse health effects. Currently, it is not possible to measure indoor PM<sub>2.5</sub> concentrations or personal PM<sub>2.5</sub> exposures of ambient origin directly, making it difficult to interpret risk estimates associated with ambient PM<sub>2.5</sub>. In a recent paper (1), we used fine particle sulfate to estimate personal exposure to PM<sub>2.5</sub> of ambient origin. An important assumption of this estimation technique is that the physical behavior (i.e., the effective penetration efficiency) of sulfur particles is representative of all outdoor PM<sub>2.5</sub>. This paper examines whether this assumption is valid using data collected as part of a comprehensive particle characterization study in the Boston area. Methods: Nine homes in the metropolitan Boston area were sampled between 6 and 12 consecutive days for indoor and outdoor particle volume and mass concentrations, particle elemental analysis, and air exchange rate (AERs). Indoor/outdoor (I/O) ratios of nighttime sulfur, PM<sub>2.5</sub> and the specific particle size intervals were used to provide estimates of the effective penetration efficiency. Mixed models and graphical displays were used to assess the ability of the I/O ratios for sulfur to estimate corresponding I/O ratios for PM<sub>2.5</sub> and the various particle sizes. Results: I/O sulfur ratios were strongly associated with corresponding I/O PM<sub>2.5</sub> ratios, suggesting that sulfur behaved in a manner that was representative of total PM<sub>2.5</sub> in Boston, MA. The degree by which sulfur was representative of PM<sub>2.5</sub>, however, varied by particle size and mean air exchange rates. Sulfur was more representative of particles in the 0.06 and 0.5  $\mu\text{m}$  size range as compared to particles in smaller and larger size intervals. Using I/O ratios for sulfur to predict corresponding I/O ratios for 0.06-0.5  $\mu\text{m}$  particles produced consistently accurate and precise results. Regression results showed that I/O sulfur ratios significantly over-predicted I/O ratios for particles less than 0.06 and greater than 0.7  $\mu\text{m}$  in size, reflecting higher effective penetration efficiencies for sulfur as compared to particles in these size intervals. Additionally, sulfur was more representative of other PM<sub>2.5</sub> sizes for homes with high mean AERs. Conclusions: The results support the conclusion that for this study location sulfur can be used as an accurate and precise tracer of outdoor PM<sub>2.5</sub>. The degree by which sulfur was representative of PM<sub>2.5</sub> varied by particle size and AERs, however, which was consistent with findings from other studies characterizing particle penetration and deposition behavior. Sulfur was more representative of particles of similar size, providing evidence that the size composition of total PM<sub>2.5</sub> is an important characteristic affecting the robustness of sulfur-based estimation methods. In addition, the results showed that using sulfur-based method in locations where residences typically have lower mean AERs, such as those with colder winters or hotter summers, will likely result in less precise sulfur-based estimates of indoor particles of outdoor origin.

## References

(1) Sarnat JA, Koutrakis P, Suh HH. *J Air Waste Manag Assoc.* 2000; 50:1184-1198.

10153- Ambient fine particulate matter exposure estimation: a comparison of approaches  
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**INTRODUCTION:** Epidemiological time-series studies have repeatedly shown positive associations between ambient particulate matter (PM) concentrations and adverse health effects. Several studies have examined the degree to which these concentrations represent the ambient PM exposures of the study population. These studies have relied on exposure estimation techniques, since direct measurement of ambient exposures is not possible. In this paper, we compare two methods to estimate the ambient and non-ambient components of personal and indoor PM: a) using sulfate as a tracer for ambient PM and b) using a random component superposition (RCS) model. **METHODS:** This comparison was made using data from an exposure and cardiovascular health study conducted in Steubenville, OH during the summer (11 weeks) and fall (12 weeks) of 2000. In each season, 24-h personal, indoor and outdoor measurements of PM<sub>2.5</sub>, sulfate, elemental and organic carbon, ozone, nitrogen dioxide, sulfur dioxide, and water soluble and total elements were made for 25 participants (mean age: 72.2 years; non-smokers) living in one of three apartment complexes. Indoor monitors were placed in participants' homes for two consecutive days each week; 10 of these participants also wore a personal monitor during each sampling day. Daily outdoor measurements were made on the roofs of two of the apartment buildings and at a central site located away from the downtown area. 22 individuals participated in both seasons, resulting in up to 46 repeated measurements per participant. **DATA ANALYSIS:** Both Sulfate and RCS models partition PM exposure measurements into ambient and non-ambient components based on linear superposition and lack of correlation between these components. The ambient component was estimated with the Sulfate method by assuming that sulfate particles penetrate indoors as efficiently as does PM<sub>2.5</sub>. The RCS model, on the other hand, uses regression techniques to partition ambient and non-ambient components. Longitudinal analyses were used to account for the repeated nature of the data. **RESULTS:** The resulting ambient and non-ambient components of each model are summarized in Table 1. Overall, ambient particles dominate both indoor and personal PM<sub>2.5</sub> concentrations. Though the two models operate very differently, we have found good agreement between the estimates. The effect of different regression techniques and accounting for other factors such as ventilation may have additional value to the precision or relative accuracy of either method.

Overall PM <sub>2.5</sub>	Components	Sulfate Model	RCS Model	Difference	Relative Difference	r*
Personal: 19.5 (10.0)	Ambient	15.5 (9.1)	13.9 (7.0)	-1.6 (4.9)	0.21 (0.23)	0.8654
	Non-ambient	4.0 (7.9)	5.6 (7.0)	1.6 (4.9)	1.18 (11.17)	0.6747
Indoor: 19.9 (11.5)	Ambient	17.0 (9.9)	15.4 (7.7)	-1.6 (4.9)	0.21 (0.22)	0.8672
	Non-ambient	2.9 (9.0)	4.5 (8.5)	1.6 (4.9)	1.82 (34.42)	0.5802

Table 1. PM<sub>2.5</sub> concentrations in µg/m<sup>3</sup> with standard deviations in brackets; N=340; for comparison, the mean outdoor PM<sub>2.5</sub> concentration was 20.6 µg/m<sup>3</sup> (sd: 10.3); \*all p<0.0001.

## **10188- MONITORING TOXIC ORGANIC GASES AND PARTICLES NEAR THE WORLD TRADE CENTER AFTER SEPTEMBER 11, 2001**

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### **ABSTRACT**

The September 11, 2001 attack on the World Trade Center (WTC) resulted in an intense fire and the subsequent, complete collapse of the two main structures and adjacent buildings, as well as significant damage to many surrounding buildings within and around the WTC complex. This 16-acre area has become known as Ground Zero. In response to this disaster, the US EPA quickly positioned air monitors and samplers around Ground Zero to characterize the resulting air plumes. One such instrument was a High Capacity Integrated Organic Gas and Particle (HiC IOGAP) sampler with a 2.5  $\mu\text{m}$  cyclone for particle discrimination to collect semi-volatile gases and particles for speciation of organic compounds.

The results indicate that after the initial destruction of the WTC the remaining air plumes from the disaster site were comprised of many pollutants and classes and represent a complex mixture. This mixture includes compounds that are typically associated with fossil fuel emissions. The molecular markers for these emissions include the high levels of PAHs observed, the n-alkanes Carbon Prefix Index  $\sim 1$  (odd carbon:even carbon  $\sim 1$ ), as well as pristane and phytane as specific markers for fuel oil degradation. These results are not unexpected considering the large number of diesel generators and oversized vehicles used in the removal phases. The mixture also includes emissions of burning and remnant materials from the WTC site. The molecular markers for these emissions include retene and 1,4a-dimethyl-7-(methylethyl)-1,2,3,4,9,10,10a,4a-octahydrophenanthrene which are typically biogenic in origin. In addition, the compound 1,3-diphenyl propane [1',1'-(1,3-propanediyl)bis-benzene] is found in significant concentrations. This species has not previously been reported from ambient sampling. It has been associated with polyvinyl chloride materials, which are believed to be in abundance at the WTC site. These emissions lasted for over three weeks (9/26/01-10/20/01) after the initial destruction of the WTC.

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## 10271- Simulation of PM2.5 home indoor concentrations in Helsinki

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PM2.5 levels in ambient air have been connected to excess population morbidity and mortality. Effective air quality management requires optimization of policy options to reduce population exposures. Modeling is the primary way to compare competing policy alternatives. A probabilistic simulation framework was built by RIVM and KTL to model population exposures to air pollution. The framework produced earlier good results in Helsinki using measured microenvironment PM2.5 concentration inputs.

As majority of population time is spent indoors, the key to exposure simulation is the modeling of indoor concentrations. This work demonstrates the modeling of (i) penetration of the ambient PM2.5 indoors and (ii) non-ETS PM2.5 indoor sources. The model is based on the equation 1, where  $C$  denotes concentration with different components indicated in the subscript and  $p_{PM2.5}$  the penetration factor for the PM2.5 of ambient origin:

$$(eq. 1) \quad C_{indoor} = p_{PM2.5} \times C_{ambient} + C_{sources}$$

Input parameters for the model were obtained by analyzing the EXPOLIS microenvironment measurements in non-ETS homes. Penetration factor was calculated for the elemental sulfur ( $p_S = C_{Sin} C_{Sou}^{-1}$ ) measured out- and inside of 98 homes in Helsinki. The sulfur penetration factor was scaled for the PM2.5 of ambient origin ( $p_{PM2.5}$ ) by using PM2.5 indoor/outdoor regression slope ( $\beta_I=0.65$  for 106 homes) and average sulfur penetration factor ( $p_S=0.72$  for 74 homes) ratio ( $0.65/0.72 = 0.90$ ). The penetration was then simulated using a 2-parameter beta distribution ( $\alpha_1=3.81$ ,  $\alpha_2=2.17$ ) fitted to the penetration data using the method of moments ( $\bar{p}_{PM2.5}=0.64$ , sd 0.18). The ambient concentration distribution was modeled using lognormal fit to the nighttime ambient data ( $\bar{C}_{ambient}=9.9 \mu\text{g m}^{-3}$ , sd  $6.8 \mu\text{g m}^{-3}$ ).

The concentration caused by non-ETS indoor sources were calculated by subtracting the indoor PM2.5 of ambient origin ( $\overline{p_{PM2.5}} \times \bar{C}_{ambient} = 7.0 \mu\text{g m}^{-3}$ , sd  $5.9 \mu\text{g m}^{-3}$ ) calculated as explained above from the measured home indoor concentration ( $\bar{C}_{indoor} = 9.3 \mu\text{g m}^{-3}$ , sd  $6.0 \mu\text{g m}^{-3}$  for 106 homes). Two-parameter lognormal distribution fitted to the indoor source concentration data using the method of moments ( $\bar{C}_{sources} = 2.5$ , sd 3.2) was then used in the simulation. The simulated indoor concentration was calculated as the sum of the penetrated and indoor source concentrations. The simulated indoor concentrations matched the observed distribution quite well, but the highest percentiles were slightly underestimated (table 1).

**Table 1. Simulated and observed indoor concentration distributions in Helsinki non-ETS homes.**

	n	mean	sd	percentiles						
				5 %	10 %	25 %	50 %	75 %	90 %	95 %
Simulated [ $\mu\text{g m}^{-3}$ ]	2000	8.80	5.82	2.8	3.4	5.0	7.4	10.9	15.6	19.5
Observed [ $\mu\text{g m}^{-3}$ ]	153	8.76	5.66	2.7	3.4	4.7	7.1	11.0	18.1	21.2
Difference:										
Sim - Obs [ $\mu\text{g m}^{-3}$ ]		+0.0	+0.2	+0.1	+0.1	+0.2	+0.3	-0.0	-2.5	-1.7
Relative to Obs [%]		+0.5	+2.9	+4.8	+1.7	+4.7	+4.8	-0.4	-13.6	-8.1

Similar analyses were carried out for the workplaces and for smoking sources. The simulated indoor concentrations for homes and workplaces will be used as inputs in the next population exposure model. This model will be validated against independently measured personal exposures.

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## 10335- Indoor Fine particles: The Role of Terpene Emissions from Consumer Products

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Experiments were conducted in an 11 m<sup>3</sup> chamber to investigate the effect of terpene emissions from consumer products on secondary particle levels in indoor environments. Experimental findings are consistent with applications of a new model to predict homogeneous indoor reactions (ICEM: Indoor Chemistry and Exposure Model). Six different consumer products were investigated: a solid air freshener, a liquid air freshener, a wood floor cleaner, a general purpose cleaner, a perfume, and a dishwasher detergent. Ozone was generated using a commercial "air purifier" with subsequent concentrations in chamber air ranging from 100 to 220 ppb. Two experiments were performed for each consumer product: one at elevated ozone levels (>100 ppb) and the other at lower ozone levels (<25 ppb). Total terpene levels were comprised mostly of  $\alpha$ -pinene and *d*-limonene; concentrations in chamber air before the introduction of the consumer products ranged from 0-2 ppb. Peak terpene concentrations after the introduction of the consumer products into the chamber ranged from 5-360 ppb. Chamber particle number and ozone concentrations were continuously measured during experiments. Particle mass concentrations were estimated based on the measured particle size distribution and published estimates of particle density. Chamber particle number and mass concentrations increased and ozone levels decreased during the course of each experiment suggesting that ozone/terpene reactions were responsible for the increases in particle levels, a finding supported by results from ICEM simulations. Increases in particle numbers and mass concentrations in excess of 800,000 particles/cm<sup>3</sup> and 125  $\mu$ g/m<sup>3</sup>, respectively, were measured for particles less than 0.7  $\mu$ m in diameter. Experiments with liquid and solid fresheners produced the highest increases in particle number and mass concentrations. Experiments with dishwasher detergent produced the lowest increases. Experimental results indicate that consumer products can emit significant amounts of terpenes that can serve as precursors to the growth of indoor fine particles. The results of this study clearly demonstrate that homogeneous reactions between ozone and terpenes from various consumer products lead to increases in fine particle mass concentrations and occupant exposures to fine particles in buildings when such products are used. This increase can be significant during periods of elevated outdoor ozone concentrations or indoor ozone releases, coupled with elevated terpene releases. Human exposure to fine particles can be reduced by minimizing indoor terpene or ozone concentrations.

## **10352- IDENTIFYING FINE PARTICLE COMBUSTION SOURCES AND SOURCE STRENGTHS USING REAL-TIME MEASUREMENT METHODS**

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Identifying the sources that contribute to pollutant exposure, and the “amount” contributed by each source, is critically important for policies designed to protect public health. Methods used today to identify sources, or “source apportionment”, are based on chemical mass balance analyses that require a sophisticated time of flight mass spectrometer or a large number of integrated samples collected over 24 hours or more. New “real time” measurement methods with rapid time responses have the potential for identifying sources for source apportionment studies rapidly and inexpensively. This paper describes experimental results designed to identify combustion sources of pollution by using real-time measurement methods based on different physical principles for simultaneous measurement of the relationships among variables. One monitor is a photoionization aerosol sensor (PAS) that ionizes the particles and measures the resulting electric charge, providing an indication of the mass concentration of particulate polycyclic aromatic hydrocarbons (PPAH). Another monitor uses diffusion charging (DC) that responds to the effective surface area of the ensemble of particles. Because of differences in the mass of PPAH relative to the surface area of the particles in different combustion processes, it is expected that PC/DC ratios are source specific and thus allow one to identify different sources. Experiments were conducted to measure PC/DC ratios for indoor sources including incense, candles, and cigarettes; outdoor sources including wood smoke and diesel exhaust; and in-traffic exposures including measurements inside the passenger compartment on Californian, Mexican, and European arterial highways. Personal monitoring of PC/DC ratios on public sidewalks outdoors was also included. Wood smoke combustion from nearby fireplaces had significantly higher PC/DC ratios than incense burned indoors, and PC/DC ratios for tobacco sources showed a slight decay pattern with time suggesting changes in the smoke particulate structure. On some experiments, simultaneous measurements were made using a size-specific laser particle counter, light scattering from a nephelometer, mass concentrations from a piezobalance, carbon monoxide from an electrochemical monitor, and PPAH from PAS monitors equipped with either excimer and mercury vapor lamps. Combined with time-of-day information and the relationships between the concentration variables from different monitors, real-time methods offer promise for source identification and source apportionment. Also these methods provide on-site information on the physical and chemical particle properties and their changes in the atmosphere. When combined with mathematical models of indoor air quality, real-time measurements also permit computation of particulate source strengths that can be generalized from one indoor setting to another indoor setting. The possible sources of error in applying such methods are discussed.

10375- Comparison of WINS and TEOM for PM<sub>2.5</sub> measurement in two Swedish cities

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Within the ECRHS II (European Community Respiratory Health Survey II) the urban background concentration of fine particles ( $< 2.5 \mu\text{m}$ , PM<sub>2.5</sub>) was measured with a Well Impactor Ninety Six (WINS) in 21 European centres. In an extended study including two participating Swedish cities (Göteborg and Umeå) PM<sub>2.5</sub> was measured simultaneously with a collocated Tapered Element Oscillating Microbalance (TEOM). The objective of this study was to investigate the consistency between WINS and TEOM in the two centres and reasons for differences if any.

The project comprised six PM<sub>2.5</sub> measuring periods between June and December 2000. Each monthly period included five 24 hour and one 48 hour measurements. In both centres the TEOM was operated at 50 °C. For the data analysis daily average TEOM values were used. The daily WINS values were achieved by weighing the filters according to a standardised protocol in one central laboratory. Apart from PM<sub>2.5</sub> other parameters were measured, such as PM<sub>10</sub>, temperature, humidity, NO<sub>2</sub>, SO<sub>2</sub>, atmospheric air pressure. After the measuring period both WINS equipments were tested at one location in order to check the instrument differences. This test showed that the measured concentrations differed less than 5%.

The mean values in Umeå were 5.4  $\mu\text{g}/\text{m}^3$  (WINS) and 5.6  $\mu\text{g}/\text{m}^3$  (TEOM) and in Göteborg 11.6  $\mu\text{g}/\text{m}^3$  (WINS) and 7.3  $\mu\text{g}/\text{m}^3$  (TEOM). The results show that there is a significant difference between WINS and TEOM in Göteborg but not in Umeå. There is a good correlation between the WINS and TEOM values in both cities (Göteborg 0.78, Umeå 0.73). Temperature has a significant influence on the TEOM values in Göteborg but not in Umeå. Temperature is not significantly correlated with the WINS values in any of the cities. Regarding the relative difference between WINS and TEOM values, i.e. (WINS-TEOM)/WINS, it shows that increasing temperature diminishes the relative difference in Göteborg significantly. In Umeå there is no

significant correlation between relative difference and temperature. In both cities, other pollution parameters did not have any significant influence on the consistency between WINS and TEOM.

In Göteborg the mean TEOM values were 37% lower than the mean WINS values, a result which is also described in other reports. However, in Umeå there is no such loss of PM. This may be explained by different particle composition due to geographical situation and differences in traffic density and industries.

## 10462- PARTICULATE AIR POLLUTION AND THE ONSET OF NONFATAL MYOCARDIAL INFARCTION

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An increased number of hospital admissions for ischemic heart disease has been linked to ambient particles in time-series analyses. We present data from a case-crossover study on particulate air pollution and nonfatal myocardial infarction.

Cases of age 25 to 74 years were recruited from the Coronary Event Registry in Augsburg, Southern Germany between February 1999 and July 2001. In personal interviews, detailed individual information was collected on activities, location, and transportation within 4 days preceding the onset of myocardial infarction. The total number of particles and the mass of fine particles (diameter below 2.5  $\mu\text{m}$  ( $\text{PM}_{2.5}$ )) were measured at 1 hour intervals. Preliminary multivariable conditional regression models adjusting for season, temperature and relative humidity and day of the week were conducted similarly to an earlier study (Peters et al (2001) *Circulation*) by comparing exposures shortly before the myocardial infarction (case period) with exposures on the days preceding the myocardial infarction (control periods).

791 cases (70% age 55+ years, 78% male) were interviewed. The data are preliminary since confirmation of diagnoses is ongoing. The average of daily  $\text{PM}_{2.5}$  concentrations was 12.6  $\mu\text{g}/\text{m}^3$ , ranging from 3 to 52  $\mu\text{g}/\text{m}^3$ . The mean total number concentrations was 12,200 particles  $\text{cm}^{-3}$ , ranging from 3,600 particles  $\text{cm}^{-3}$  to 39,100 particles  $\text{cm}^{-3}$ . Correlation between  $\text{PM}_{2.5}$  and total number concentrations was only moderate ( $r = 0.44$ ), but higher between  $\text{NO}_2$  and total number concentrations ( $r = 0.73$ ). An increase in  $\text{PM}_{2.5}$  concentration of 7  $\mu\text{g}/\text{m}^3$  two days before the onset of symptoms was associated with an increase in nonfatal myocardial infarctions, odds ratio (OR) 1.19 (95% confidence interval (CI): 1.03 to 1.37). An increase of 6,500 particles/ $\text{cm}^3$  three days before the onset of symptoms was associated with the onset of MI, OR 1.19 (95% CI: 1.00 to 1.43). Nitrogen dioxide (16  $\mu\text{g}/\text{m}^3$ ) was associated with the onset of myocardial infarction with a lag of 3 days (OR : 1.14 (95% CI: 0.97 to 1.35)).

The preliminary analyses suggest an association between ambient particulate matter and exacerbation of coronary artery disease.

## 10467- Allergic Diseases in School Children and Association with PM<sub>10</sub> and Other Environmental Factors

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Allergic diseases in children in Thailand have increased alarmingly in the past 20 years. Particulate matter and other air pollutants have been reported to be one of the contributing factors. The objectives of this study were to investigate PM<sub>10</sub> levels in 12 schools in 4 provinces in Thailand, prevalence of allergic diseases among secondary school students, and the association between allergic diseases and environmental factors.

Allergic diseases (asthma, rhinitis, and eczema) were identified, using the ISAAC (International Society of Asthma and Allergies of Childhood) questionnaire, among students aged 12-15 years in 12 schools in 4 provinces. Air quality at each school was assessed using PM<sub>10</sub> levels measured by High Volume Air Sampler continuously for 14 days. Over half of the cases were further investigated for a relationship with PM<sub>10</sub> and other environmental risk factors. The PM<sub>10</sub> mean levels at 12 schools ranged from 0.0609 to 0.2542 mg/m<sup>3</sup>, with the mean levels at 4 schools exceeding the 24-hour average concentration of 0.120 mg/m<sup>3</sup>, the ambient air quality standard of Thailand. Of the 3,830 students participating in the study, 29 % were identified as having allergic diseases. Over half of these cases were followed, using a standard questionnaire identifying 7 environmental risk factors: having rugs, having cotton wool, using an air-conditioner, and using a fan in the bedroom, having pets in the house, using a broom, and PM<sub>10</sub> exceeding air quality, then comparing results to their peers who were not cases. Logistic regression analysis showed significant associations between allergic cases and 3 risk factors namely, having rugs in the bedroom (P= 0.012), having cotton wool in the bedroom (P= 0.049), and PM<sub>10</sub> exceeding air quality standard (P= 0.025). When controlling other variables, the OR was 1.34 for PM<sub>10</sub> and 1.52 for rugs in the bedroom. The study results indicate that the main environmental risk factors for allergic diseases are PM<sub>10</sub> and any materials generating dust in the home.

## 10477- Comparative Receptor Modeling Study of PM<sub>10</sub> and PM<sub>2.5</sub> in Seoul, Korea

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A receptor modeling study on PM<sub>10</sub> and PM<sub>2.5</sub> was carried out. Air particles were selected using the dichotomous sampler for a year (from 29 October 2000 to 26 September 2001). The purpose of this study is to compare chemical components and source apportionment of particulate matters sampled in sub-residential area in Seoul. Data was collected on 34 different days with a 7-days sampling period from the rooftop of the building (15 m above ground level). Elemental concentrations of PM<sub>10</sub> and PM<sub>2.5</sub> for 34 samples were analyzed by ICP-MS. The main sources and their contributions to the measured concentrations of particulate were estimated by receptor modeling using a factor analysis-multiple linear regression (FA-MLR) model. The mean concentrations of PM<sub>10</sub> and PM<sub>2.5</sub> were 44.62  $\mu\text{g}/\text{m}^3$  and 23.99  $\mu\text{g}/\text{m}^3$ , respectively. The ratios of PM<sub>2.5</sub>/PM<sub>10</sub> mass concentrations is about 0.54 and the proportional ratios (each metal concentration in PM<sub>2.5</sub>/each metal concentration in PM<sub>10</sub>) of hazardous metals (i.e. Cr, Cd, Pb., etc) were larger than 1.0. Source contributions of weekly mean levels for PM<sub>10</sub> and for PM<sub>2.5</sub> are possible to estimate by setting the weekly tracer concentrations of each source to the regression equation. Our analysis showed that PM<sub>10</sub> consisted of 12 % (range : 6 % - 19 %) from soil and street dust, 46 % (range : 37 % - 58 %) from field burning, 37 % (range : 32 % - 44 %) from fuel combustion, and 5 % (range : 1 % - 19 %) from unidentified sources. For PM<sub>2.5</sub>, it was found that soil and street dust was a major contributing source (33 %). In conclusion, we suggest that the health effect of PM<sub>2.5</sub> would be larger than that of PM<sub>10</sub> based on principal component analysis (PCA), not on source apportionment in the Seoul area. The next step in specifying the source contributions in Seoul could be source sampling to achieve the local source profiles and then use chemical mass balance (CMB) in source apportionment.

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10535 - Ambient and Personal Exposure Levels of Fine Particulate Matter (PM<sub>2.5</sub>) in the Airshed of Prince George, British Columbia, Canada

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The goal of this study was to develop a preliminary understanding of the relationship between ambient concentrations and children's personal exposure to PM<sub>2.5</sub> and to characterize the spatial variation of ambient PM<sub>2.5</sub> within the airshed of Prince George, British Columbia. Air pollution is a serious concern in the city of Prince George because of the topography of the area and the amount and location of industrial development. The core of Prince George (population 80,000) is situated in a valley where two rivers converge. Three pulp and paper mills, an oil refinery and several sawmills are also located in this valley. Under certain meteorological conditions, air pollutants frequently become trapped in the valley resulting in air pollution episodes. 24-hour average ambient and personal samples of PM<sub>2.5</sub> were collected each weekday during a six-week field study in February and March 2001. Elementary school children, aged 10 to 12, carried the personal PM<sub>2.5</sub> monitors and ambient monitoring was conducted on school roofs in five different neighbourhoods throughout the city. 9 to 10 personal samples were collected from each subject on a non-random rotating schedule enabling better representation of individual exposure over the 6-week period. 30 ambient samples were collected at each outdoor location. Harvard Personal Environmental Monitors were used for both the personal and ambient sampling. Samples were analyzed for mass, sulphate and elemental carbon to assess the contribution of regional and local outdoor sources on 24-hour personal exposures. Sulphate was determined by ion chromatography and elemental carbon was assessed indirectly by measuring absorbance using a simple reflectance method. This reflectance method was calibrated to actual elemental carbon levels determined by thermal optical reflectance on samples from a pilot study. Analysis of variance performed on the outdoor data indicated some spatial variation in PM<sub>2.5</sub> within the airshed. The results suggest that the addition of another permanent PM<sub>2.5</sub> monitor would enable better characterization of PM<sub>2.5</sub> levels in the city. The following table summarizes the correlations between personal exposure and ambient concentration for each individual:

	<u>Mean</u>	<u>Median</u>	<u>Minimum</u>	<u>Maximum</u>
<b>PM<sub>2.5</sub></b>	0.44	0.49	-0.34	0.82
<b>SO<sub>4</sub></b>	0.97	0.98	0.94	0.99
<b>EC</b>	0.71	0.72	0.19	0.99

These data suggest that for total PM<sub>2.5</sub> ambient concentration is not an adequate surrogate measure for personal exposure. Both sulphate and elemental carbon may be more useful indicators of exposure to particles of ambient origin. An average personal – ambient sulphate ratio of 0.59 (range 0.49-0.70) was calculated from the data. A slightly higher personal –ambient ratio of 0.74 (range 0.55-1.00) was found for elemental carbon at 4 of the 5 monitoring locations. High elemental carbon ratios (mean 1.76) at the Glenview site suggest that there may be an important personal PM<sub>2.5</sub> source in this neighbourhood that was not well characterized by the neighbourhood ambient monitor. One possible explanation for this finding is residential wood smoke.

10575- Effect of fine PM on measures of inflammation and thrombosis in an elderly population. J. Sullivan, N. Ishikawa, C. Trenga, S. Liu, J. Koenig, W. Chandler, J. Kaufman. Departments of Environmental Health, Biostatistics and Laboratory Medicine, University of Washington.

The mechanisms behind the triggering effect of fine particulate matter (PM) air pollution on cardiovascular events remain elusive. We postulated that elevated levels of fine PM would be associated with increased levels of inflammatory blood markers (C-reactive protein [CRP] and fibrinogen) and a thrombotic marker (D-dimer). Methods: We utilized a panel study in Seattle measuring PM exposure in elderly individuals with (n=16) and without (n=20) heart disease between March 2000 and May 2001. The blood markers were measured in 36 subjects on 3 mornings (day 3, 7 and 10) during a 10-day session. These levels were paired to concurrent measures of time-resolved outdoor fine PM by light-scattering nephelometry and community monitors for PM 2.5 by TEOM. The analyses utilized a random effects GLM model to determine the within-individual effect of a zero-day to two-day lagged  $10 \mu\text{g}/\text{m}^3$  increase in fine PM on the log-transformed levels of D-dimer, fibrinogen and C-reactive protein after adjusting for temperature, relative humidity, and health status. Results: The median age of participants was 74 years (range: 64-89). The 108 measures of blood markers were paired to outdoor and central site nephelometry exposure data. In those with cardiac disease the median CRP level was 0.29 mg/ml (range: .02-4.6) and the median D-dimer level was 374 ng/ml (range 226-4359). In those without cardiac disease the median CRP level was 0.48 mg/ml (range: 0.05-3.6) and the median D-dimer level was 434 ng/ml (range: 164-2160). A  $10\mu\text{g}/\text{m}^3$  increase in PM measured on the same day by nephelometry outside the individual's residence was associated with a 60% increase in the median log-transformed level of CRP [95% C.I.: 19-135%] in individuals with cardiac disease. The increase in CRP in the CV group was not observed using central site exposure data (8% increase [95% CI: -73, 220]). A  $10\mu\text{g}/\text{m}^3$  increase in PM measured by nephelometry outside the individual's residence on the day of D-dimer measure was associated with a 26% increase [95% CI: (11%, 66%)] in median D-dimer level in healthy subjects. A  $10\mu\text{g}/\text{m}^3$  increase in PM measured by nephelometry outside the individual's residence on the day prior to exposure was associated with a 47% increase [95% CI: (-3%, 122%)] in the median D-dimer level in CV subjects. There was no relation between PM and fibrinogen levels in those with or without cardiac disease using either the outdoor or central site measures of PM.

Conclusion: Our study suggests that fine PM may affect levels of inflammation and thrombosis in susceptible individuals as measured by CRP and D-dimer levels, respectively.

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**10583- Personal, indoor, and outdoor concentrations of PM<sub>2.5</sub>, particulate nitrate, and elemental carbon for individuals with COPD in Los Angeles, CA**

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**Abstract**

This study characterizes the personal, indoor, and outdoor concentrations of PM<sub>2.5</sub> and the major components of PM<sub>2.5</sub>, including nitrate (NO<sub>3</sub><sup>-</sup>), and elemental carbon (EC) for individuals with chronic obstructive pulmonary disease (COPD) living in Los Angeles, CA. Monitoring was performed for 15 participants for 7 consecutive days in the winter and summer of 2000, respectively. During each sampling day, 24-hr personal, indoor, and outdoor samples of the targeted pollutants was collected simultaneously. Housing characteristic information and time-activity diaries were also obtained. In each season, participants reported spending approximately 87% of each day within their residences. The overall 24-hr mean personal exposures to PM<sub>2.5</sub>, nitrate, and elemental carbon were 22.4 ( $\pm$  18.2), 1.4 ( $\pm$  1.1), and 1.1 ( $\pm$  1.2)  $\mu$ g/m<sup>3</sup>, respectively. Significant seasonal differences were found for all of the PM<sub>2.5</sub>, nitrate and elemental carbon measures, except for outdoor nitrate, where no seasonal difference was observed. Personal PM<sub>2.5</sub> exposures were higher than corresponding indoor and outdoor concentrations in both seasons, while the same pattern was not persistent among the major components of PM<sub>2.5</sub>. Higher outdoor nitrate concentrations, as compared with the corresponding indoor and personal measurements, were found in both seasons, which reflects the fact that the major sources of nitrate are from motor vehicles. Additionally, a similar but less distinct pattern was shown for elemental carbon concentrations. Personal exposures were significantly correlated with both indoor and outdoor concentrations for PM<sub>2.5</sub>, nitrate, and elemental carbon in both seasons, as were those between indoor and outdoor concentrations. The association between personal PM<sub>2.5</sub> exposures and corresponding outdoor levels was stronger in the summer (Spearman correlation coefficient,  $r_s = 0.62$ ;  $p$ -value  $< 0.05$ ), as compared to that in the winter ( $r_s = 0.52$ ;  $p < 0.05$ ). In addition, indoor PM<sub>2.5</sub> concentrations were more strongly correlated with personal exposures during the wintertime ( $r_s = 0.77$ ;  $p < 0.05$ ), as compared to the

summertime ( $r_s = 0.63$ ;  $p < 0.05$ ). Longitudinal analyses were conducted to account for the repeated measurements for each subject. For  $PM_{2.5}$ , the relationship between personal exposures and indoor/outdoor concentrations followed patterns observed in previous studies, where the effect of indoor concentrations on personal exposures became more dominant in the winter due to the low air exchange rate. This work has been funded by the U.S. Environmental Protection Agency under EPA Cooperative Agreement number (CR 827159-01-0). It has been subjected to Agency review and approved for publication.

**10592- Predicting 24-hr personal PM<sub>2.5</sub> exposures: assessing the relative importance of 24-hr and 1-hr ambient PM<sub>2.5</sub> concentrations, 1-hr personal PM<sub>2.5</sub> exposures, and time activity data**

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**Abstract**

Personal PM<sub>2.5</sub> data from two recent personal exposure studies, the Scripted Activity Study and the Older Adults Study, were used to develop models predicting 24-hr personal PM<sub>2.5</sub> exposures. Both studies were conducted concurrently in the summer of 1998 and the winter of 1999 in Baltimore, MD. In the Scripted Activity Study, 1-hr personal PM<sub>2.5</sub> exposures were measured. Data were used to identify significant factors affecting personal exposures and to develop 1-hr personal exposure models for five different microenvironments. Along with the time activity diary data, these models were combined to develop a time-weighted microenvironmental personal exposure model (Model 1) to predict 24-hr PM<sub>2.5</sub> exposures for individuals measured in the Older Adults Study. 24-hr time-weighted models were also developed using 1-hr ambient PM<sub>2.5</sub> levels and time activity data (Model 2), or using 24-hr ambient PM<sub>2.5</sub> levels and time activity data (Model 3). The performance of these three models was compared to that using 24-hr ambient concentrations alone (Model 4). Results showed that factors affecting 1-hr personal PM<sub>2.5</sub> exposures included air conditioning status and presence of environmental tobacco smoke (ETS) for indoor microenvironments, as well as proximity to roads for outdoor microenvironments, which were consistent with previous studies. ETS exposure was identified as a significant contributor to measured 24-hr personal PM<sub>2.5</sub> exposures, as staying in an ETS-exposed microenvironment for one hour elevated 24-hr personal PM<sub>2.5</sub> exposures by approximately 4 µg/m<sup>3</sup> on average. Cooking and washing activities were identified in the winter as significant contributors to 24-hr personal exposures as well, increasing 24-hr personal PM<sub>2.5</sub> exposures by about 4 and 5 µg/m<sup>3</sup> per hour of activity, respectively. The abilities of Models 1 through 3 to estimate 24-hr personal PM<sub>2.5</sub> exposures were comparable and consistently greater than that of Model 4. Results indicated that using time activity data with one-hour exposure information – either as microenvironment-specific exposures or as ambient concentrations – improves our ability

to estimate personal PM<sub>2.5</sub> exposure over the model using 24-hr averaged levels alone. Although model performance differed by season, crude R<sup>2</sup> values were higher when the models were performed for subjects participating in both seasons, where the R<sup>2</sup> values equaled 0.53, 0.55, 0.46, and 0.38 for Models 1 to 4, respectively. These results suggested that the low predictive ability in the winter for Models 1 to 3 might be in part attributed to the small dynamic range of personal PM<sub>2.5</sub> exposures.

## 10624- A PANEL STUDY OF PARTICULATE MATTER AIR POLLUTION AND PEAK EXPIRATORY FLOW RATE AMONG THE ELDERLY

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**Background:** Epidemiologic findings suggest that exposure to short-term ambient levels of particulate matters is associated with adverse health effects and that health effects are more strongly associated with fine particle mass than with crude particle mass. Most of existing studies of particulates and human health outcomes used total suspended particulate or PM<sub>10</sub> as the measurement for particulate matter exposure, and little data exists in which PM<sub>2.5</sub> is used as the exposure measure. The objective of this longitudinal study is to investigate an association between particulate matter and peak expiratory flow rate (PEFR) in the elderly and to compare the estimated risks using PM<sub>10</sub> or PM<sub>2.5</sub> as the exposure measure.

**Methods:** We contacted the subjects living in an asylum for the aged in Seoul. They were informed that they were part of an environmental study and asked to participate in the 5-week longitudinal study (from November 11, 2000 to December 15, 2000). Each subject was provided with a peak flow meter (Vitalograph Inc., Lenexa, Kansas) and a preformatted health symptom diary for 5 weeks. Participants were instructed to perform the peak flow test three times in the standing position, three times daily (in the morning, in the afternoon, and in the evening), and record all the readings along with the symptoms experienced that day, and simple time-activity patterns of the day. Daily levels of particulate matter were measured from two separate MiniVol<sup>TM</sup> Portable Air Samplers (Airmetrics, Eugene, Oregon) (one for PM<sub>10</sub> and the other for PM<sub>2.5</sub>) placed on the rooftop of the two-story residence building for the elderly. Using the MIXED procedure in SAS Software version 8.1, analyses were conducted with the assumption that the expected response varied linearly, for each participant, with an intercept and slopes that may depend on fixed or time-varying covariates.

**Results:** The number of participants being used in this analysis is 53 (43% for male) and the mean age was 80 year-old. The daily mean concentrations of PM<sub>10</sub> and PM<sub>2.5</sub> during the study periods were 71.8  $\mu\text{g}/\text{m}^3$  and 50.6  $\mu\text{g}/\text{m}^3$ , respectively. The daily mean PEFR was 237.8 l/min. An interquartile range (IQR) increment in daily mean levels for PM<sub>10</sub> (IQR=44.1  $\mu\text{g}/\text{m}^3$ ) and for PM<sub>2.5</sub> (IQR=34.4  $\mu\text{g}/\text{m}^3$ ) was significantly associated with a decreased PEFR levels (3.56 l/min for PM<sub>10</sub>, 95% CI=1.97-5.19; 4.73 l/min for PM<sub>2.5</sub>, 95% CI=2.97-6.49). These associations were independent to other covariates such as gender and weather variables.

**Conclusion:** We observed that particulate matter air pollution at sub-standard air quality levels is harmful to sensitive persons such as the elderly. This study also reveals that acute lower peak flows in the elderly were more strongly associated with fine particulate mass than with PM<sub>10</sub>.

10654- Repeated cross-sectional health effects analysis in children with different indicators of ambient air pollution (PM10, PM2.5, NO2) - Results of the SCARPOL study.

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**Introduction.** In a first cross-sectional investigation in 1992, significant associations between ambient air pollution levels and respiratory symptoms and diseases have been observed in the Swiss study on Childhood Allergy and Respiratory Symptoms (SCARPOL). For PM10, generally stronger effects have been observed than for NO2. A new cross-sectional health assessment of SCARPOL between 1998 and 2000 and concurrent measurements of PM10, PM2.5 and NO2 should allow to further assess the contribution of different components of ambient air pollution to respiratory health of children in Switzerland. **Methods.** In total, 4400 school children (1<sup>st</sup> and 8<sup>th</sup> graders) in 10 regions of Switzerland participated between 1998 and 2000 in the cross-sectional assessment. Parents filled in an extensive questionnaire, identical to the one used in 1992. It included questions on health-status, spare time activities, family history of diseases, indoor exposures and on residential situation. For fine particles, annual averages measured at fixed site monitors in each region were used as exposure metric. For NO2, individual exposure estimates could be assigned. These were based on NO2-passive sampler measurements, fixed site levels and the residential category of the children (low/high traffic volume; city centre/agglomeration). **Results.** Between 1992 and 1999 both, prevalences of respiratory symptoms and air pollution levels, generally decreased. Between the 10 regions annual means of PM2.5 ranged in 1999 from 9-26 µg/m<sup>3</sup>, those of PM10 from 11-33 µg/m<sup>3</sup>. Average NO2 assigned according to residential category ranged from 15-37 µg/m<sup>3</sup>. Adjusted for demographic and socio-economic factors, family history of respiratory diseases, number of siblings, smoking of mother and other relevant indoor exposures, prevalences of nocturnal dry cough varied in the 10 regions between 9-20%, those of Bronchitis between 5-12%. In 1999, neither for nocturnal dry cough nor for bronchitis significant associations with the chosen indicators of air pollution were found. While a tendency of a positive association could be observed for nocturnal dry cough (increase of pollutant by 10 µg/m<sup>3</sup>: PM10: Odds Ratio (OR): 1.16; 95%CI: 0.90-1.50; PM2.5: OR: 1.25; 95% CI: 0.88-1.78; NO2: OR: 1.10; 95%CI 0.99-1.22), for bronchitis no associations or even negative point estimates for PM10 (OR: 0.88; 95%CI 0.66-1.18) and NO2 (OR: 0.89; 95%CI: 0.79-1.02) were found. **Conclusions.** In 8 of the 10 study regions very similar fine particle levels between 20-25 µg/m<sup>3</sup> PM10 and 14-20 µg/m<sup>3</sup> PM2.5 were measured in 1999, reducing the exposure contrast compared to 1992 and, consequently, reducing the power to detect health effects. Moreover, PM10 and PM2.5 were highly correlated across the 10 regions (r=0.9). Thus, the current assessment of health effects due to air pollution has reached methodological limits and the question regarding the health relevance of different fractions of fine particulates cannot be answered.

## 10679- Applicability of ambient and indoor monitoring for personal exposure assessment to PM<sub>2.5</sub> from different emission sources

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Exposure to fine particulate matter (PM) is routinely assessed by monitoring ambient air quality at fixed sites. PM is not homogenous in composition or size. Although the mechanisms causing adverse health effects are not yet understood, it is important to divide the PM exposure to its fractions or constituents. This paper analyses the applicability of total PM<sub>2.5</sub> monitoring to assess the exposure to PM from the main emission sources.

Main sources of PM<sub>2.5</sub> exposure samples were determined as a part of the *EXPOLIS* - Helsinki study. The PM<sub>2.5</sub> samples were collected by personal exposure monitors (GK2.05 cyclone by BGI Inc., Waltham, MA, USA) at 4 L/min for 48-hour sampling periods. Elemental analyses of 499 PM<sub>2.5</sub> samples were performed by energy-dispersed X-ray fluorescence spectrometry (ED-XRF) for those participants with valid PM<sub>2.5</sub> samples from all microenvironments. Principal component analysis and mass reconstruction techniques were applied to identify and quantify the main source contributors, which were; inorganic secondary PM; soil dust; sea salt; detergents; and particles from combustion and other sources (CoPM). Finally, linear regression analysis was applied to assess the applicability of ambient and microenvironmental PM<sub>2.5</sub> monitoring to predict exposure to PM from these source categories.

Results showed that total PM<sub>2.5</sub> monitoring could predict exposure to inorganic secondary particles better than exposure to particles from other source categories. The models could predict 58 - 80% of the secondary PM exposure variation, except PM<sub>2.5</sub> concentration in workplaces which predicted only 30%. Total PM<sub>2.5</sub> monitoring could not at all predict exposures to particles from soil dust, sea salt and detergents. Exposure to particles from combustion and other sources could be moderately predicted (32-45%) by monitoring residential and workplace total PM<sub>2.5</sub> concentrations, but the best predictor for CoPM was, however, the measured total PM<sub>2.5</sub> exposure, explaining 73% of the exposure variation.

Thus, ambient PM<sub>2.5</sub> monitoring was a good predictor of exposure to inorganic secondary particles, moderate for the particles from combustion and other sources and poor for soil particles. A similar pattern was found when microenvironmental PM<sub>2.5</sub> monitoring was used as a predictor.

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10706- Sources of ultrafine and accumulation mode particles and daily mortality in Erfurt, Germany – a pilot study

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The objective of this study was to investigate the sources of ultrafine and accumulation mode particles and their impact on daily mortality.

From September 1997 to December 1998, a Berner Impactor was run to collect particulate matter in five different size ranges from 0.05 to 1.62  $\mu\text{m}$  on an almost daily basis in Erfurt, Germany. The elemental composition of these samples was determined by PIXE (Proton induced X-ray emission). Mass concentrations of 19 elements in different size ranges were measured. Concurrently, number concentrations (NC) of ultrafine particles and mass concentrations (MC) of accumulation mode particles, concentrations of gaseous pollutants, and meteorological data were collected. Death certificates were obtained and aggregated to daily total counts of mortality.

We analyzed separately the elemental composition data for stage 1 (covering a size range from 0.05-0.1 $\mu\text{m}$  in the ultrafine range) and stage 3 (0.19-0.40 $\mu\text{m}$ , accumulation mode) of the Berner Impactor by Principal Component (PC) Analysis followed by a Procrustes rotation. The particle number and mass concentrations and the concentrations of gaseous pollutants were included in each PC analysis. Associations of the daily factor scores with daily mortality were investigated in Poisson regression models with adjustment for trend, season, day of week, and meteorology.

In both stages, the following patterns could be identified: One PC has high loadings on Al, Si, and Ti in both stages and explains 12 % of the variance each. It is interpreted as originating from crustal material. In stage 1 it could be due to combustion products of embeddings of crustal material in fuel. Another PC in both stages has high loadings on Zn, Pb (only stage 3), K, NC, CO, NO, and NO<sub>2</sub>. It explains 24 and 29% of the variability, respectively, and is due to mobile sources. The 3<sup>rd</sup> PC consists of S, Fe, and Mn in stage 1 and of S, Ni, and V in stage 3 and might indicate combustion particles. The explained variance amounts to 16 and 18%, respectively. The 4<sup>th</sup> PC was only retained in stage 1. It is formed by the MC whereas in stage 3 the MC's are correlated with the combustion-related PC and to a lesser extent with the traffic-related PC.

In the Poisson regressions with mortality we found that the average of lag 0 and 1 of the crustal-related PC (Relative Risk for the Interquartile Range [RR]=1.033, 95% Confidence Interval [CI]=[0.981-1.089]) and the traffic-related PC (RR=1.035, CI=[0.975-1.098]) in stage 1 as well as the combustion-related PC in stage 3 (RR=1.039, CI=[0.982-1.100]) indicate non-significant associations with increased daily mortality.

We conclude that particulate matter from mobile sources in the ultrafine range and from combustion sources might be associated with increases in mortality. These findings should be confirmed in a follow-up of this pilot study.

10708- First results from the CorPuScula study on acute health effects of particles.

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In many PM morbidity and mortality studies elderly people have been found to be a risk group for PM health effects. Still unresolved is, which mechanisms can be made responsible for this and which particle fraction (PM<sub>10</sub>, PM<sub>2.5</sub> or Ultrafines) represents the highest potential for adverse health effects. In order to get more information on associations between environmental PM concentrations in different size ranges and acute health effects we conducted a longitudinal study with a group of 52 elderly persons (CorPuScula study). The mean age of these 41 female and 11 male non-smoking subjects was 78 years (59-95 years). All of them lived in a home for the aged in the Northern suburbs of Munich (Germany) or in the direct vicinity. Each subject on average was tested on 40 days (approximately once a week) between July 2000 and July 2001. Tests for each subject were fixed at same day of the week and time of the day and performed in a mobile laboratory at the place where they lived. Concentrations of PM<sub>10</sub> and PM<sub>2.5</sub> (daytime means) were measured in the park of their residence, Ultrafines (UF) in a distance of about 3 km. The PM concentrations ranged between 1 and 81 µg/m<sup>3</sup> (mean 14) for PM<sub>2.5</sub>, 1-92 µg/m<sup>3</sup> (mean 19) for PM<sub>10</sub> and 2-98 thousand particles/cm<sup>3</sup> (mean 25000) for UF. There was a strong correlation between PM<sub>2.5</sub> and PM<sub>10</sub> concentrations ( $r^2=0.88$ ), but only a weak association between PM<sub>2.5</sub> concentrations and UF counts ( $r^2=0.33$ ).

Interquartile logistic regression analysis for symptoms resulted in significantly lower prevalences of subjectively perceived heart rhythm disturbances at higher PM concentrations (OR: PM<sub>2.5</sub> same day 0.720 (CI: 0.558-927), PM<sub>10</sub> same day 0.709 (CI: 0.543-0.926)). Linear regression between a sum score of irritations (built from 12 different symptoms) and PM<sub>10</sub>, PM<sub>2.5</sub> and UF (lags from 0 to 2) did not show any significant associations. Univariate linear regression analyses of blood pressure showed significant associations for same day PM<sub>2.5</sub> and UF as well as for 1-day-lag PM<sub>2.5</sub> and UF. After adjusting for thermal effects by means of the Physiologic Equivalent Temperature PET (a physiologically relevant index for the thermal environment) significance of PM associations disappeared while strong associations between PET and blood pressure remained. The results suggest that for the health endpoint blood pressure thermal effects are dominating the changes seen between days with low or high PM concentrations.

The CorPuScula study will be going on until the end of 2002, more results on heart rate variability, inflammatory markers in blood and lung function will follow.

The study was funded by the Bavarian State Ministry for Environmental Protection

10711- Comparative source apportionment of ambient PM<sub>2.5</sub> in two European cities  
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There are some indications that chemical composition is linked to the adverse health effects caused by particulate matter. Therefore, main sources of fine particulate matter (PM<sub>2.5</sub>) in two European cities were determined from data collected during an epidemiological study on cardiovascular health effects of PM. Gravimetric mass and chemical composition of PM<sub>2.5</sub>, concentrations of gaseous air pollutants, and meteorological parameters were measured in the winter of 1998-99 in Helsinki, Finland, and Amsterdam, The Netherlands. The sampling spanned six months yielding valid 24-hour data for 164 and 174 days from Helsinki and Amsterdam, respectively. PM<sub>2.5</sub> samples were analysed for elemental composition using energy-dispersive X-ray fluorescence spectrometry (ED-XRF). First, principal component analysis (PCA) of PM<sub>2.5</sub> elemental composition (K, V, Mn, Cu, Zn, Si, S, Cl, Ca, Fe, Ni) and nitrogen oxide (NO<sub>x</sub>) data was applied to identify main source categories. Second, estimates of daily source-specific PM<sub>2.5</sub> immissions at the measurement site were obtained by regressing the measured daily PM<sub>2.5</sub> on daily absolute principal component scores obtained from the PCA. Average concentrations of the elements included in the PCA/multivariate regression analyses were roughly equal in the two cities except for Cl and Cu, which both were >2 times higher in Amsterdam and Si, which was >2 times higher in Helsinki. Mean concentration of NO<sub>x</sub> in Amsterdam was 1.5 times higher than in Helsinki. Six principal components with post-rotation eigenvalues >1.0 were obtained from preliminary analyses in both Helsinki and Amsterdam. Four of the components were rather similar with regard to the loadings of elements to the components. These four components were tentatively interpreted as traffic, crustal, oil combustion, and salt sources. The fifth component was associated with mainly sulfur, and was assigned to long-range transported aerosol. The sixth source component was possibly associated with metal industry and/or resuspension. The main difference as for the source contributions to average ambient PM<sub>2.5</sub> was the larger proportion of long-range transported aerosol in Helsinki PM<sub>2.5</sub>.

10753- The Health Effects of PM2.5 :

**Evidence from Korea Using Daily Data<sup>1</sup>**

Jong Ho Hong<sup>2</sup>, Yoon Shin Kim<sup>3</sup>, Jong Tae Lee<sup>3</sup>,  
Yookyung Ko<sup>4</sup> and Yong Sung Cho<sup>3</sup>

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<sup>1</sup> This research was supported by a grant from G- 7 Project sponsored by the Ministry of Environment, Korea.

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## **Abstract**

This paper reports on the results of epidemiological investigation of daily health effects in the elderly associated with daily exposure to particulate matters in Korea. Our main focus is on the potential difference in health effects between PM10 and PM2.5. While the Korean environmental authority has set an ambient standard for PM10, the government currently does not monitor PM2.5, which has no national standard. A daily data on respiratory symptoms as well as PM concentrations are collected for a total of 120 days. Using a probit model, we find statistically significant negative health effects of PM2.5 on respiratory symptoms among the nonsmoking elderly, while PM10 does not show such effects from the estimation. This result suggests that, for air quality regulatory purposes, PM2.5 can be a more appropriate air pollutant than PM10.

## Extended Abstract

The purpose of this paper is to investigate the epidemiological effects of particulate matters on the respiratory health symptoms using Korean data. The U.S. has already introduced NAAQS for fine particulates, or PM<sub>2.5</sub>, in 1997. Many developing countries including Korea, however, do not have ambient standards for PM<sub>2.5</sub> at any governmental level. Meanwhile, Korea has air quality standard for PM<sub>10</sub> since 1995, and the environmental authority currently monitors PM<sub>10</sub> concentrations in many cities. For the first time in Korea, this paper tries to collect empirical evidence on whether there are differences between PM<sub>2.5</sub> and PM<sub>10</sub> in respiratory health effects. The result can have a potential policy implication for air pollutant regulatory policy of Korea.

Data collection process is as follows: A daily data on PM concentrations by actual monitoring is performed for 120 days from a receptor in the southern part of Korea. 120 days are divided into three periods of 40 days each with a certain interval between them. For the corresponding period, a daily survey on respiratory symptoms and other variables is conducted for a sample of 62 elderly people living in the same area. The ages are in the range of 50's and 70's. The elderly are picked since they are considered to be more sensitive to air pollutants than adults.

A discrete choice probit model is used in estimating the model. Our main results show that PM<sub>2.5</sub> is statistically significant at 10% level in explaining the respiratory symptoms, while PM<sub>10</sub> is not. Furthermore, we consistently find statistically significant (at 1% level) negative health effects of PM<sub>2.5</sub> on respiratory symptoms among the nonsmokers, while PM<sub>10</sub> is either marginally significant at 10% level or does not reveal such health effects based on the choice of other explanatory variables. For the smoking elderly, neither pollutant has statistically significant health effects, which is consistent with results reported by previous epidemiological studies with other air pollutants such as ozone.

Our study has empirical contribution to the literature on examining the

health effects of particulate matters, especially the potential health difference between PM<sub>2.5</sub> and PM<sub>10</sub>. Our result suggests that, for regulatory purposes, PM<sub>2.5</sub> can be a more appropriate air pollutant than PM<sub>10</sub>. This has a certain implication in redirecting the air quality policy measures in the developing countries as well as in Korea.

## **10767- Long-term Exposure to Ambient Air Pollution: the Reduction in FEV1 is Consistent with the Observed Decrease in Life-expectancy.**

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Analyses and reanalyses of US cohort studies suggest that outdoor air pollution reduces life expectancy. For a 10 µg/m<sup>3</sup> increase in the annual PM10 concentration, mortality increased in the range of 2-5% (Krewski, 2001). The size of these estimates and the transferability to Europe are subject to debates.

So far, estimates of the association between air pollution exposure and life expectancy are based solely on US studies. However, other studies in different parts of the world have shown that low volume expired in the first second (FEV1) is predictive of reduced life expectancy. In the cross-sectional Swiss Study on Air Pollution and Lung Disease in Adults, SAPALDIA, we have shown low FEV1 to be associated with long-term ambient air pollution. The study found a 1.6% (95%CI: 0.59-2.25%) difference in FEV1 per 10 µg/m<sup>3</sup> mean PM10 (Ackermann-Lieblich et al, AJRCCM, 1997). Predictions suggest that the SAPALDIA population needs to be followed for more than twenty years to directly test the "air pollution – life expectancy" hypothesis. We therefore use the 10-year mortality follow-up data of the SAPALDIA cohort to quantify the effect of a reduced FEV1 baseline value (1991) on the hazard rate. This is an indirect test of the plausibility and transferability of the US mortality estimates.

By the end of 2000, a total of 142 deaths (1.5% of the population) has been recorded. In a multivariate proportional hazard model, controlling for sex, low education, foreign citizenship, smoking status and regular passive smoking, a 1.6% lower FEV1 at baseline was associated with a 4.0 % (2.1-6.2%) higher mortality rate.

Although we cannot yet directly assess the effect of outdoor air quality on life expectancy in Switzerland, the observed estimates at least suggest that the US results might be generalized to Europe. The results are in line with the assumption that 1) life expectancy depends both on the level of lung function and of ambient air pollution and 2) that ambient air pollution causes a reduction in FEV1.

The currently ongoing reassessment of the SAPALDIA population will provide a cohort with extensive subjective and objective health and exposure measures, including a large sample of serologic and genetic material. This will allow to further investigate causal pathophysiologic links between , air pollution , pulmonary function decline and life expectancy, and the contribution of genetic factors to the respective associations.

10822- EFFECT OF FINE PARTICULATE (PM<sub>2.5</sub>) AIR POLLUTION EXPOSURE ON PULMONARY FUNCTION IN PEDIATRIC SUBJECTS WITH ASTHMA CA Trenga, C Slaughter, B Goldman, M Budge, J Sullivan, JD Kaufman, L Sheppard, L-JS Liu, GG Shapiro<sup>1</sup>, JQ Koenig. EPA NW Research Center for Particulate Air Pollution and Health, <sup>1</sup>Department of Pediatrics, University of Washington, Seattle, WA.

Studies have shown asthma exacerbation associated with ambient levels of particulate matter measured at central sites but rarely with more precise estimates of exposure.

**Methods:** We studied 17 children with physician-diagnosed asthma between November 2000 and May 2001. This group was part of a larger panel study of PM exposure in Seattle. Indoor and outdoor nephelometer measurements were made at subjects' homes for ten consecutive 24-hour periods to estimate PM<sub>2.5</sub> exposure. Central site 24-hr average PM<sub>2.5</sub> values were obtained by TEOM at 3 community monitoring sites. Coached spirometry measurements were obtained from subjects in the late afternoon at each daily home visit during the 10-day monitoring session using MicroDL portable spirometers.

We applied mixed-effects random intercept regression models to test for a within-subject effect of zero-day to two-day lagged PM<sub>2.5</sub> exposure on forced expiratory volume in 1 second (FEV<sub>1</sub>), peak expiratory flow (PEF), and mid-expiratory flow (MEF). **Results:** Data from 18 subject-sessions including 123 observations paired to exposure data were analyzed. Median age of subjects was 9 years (range 6-13 yrs), with 13 males and 4 females participating. Mean 24-hr PM<sub>2.5</sub> values from 3 central sites in the Seattle area were 12.6 µg/m<sup>3</sup> ± 6.5 (246 days). Mean 24-hr PM<sub>2.5</sub> estimated by nephelometry outside subjects' residences was 13.1 µg/m<sup>3</sup> ± 12.9 (169 days). Indoor PM<sub>2.5</sub> estimates from nephelometry were 12.6 µg/m<sup>3</sup> ± 8.6 (184 days). No significant association between 0-2 day lagged local outdoor PM<sub>2.5</sub> exposure and coached FEV<sub>1</sub>, PEF or MEF was observed in models adjusted for temperature and relative humidity. A 10 µg/m<sup>3</sup> increase in 1-day lagged PM<sub>2.5</sub> (15 subjects, 106 observations) was associated with a 29ml decrement [95%CI: -100, 40] in FEV<sub>1</sub>. Indoor PM<sub>2.5</sub> showed the strongest association for 1-day lagged PM<sub>2.5</sub>, with decrements in MEF [-109ml, 95%CI: -229, 11] and FEV<sub>1</sub> [-27ml, 95%CI: -96, 42]. No consistent associations were found for PEF and PM<sub>2.5</sub> exposure.

**Conclusion:** In this analysis, we found no significant association between PM<sub>2.5</sub> exposure and FEV<sub>1</sub>, PEF or MEF in pediatric subjects with asthma. The lack of observed effect of PM<sub>2.5</sub> on lung function may be explained by the time of day at which the coached lung function tests were conducted or the relatively low PM levels.

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**10931- Are Age and Gender Modifiers of the Effects of Airborne Particles on Hospital Admissions for Myocardial Infarction?**

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While several studies have examined how the effect of particulate matter (PM10) on various health outcomes is modified by individual's personal characteristics, the Poisson time series studies assess potential effect modifiers such as age by dividing age into categories and analyzing the subsets of different age groups separately. One benefit of the case-crossover study design is the ability to evaluate interactions among continuous covariates in the same model. We examined the association between daily PM10 (the mean of lags 0-1), and Medicare data on hospital admissions for myocardial infarction (ICD-9: 410) in the city of Chicago and surrounding Cook County, Illinois for the years 1988-1991. The Medicare data are limited to persons over 65 years of age. We used a symmetric bidirectional case-crossover study design with referent exposure days chosen 6-14 days preceding, and following, each hospital admission. Selection bias was avoided by choosing referent days from the same time frame that generated the case events. We used data on each individual's age and gender to model the interactions between PM10, age, and gender as linear predictors while controlling for weather and day-of-the-week effects. Seasonality was controlled for by the case-crossover study design. In a model without interaction terms, we found the odds ratio associated with a 100 $\mu$ g increase in PM10 exposure was increased by 7.75% (95%CI: 0.04%, 16.0%). In a model that included two-way interaction terms for age and PM10, and gender and PM10, and a three-way interaction term for age and gender and PM10, we found that the association between PM10 and hospital admissions for myocardial infarction was clearly modified by both age and gender with the risk increasing for women by 2.0 % per year of age and per 100  $\mu$ g increase in PM10 exposure (95 % CI: 0.3 %, 3.7 %).

10933- Indoor/Outdoor ratios of particulate bound elements and air exchange rates in homes of inner-city teenagers in New York City

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Among the research needs related to the epidemiology of fine particles is better characterization of human exposures to fine particle sub-components. Most investigations of potential health impacts of respirable particulate matter (PM<sub>2.5</sub>) are from ambient monitoring stations even though individuals spend most of their time indoors. The TEACH (Toxic Exposure Assessment-A Columbia Harvard) study was designed to characterize levels of and factors influencing personal exposures to urban air toxics among high school students living in inner city neighborhoods of New York City and Los Angeles. In the NYC phase of the project, 46 non-smoking students at the A. Philip Randolph High School in the Harlem neighborhood of Manhattan were recruited to undergo 48-hour personal, home indoor, and home outdoor PM<sub>2.5</sub> exposure measurements in Winter and/or Summer. Mean air-exchange was measured in all apartments in both seasons using a perfluorocarbon tracer gas method. Monitoring also was carried out on the school roof and at a non-urban upwind ambient site. Field measurements took place over an 8 week period in each season, with up to 5 subjects monitored simultaneously each week. PM<sub>2.5</sub> was collected at 4 LPM onto Teflon filters downstream of a cyclone (BGI Inc). After post-weighing, filters were analyzed for optical absorbance and then underwent multi-element analysis by magnetic sector high-resolution, inductively-coupled-plasma mass-spectrometry (HR-ICP-MS), a highly sensitive technique which yielded data on 28 elements. Here we report indoor/outdoor ratios (across subjects) for all elements, as well as PM<sub>2.5</sub> and optical absorbance. Median I/O ratios were generally under 1.5 for all elements. In NYC summertime, the analytes with at least half of the homes having only ambient sources (median I/O < 1) were SO<sub>4</sub>, Abs\*, Be, Se, Co, Ni, V, La, Fe, Cs, Pb, Al, Mn, and Mg. Elements with at least half of the homes having indoor sources (median I/O >1) included PM<sub>2.5</sub>, Na, Ca, Cu, Tl, Zn, Cd, Ag, Sn, Cr, As. Seasonal differences were observed for indoor-outdoor ratios of many of the elements, with the distributions moving closer to a ratio of 1.0 in the summer when air exchange rates were higher by roughly a factor of two on average when compared to winter air exchange rates. Within each season, apartments with higher air exchange rates tended to have indoor/outdoor ratios closer to one as compared to homes with lower air exchange rates, consistent with the process of ventilation. These preliminary data are consistent with ambient sources dominating indoor concentrations for many PM<sub>2.5</sub> sub-components.

10940- Ecologic-level exposure characterization error of PM and gaseous pollutants in the contiguous U.S.

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Numerous studies have reported short-term associations between ambient air pollution concentrations and mortality and morbidity. Particulate matter (PM) was often implicated as the most significant predictor of the health outcomes among the air pollutants. However, a question remains as to the potential role played by the relative error associated with each pollutant. One important component of such error is the monitor-to-monitor temporal correlation that reflects the spatial uniformity of the temporal fluctuations of air pollution in a given city.

This study characterized the monitor-to-monitor temporal correlation for PM<sub>10</sub> and gaseous pollutants (NO<sub>2</sub>, SO<sub>2</sub>, CO, and O<sub>3</sub>) in the nationwide data between 1988-1997. For each monitor, the median of temporal correlation with other monitors within the Air Quality Control Region (AQCR) was computed. The resulting median correlation was modeled as a function of qualitative site characteristics (i.e., land-use, location-setting, and monitoring-objective) and quantitative information (median separation distance, longitude/latitude) for each pollutant. Generalized Additive Model was used to fit the smooth function of the separation distance and regional variation.

The intercepts of the models across pollutants revealed the overall rank in monitor-to-monitor correlation on the average: O<sub>3</sub>, NO<sub>2</sub>, PM<sub>10</sub>, (0.7~0.8) > CO (~0.6) > SO<sub>2</sub> (~0.4). Both the separation distance and regional variation were important predictors of the correlation. A separation distance of 50 miles would result in a drop of 0.1 in correlation. For PM<sub>10</sub>, for example, the correlation for the monitors along the East Coast was higher by ~0.1 than average. The qualitative monitor characteristics were often significant predictors of the variation in correlation, but their impacts were not substantial in magnitude for most categories.

These results suggest that the regional heterogeneity in PM effects, as well as the difference in the significance of health outcome associations across pollutants may in part be explained by the difference in monitor-to-monitor correlation by region and across pollutants.

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10948- Particulate matters of the heart: air pollution and heart rate variability in the Coachella Valley, California

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Epidemiological studies have demonstrated consistent associations between exposure to ambient particulate matter (PM) and increased morbidity and mortality. Mortality effects appear to be greatest among elderly people with pre-existing cardiac and respiratory diseases, especially ischemic heart disease, congestive heart failure and chronic obstructive lung disease. We reported previously that exposures to PM are associated with an increased risk of daily mortality, including deaths from cardiovascular diseases, in the Coachella Valley, California, a desert resort area where the PM mass is dominated by coarse particles. The mechanisms underlying reported associations between exposures to ambient PM and daily mortality are unknown, but may involve disturbances of the autonomic nervous system and the electrical activity of the heart. In this study, we examined whether, in a population of 19 adults, aged 60-80, with clinically documented coronary artery disease, exposures to ambient PM<sub>10</sub>, PM<sub>2.5</sub>, and the coarse fraction (PM<sub>10</sub> - PM<sub>2.5</sub>) were associated with altered cardiac autonomic nervous system regulation, measured as decreased heart rate variability (HRV). Decreased HRV has been linked to an increased risk of cardiovascular mortality in multiple subsets of patients with cardiovascular disease. To assess HRV in this study population, we conducted serial 24-hour electrocardiographic monitoring at weekly intervals, using digital Holter monitors (Forest Medical, model Trillium 3000) for up to 12 consecutive weeks from April to June 2000. Exposure assessment consisted of real-time monitoring of ambient PM<sub>10</sub> and PM<sub>2.5</sub>, ozone, nitrogen dioxide, and carbon monoxide at two fixed-site monitors located at either end of the population corridor in the Coachella Valley. We used random-effects generalized least squares regression to examine relationships between the various pollutant metrics and changes in HRV, controlling for relevant meteorological factors. Preliminary results suggest that all three particle metrics were associated with small, but significant, decrements in at least one measure of HRV. Notably, both PM<sub>10</sub> and coarse particle concentrations were associated with decrements in SDNN (standard deviation of all normal-to-normal beat intervals over the duration of the monitoring period), SDANN (standard deviation of the mean of normal-to-normal beat intervals for 5-minute periods over the entire monitoring duration), and the triangular index over the course of a two-hour period in the evenings (6:00 – 8:00 p.m.), when daily particle levels tended to be the highest. None of the gases were associated with changes in HRV in this time window. Several previous reports have linked exposures<sup>3</sup> to ambient and indoor fine particles with decreases in HRV; to our knowledge this is the first report linking exposure to ambient coarse particles to decrements in HRV in individuals with established heart disease. The clinical significance of small pollutant-associated changes in HRV remains to be established.

# 11013- Personal PM<sub>2.5</sub> exposures, residential and workplace indoor and residential outdoor concentrations: Comparison of Seven European cities in the EXPOLIS study

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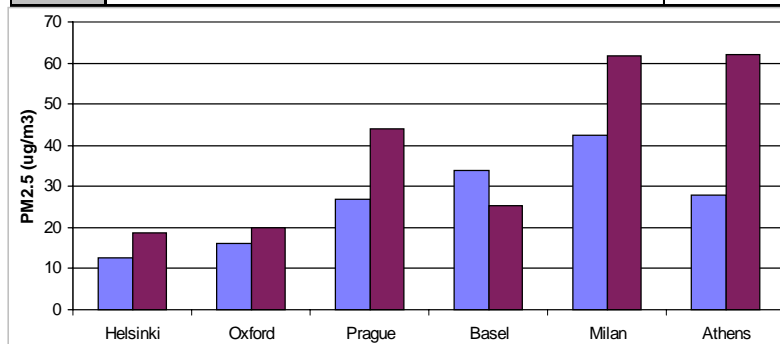
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PM<sub>2.5</sub> exposures and simultaneous (covering 48 h. for each subject) concentrations in residential and occupational indoor microenvironments as well as residential outdoor environments were measured in 1996-98 for ca. 400 randomly chosen 25-55 year old urban individual in 7 European cities (albeit some variations and exceptions between the cities). Personal exposures were measured separately for workday (including commuting) and leisure time (covering the rest of the day). Microenvironment concentrations were measured during the times when the individuals were expected to be in the vicinity, i.e. residential indoor and outdoor only during the leisure time. The present abstract focusses on comparing the total PM<sub>2.5</sub> masses across the cities. Other presentations look more closely at the different constituents and contributions of different sources to these concentrations and exposures.

Comparison of the basic statistics between the cities reveal a broad range of city average residential outdoor concentrations from 10 to 39 µg/m<sup>3</sup> (compare to 12-29 in the Six Cities study), residential and workplace indoor concentrations from 12 to 43 µg/m<sup>3</sup> and 12 to 91 µg/m<sup>3</sup>, and personal 48 h exposures from 15 to 49 µg/m<sup>3</sup>, in average 5-11 µg/m<sup>3</sup> higher than the residential outdoor concentration (Table 1). Comparison of the workday and leisure time exposures reveals also great variation between the cities. In Basel on one extreme the exposure is in average lower in the workday than leisure time. In Athens on the other extreme the exposure is in average more than 2 times higher in the workday than leisure time (Figure 1). In Helsinki the leisure time and workday exposures correlated with each other only for smokers.

**Table 1.** Exposure, indoor and outdoor PM<sub>2.5</sub> data for adult citizens in 7 European cities.

PM <sub>2.5</sub> (µg/m <sup>3</sup> )	personal leisure			personal workday			personal 48 h			home indoors			workplace			home outdoors		
	AM	GM	90 %	AM	GM	90 %	AM	GM	90 %	AM	GM	90 %	AM	GM	90 %	AM	GM	90 %
Helsinki	12.6	8.9	23.1	18.8	11.5	36.9	15.4	10.9		12.2	8.5	21.8	15.9	7.9	26.5	9.7	7.8	18.3
Oxford	16.0	11.4	33.4	19.8	12.4	56.8	17.3			17	11.9	29.4	11.8	7.8	20.5	10.6	8.1	22
Basel	33.8	21.3	65.2	25.2	18.9	41.0	30.3	21.7		24.4	18.5	64.2	27.5	16.1	60.1	19.4	16.5	30.1
Grenoble							32.5	26.7	64.5									
Prague	26.8	20.7	50.5	43.9	35.2	94.3	35.2	29.0		35.9	28.1	91.2	43.8	30.8	97.7	26.9	24.9	40.9
Athens	27.8	22.7	60.4	62.2	40.5	224.6	37.1	30.8		32.4	27.5	68.3	91.9	65.8	249.6	36.6	30.2	72.0
Milan										42.7	31.5	78	59	51.3	86.5	39.3	38	73.5



**Figure 1.** Average leisure time (left) and workday (right) exposures.

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11034- Ultrafine Particle Count and Size Data from A Routine Community Monitoring Program  
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Introduction: Some health scientists postulate that ultrafine particulate matter (UFPM) in ambient air is especially harmful to health. Experimental studies support this view. UFPM has also been linked, tentatively, to mortality and morbidity in epidemiological studies. UFPM data are rarely available; therefore, clear demonstration of health impacts remains elusive. We describe here an ambitious monitoring effort and results from the first year of near-continuous measurement of UFPM in several southern California communities. Methods: In January 2001, Condensation Particle Counters (CPC) (TSI 3022A) were deployed to air monitoring sites in the 12 southern California communities of the Children's Health Study. By fall 2001 all were reporting particle count data by telemetry. At two of the sites electrostatic classifier units (ECU) (TSI 3080L) were installed to provide particle size distribution data. The CPCs will operate through 2003 and the ECU will be circulated among the sites to provide time- and size-resolved UFPM data. Results: There is a distinct bimodal daily pattern with strong morning peaks (6 – 9 am), and lower longer-duration evening peaks (6 pm to midnight). Striking associations were found between particle counts and levels of other pollutants, especially combustion-derived emissions (CO, NO, and NO<sub>2</sub>; and to a lesser extent PM<sub>10</sub>) over various time intervals. UFPM count data from sites outside the Los Angeles (LA) air basin are typically low; in the 1000's of particles per cubic centimeter, still recording brief peaks approaching 100,000 particles per cubic centimeter, while most basin sites typically have counts in the tens of thousands. Some sites within the basin with high levels of secondary pollutants show low UFPM counts. Particle size data demonstrate complex diurnal structure, with large variability of size-specific counts occurring over periods of a few hours that appear related to local sources, transport, and physical processes. At LA basin receptor sites, UFPM geometric mean diameters decrease approximately 20nm throughout the day, possibly due to volatilization of UFPM-bound water, which would occur as the day progresses, the temperature increases and relative humidity decreases. At source sites in proximity to vehicular emissions, the UFPM mean size decreases during the morning traffic hours due to contributions from fresh emissions. UFPM mean size further decreases through the day and increases at nighttime possibly due to growth of hygroscopic components of UFPM. Further analysis is currently under way. Conclusions: One clear observation is that UFPM often tracks other pollutants. Both particle count and particle size distributions exhibit complex diurnal and spatial variability that will require additional efforts to fully clarify. Results suggest that community health studies that have observed statistical associations with other pollutants may need to be reconsidered in light of UFPM and future research considering UFPM should be very carefully designed. Further, it suggests that summarizing this data into exposure profiles for communities and individuals will be challenging.

11099- Personal, indoor and outdoor concentrations of fine particles in relation to daily variations of urinary concentrations of lung Clara cell protein CC16.

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The aim of the investigation was to assess the relation between daily variations in ambient levels, indoor levels, and personal exposure to (components of) fine particles and urinary concentrations of lung Clara cell protein CC16, a marker for lung damage. In the framework of the Ultra study, panel studies were conducted in Amsterdam and Helsinki. Panels consisted of elderly subjects with cardiovascular disease. Subjects were followed for 6 months with biweekly clinical visits, including collection of spot urinary samples. Urinary concentrations of CC16 were measured by an automated latex immunoassay. Each subjects' indoor and personal exposure was measured biweekly, during the 24-hour period preceding the clinical visits. Outdoor PM<sub>2.5</sub> concentrations were measured at a fixed site. Particle reflectance was measured as a marker for elemental carbon, a major part of diesel soot. Elemental content of part of the personal and indoor measurements and all outdoor measurements was measured using energy dispersive XRF.

The geometric mean of the CC16/creatinine ratio was 8.6 for 390 measurements from 34 adults in Amsterdam and 9.7 for 403 measurements from 42 adults in Helsinki. Median personal and indoor PM<sub>2.5</sub> concentrations during the 24-hour preceding the collection of the urinary samples were 13.6 µg/m<sup>3</sup> (n=308) and 13.8 µg/m<sup>3</sup> (n=380) respectively in Amsterdam and 9.8 µg/m<sup>3</sup> (n=262) and 9.5 µg/m<sup>3</sup> (n=393) respectively in Helsinki. Corresponding median outdoor levels were 16.6 µg/m<sup>3</sup> in Amsterdam and 11.1 µg/m<sup>3</sup> in Helsinki.

The association between daily variations of CC16 concentrations and air pollution was assessed using either personal, indoor or outdoor concentrations as exposure variable. Use of indoor or personal PM<sub>2.5</sub> concentrations as exposure yielded effect estimates that were similar to the ones found with outdoor PM<sub>2.5</sub> concentrations, with significant associations found for all 3 measures of exposure (personal, indoor, outdoor) in Helsinki and none in Amsterdam.

The result suggest that effect estimates derived from outdoor PM<sub>2.5</sub> concentrations from fixed site monitoring are similar to those from personal PM<sub>2.5</sub> exposures.

11109- Implications of Using Ambient PM Concentration as a Surrogate For PM Exposure in Statistical And Epidemiologic Analyses of Time Series Data

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The question “What information may be obtained from a time-series regression of health effects on ambient PM concentrations?,” is of interest to exposure analysts and epidemiologists, especially since exposure analysts find low and frequently non-significant correlations between daily ambient PM concentrations and daily personal exposures to total PM. Zeger et al. (2000) provide a framework for the analysis of the effect of PM exposure error on the results of epidemiologic analyses using ambient PM concentrations. In their analysis, they made three important assumptions. However, an alternate set of assumptions are possible. This paper will examine the experimental evidence for each set of assumptions, conclusions resulting from each set of assumptions, and key questions posed for exposure analysts and epidemiologists. (Both Zeger and this paper assume that the relationship between exposure and health effect is linear.)

<i>Assumptions (Zeger et al, 2000)</i>	<i>Alternate Assumptions</i>
The health risk due to exposure to PM is the same for ambient, nonambient, or total PM.	The health risk due to exposure to ambient PM may be different from that for nonambient PM.
Daily nonambient PM exposures may be correlated with daily ambient PM concentrations.	Daily nonambient PM exposures are independent of daily ambient PM concentrations.
The health risk associated with total personal PM exposure is the key parameter.	Separate health risks are needed for ambient and nonambient PM exposure
<i>Conclusions (Zeger et al, 2000)</i>	<i>Alternate Conclusions</i>
Health effects should be regressed against total personal PM exposure.	Health effects should be regressed against ambient PM concentrations.
The ambient and nonambient PM exposures need to be measured or modeled and summed to obtain total personal PM exposure.	The nonambient PM exposure does not influence the health risk associated with ambient PM exposure or ambient PM concentrations.
A regression of health effects on ambient PM <i>exposure</i> is needed for an unbiased estimate of the health risk coefficient.	A regression on ambient <i>concentrations</i> will give an unbiased measure of the effect of a change in ambient concentrations on health effects in the same city.

11111- Would You Believe a 20% Excess Risk of Cardiovascular Mortality for a 10µg/m<sup>3</sup> Increase in Fine PM (for People 65-99 Years Old in Phoenix, AZ 1995-1997)? If So, What Is Special about Phoenix? If Not, Find the Error!

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The initial study of the relationship between air pollution and mortality in Phoenix (Mar et al., 1999) did not find a statistically significant relationship between total or cardiovascular mortality (CVM) and PM<sub>2.5</sub> measured by a filter collection technique similar to the Federal Reference Method. However, a statistically significant relationship was found between CVM and PM<sub>2.5</sub> measured with a TEOM. Both the difference in results for the two PM<sub>2.5</sub> measurements and the high % excess risk (%ER) for the TEOM measurement led to further analyses with consideration of a variety of alternate model specifications and to an integration of risks over multiple lag days.

# Days	Missing Days <sup>1</sup>	Indicator	%ER CVM per 10µg/m <sup>3</sup> (CI) <sup>2</sup>	t-statistic	Lag Day(s)
768	Avg	Filter PM <sub>2.5</sub>	4.1 (-1.2,9.7)	1.52	1
942	Avg	TEOM PM <sub>2.5</sub>	7.1 (2.2,12)	2.90	1
768	Omit	Filter PM <sub>2.5</sub>	7.7 (1.8,14)	2.56	1
768	Omit	Filter PM <sub>1</sub>	9.6 (2.2,18)	2.57	1
942	Omit	Filter PM <sub>1</sub>	9.7 (3.1,17)	2.94	1
942	Omit	Filter PM <sub>1</sub>	11.4 (4.4,19)	3.25	1, Control for inlet change <sup>3</sup>
942	Omit	Filter PM <sub>1</sub>	19.6 (9.8,30)	4.10	Running average 0 through 5
942	Omit	Filter PM <sub>1</sub>	19.8 (9.9,30)	4.08	Unconstrained lag 0 through 5

1. In the initial study, missing PM data was replaced with the average concentration for the three year period. In later analyses missing days were omitted.

2. 95 % confidence limits.

3. A cyclone was used for the first two years and an impactor for the third year.

Factors that might lead to higher risks associated with PM concentrations in Phoenix than in other cities include 1) mortality data was limited to a relatively small area of the city near the monitoring station so the spatial distribution of the PM concentrations may be more uniform and the population demographics may be less variable, 2) in hot cities such as Phoenix, deaths are not correlated with temperature, 3) the concentration of sulfate, relative to other PM components, is lower than in eastern U.S. cities which may allow effects of both regional sulfate and local combustion particles to influence the associations, 4) as observed in other studies, the use of cause-specific mortality yields greater significance and a higher excess risk.

### **11154- Particle exposure in a susceptible population: A comparison of personal and ambient concentrations**

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This research extends previous investigations of potential adverse cardiovascular effects associated with particulate air pollutants by investigating patients with implanted cardiac defibrillators (ICDs). The objectives are to assess personal exposures of a susceptible population to specific particle indicators and to test the hypothesis that refined assessment of exposure enhances the detectability of effects of air pollution on cardiac health.

Nineteen patients with ICDS and residing in Vancouver BC were monitored for exposure between May 14 and August 30, 2001. Each patient wore a personal air sampler for 7 randomly selected 24 hour periods ( $\geq 8$  days apart). Air was drawn through pre-weighed 37mm Teflon filters at a flow rate of 4L/min. All filters were analyzed for PM<sub>2.5</sub> mass concentration, filter optical absorbance (a surrogate for elemental carbon, a marker of traffic-related particles), and sulfate (a marker for regional ambient source PM). Supplementary data specific to exposure-related activity was collected using time activity diaries. Ambient measurements of PM<sub>2.5</sub>, sulfate and absorbance were also made at a single ambient monitoring location for the same period.

Of 133 attempted personal samples, 124 (93%) were successfully collected. The geometric mean personal PM<sub>2.5</sub> concentration was 16.5ug/m<sup>3</sup>. The median ambient PM<sub>2.5</sub> concentration was 6.4ug/m<sup>3</sup>. Median ambient and personal absorbance values were  $10.8 \times 10^{-5} \text{m}^{-1}$  and  $7.2 \times 10^{-5} \text{m}^{-1}$ , respectively. Median personal and ambient sulfate concentrations were 1.15ug/m<sup>3</sup> and 1.2ug/m<sup>3</sup>, respectively.

Relationships between personal exposures and ambient concentrations were assessed to evaluate the validity of using ambient measurements for exposure assessment. Median r values for individual personal versus ambient regressions for PM<sub>2.5</sub>, absorbance, and sulfate were 0.37, 0.50, and 0.85, respectively. Analysis of time activity data revealed that subjects spent a high proportion of their time indoors (median = 0.86), indicating that indoor sources may account for the poor correlation between personal and ambient concentrations. Higher personal to ambient correlations for absorbance and sulfate were consistent with these components being associated with local and regional outdoor sources, respectively.

Time activity and geographic data specific to traffic will be used to develop predictive models for personal exposures. These predicted exposures will then be used to determine whether such estimates improve the ability to detect exposure response relationships. By investigating potential links between exposure to air pollution and cardiovascular health effects this research will help to determine the importance of air pollution as a risk factor for cardiovascular disease.

TOPIC: Particulate Matter