

10014- Performance of different exposure assessment approaches in a study of bitumen fume exposure and lung cancer mortality

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The International Agency for Research on Cancer conducted a cohort study of mortality among asphalt workers in 8 countries (Denmark, Finland, France, Germany, the Netherlands, Norway, Sweden, Israel). One of the study's aims was to assess the occurrence of lung cancer among workers exposed to bitumen. This paper evaluates the performance of different exposure assessment approaches in achieving this goal. In the whole cohort, the use of job titles and semi-quantitative exposure scores failed to identify any positive associations. Quantitative exposure estimates were available for members of the cohort selected for the current analysis: males employed only in asphalt paving. An inception/entry sub-cohort was also identified among these persons. The Swedish cohort was excluded because duration of exposure could not be accurately estimated within it. An exposure matrix was developed, based on statistical models of exposure measurements and questionnaires on past production conditions. Three exposure indices were considered: duration of exposure (years), average exposure (mg/m<sup>3</sup>) and cumulative exposure (mg/m<sup>3</sup>\*years). Two latency models were considered for the association between lung cancer and bitumen fume: one with a 15-year lag and one without. We examined rank correlation among bitumen fume exposure indices. Relative risk associated with bitumen fume exposure was estimated via Poisson regression. All models were adjusted for coal tar exposure (ever/never), age, calendar period and country. Competing exposure-response models were compared by using a log-likelihood ratio test (measure of model fit). We selected 12,367 workers for analysis. Among these persons, 10,060 belonged to the inception cohort. In the whole cohort, there were 135 deaths due to lung cancer. Only exposure ranks based on strata of duration and cumulative exposure indices were correlated. There was no association between lung cancer risk and either duration or cumulative bitumen exposure. However, there was the suggestion of an increase in lung cancer risk with rise in average exposure. Only models with average bitumen fume exposure (with or without lag) markedly improved model fit. Average bitumen fume exposure indices with and without a 15-year lag improved model fit to the same extent. Thus, no clear latency model emerged from analysis. We concluded that constructing different quantitative exposure indices was justified because (a) the uncertainties in the effect of exposure duration required valid and precise estimation of exposure intensity and (b) we identified statistically significant associations between bitumen fume exposure and lung cancer risk that require further investigation.

## 10018- Use of Personal Motion, Light, and Temperature Loggers to Verify Continuous Wearing of Personal Exposure Monitors

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One problem with the use of personal exposure monitors is possible non-compliance by wearers. This study evaluated the utility of small light weight data logging devices in assessing wearer behavior and compliance. The data loggers used were small electronic instruments that recorded measurements of temperature and relative humidity (RH); light intensity; and motion (on/off state changes) (Hobo® models HLI, H08-003-02, H06-003-02, Onset Computer Corporation). The study population consisted of 17 asthmatic children, ages 9-18, participating in the Alpine Asthma Study (NIH, NIEHS # ES-06214-06A2, PI Ralph Delfino). Each subject wore a personal particulate monitor (pDR-1000, MIE Inc.) during waking hours for 14 consecutive days. The data loggers were fastened to the monitor. From daily questionnaires, 11 episodes were identified where the subject admitted not having worn the sampler. In order to evaluate the utility of each logger in identifying these admitted episodes, metrics of the data from each data-logging device were computed and compared to equivalent time periods before and after each episode. The motion detection data loggers provided the most discriminating and useful information in verifying subject-reported non-compliance. The average count of motion events per 15-minute time block during each episode was always <1, while counts before and after episodes were always > 10 (median 57 and 39, respectively). For light intensity (indoor episodes only) 10 lumens proved to be the most discriminating cut-point (100% of episodes had no reading greater than 10 lumens, whereas 12% of the periods before and after the episodes also had no readings > 10 lumens). Temperature and RH were not useful for verification, although there were clear correlations with reported locations. In conclusion, as personal exposure devices become more portable and widely used, the use of these inexpensive data-logging devices will aid in compliance verification.

10090- A Facility for Exposure Studies with Aerosols Present in Urban Atmospheres  
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Atmospheric chemistry research facilities at Brigham Young University include a collapsible 40 m<sup>3</sup> Teflon chamber equipped with a UV and black lamp system for the simulation of ambient sunlight. Adjacent to this chamber is an 15 m<sup>3</sup> exposure room with a dedicated recirculation system for controlled exposure studies. The Teflon chamber is being used to generate a stable test aerosol with PM<sub>2.5</sub> concentrations about two to three times that desired in the exposure room. A fraction of this stable aerosol is transferred from the Teflon bag to the exposure room at the beginning of a controlled exposure study. The exposure room will be used for studies on the effect of PM exposure on cardiovascular function. Instruments used for monitoring the PM both in the Teflon chamber and in the exposure room include a RAMS, a TEOM monitor, a TSI CPC monitor (for detailed particle size distribution determination), an Anderson Aethalometer, a BOSS sampler (for detailed PM<sub>2.5</sub> chemical composition determination during the exposure period) and monitors for gas phase CO, NO<sub>x</sub> and NO<sub>2</sub>. The aerosols being studied are those represented by the PM<sub>2.5</sub> in the Wasatch Front ambient air: 1. Concentrated ambient particles (CAPS), 2. Fresh wood smoke emissions and 3. Wood smoke emissions aged for 4-6 hours with the UV-black lamp system associated with the Teflon chamber. The fresh wood smoke emissions are sampled from the flue line of a certified wood stove. The concentrations of CO are reduced 90% by passage through a heated (100C) honeycomb Au metal catalyst. The NO, NO<sub>2</sub> and gas phase organic compound concentrations are unchanged to facilitate the photochemical aging of the wood smoke emissions. After the Teflon chamber has been charged with fresh wood smoke emission to the desired ~500µg/m<sup>3</sup> PM<sub>2.5</sub>, the aerosol in the Teflon chamber is either introduced into the exposure room until the desired concentration is attained in the exposure room, or the aerosol is first aged for 4-6 hours with the UV, black lamp system and then introduced into the chamber. As either the fresh or aged wood smoke aerosol is transferred to the exposure room, it is passed through a TEA denuder, to reduce the concentrations of NO<sub>x</sub> and O<sub>3</sub> to less than half the national ambient air quality standard without removing either the PM<sub>2.5</sub> or the gas phase semi-volatile organic compounds in equilibrium with the particles. The composition of fresh and aged wood smoke emission present in the exposure room, as compared to the initial wood smoke emissions will be detailed.

## 10109- Personal exposure and fixed individually related measurements of formaldehyde and acetaldehyde in Sweden.

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**Introduction** Formaldehyde is probably, and acetaldehyde is possibly, carcinogenic to humans according to IARC. There is only limited knowledge about personal exposure to these air pollutants. The aim of this study was to investigate aldehyde exposure in the general population with personal as well as stationary measurements.

**Methods** Diffusive GMD samplers were used to measure personal exposure to formaldehyde and acetaldehyde during six days among 40 randomly selected subjects (age 20-50 years) living in Gothenburg. Concurrently stationary measurements were done in the participants' bedrooms and outside their homes. The modified GMD sampler (3.5 mg DNPH) was analyzed using HPLC with UV-detection. The detection limit was 0.5  $\mu\text{g}/\text{m}^3$  for formaldehyde and 1  $\mu\text{g}/\text{m}^3$  for acetaldehyde. Twenty of the personal measurements were repeated in order to study the variability between- and within-individuals.

**Results** The median personal exposure to formaldehyde was 19  $\mu\text{g}/\text{m}^3$  (95% CI 17-26  $\mu\text{g}/\text{m}^3$ ). The bedroom concentrations were slightly higher (median 24  $\mu\text{g}/\text{m}^3$ , 95% CI 20-28  $\mu\text{g}/\text{m}^3$ ), while the outside concentrations were low (median 3.3  $\mu\text{g}/\text{m}^3$ , 95% CI 2.7-3.7  $\mu\text{g}/\text{m}^3$ ). A high correlation ( $r_s=0.83$ ,  $p<0.001$ ) was found between personal and bedroom measurements. Subjects living in one-family houses had significantly higher exposure to formaldehyde compared with subjects living in apartments, medians 31  $\mu\text{g}/\text{m}^3$  and 18  $\mu\text{g}/\text{m}^3$  ( $p=0.01$ ). This was also true for the bedroom results. The personal and bedroom concentrations of acetaldehyde were similar, median 2.0  $\mu\text{g}/\text{m}^3$ , whereas all outside measurements were below the detection limit. For formaldehyde, only 10% of the total variability was attributable to the within-individual source of variation. In an earlier study using a 24 hours sampling period we found, as expected, a somewhat higher within-individual variability, about 30%.

**Conclusions** The median formaldehyde level was within the guideline value range of 12-60  $\mu\text{g}/\text{m}^3$  proposed in Sweden. The exposure is mainly related to indoor sources. One-day and six-days sampling periods yield a relatively low within-individual variability for formaldehyde measurements with GMD samplers. The median level of acetaldehyde was far below concentrations that cause irritative effects in humans.

## **10117- A TIERED APPROACH TO ENVIRONMENTAL EXPOSURE ASSESSMENT IN THE ENVIRONMENT AGENCY**

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The Environment Agency of England and Wales has responsibilities for regulating, managing and advising on a wide range of environmental risks, ranging from risks from flooding, waste management facilities, contaminated land to environmental aspects of BSE and food and mouth disease.

Risk assessments undertaken by the Agency, or on its behalf, are used to inform decisions on how to manage risks to or from the environment and may be conducted for a wide range of purposes and scales, ranging from assessments to support policy development to site-specific assessments. Key to assessing these risks is to establish whether there are linkages between the hazard(s) (e.g. toxic agents such as substance or micro-organisms) and receptors (humans or the wider environment) of concern. A range of tools and techniques are available to undertake this type of exposure assessment, ranging from qualitative screening approaches to sophisticated numerical packages. A tiered approach that allows for screening and prioritisation prior to undertaking a more detailed quantified assessment is essential in ensuring that all potential sources, pathways and receptors are considered and that efforts are focussed on the key risks identified at the screening stage.

This paper will outline developments in environmental exposure assessment adopted by the Environment Agency, drawing on from experience gained in recent years, and will illustrate the key themes that are emerging by reference to a number of assessments recently undertaken by the Agency and/or government (or on their behalf). Key emerging themes include the importance of:

- Developing a conceptual model to ensure a clear understanding of the site under study and to ensure that all potential sources (of the hazards), pathways and receptors have been considered.
- Screening and prioritisation to assist in establishing the existing and potential connectivity between the key sources and receptors so that the more detailed exposure assessment can focus on the critical pathways of concern
- Transparent audit trail that provides justification for screening out pathways where the probability of exposure is considered negligible or low
- Proportionality of approach so that the exposure assessment model selected matches the problem and input quality of data
- The importance of translating scientific advances to the needs of end users addressing authentic problems on the ground. This involves balancing the complexity in the science with the demand for simple, transparent decision making.

In addition, this paper will draw from experience gained by the UK Interdepartmental Group on Health Risks from Chemicals (IGHRC) who are developing guidance to assist government departments to undertake and/or evaluate exposure assessments to chemical substances.

10149- Further Refinements and Testing of APEX(3.0): EPA's Population Exposure Model for Criteria and Air Toxic Inhalation Exposures. H.M. Richmond,<sup>1</sup> T. Palma,<sup>1</sup> J. Langstaff,<sup>1</sup> T. McCurdy,<sup>1</sup> G. Glen,<sup>2</sup> and L. Smith.<sup>2</sup> <sup>1</sup>U.S. Environmental Protection Agency, Research Triangle Park, NC; <sup>2</sup>ManTech Environmental Technology, Inc., Durham, NC.

The Air Pollutants Exposure Model (APEX(3.0)) is a PC-based model that was derived from the probabilistic NAAQS Exposure Model for carbon monoxide (pNEM/CO). APEX will be one of the tools that used to estimate human population exposure for criteria and air toxic pollutants as part of EPA's overall Total Risk Integrated Methodology (TRIM) model framework. The U.S. Environmental Protection Agency (EPA) has made further revisions to APEX over the past year. The model is intended to be applied at the local or urban scale and currently only addresses inhalation exposures. The model simulates the movement of individuals through time and space and their exposure to the given pollutant in indoor, outdoor, and in-vehicle microenvironments. The model has been made flexible so that various pollutants can be analyzed by inputting appropriate pollutant-specific information. The user may choose the number and types of microenvironments to be included, select the time period of interest, use either monitored ambient data or values provided from dispersion or other modeling runs, and use either a mass balance approach or an empirical ratio based approach to estimate indoor or in-vehicle concentrations.

The main exposure program stochastically generates simulated individuals using census-derived probability distributions for the demographic variables. Each such individual is assigned a series of time-activity diaries that are matched on the day type, temperature, age, gender, employment status, and optionally on other variables. The model then estimates the sequence of pollutant exposures for that individual, along with inhaled dose and (for CO only) the sequence of blood carboxyhemoglobin levels. Any number of simulated individuals can be modeled, and collectively they represent a random sample of the study area population. The model output is typically summarized into the number and percentage of person-days of exposure over various concentration cutpoints.

A number of enhancements have been made in this latest version of APEX. These include: (1) allowing for finer geographical units such as census tracts and automatically assigning population to the nearest monitor with a cutoff distance, (2) allowing exposure district specific temperatures to be specified, (3) allowing the user to select the variables that affect each parameter (e.g., the air exchange rate parameter in certain indoor microenvironments may depend on air conditioning status or window position, and (4) enhancing the mass balance algorithms to allow window position or vehicle speed to be considered in determining air exchange rate values. This poster will discuss these enhancements as well as EPA's plans to apply this modeling tool to estimate CO exposures in the Los Angeles urban area and compare the results with pNEM/CO estimates for this same area.

Any opinions, findings, conclusions, or recommendations are those of the authors and do not necessarily reflect the views of the U.S. Environmental Protection Agency or ManTech Environmental Technology, Inc.. This work has been supported by EPA under Contract No. OD-6260-NALX.

## 10171- Stability of Arsenic Species & Insoluble Arsenic in Human Urine

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### ABSTRACT

Urinary arsenic species are important short-term biomarkers that have been used in many epidemiologic studies. However, the stability of soluble arsenic species and the amount of arsenic lost during sample pretreatment remain unclear. The objective of this study is to evaluate the stability of soluble arsenic species in urine and aqueous standards as well as to assess the amount of insoluble and soluble arsenic lost during pretreatment (centrifugation and filtration, respectively). HPLC-ICP-MS was used to speciate arsenic species (As(III), As(V), MMA, DMA, and AsB) in aqueous standards and in urine samples. The arsenic levels in both freshly collected urine samples (pH = 5.5 to 7.0) and NIST SRM 2670 toxic elements in frozen-dried urine (pH = 4.4) remained constant up to 6 months when stored at  $-20^{\circ}\text{C}$ . In an aqueous solution mixed with  $10\ \mu\text{g/L}$  of As(III), As(V), MMA and DMA standards and stored at  $4^{\circ}\text{C}$ , As(III) and As(V) were stable only up to 4 weeks and MMA and DMA remained stable up to 4.5 months. The same phenomenon was observed for  $100\ \mu\text{g/L}$  mixed aqueous standards. There was no significant loss of arsenic species in urine ( $<5\%$ ) when passed through a  $0.45\ \mu\text{m}$  filter. The amounts of insoluble arsenic in urine lost during centrifuge ranged from  $1/2$  to  $1/17$  of soluble arsenic. These findings indicated that the urinary matrix plays an important role in stabilizing arsenic species. Also, the loss of insoluble arsenic in urine during centrifuging results in underestimation of arsenic exposure, and may explain the null association between arsenic exposure and the risk of health outcomes reported in some epidemiologic studies.

Abbreviations used: Arsenite, As(III); arsenate, As(V); monomethylarsonic acid, MMA(V); monomethylarsonous acid, MMA(III); dimethylarsinic acid, DMA(V); arsenobetaine, AsB; high-performance liquid chromatogram inductively-coupled plasma mass spectrometry, HPLC-ICP-MS.

## **10175- Re-conceptualizing Exposure to Unemployment: Why this is Important for Workers, Workplace Health, and Workers' Compensation Boards.**

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Classic research studies demonstrating adverse health effects due to unemployment were conducted during the Great Depression in the 1930s. These and more recent and better controlled studies have shown that the unemployed suffer higher mortality rates and greater psychological morbidity than employed workers. While the health problems of the unemployed worker may be severe they occur outside the workplace which has tended to minimize the importance of unemployment as an occupational/workplace exposure. A similar situation is found in the policy realm as the unemployed tend to disappear from Workers' Compensation Boards' horizons and move into the orbit of Welfare, and Unemployment Insurance policy makers and those who deal with re-training initiatives.

There are a number of reasons why this research and policy situation may be changing. First, several studies have shown that workplace accident rates may be broadly influenced by the employment cycle. In particular, these studies indicate (somewhat counter-intuitively) that during periods of high unemployment workplace accident rates may be lower than during periods of low unemployment. Better understanding of the relationship between unemployment and accident rates may help reduce accidents during periods of low unemployment. This has implications for productivity as it is during these periods, when the need for labour is high, that productivity losses due to increased accidents may be most keenly felt. Second, several studies have shown that the threat of unemployment produces psychological health impacts that may be even more severe than the impact of the experience of unemployment making "threat of unemployment" a legitimate workplace concern for researchers and policy makers. Third, and perhaps most importantly, a few studies have shown that the recent widespread unemployment which has occurred, particularly in manufacturing workplaces, may have adverse health impacts on the "survivors" who remain working at these facilities.

This study consists of a literature review, describing these studies, and an empirical component in which the impact of a 20 years period of sustained unemployment on both the work conditions and health status of "survivors" is analyzed in a cohort of Western Canadian sawmill workers. Results of this study indicate that work conditions and self-reported health status of workers who remain employed in sawmills during this period of sustained downsizing were worse than work conditions and health status of workers who were unemployed and subsequently found re-employment outside the sawmill sector.



**10179- Title: Use of routine statutorily required data to generate a job exposure matrix for Mn mineworkers, and correlating this with biological exposure indices**

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**Introduction:** South Africa's Mine Health and Safety Act requires mines which generate hazardous levels of dust to do periodic systematic personal sampling of miners' exposure to dust.

**Objective:** To explore the utility of routine exposure data for exposure-response analysis with neurobehavioral outcomes.

**Method:**

Occupational hygiene data collected routinely, as mandated by South African legislation, for the years 1995 through 2000 were collated for 4 manganese mines and a sinter plant in the Northern Cape, South Africa. The data were extracted from the original entry journals of the occupational hygienists of the two mining companies involved. Data were organized and entered by occupation code, job title and statistical population (a form of homogeneous exposure group) as required statutorily. A job exposure matrix was constructed using arithmetic mean values for dust and for Mn concentration based on occupation code vs statistical population (modified by job title). This will generate individual exposure measures for cumulative exposure and average exposure intensity for correlation with blood and urine Mn. A validation study was also done whereby the sampling and analytic methods used for routine data collection by the mining companies were validated against the IOM sampling head and NIOSH analytic methods for dust and Mn.

**Results:** It is expected that this exploration of the utility of routinely required exposure data can be harnessed to prevent possible early nervous system effects. This will depend upon the quality, validity and timeous availability of the data collected.

**Conclusions:** It is hoped to enhance the quality and value of statutory occupational hygiene monitoring on the basis of these results.

## 10180- Mailman's exposure to ozone and volatile organic compounds

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**Objective:** To assess mailman's exposures to ozone and volatile organic compounds during daily mail delivery by using fixed-site and personal measurements.

**Background:** Mailman's occupational exposures to ozone and Volatile Organic Compounds (VOCs) has not been characterized in past studies even though about 10,000 mailmen spent a majority of their working hours outdoors and were potentially exposed to high concentrations of ozone and VOCs during mail delivery.

**Materials and Methods:** We recruited 40 mailmen from two cities in a high ozone polluted area to assess their exposures to ozone and VOCs. There were 25 mailmen from a metropolitan area with a population over 1 million and 15 mailmen from a downwind township with a population of 100,000. The 25 mailmen in the metropolitan area belonged to three departments with different working hours and all participants in the downwind township belonged to one department. We measured each subject's personal exposures to ozone and VOCs during work for three consecutive days per month for three months. The Ogawa passive sampler and ion chromatography was used to determine ozone concentrations. The VOCs were collected by Tedlar bag with pump and analyzed by a gas chromatography with flame ionization detector (GC-FID). Measurements from nearby monitoring stations were also used to represent these mailmen's exposures.

**Results:** Mailman's mean ozone exposures (working hours) were  $35.1 \pm 19.0$ ppb (3.5hrs),  $29.7 \pm 23.7$ ppb (6.2hrs),  $21.4 \pm 8.6$ ppb (4.4hrs) in the metropolitan area, and  $57.8 \pm 29.7$ ppb (5.2hrs) in the downwind township. By contrast, mean ozone exposures were  $26.5 \pm 5$ ppb,  $25.7 \pm 3.9$ ppb,  $25.2 \pm 4.0$ ppb, and  $62.1 \pm 5.5$ ppb by using nearby fixed-site monitoring data. The Pearson correlation between personal exposures and fixed-site monitoring data was 0.48 ( $p < 0.01$ ). The 56 VOCs measured were: ethane, ethylene, propane, propylene, iso-Butane, n-Butane, Acetylene, t-2-butene, 1-Butene, iso-Butene, cis-2-Butene, Cyclopentane, iso-Pentane, n-pentane, 2-methyl-2-butene, Cyclopentene, 3-methyl-1-butene, 1-pentene, t-2-pentene, c-2-pentene, 2,2-dimethylbutane, 2,3-dimethylbutane, 2-methylpentane, 3-methylpentane, iso-prene, 2-methyl-1-pentene, 4-methyl-1-pentene, n-Hexane, t-2-hexene, c-2-Hexene, Methyl-cyclopentane, 2,4-dimethylpentane, Benzene, Cyclohexane, 2-methylhexane, 2,3-dimethylpentane, 3-methylhexane, 2,2,4-trimethylpentane, n-Heptane, Methylcyclohexane, 2,3,4-trimethylpentane, Toluene, 2-methylheptane,

3-methylheptane, n-Octane, Ethylbenzene, p,m-xylene, Styrene, o-Xylene, Nonane, Isopropylbenzene, n-propylbenzene,  $\alpha$ -Pinene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene. Mean personal exposure levels of these VOCs were 0.2-52.9 ppb. For most VOCs except iso-butane, personal exposures were 10 times higher than the measurements at the fixed site. The 56 VOCs of personal exposure samples were highly correlated ( $r=0.42-0.99$ ,  $p<0.05$ ). The association between personal exposures and fixed-site measurements was not significant.

**Conclusion:** Fixed-site measurements tended to underestimate personal exposures to ozone and VOCs. Fixed-site monitoring was moderately representative of mailman's spatial variation in ozone exposures but not VOC exposures. The patterns of VOC profiles indicated that mailman's VOC exposures were possibly from similar sources, which were mobile emissions.

## **10204- OBJECTIVES**

Motor vehicle exhaust accounts for approximately 80% of the population exposure to ambient benzene and the population-weighted average benzene concentration in California was estimated to be 3.3ppb. The measurement of biomarkers could become a potentially powerful tool for a better risk estimate of exposure to benzene.

This study reports an epidemiological pilot study of the use of urinary phenyl mercapturic acid (PMA) to determine benzene uptake in groups exposed to high and low levels of ambient benzene in air.

## **METHODS**

Two geographic areas within the City and County of Swansea were selected on the basis of their differing levels of ambient benzene in air (i.e. high and low). Sixty individuals were then randomly selected and asked to supply a urine sample and complete a short questionnaire to determine smoking habit and possible occupational exposure. The urinary concentration of the benzene specific metabolite (PMA) was subsequently determined based on the reaction of a unique antibody reagent. Urinary PMA has previously been demonstrated to provide a reliable indicator of benzene exposure.

## **RESULTS**

The ratio of micromol/mol PMA to Creatinine was determined for each individual urine sample. In the "low" environmental benzene area the mean ratio was 0.64 (s.d. = 0.32) and in the "high" environmental benzene area the mean ratio was 0.97 (s.d. = 0.51). the difference between the means in the two areas was statistically significant (non-parametre Mann-Whitney test  $p = 0.02$ , t test  $p < .01$ ).

## **CONCLUSION**

Donation of urine samples was acceptable to the general public in this pilot community survey. Individuals can post their own sample to the laboratory which makes population sampling cost-effective. The analytical test is rapid and inexpensive. In non-smokers, urinary PMA permits identification of groups exposed to higher than background levels of benzene in air.

10219- Study on the Exposure Level of Indoor Air PM10/PM2.5  
in The Residential Houses of Beijing

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**Objectives:** in order to study the exposure level of the indoor air PM10/PM2.5 and related confounding factors for exposure assessment in urban areas of Beijing, China. **Methods:** about 300 households from 3 residential district (Haidian, Dongcheng and Shijingshan) in urban areas of Beijing were selected randomly as our study subjects, we measured the indoor air level of PM10/PM2.5 in the bedroom and the kitchen of their households with DustTrak Aerosol Monitor (Model-8520) respectively. At the same time, we have also interviewed all household members with the questionnaire for their time-activity patterns daily and other confounding factors (smoking, type of heating in winter, cooking styles and their general health situations). **Results:** daily average concentration of PM10 were 318~694  $\mu\text{g}/\text{m}^3$  in bedrooms and 276~636  $\mu\text{g}/\text{m}^3$  in kitchens, while the concentration of PM2.5 were 277~644  $\mu\text{g}/\text{m}^3$  in bedrooms and 241~606  $\mu\text{g}/\text{m}^3$  in kitchens. The particulate concentration indoors of city center is relatively high than that of the industrial area in Beijing. **Conclusion:** there was seriously indoor air pollution of particulates in the residential areas of Beijing, and the exposure level of PM10/PM2.5 indoor air were associated with outdoor air pollution, the type of heating system of the houses in winter, smoking and cooking styles at home rather than the industrial pollution.

## 10283- A COMPARISON OF TECHNIQUES FOR MODELLING EXPOSURE TO TRAFFIC-RELATED AIR POLLUTION IN CONTRASTING URBAN ENVIRONMENTS

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Previous epidemiological studies have used a wide range of exposure measures as a basis for assessing health effects of traffic-related pollution. This makes comparison of results from different studies difficult and has contributed to the continuing uncertainties about the association between exposure to traffic pollution and health outcome. This study compares the performance of a range of commonly used exposure measures. Three types of method are compared: 1) PM<sub>10</sub> estimated using dispersion modelling techniques (ADMS-Urban), 2) NO<sub>2</sub> derived using a regression-based method (SAVIAH), and 3) a number of location- or traffic-based indicators (e.g. distance from road, traffic density). These three approaches were developed, tested, and compared in two contrasting urban environments in the UK (London, Sheffield). A GIS was developed for each study area, integrating data on monitored levels of PM<sub>10</sub> and NO<sub>2</sub>, roads and traffic flows, land use, altitude, meteorology, and population. ADMS-urban was used to model long-term average PM<sub>10</sub> concentrations at postcode delivery points within each study area (Sheffield n ~ 15,000, London n ~ 20,000). Estimates of NO<sub>2</sub> concentrations were also made for the same postcodes using the SAVIAH method. GIS techniques were used to compute measures from each of the traffic- and location-based indicators. The performance of all the techniques was compared within each study area using regression analysis and by comparing the percentage of sites classified in the same exposure quintile. In addition, the performance of ADMS and the SAVIAH method were assessed by comparing modelled results with monitored concentrations at available monitoring sites. The results show that the various methods give markedly different measures of exposure and highlight the risks of exposure misclassification in many epidemiological studies.

10313- Estimating Adequate Duration of Short-term Samples in an Experimental Room  
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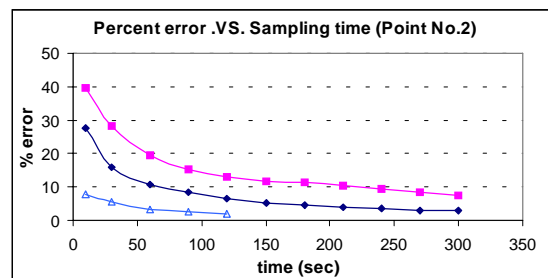
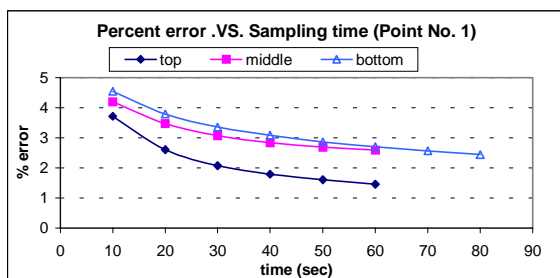
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A central issue in occupational and indoor air sampling strategies is the duration of an integrated sample needed to estimate the mean concentration. Sampling times that are too brief may result in significant errors, while those that are unnecessarily long may waste time and money. Required sampling time at a specific location depends upon concentration variability. Here we consider approaches for determining adequate sampling duration for short-term samples.

Tracer gas (propylene) was released into a ventilated room (2.86m (L) x 2.35m (H) x 2.86m (W)) from a 1-m high source at the room center. At nine room locations, gas concentrations at steady-state were measured every 2 seconds using a photoionization analyzer for 20 minutes. Concentration also was measured in the exhaust duct. Two flowrates (Re=2870 (ACH=22) and 2070 (ACH=16)) were employed, and the observed concentrations were divided by the 20-min average concentration ( $C/C_{avg}$ ) to yield the normalized concentration ( $C_N$ ). Data analysis included descriptive statistics, autocorrelation coefficients, percent error versus sampling time, and comparison of measured versus theoretical autocorrelation estimates.

The graphs below show the percent error expected to occur with a probability of less than 0.05 for each sampling time at two horizontal locations and three vertical levels. Large random variations were observed downwind of the source table (e.g, point No.2 middle) for both flowrates, requiring samples as long as 240 s and 720 s to limit the probability of 10% and 5% errors, respectively, to less than 0.05. Monitored locations upwind from the source showed much less variation at both flow rates. The sampling time 30 seconds is more than enough to obtain less than 5% error in sampling point No. 1. Autocorrelations with a lag of 2-s were estimated from these data and a modification of the Roach equation. The modified Roach estimates were all quite high (0.98-0.99) while estimates from measured values ranged from 0.27-0.89. This suggests that the modified Roach equation would overestimate required sampling time in this room with constant emission and airflow rates, perhaps because variability here resulted primarily from turbulent velocity fluctuations, not emission rate variation. The required sampling time found here probably represents a minimum for rooms with similar airflow characteristics. Of the possible sources of concentration variability common to other indoor environments, the only source here was turbulent velocity fluctuations. However, this approach may be applied in other circumstances when continuous monitoring data is available.



## **10322- Assessment of exposure to respirable crystalline silica dust in a cohort of UK industrial silica sand workers.**

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**Introduction:** In 1986, the UK Health and Safety Executive assembled a cohort of industrial silica sand workers from 7 quarries owned by a single company. The aim was to examine mortality patterns, especially from lung cancer and other respiratory diseases. This paper describes the silica measurement data that have been collected, and a method of assessing exposure for each individual cohort member. **Methods:** Personal and static respiratory crystalline silica dust (RCSD) measurements collected between 1978 and 2000 as part of a routine monitoring programme were obtained. These samples had been collected using a cyclone and membrane filter, and analysed by infrared spectrometry until 1996, and by x-ray diffraction thereafter. No samples were available before 1978. Job history information for the cohort had previously been collated. **Results:** Between 1978 and 2000, 2536 personal and 584 static dust samples were taken. These were combined for statistical analysis. The overall geometric mean RCSD concentration was  $59.1\mu\text{g}/\text{m}^3$  (GSD 5.1), with a range of less than 1 to  $18020\mu\text{g}/\text{m}^3$ . Levels fluctuated over time showing a ten-fold reduction from  $786\mu\text{g}/\text{m}^3$  in 1978 to  $79\mu\text{g}/\text{m}^3$  in 2000. The most heavily exposed job categories included silica flour workers ( $87.5\mu\text{g}/\text{m}^3$ ), dryer operators ( $67.1\mu\text{g}/\text{m}^3$ ), other dry processing operatives (including milling and screening) ( $59.7\mu\text{g}/\text{m}^3$ ), baggers ( $63.5\mu\text{g}/\text{m}^3$ ), site maintenance workers ( $41.2\mu\text{g}/\text{m}^3$ ) and laboratory technicians ( $42.6\mu\text{g}/\text{m}^3$ ). There were too few samples to estimate exposures for each combination of job (16 categories), quarry (7) and year (23). Regression models allowed us to create a job exposure matrix by combining samples into quarry (4), time period (3) and job (13) categories. The means for the 4 quarry groups were:  $21.3\mu\text{g}/\text{m}^3$ ,  $35.0\mu\text{g}/\text{m}^3$ ,  $40.9\mu\text{g}/\text{m}^3$  and  $80.6\mu\text{g}/\text{m}^3$  respectively; and for the time-periods were: 1978/85 -  $52.2\mu\text{g}/\text{m}^3$ , 1986/94 -  $24.6\mu\text{g}/\text{m}^3$ , 1995/00 -  $34.2\mu\text{g}/\text{m}^3$ . **Discussion:** Overall, exposure to RCSD in this cohort has consistently been greater than that experienced by US Industrial Sand Workers. In the US, levels have been below  $20\mu\text{g}/\text{m}^3$  since 1982. In this UK study, levels have increased slightly in recent years, although they remain below the UK maximum exposure limit of  $300\mu\text{g}/\text{m}^3$ . The most heavily exposed job categories are the same as those in the US studies. No measurement data are available before 1978, so if we were to only include those individuals in employment after 1978 the power of the study would be greatly reduced. Alternatively, existing exposure data could be used to estimate historical exposure and the robustness of the results explored by sensitivity analysis. We could test three assumptions: firstly, that exposure levels between 1950 and 1978 had not changed; secondly, a regression line derived from the existing data could be extrapolated back to 1950; and thirdly, assume the regression line is mid-way between the estimates derived from the above two methods. The impact of these assumptions on the relationship with mortality and cancer incidence will be explored.

## 10377- Time-activity modelling of domestic exposures to radon

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### **Abstract**

Radon gas occurs naturally in the environment with a variable distribution, and in some areas concentrates sufficiently within the built environment that it is considered a risk to public health. To mitigate these risks, the UK – like many other countries – has established Radon Action Levels, above which remedial action is recommended to reduce indoor concentrations. In the UK the radon action level for domestic premises is set at 200 Bq/m<sup>3</sup>, and is based on the assumption that people spend approximately 80% of their time at home, of which about 55% is spent upstairs and 40% downstairs. The actual dose received by the public in their homes, however, clearly varies according to time activity patterns, and previous surveys have suggested that some population subgroups – such as housewives and the elderly – may spend much longer indoors, and thus receive significantly higher doses than implied by the action levels. This paper presents results of using data derived from time activity surveys from a radon affected area (Northamptonshire, UK), together with radon data from a representative home, to model potential exposures for different population sub-groups (adults, children and students). Average home occupancy rates ranged from 14.8 ( $\pm$  3.7) hours for students to 17.7 hours ( $\pm$  4.6) hours for adults; schoolchildren spent an average of 14.9 ( $\pm$  1.8) hours at home. About 30% of adults, however, had home occupancy rates of 22 hours or more per day. These differences in home occupancy patterns lead to substantial differences in radon exposure. In a home with an average hourly ground floor radon concentration of 467 Bq m<sup>-3</sup>, modelled hourly average exposures ranged from ca. 250 Bq m<sup>-3</sup> for students and schoolchildren, to over 340 Bq m<sup>-3</sup> for women based at home. Modelled exposures show a non-linear association with total time spent at home, suggesting that exposure estimates based on linear models may provide misleading estimates of health risks from domestic radon and the potential benefits of radon remediation. Highest hourly exposures, approaching the average ground floor radon concentration, are likely to be experienced by people living in single-storey, ground floor accommodation (e.g. the elderly and infirm). Since these are likely to be least aware of radon risks, and least able to take up remediation measures, they should be specifically targeted for radon monitoring and for assistance in radon schemes.

## 10389- Issues in Developing a Pooled Job-Exposure Matrix for Female Employees at 12 Nuclear Weapons Facilities

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Epidemiologic studies of employed populations frequently encounter limited information on toxic exposures. Job-exposure matrices may be used to estimate potential exposures to hazardous substances. Numerous issues were encountered in an attempt to develop a job-exposure matrix of toxic exposures for a pooled cohort of 67,961 female employees from 12 nuclear weapon facilities. Records based job histories and titles, and results from a questionnaire on the history of chemical use at each study facility, were used to construct job categories with similar potential exposures. Job classes with the highest estimated exposures were machinists/mechanics (metal dusts, welding/soldering fumes, polycyclic/aromatic hydrocarbons [PAH's], solvents and noise); construction workers (asbestos, silica, wood dust, solvents, metals, welding and soldering fumes, PAH's, noise); transportation workers (gasoline and diesel fumes, asbestos, PAH's); technical operators/maintenance (PAH's, solvents, metal and wood dusts, welding and soldering fumes, noise). Clerks and administrators were considered unlikely to encounter significant potential exposures. Major issues that were encountered are: nonparticipation by 50% of the facilities, differences between study facilities in operations, job definitions, administrative and record keeping practices, long follow-up period (50 years) with changes in processes and records keeping practices, inadequate and variable industrial hygiene data, spotty records, barriers to data collection due to questions of privacy and interagency data ownership, inability to link workers to specific plant areas where exposure monitoring was sometimes completed, multiple chemical exposures that also varied with time, facility and areas within a facility. Because of these issues, attempts to estimate toxic exposures for this pooled cohort are problematic and must be subjected to validation studies before attempting to estimate exposure effects on worker health.

## **10391- The German Environmental Survey for children and teenagers (GerES IV): First results of the pilot study.**

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The German Environmental Survey (GerES) is a representative population study which has been repeatedly carried out in Germany repeatedly since the mid-1980ies. GerES IV is the first survey for children and teenagers only. It will be conducted on a random sample of 4000 children up to 17 years taken from the study population of the National Health Survey.

The parameters to be analysed in blood, urine, house dust, indoor air and tap water include neurotoxins (PCBs, Pb, Hg), carcinogenic/cocarcinogenic substances (PAHs, benzene, halocarbons), substances that cause disorders or irritation of the respiratory tract, allergies and asthma (VOC, formaldehyde, house dust mite, pet allergens), substances that may have an effect in the metabolism with potentially long-term consequences (such as DEHP). An additional part will focus on noise and stress.

A pilot study on 560 children and teenagers has been conducted to test the suitability of the different instruments intended to be used for the different age groups (recruitment, sampling procedures, questionnaires). The results of this study will show *inter alia* whether the response rate is influenced by the type of recruitment (population registration offices vs. schools), by the region (rural/urban, East/West) or by age and gender.

The preliminary evaluation of the results of the pilot study shows that:

- the response rate is lower than in earlier GerES with adults, lowest with teenagers,
- the reduced response rate goes along with the level of education and the marital status of the mother,
- children of the lower age group (3-10 years) show higher levels of lead, HCB, DDE and PCB in blood than children of the higher age group (11-17 years),
- the urine levels of mercury and cadmium are higher in the higher age group while the arsenic level is higher in the lower age group,
- children from East-Germany show a higher level of DDE in blood,
- concentrations of benzene and toluene in indoor and personal air are relatively low compared to earlier GerES, the concentrations of formaldehyde have only decreased slightly.

10436- The Significance of Interpopulation Variability to Exposure Estimation  
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Recently, the European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) published a sourcebook of exposure factors data for European populations. The significance of interpopulation variability in exposure factors is illustrated through several examples comparing exposure estimates calculated using data provided in the ECETOC sourcebook and other available exposure factors references (e.g. AIHC Exposure Factors Sourcebook, USEPA Exposure Factors Handbook). This analysis found that factors which are the least well characterized for interpopulation variability (i.e., time-activity data and food ingestion rates) had the greatest impact on assessment results. The analysis also demonstrated that typical default values resulted in conservative exposure estimates for all of the populations considered. Point estimates calculated using typical default values fell above or within the upper range of probabilistic results, with the exception of a probabilistic analysis in which distributional data based upon short-term fish ingestion rates of fish consumers were used to represent long-term consumption. Using multiple distributional inputs for probabilistic analyses extended the tail size (i.e. upper bound) of the probabilistic results. Overall, these results confirmed the value of following good exposure assessment principles, including: a) understanding the significance/basis of default assumptions, b) considering the relevance of estimation inputs to the target population or exposure scenario, and c) keeping correlated factors coupled when performing probabilistic analyses.

10464- Monitoring of Motorcyclist Exposure to Volatile Organic Compounds in  
Kaohsiung , Taiwan

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**Abstract**

With a motorcycle density around 280 per square kilometer, the potential health risk caused by the toxicants emitted from motor vehicles is one of the major concerns for motorcyclist population in Taiwan. Due to the traffic jam and inefficient ventilation in some city tunnels, the motorcyclist exposed higher VOCs levels while commuting in Kaoshiung metropolitan area in Southern Taiwan. The purposes of this study were to monitor the motorcyclist exposure to VOCs in the air of Kaoshiung metropolitan area and to estimate the potential human health risk. The first part of the study was conducted in Chi-Chin tunnel, which is the longest tunnel in Kaoshiung. The characteristics of some VOCs (benzene, toluene, ethyl benzene, and xylene) emissions in the tunnel were fully investigated, and the probability distributions of daily doses and health risk of motorcycle riders were estimated using Monte Carlo analyses. For non-carcinogenic air toxicants (toluene, ethyl benzene, and xylene), the intake through inhalation for a motorcycle rider (10 min/days, 50 years) will not cause significant health problem. However, for carcinogenic air toxicants like benzene, the intake amount through inhalation and the individual lifetime cancer risk were estimated as 3.7  $\mu\text{g}/\text{Kg}\cdot\text{day}$  and  $4.1\times 10^{-5}$ , respectively. The second part of the study was to measure the VOCs levels of riders' breathing zones in some major roads and intersections of Kaoshiung. Results showed that motorcyclists were exposed to the higher VOCs levels during intersection waiting periods. The highest VOCs inhaled rates were found while riders were waiting for green lights during rush hours on weekdays. The results of this study show that the chronic exposure to ambient VOCs may cause a serious health risk to motorcyclists in Kaoshiung.

## **10496- Assessment of pesticide exposure in vineyard workers**

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Epidemiological studies on chronic effects of pesticides are limited by difficulties in assessing individual exposure over long-term periods. The aim of our project is to develop an index for estimating individual long-term exposure to pesticides in vineyards workers. As no adequate data is available on exposure during mixing or application in vineyards, the first step consists in field studies to identify the main parameters related to external contamination of workers under usual conditions of use.

We present here the pilot study which was carried out in nine vine-growers in the Bordeaux area between April and August 2001. They were chosen to represent main agricultural techniques and conditions in vineyards (standard and straddling tractors with or without a cab, small and large tanks, high and low vines,...). Dithiocarbamates were chosen as an exposure marker, as they have been widely used in vineyards for over 40 years and the measurement of their common metabolites (CS<sub>2</sub> and ETU) is feasible. During the whole treatment days, we monitored dermal exposure and performed ergonomic observations of tasks and treatment conditions during mixing, spraying, and equipment cleaning. Dermal exposure assessment relied on the patch method (beneath clothing) and hand-washing, following OECD guidelines. The dithiocarbamates contained in patches and hand-wash water were transformed in CS<sub>2</sub> under acidic conditions. CS<sub>2</sub>, whether as a metabolite or as a degradation product of dithiocarbamates was determined by headspace gas chromatography-mass spectrometry, separately for each phase of treatment (mixing, application and cleaning), and for each area of the body (head, back, chest, each forearm, each upper arm, each thigh and each lower leg). Ergonomic observations provided detailed information on the types of equipment, amounts of pesticides used, duration of tasks, sprayed acreage, meteorological conditions, clothing and use of personal protective devices. In the same workers, we collected urine samples from the beginning of treatment to the second day after (H+0, H+4, H+12, H+24, H+48) and determined CS<sub>2</sub> as mentioned above and ETU by another gas chromatography-mass spectrometry technique.

Daily dermal contamination of CS<sub>2</sub> for the 9 vine-worker ranged from 0.02 mg to 13.7 mg. Proportion of the dose related to mixing ranged from 11% to 68%, and the proportion related

to application ranged from 29% to 77 %. Hands corresponded up to 72% of the dose and the head up to 45%. Preliminary correlation between total amount of the active compound (external contamination) and treatment characteristics will be shown. Results will be compared with those obtained from a model used for pesticide registration (UK POEM). ETU levels in urine increased until the 24th hour , and reached 80 µg/liter in one worker . As the pilot study proved its feasibility and provided useful data, a larger study on 30 farmers is planned for 2002 following the same protocol.

10497- Exposure Assessment for Consumer Products: A Complete Set Of Models.  
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### Introduction

Exposure to chemical compounds in consumer products is hard to assess due to the large diversity in products and product uses. Measured data are hardly available. In order to facilitate the exposure assessment to chemical compounds in consumer products, classification of consumer products with respect to their use and exposure characteristics is attempted. For each of these product classes mathematical models are developed that can be used to estimate exposure for products in that class, taking into account the use of the product. Secondly, a database with data that characterise the use pattern of these product classes is compiled. These data serve as input for the corresponding exposure model.

### Methods

For all product classes both simple, first order screening models and complex mechanistic models are developed. Where feasible, models are provided in analytical form. Otherwise numerical solutions are given. Probabilistic approaches are supported by the implementation of Monte Carlo simulation techniques. All developed models have been implemented in a computer program (CONSEXPO). The default data on product use patterns are gathered from published literature, industry, expert judgement and occasionally by direct experiment. In choosing values from statistical data 'reasonable worstcase' assumptions are made, which means that 75 percentile values have been chosen, when enough data was present.

### Results

The mathematical models developed cover a wide range of product applications. In the exposure assessments a distinction is made between inhalatory, dermal and oral routes of exposure. The models calculate not only external exposures, but internal (systemic) doses as well by modelling the uptake through the boundary of the body. Exposure estimates result in point values corresponding to different toxicological limits such as maximum event concentrations, mean event concentrations and chronic exposure. But beside point evaluations, the models support probabilistic approaches. So far, complete classifications of the product groups paint, pest control products, children's toys and cosmetics have been done, including the development of the mathematical models that describe each class, and the appropriate default data for products in the classes. Currently, classification of cleansing agents is underway.

### Conclusion

The exposure models implemented in CONSEXPO, together with the database of default data, provide an answer to the diversity of exposure from chemical compounds in consumer products. The exposure assessment thus obtained can be used as a starting point for a more realistic risk assessment. The developed models can easily be extended to incorporate exposure for similar products in occupational use situations (for instance: paint used by professional painters, hairspray used by hairdressers).

10507- Development of a Sensitive Diffusion Sampler for the Measurement and Assessment of Personal Exposure to PAHs in Air

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A sensitive passive diffusion sampler will be developed for the measurement and assessment of personal exposure to polycyclic aromatic hydrocarbons (PAHs) and other volatile and semi-volatile carcinogenic organics in air in community and residential situations. The passive sampler consists of a denuder, which is made from one or more 0.5-cm sections of a multi-capillary gas chromatography (GC) column (900 of 40- $\mu$ m internal diameter). Due to the high value of diffusive area (inner cylindrical surface) to diffusive path length (the radius of the each column), the sampling rate will be about 100 times higher than the traditional badge or tube-type diffusive samplers. The denuder-type geometry would allow constant sampling rates in a wide range of sampling conditions. Also, the stationary phase of the capillary column allows directly thermal desorption of analytes to GC/FID or GC/MS, which avoids dilution of the sample by solvent and increase the sensitivity by a factor of 100. The sampler can be used repeatedly without any regeneration process. The sampling rate of the passive sampler under different sampling conditions, including different air concentration, sampling duration, temperature, humidity, and face velocity, will be tested, and the performance of the sampler in side-by-side comparisons with proven active sampling method will be reported.

## **10588- AN INTEGRATED AIR SAMPLING SYSTEM FOR FIELD USE**

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**OBJECTIVES:** Many occupational and environmental field studies require multiple systems, each of which performs simultaneous measurements on several different types of filters or other media plus real-time monitoring of environmental variables. Installing and removing filters, charging or changing batteries, and downloading data from data-loggers are time-consuming procedures and limit the number of sampling systems that a small field crew can manage. We have developed a low-cost integrated "Harvard Sampling Box" that dramatically reduces the time in the field to replace filters and batteries for a complex sampler system. **METHODS:** As part of the Trucking Industry Particle Study, an extensive nation-wide study of the US trucking industry, we are using the Sampling Box to collect size selective gravimetric and elemental carbon/organic carbon (EC/OC) filter samples, along with temperature, relative humidity, and carbon dioxide measurements. The Harvard Sampling Box consists of a single impact resistant plastic box (11"×7"×5") containing the instruments, a front panel displaying the status of the pumps, a side panel with jacks for power supplies, data logging, and control of the pumps. The cyclones and filter cassettes for PM<sub>2.5</sub> and PM<sub>1</sub> are mounted on the outside of the box. There is a separate battery pack providing power for instruments at 6 and 24 volts. Filters are mounted in plastic cassettes in the laboratory before being moved to the field. Each filter has its own pump with an automatic flow controller within the box. Cyclones are used for particle cut-points instead of impactors because they require less maintenance in the field. Data is downloaded to a laptop at the end of each sampling session. A simple set of software was used to cue the field technician and record observations in a spreadsheet that also received the downloaded real-time data.

**RESULTS:** It takes less than ten minutes to exchange filters, exchange battery packs, and download the real-time data. This is done once every twelve hours. Over the course of a week of sampling, the Harvard Sampling Box was mounted in a fixed sampling location, with the only maintenance being replacement of filter cassettes and battery packs, and downloading the real-time data once a session. Sampling Boxes were also mounted in the cabs of trucks and on forklifts to monitor operator personal exposures.

**CONCLUSION:** The Harvard Sampling Box provides an inexpensive, quick and easy to use, physically sturdy method for integrating multiple measurements for field studies. The cuing software minimized operator errors and sample mishandling. Because of its ease of use, a single field technician could attend the operation of 6 to 10 Sampling Boxes within reasonable geographic proximity on a round the clock sampling schedule. Other configurations of the unit can be readily prepared as needed for other types of monitoring.

## 10604- Retrospective Noise Exposure Estimates Using an Alternative Approach

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### Background.

As part of a case referent study of the effects of occupational noise exposure on cardiovascular mortality, a team of occupational hygienists assessed available data for the retrospective estimation and validation of noise exposure.

### Methods

Cases (of death from myocardial infarction) and age matched surviving referents were drawn from all male industrial workers employed at two facilities in the North West of England between 1945 and 1999 (N = 2412). Information on the workers and their employment with the company was obtained from personnel files, records of routine periodic medical examinations at work and radiation dosimetry records. Data on noise exposure were available from 6850 sound pressure measurements collected since 1965. Information on changes in process and use of hearing protection was obtained from interviews with retired and long-term company personnel.

The nature of the data and the physical properties of noise indicated a method that differed from most other retrospective assessments. Hygienists first estimated average area noise levels (AANLs) for each workplace where samples had been collected, estimated noise exposure contours in the vicinity of noise sources, and then adjusted estimates based on job title. In all more than 50,000 unique combinations of worker, job title, location and year were assessed. For subsequent use in the case referent analysis, work histories were used to calculate exposure indices of cumulative, average intensity and exposure duration over 90 dBA. These indices were validated against hearing loss in a sub-population with contemporary audiometric measurements carried out periodically within the company occupational health department.

### Results

Noise exposure estimates ranged from 60 to 97 dBA, with a median of 86 dBA. Cumulative noise exposure, estimated blind to case and hearing status, was associated with changes in audiometry.

### Conclusion

An approach using estimates of area noise, then adjusting for job title, produced exposure indices with some validity when used to predict a known health effect. This result will give credibility to any later finding of increased cardiovascular mortality.

10637- Infant mortality, stomach cancer, and stroke mortality: Ecological analysis for 47 prefectures in Japan

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**Background and objective:** Infant mortality rates are widely used as an index of past living conditions. Leon and Davey Smith have demonstrated an interesting association between mortality rates from stomach cancer and stroke in the elderly and the infant mortality rate prevailing at the time of the subjects' birth. This was based on national statistics from 27 countries, including Japan. In Japan, health statistics have been recorded separately for each of 47 prefectures since 1935. It was therefore of interest to find out whether the association of stomach cancer and stroke mortality with past infant mortality holds good also within Japan, by means of an analysis of data from the 47 individual prefectures.

**Methods:** Data for each prefecture for infant mortality in 1935, and for mortality from stomach cancer (ICD-9: 29), stroke (ICD-9: 430-438) and other causes in people aged 60-84 years in 1995, were obtained from national vital statistics reports. The age range for the elderly in 1995 was extended to include people born in the 25 years before 1935, in order to provide sufficient deaths in the prefectures with small populations. Age-adjusted mortality rates were calculated using direct standard methods, and the world population was used as the standard. Pearson and partial linear correlation methods were used to examine the associations. To control for the possible confounding effects of current circumstances, and also to compare the results with Leon and Davey Smith's paper, infant mortality in 1995 was examined also.

**Results:** Significant positive associations were found between 1935 infant mortality and 1995 stomach cancer and stroke mortality for men and women aged 60-84. After adjustment for the 1995 infant mortality rates, the associations remained significant (partial correlation coefficients: 0.47 and 0.45 for stomach cancer; and 0.35 and 0.36 for stroke in men and women). No such association was found between the 1995 infant mortality rates and the 1995 mortality from stomach cancer and stroke. Ischaemic heart disease showed no significant association with either the 1935 or 1995 infant mortality rate. In women, a significant negative association between infant mortality in 1935 and subsequent lung cancer was found ( $p < 0.05$ ).

**Conclusion:** These results from Japan's 47 prefectures are consistent with Leon and Davey Smith's findings on the relationship of stomach cancer and stroke mortality to earlier infant mortality, thus providing evidence of the associations in one ethnic population (e.g. the Japanese). This is presumptive evidence of the robustness of the associations. This adds that circumstances in early life need to be taken into consideration in understanding the mechanisms of stomach and stroke.

**10639- INFLUENCE OF OUTDOOR SOURCES ON INDOOR AND PERSONAL FINE PARTICLE CONCENTRATIONS: ANALYSES OF RIOPA DATA**

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“Relationship of Indoor, Outdoor and Personal Air” (RIOPA) was designed to study indoor, outdoor and personal exposures to several air pollutants: VOCs, aldehydes and PM<sub>2.5</sub>. Sampling sites covered a range of geographical locations, climate conditions, seasons, building constructions, local ambient sources, and ventilation practices. Samples were collected from summer, 1999 to spring, 2001 in Houston (TX), Los Angeles (CA), and Elizabeth (NJ). Indoor, outdoor and personal PM<sub>2.5</sub> samples were collected in 212 non-smoking residences and 162 of these residences were sampled twice. Some homes were chosen due to close proximity to ambient sources of one or more target analytes, while others were farther from sources. All PM<sub>2.5</sub> samples were analyzed for mass and functional groups. Selected samples were also analyzed for trace elements, organic and elemental carbon, and PAHs. VOC and aldehyde concentrations, air exchange rate, questionnaires and time-activity information were also collected. Median indoor, outdoor and personal PM<sub>2.5</sub> mass concentrations are 14 µg/m<sup>3</sup>, 14 µg/m<sup>3</sup>, and 31 µg/m<sup>3</sup> respectively. PM<sub>2.5</sub> mass concentrations are lognormally distributed, and personal concentrations are significantly greater than indoor and outdoor concentrations with 95% confidence limits according to a one-way ANOVA on the logtransformed data. No significant difference was found between indoor and outdoor concentrations. Homes were segregated based on proximity to identified primary PM<sub>2.5</sub> sources (such as motor vehicle and other combustion sources) and possible PM<sub>2.5</sub> sources (such construction, gas station, refinery, bakery and restaurant, industry, and commercial). The impact of proximity to primary PM<sub>2.5</sub> sources on PM<sub>2.5</sub> concentrations at the study homes was examined for homes closer and farther than 200 ft and closer and farther than 0.5 miles from identified and possible sources. PM<sub>2.5</sub> concentrations outside homes in close proximity to primary PM<sub>2.5</sub> sources were not significantly different than concentrations outside homes far from identified primary PM<sub>2.5</sub> sources (ANOVA with  $\alpha=0.05$ ). The contributions of outdoor and indoor sources to indoor concentrations were examined using 1) a single compartment box model with measured air exchange rate, 2) a random component superposition (RCS) model, and 3) sulfate as a tracer for outdoor air. The outdoor contribution to indoor PM<sub>2.5</sub> is estimated to be 59% and 50% of the indoor PM<sub>2.5</sub> concentration for the overall study based on the box model and RCS model, respectively (65% and 56% for CA homes, 70% and 50% for NJ homes and 40% and 44% for TX homes). The distribution of outdoor contributions across study homes agreed well for these two approaches.

### **10677- Dietary exposure to ochratoxin A in the Netherlands.**

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Ochratoxin A (OTA), a mycotoxin produced by fungi, can cause an irreversible and fatal kidney disease in humans. OTA is predominantly found in cereals and cereal products, but also in raisins, grape juice, wine, coffee, cocoa and in some pulses and nuts, mainly as a result of poor storage of the commodities. As OTA is very persistent, products such as meat and dairy have been found to contain this contaminant as well. In the present study the human dietary intake of OTA in the Netherlands is assessed by combining data on concentrations in different food products and the consumption rate of these products. The Dutch Inspectorate for Health Protection and Veterinary Public Health provided data on OTA concentrations in grain, coffee, wine, nuts and spices. The Dutch data were combined with data from other countries for white wine, cocoa and nuts, rye, meat, milk and beer reported by the FAO/WHO, the EU and the Dutch State Institute for Quality Control of Agricultural Products. The consumption rate of the products containing OTA was examined with the Dutch National Food Consumption Survey (DNFCS), which describes the consumption pattern of the Dutch population in 1998 and includes information on the daily consumption over two consecutive days and a record of age, sex and body weight of 6250 individuals. Combining the concentration and consumption data results in two daily OTA intakes of all individuals included in the survey. It appears that more than half of the intake of OTA occurs via the consumption of cereals. Together with coffee, red wine and meat, 80% of the total intake of OTA is covered, while milk and beer add another 9%. The total geometric average intake calculated in this manner is 59 ng/day (0.9 ng/kg body weight/day). This is somewhat higher than that of 45 ng/day found in an earlier study in the Netherlands, which is due to higher concentrations in meat, nuts and cocoa used in the present calculation. The geometric mean of 51 ng/day (0.7 ng/kg body weight/day), measured in a duplicate diet study performed at our institute, agrees well with the value determined in the present study. To distinguish the variation between individuals from the daily fluctuations in consumption, we used the Statistical Exposure Model STEM, which is developed at our institute, and estimates the mean dietary intake as a function of age. It combines regression analysis on age by fitting an appropriate curve to the data with a nested analysis of variance. Analysing the data with STEM shows that the relative intake per age class is between 0.5 and 2 ng/kg body weight/day and decreases with age. The maximum value for the 99<sup>th</sup> percentile (age 1 year) is 5.5 ng/kg body weight/day, which is still lower than the provisional TDI (100 ng/kg body weight/week or 14 ng/kg body weight/day).

10733- Does the investigation of mother-child pairs improve the assessment of environmental exposure in epidemiological studies?

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An ideal approach for exposure assessment would be the comparison of groups which are exposed homogeneously, but at different levels. Under several aspects of exposure, mother-child pairs are such homogeneously exposed groups. In a cross-sectional study, we investigated health indicators (diagnoses, biomarkers) on mother-child pairs to analyse their association with environmental exposure. In four areas (three of them in highly industrialised cities, one in a small rural town) with different air pollution burdens, 870 mother-child pairs who were roughly equally distributed over the four areas participated with a response rate of about 60% in our study in 2000. Mean ages of mothers and children were  $34.9 \pm 5.3$  y and  $6.4 \pm 0.4$  y, respectively. The data set contains diagnoses and symptoms (questionnaire self-assessed by the mother), biomarkers of the functional status of the immune system (blood samples and skin tests) and of exposure to xenobiotics (blood and urine samples). In a multivariate statistical analysis of these health indicators as dependent variables, we considered as independent variables the area indicating environmental exposure and the educational level as lifestyle indicator. We compared the results of child-only analyses with those of mother-child-pair analyses. A strong correlation between mother and child would indicate either a common environmental exposure factor or a hereditary predisposition or a mixture of both. Additionally for self-assessed variables, one has to take into account a classification bias toward a positive correlation between mother and child. For all kinds of health variables (infectious and allergic respiratory diagnoses and symptoms, atopic skin symptoms and diagnoses, allergic sensitisation, immunological status, biomarkers of xenobiotics), we saw significant correlation between child and mother, e.g. bronchitis and eczema ever diagnosed by a physician with odds ratios of 4.9 and 6.1, respectively, IGG in serum and Ni in urine with  $r=0.32$  and  $r=0.25$ , respectively. The associations between mother and child were persistent after adjusting for area and educational level. Also on the other hand, the area persisted as significant determinant of the child's health variables after adjusting for mother-child association, but with two interesting exceptions, i.e. eczema and neurodermitis ever diagnosed. For most of the xenobiotic biomarkers, the mother-child association still explained between 20 and 60 percent of the residual variance after adjusting for area and educational level in mixed model analysis of variance. Since predisposition and misclassification by self-assessment can be excluded, we interpret this persistency as indication of local and household-specific exposure (e.g. hot spots, nutrition) in contrast to the general exposure in the area of investigation. The study of mother-child pairs offers additional information which helps to assess environmental exposure, especially for exposure to xenobiotics.

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10734- Potential exposure to isoproturon in open field farming in France

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Concerns about human long term pesticide toxicity arose following the dramatic increase in the amount and the widespread use of pesticides. Despite many epidemiological studies having been conducted, it is necessary to validate relevant parameters usable in epidemiological studies to provide accurate quantitative assessment of pesticide exposure. An exposure study on the herbicide isoproturon is currently being conducted with measurement of external contamination according to OECD recommendations. To measure potential dermal exposure, the whole body plus cotton cap plus cotton gloves method was used. Mixing-loading and application tasks were evaluated separately with detection of isoproturon in 13 different body locations : forearm, arm, leg and thigh left and right sides separately, back and stomach and hands with cotton gloves (left and right separately) and cap. Overall, at least 26 measurements were taken for each farmer. Validation of the analytical method was realized and lead to a quantification limit of 1 µg per body location. Each item of clothing was rinsed twice with water (2 liters then 1 liter), a sample of 50 ml from the 3 liter of water was extracted on a C18 column, eluted with a methanol/acetonitrile mixture (V/V). The method used for the detection of isoproturon was a HPLC-diode array detector.

For the pilot study conducted during the winter of 2001 on 9 farmers, the mean area sprayed with isoproturon for the study was 36 ha (range : 16 to 58). The mean total quantity of isoproturon used was 31.5 kg (range : 12.5 to 49). The average isoproturon deposited on clothing was 97 mg (range : 2 to 356) corresponding to an average 47 mg/hour of spraying, (range : 0.9 to 178). The proportion received during mixing-loading tasks ranged from 23% to 97%. For mixing-loading tasks, mean proportion of isoproturon detected on hands, trunk, legs+thighs and arm+forearm was 65%, 5%, 16% and 14%, respectively. For application, mean proportion for the same body locations was 64%, 11%, 12% and 13%. High interindividual variability was observed for the repartition between body areas. Preliminary results on correlation between deposited quantity of isoproturon and pesticide exposure related-parameters are interesting. No correlation was observed between area sprayed or duration of spraying and the total quantity of isoproturon or tthe quantity deposited during application. However, the number of spraying tanks prepared was slightly correlated with the total quantity of isoproturon ( $r^2=0.24$ ,  $p=0.22$ ) and significantly with the quantity received during mixing-loading tasks ( $p=0.001$ ,  $r^2=0.81$ ).

A second part of the survey is on-going and will include at least 30 additional farmers before the end of March 2002. To date, 22 farmers are included and results concerning data from the two parts of the survey will be presented.

10741- AN EVALUATION OF POTENTIAL HUMAN EXPOSURES TO TRACE METALS AND RADIONUCLIDES IN CONSTRUCTION AND BUILDING MATERIALS CONTAINING COAL COMBUSTION PRODUCTS. Christopher M. Long and Barbara D. Beck, Gradient Corporation, Cambridge, Massachusetts, U.S.A.

Nationwide more than 30 percent (approximately 33 million tons) of the total coal combustion products (CCPs) generated each year are recycled in a variety of beneficial uses. CCPs such as fly ash, bottom ash/slag, and flue gas desulfurization (FGD) materials can improve the quality and performance of a variety of construction and building materials including cement and concrete, structural and flowable fills, road base and subbase, roofing materials, and wallboard. The U.S. EPA made a strong endorsement of CCP beneficial uses in its 1999 Regulatory Determination on Wastes from the Combustion of Fossil Fuels based upon a general evaluation of potential environmental impacts. In this evaluation, a risk assessment framework was used to conduct a more detailed and use-specific assessment of potential human exposures to trace metals and radionuclides that are naturally found in coal and that may be present in construction and building materials containing CCPs. Due to their higher exposure potentials, two primary exposure pathways were considered in this evaluation: (1) leaching of metals from construction applications and migration to groundwater and surface water supplies, and (2) emissions of mercury and radionuclides from building materials into indoor air. Potential exposures were assessed using several types of information: (1) available case-study reports and leaching data for CCPs in construction and building materials, (2) product assessments which consider the impact of manufacturing and final uses on CCP characteristics and metal speciation and mobility, (3) comparisons with traditional construction and building materials, and (4) screening-level indoor air modeling calculations. We evaluated both laboratory and field leaching data which indicate that potential leaching impacts for beneficial use products such as concrete, cement, and other construction fills are limited by several factors, including low permeabilities, coal ash characteristics (*e.g.*, metal speciation, alkalinity, self-cementing properties), and the encapsulation of coal ash and its constituents in a final product. Airborne emissions of radionuclides from CCPs in common building materials are low based on data indicating that radionuclide activity concentrations of CCPs are within ranges observed for traditional building materials such as concrete and red brick. In addition, due to reduced radon exhalation rates, releases of radon gas are potentially lower for CCP building materials than for conventional materials. Conservative screening-level calculations demonstrate that volatilization of mercury in FGD materials used as synthetic gypsum in wallboard is unlikely to be a significant exposure pathway in indoor environments. An average daily indoor mercury exposure concentration of approximately  $0.09 \text{ ng/m}^3$ —over three orders of magnitude lower than the EPA Reference Concentration (RfC) of  $300 \text{ ng/m}^3$ —was estimated for a small room constructed from wallboard containing synthetic FGD-gypsum. The results of these analyses thus demonstrate that, when used properly, CCPs in a variety of construction and building materials are unlikely to result in significant environmental exposures.

## 10797- Using Geostatistics to Assess Atrazine Exposure in a Population-Based Case Control Study of Breast Cancer

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Accurate exposure assessment is crucial in epidemiologic studies. Individual exposure assessment through biomonitoring is impractical in large population-based studies of rare diseases due to expense, burden on study participants, and the relevant exposure may be long past. Indirect exposure estimation techniques based on publicly available datasets are a practical alternative for assigning exposure levels to study participants, and they may provide a historical assessment that is particularly germane to studies of cancer. We modeled the spatial variability of atrazine concentration using a publicly available dataset of agricultural chemical contamination (years 1982-2000) in private well water in Wisconsin (19226 wells) compiled by the Wisconsin Department of Agriculture, Trade and Consumer Protection using indicator kriging. First, we modeled the spatial correlation amongst the indicator variables using exponential and spherical semivariograms. The spherical model was preferred and indicated modest spatial dependence in atrazine levels. Nonparametric estimates of the probability of atrazine concentration were obtained using standard kriging techniques based on the estimated semivariogram model. Probability contours for atrazine levels were constructed based on these estimates and plotted. These plots provide information about the spatial distribution of atrazine and provide an indirect assessment of atrazine exposure associated with residency in a particular area along with measures of uncertainty in the estimates. We then assigned atrazine exposure levels based on the indicator kriging results to participants in a population based breast cancer case control study in Wisconsin based on the location of their residence. More specifically, we geocoded residences (95% matched successfully) of the 14,808 breast cancer cases and controls. This point map of study participants' locations was overlaid on the contour plot to assign individual level exposure to atrazine. Further analysis will compare exposure levels to atrazine among breast cancer cases and controls. Procedures similar to the one outlined here could be used with other publicly available databases to assign environmental exposures levels.

10801- Personal exposure of patients with COPD or chronic asthma to ultrafine particles

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Recently studies suggest that ultrafine particles (<100nm) may be responsible for the observed adverse health effects from particulate air pollution. Only a few studies have investigated the relationship between exposure to ambient ultrafine particle number concentrations and health effects and so far there are no studies that have examined potential associations for personal exposure to ultrafine particle numbers. We developed a model to estimate personal exposure to ultrafine particle numbers and have investigated the relationship with health effects in patients with chronic lung disease.

To develop the model, particle number measurements were made with a TSI PTrak in different microenvironments and during different activities. Total personal exposure over 24 hours was defined as being the sum of an individual's exposures in different micro-environments and the exposures during different activities.

Forty five current non-smokers with chronic lung disease were studied for 8 weeks between October 2000 and March 2001. Each kept a daily diary of activities, whereabouts, symptoms and peak flow rates. The information from the activity diaries was used to estimate the daily personal exposure of the patients. During the study city centre measurements were continuously made of particle numbers (using a Scanning Mobility Particle Sizing system), PM<sub>2.5</sub> (DustTrak), PM<sub>10</sub> (TEOM), temperature, humidity and windspeed.

In the univariate analyses there was a significant association found between daily mean and 95<sup>th</sup> percentile ambient ultrafine particle concentration and peak flow rate on the next morning ( $p = 0.02$  and  $0.01$  for mean and 95<sup>th</sup> percentile, respectively). Higher daily ambient particle concentrations on the previous day were associated with lower peak flow rate on the following morning. After adjusting for weather and bronchodilator use the 95<sup>th</sup> percentile daily concentration stayed statistically significant ( $p=0.04$ ). There was no association found between any other particle metric (PM<sub>2.5</sub> and PM<sub>10</sub>) and peak flow rates. After adjusting for the weather variables and bronchodilator use there was only a statistically significant association between shortness of breath during the day and ultrafine particle number concentration ( $p=0.05$ ), although the association was found to be in the opposite direction to that expected.

Preliminary analyses show no association between peak flow rates and the personal exposure to ultrafine particle number concentration.

The paper will present a comparable analysis of lung function and symptoms data for personal exposure estimates to ultrafine particle number concentration and other particle measurement metrics. We will also discuss which metric (mass or number) might be more relevant to health effects and whether indoor or outdoor generated particles might be more important in causing effects on health.

# 10841- THE USE OF LIGHT SCATTERING DATA TO ESTIMATE THE CONTRIBUTION OF INDOOR- AND OUTDOOR-GENERATED PARTICLES TO INDOOR AND PERSONAL AIR

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Many epidemiologic studies have shown an association between adverse health effects and particulate concentrations measured at centrally located sites. Other studies have been conducted to examine relationships between personal exposures and central site measurements. Few studies quantify the contribution of indoor and outdoor sources to personal exposures, as particles in these two environments differ in sources and composition, and exhibit temporal and between-residence variability. This study is a subset of a larger exposure assessment study conducted between October 99 and May 01. Subjects were recruited throughout the metropolitan Seattle area, including 67 elderly and 18 pediatric asthmatics. Particle mass and light scattering were monitored on 19 subjects using the Thermo-MIE personal DataRAM, and at 85 residences, including 42 apartments or group homes and 43 private homes, using the Radiance Research nephelometer. This paper uses a censoring technique to identify and remove indoor sources from the continuous light scattering measurements. The censoring technique removes peaks where there is a sharp increase in indoor concentration but no such increase in outdoor concentration. We then apply a recursive mass balance model to the censored time series data to estimate the contribution of indoor- and outdoor-generated particles to indoor air and to personal air. The real-time personal exposure measurements are combined with the real-time indoor and outdoor particle measurements, time-activity-location information, potential particle events, and home ventilation logs to determine the contributions from various indoor and outdoor particle sources to total personal PM exposure. The mean personal exposure for pediatric subjects is  $16.8 \pm 26.1 \mu\text{g}/\text{m}^3$ , while for the adult subjects the mean of all personal exposures is  $12.7 \pm 11.7 \mu\text{g}/\text{m}^3$ . The particle infiltration efficiency estimated by the recursive model is  $0.53 \pm 0.25$  (Mean $\pm$ SD) and differs significantly across dwelling types and by season. Despite having higher outdoor particle concentrations and spending more time outdoors, the pediatric subjects, as compared to elderly subjects, have no higher exposure to ambient particles. This is due to the fact that the average infiltration efficiency is lower for the pediatric residences ( $0.40 \pm 0.16$ ) than for adult residences ( $0.57 \pm 0.25$ ; ANOVA  $p < 0.05$ ), demonstrating the influence of building characteristics on exposure to particles of ambient origin.

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10855- Retrospective assessment of exposure to automobile air pollution in epidemiological studies.

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Epidemiological studies dealing with long-term health effects of traffic pollutants require to estimate accurately individual exposures to these pollutants. This exposure assessment is usually based on background air pollution levels measured by air quality networks. A French validated model (ExTra) was developed to evaluate concentrations of pollutants generated by motor vehicles in front of living or working places in urban settings.

The aim of this study is to estimate :

(i) by applying the ExTra model the lifelong concentrations to a transport-related pollutant, nitrogen oxides (NO<sub>x</sub>), 403 children included in a multicentric case-control study were exposed to,

(ii) the concentrations due to local traffic,

(iii) in which cases using the ExTra model is better than only using background air pollution levels and enables to avoid exposure misclassification,

For each residence and school attended by the children, ExTra calculates NO<sub>x</sub> concentrations by adding to the background pollution a local component modelled according to traffic conditions, topography, and wind direction and strength. These data, combined with time-activity diaries enable children life-long cumulative exposure to be assessed. A discriminant analysis with regression trees was performed to identify lifelong topographic and traffic characteristics predictive of the local traffic.

On average, ExTra estimates that children lifelong outdoor NO<sub>x</sub> concentrations was 74 [± 49] µg.m<sup>-3</sup> equivalent NO<sub>2</sub>. With reference to background air pollution level, concentration due to local traffic is on average 29.5 ± 44% (median = 13.5 %). These concentrations can be predicted from a few lifelong topographic and traffic characteristics of homes and schools, mainly traffic density and distance to the nearest street.

These characteristics are used to propose in which cases the assessment of transport-related pollution concentrations can be based upon data from air quality networks and in which cases it is necessary to use the ExTra model to avoid exposure misclassification.

## 10876- Urinary Creatinine Measurements Minimize Relative Differences Of Organophosphate Insecticide Exposures Of Children And Adults

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Urine of children and adults is the most important route of excretion of pesticide biomarkers of short-lived chemicals ( $t_{1/2} < 48$  h) such as organophosphate insecticides. Since the disposition of dialkyl phosphate and the most electronegative leaving group is well described, absorbed daily dosage (ADD; ug equivalents/kg-day) can be estimated from urine excretion data. Complete 24-hour urine specimens are less frequently available than convenience voids or spot samples for exposure assessment. In those cases a creatinine adjustment (g/L) of urine volume may be useful to estimate ADD.

Creatinine was first used for this purpose in 1952 and the subject has been reviewed and limitations discussed by Boeniger et al., 1993. Biomarker data are commonly expressed as ug biomarker/g creatinine. When factored by urine volume and referenced to published norms of 1.7 g creatinine/day for males and 1.0 g creatinine/day for females (ICRP, 1994), daily biomarker excretion can be estimated. Children have a much smaller daily creatinine excretion rate due to their smaller muscle mass. It has been estimated that creatinine excretion increases at a rate of 0.08 g/year of age to about age 12 (Krieger et al., 2001). This relationship is consistent with recent creatinine measurements made during residential pesticide monitoring studies of families in California and Missouri.

Chlorpyrifos exposures have been measured in adults and their children (3 only under 9 years of age). Adult exposures ranged from 0.1-1.7 ug CP equivalents/kg bw-day and those of the children ranged 1.4-5.3 ug CP equivalents/kg bw-day. Persons that protected their pets from fleas excreted creatinine-corrected biomarker at above background rates, but the relative differences were minimal relative to toxic levels for both children and their parents. Studies that do not take the small muscle mass of children into account when exposures are compared to those of adults, i.e. the exposure of a 5-year-old child (0.08 g creatinine/day-year x 5 years = 0.4 g) is inflated 2.5x if referenced to a 1.0 g creatinine/day excretion rate. The impact of a creatinine correction for children's age on exposure will be presented (Moses, unpublished report; Esteban et al., 1996; Lowenherz et al., 1997). The age-adjusted exposures in these reports are important for responsible risk assessment, but the exposures themselves are of health policy and regulatory importance rather than of health significance to exposed persons.

10879- Biomonitoring Of Concurrent Carbaryl And Guthion Exposures During Apple Thinning  
And Suckering In California And Washington State

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As part of integrated pest management programs apple orchards were sprayed with carbaryl and guthion at different times under normal conditions. Workers that thinned and suckered apples in California and Washington State were monitored for concurrent exposure to carbaryl and guthion using urine biomarkers. Work tasks involved hand removal of fruit and non-bearing growth from 10-15 ft trees with the aid of a short ladder. During these pesticide exposure studies dislodgeable foliar residues (DFRs, Iwata et al., 1977;  $\mu\text{g}/\text{cm}^2$ ) were measured to represent transferable residue. The average daily dosage was calculated from the middle four days in California and the middle three days in Washington State from 6-day monitoring periods of 24-hour urine collection. Exposure to carbaryl was measured as  $\alpha$ -naphthol. Exposure to guthion was measured as the sum of dimethyl phosphates (DMP, DMTP, and DMDTP). The algorithm used to back-calculate potential dermal carbaryl exposure from average urinary  $\alpha$ -naphthol excreted included a urine excretion factor (100/88), an  $\alpha$ -naphthol metabolite factor (100/85), a stoichiometric factor (201/144), and a dermal absorption factor (100/12.66). Guthion exposure is the product of total dimethyl phosphate excreted, a urine excretion factor (100/69.5), and a dermal absorption factor (100/21.9). Mean body weight was  $78 \pm 13$  kg (male) for California apple workers and  $68 \pm 7$  kg for female and  $72 \pm 10$  kg for male Washington apple workers. The California workers ( $n = 13$ ) had an absorbed daily dosage of  $2.8 \pm 1.3$   $\mu\text{g}$  carbaryl/kg-day and an absorbed daily dosage of  $34 \pm 16$   $\mu\text{g}$  guthion /kg-day when dislodgeable foliar residues were  $0.19$   $\mu\text{g}/\text{cm}^2$  and  $0.65$   $\mu\text{g}/\text{cm}^2$ , respectively. Washington workers ( $n = 26$ ) had an absorbed daily dosage of  $0.39 \pm 0.29$   $\mu\text{g}$  carbaryl /kg-day and an absorbed daily dosage of  $5.9 \pm 2.6$   $\mu\text{g}$  guthion/kg-day when carbaryl DFR was  $0.085$   $\mu\text{g}/\text{cm}^2$  and  $0.74$   $\mu\text{g}/\text{cm}^2$ , respectively. Transfer factors (TF;  $\text{cm}^2/\text{hr}$ ) were calculated as potential dermal exposure divided by the product of DFRs and time worked. TFs derived from these studies for workers in California for carbaryl and guthion were  $1500 \pm 700$   $\text{cm}^2/\text{hr}$  and  $3300 \pm 1500$   $\text{cm}^2/\text{hr}$ , respectively. Transfer factors calculated for workers in Washington for carbaryl and guthion were  $450 \pm 320$   $\text{cm}^2/\text{hr}$  and  $470 \pm 230$   $\text{cm}^2/\text{hr}$ , respectively. Dry, hot field conditions in California were associated with higher worker exposure to each insecticide. Transfer factors for both carbaryl and guthion were significantly different between the two study sites (Students' t-test; carbaryl  $p < 0.01$ ; guthion  $p < 0.01$ ).

## 10880- Linking the California Pesticide Use Reporting Database with Spatial Land Use Data for Exposure Assessment

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In regions of intense agricultural production, the potential for exposure to agricultural pesticides has become an important topic of public health concern. Exposure to agricultural chemicals has been associated with cancer, immune system disorders, adverse reproductive outcomes, developmental disorders, and neurological disease. The State of California has developed a Pesticide Use Reporting Database (CPUR), with the objective of providing complete pesticide-use data for evaluating possible associations with human illness clusters. However, the reporting unit for the database is 1 mi<sup>2</sup>, which may be too large for accurately predicting exposure at the individual residence level necessary for some epidemiological studies. We used the California Department of Water Resources (CDWR) crop map database to improve the crop location attributes of the CPUR database. We generated exposure metrics based on CPUR alone and CPUR linked to CDWR for birth residences in 1988-1994 in a childhood cancer study conducted by the California Department for Health Services. Sixty-six residences had both CPUR and CDWR data for the child's birth year. We calculated metrics predicting the lbs/mile<sup>2</sup> of pesticide for 6 pesticides with high use in the study area: herbicides, simazine and trifluralin; insecticides, dicofol and propargite; and fumigants, methyl bromide and metam sodium. We first compared the exposure classification (exposed / not exposed) to each pesticide and evaluated agreement using a chi-squared test and Cohen's kappa. We then assessed differences in predicted lbs/mile<sup>2</sup> of pesticide within a 500-meter buffer around each residence between the metrics, a distance used in previous studies of pesticide exposure. Four of the six pesticides, simazine, trifluralin, dicofol, and methyle bromide, indicated similar categorical assignment of exposure for each metric. Cohen's kappa values for these pesticides ranged from 0.11 to 0.66. The Wilcoxon signed-rank test indicated significant differences in estimated lbs/mile<sup>2</sup> applied within the residential buffers between the CDWR metric and the CPUR metric for 3 of the pesticides. The medians and interquartile ranges were propargite, CDWR = 0.04 (0.00-0.57) and CPUR = 89.41 (14.47-233.69); simazine, CDWR = 0.00 (0.00-0.03) and CPUR = 8.77 (0.00-50.13); methyl bromide, CDWR = 0.00 (0.00-0.00) and CPUR = 0.00 (0.00-342.27). These pesticide exposure metrics are pending field validation but show promise in predicting potential pesticide exposure. Exposure metrics that refine the locational attributes of pesticide use data such as CPUR may reduce exposure misclassification for subjects with high or low exposure.

## 10882- Availability And Human Exposure Potential Of Pesticide Residues On Turf

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Substantial amounts of herbicides, insecticides, and fungicides are annually applied to turf in the United States as part of residential, recreational, or institutional pest management. The human exposure potential of these pesticide uses is low, but incompletely studied. Aggregate exposure assessments for residential pesticide use derived from default assumptions may inflate exposure and unreasonably reduce margins-of-exposure for risk assessment and risk management. Identical chlorpyrifos applications were made to short (1.6 cm; bermuda grass) and long turf (5 cm; perennial rye). Application rate measured with deposition coupons was  $33.4 \pm 2.5$  and  $34.2 \pm 1.1$  for short and long turf. Transferable turf residues (TTR;  $\mu\text{g}/\text{cm}^2$ ) were determined by analysis of cotton cloths rolled 5, 10, or 20 times using a 25-pound (11.4 kg) and a 30-pound (13.6 kg) modified CDFR roller (Ross et al, 1990). TTRs were significantly different between the turf types (Students t-test;  $p < 0.05$ ). TTRs measured for the 25- and 30-pound rollers were significantly different on long turf (Students t-test;  $p < 0.05$ ), but not significantly different on short turf ( $p > 0.05$ ). The number of rolls was also significant (ANOVA;  $p < 0.05$ ). Five and 10 rolls transferred significantly less chlorpyrifos than 20 rolls.

From a previous human exposure study, chlorpyrifos TTRs ( $0.085 \pm 0.024$   $\mu\text{g}/\text{cm}^2$ ), a transfer factor ( $43,000$   $\text{cm}^2/\text{h}$ ), and time (0.33 hours) were used to estimate an absorbed daily dosage ( $0.5$   $\mu\text{g}/\text{kg}\text{-day}$ ; Bernard et al., 2001). Given the intensity of physical contact during the structured activity program, the experimental transfer factor for intensive turf contact (representing 2 or more hours) is more likely  $\approx 7,000$   $\text{cm}^2/\text{h}$  or less ( $43,000$   $\text{cm}^2/\text{h} \div 2/0.33$ ). The difference is substantial with respect to current regulatory policy. The validation of methods to assess the exposure potential is required to establish the usefulness of modeling for pesticide regulation and product stewardship.

10897- Environmental Measurements of Organophosphate and Pyrethroid Pesticides to Assess Exposures of Young Children Living in Jacksonville, FL

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The Duval County Health Department (DCHD, Jacksonville, FL), in collaboration with the Centers for Disease Control and Prevention (CDC) and the US Environmental Protection Agency (EPA), conducted a research study to characterize young children's potential exposures to organophosphate and pyrethroid pesticides. The overall objectives of this study were to: (1) measure the urine metabolite levels of organophosphate and pyrethroid pesticides from a group of 4-6 year old children living in the greater Jacksonville area, (2) identify possible household sources of these pesticides by performing screening measurements and pesticide inventories, (3) investigate whether the environmental pesticide levels correlate with the biological levels, and, (4) correlate questionnaire exposure information with the environmental data.

The study was designed as a three-tiered approach:

- tier 1: recruitment of 200 children into the study, completion of a questionnaire, and collection of a urine sample from each participating child;
- tier 2: collection of environmental screening samples from approximately 25% of the children who participated in tier 1;
- tier 3: a detailed exposure assessment in nine of the homes sampled in tier 2.

Participation in tier 2 was dependent on the answers to the pesticide related questions in the initial questionnaire. Participation in tier 3 was dependent on both the answers to the pesticide related questions in the initial questionnaire and the results of the household pesticide inventory. Results of the pesticide inventory showed that synthetic pyrethroids were the primary pesticides used in the residences. Data from tiers 1 and 2 will not be presented in this paper.

For the nine participants in tier 3, an aggregate exposure assessment was performed that included the collection of environmental (surface wipes, transferable residues, indoor/outdoor air) and personal samples (a time activity diary, pesticide residues on cotton socks, duplicate diet, urine) to evaluate potential exposure from each route (inhalation, dermal, dietary, indirect ingestion).

Data from the aggregate exposure assessment will be presented (tier 3). These data will be used to evaluate the exposure algorithms developed by EPA as part of its draft protocol on how to conduct an exposure assessment study with young children. Data will also be presented on the applicability of questionnaire responses as predictors for environmental loadings of pesticide residues.

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## 10908- Systematic Model Reduction for Efficient Multimedia/Multipathway Exposure and Dose Assessments

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Traditional methods of modeling exposure and internal dose typically use simplified (and conservative) algebraic equations to calculate these quantities from environmental concentrations. The estimates obtained through these methods usually provide an upper bound of the exposures and doses that actually occur, since they do not account for dynamic concentration variations in microenvironments and have to assume steady-state processes for physiological uptake by the human body. A more accurate approach for calculating exposures and doses requires the combined solution of the differential mass balance equations that govern the microenvironmental and biological concentration levels (physically and physiologically based modeling). However, the computing time and resource requirements for implementing this approach are often prohibitive. The objective of the present study is to demonstrate a method for deriving adjusted exposure factors, which can better reflect the detailed exposure and human intake processes, while allowing the use of simple algebraic relations. The systematic construction of the adjusted exposure factors is performed via the High Dimensional Model Representation (HDMR) approach. In the case study presented here HDMR is used to parameterize the coupled microenvironmental/pharmacokinetic model of the MENTOR (Modeling Environment for Total Risk Studies) framework. As an example, adjusted exposure factors are constructed for modeling the exposures and associated internal doses for waterborne contaminants within a residence. The coupled microenvironmental/pharmacokinetic model considers the properties of the contaminant, three exposure routes (ingestion, inhalation, and dermal absorption), release of the contaminant from water into the air within different rooms in the home, the activities of individuals and the physiological uptake processes. By parameterizing this modeling system through the HDMR technique, adjusted exposure factors are developed for different exposure scenarios involving the contaminant water concentration, activity patterns, house characteristics, and individual physiological attributes.

10936- Comparison of three approaches to derive estimates of longitudinal exposures using short-term data

Barraj, L; Walls, C; Scrafford, C; and Johnston, J.. Novigen Sciences, Inc.,

In risk assessment, it is important to characterize both the time frame for exposure (e.g., what is the exposure duration?) and for the toxic effect (e.g., what are the time to peak effects and the time to recovery?). Exposure estimates must be compared to measures of toxic effect based on the same time frame. In a recent Preliminary Cumulative Risk Assessment of the Organophosphate Pesticides (OPs), the US EPA has used cholinesterase (ChE) data from toxicity studies of 21 days and longer to characterize the relative toxicity of the various OPs and to derive a Point of Departure (POD) value for use in the risk assessment, while it characterized dietary exposures using one day consumption data. The EPA recognized this shortcoming, which is due to the fact that the consumption data available are not for multiple consecutive days, but are limited to two non-consecutive days of data for each interviewed individual. Discussions at a the Science Advisory Panel meeting reviewing EPA's preliminary assessment, focused on the impact of using the same two days data over and over to estimate average exposures over the 21 day duration (Method A), versus creating "random" 21-day diets by pooling consumption data across individuals who share the same demographic characteristics (Method B). Alternatively, food frequency data may be used to better characterize these longitudinal dietary profiles (Method C). We used case studies using actual consumption data from USDA's CSFII and NHANES to compare the approaches and their impact on the upper percentiles of the intake distributions. Distributions derived using Method A generally showed larger variability than those derived using Methods B or C. The difference was most accentuated when the foods considered included infrequently consumed foods. For foods consumed on a regular basis, estimates derived using Method B generally showed less variability than those derived using Methods A or C. The results highlight the need for studies collecting data on longitudinal activity patterns.

10943- Impact of between and within person variability on estimates of longitudinal exposures using short-term data.

Barraj, L; Walls, C; Scrafford, C; and Johnston, J. Novigen Sciences, Inc.,

In a recent Preliminary Cumulative Risk Assessment of the Organophosphate Pesticides (OPs), the US EPA has used cholinesterase (ChE) data from toxicity studies of 21 days and longer to characterize the relative toxicity of the various OPs and to derive a Point of Departure (POD) value for use in the risk assessment, while it characterized dietary exposures using one day consumption data. The EPA recognized this shortcoming, which is due to the fact that the consumption data available are not for multiple consecutive days, but are limited to two non-consecutive days of data for each interviewed individual. Discussions at the Science Advisory Panel meeting reviewing EPA's preliminary assessment, focused on the impact of using the same two days day over and over to estimate average exposures over the 21-day duration, versus creating "random" 21-day diets by pooling consumption data across individuals who share the same demographic characteristics. We present simulated case studies using hypothetical data generated assuming various levels of within person (between day) and between person correlations. The difference in the intake distributions derived using the two methods increased as the number of days over which the estimates are averaged increased and as the level of within person variability decreased as compared to the level of between person variability. The results of these analyses may be used to put bounding estimates on estimates derived using actual data covering a limited number of consumption days per subject.

## 10947- Mixed Models Analysis of Urbanization Level on Chlorpyrifos Exposure

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The National Human Exposure Assessment Survey (NHEXAS) pilot studies were conducted from 1995 through 1997 to examine human population exposure to a wide range of environmental contaminants. In one of the studies, NHEXAS-Maryland, a longitudinal design was used to repeatedly measure aggregate residential chlorpyrifos exposure in a stratified random sample of 80 individuals. Chlorpyrifos is a semi-volatile insecticide which has been found to persist for weeks following application. Until its recent removal from the retail market, chlorpyrifos was commonly used for indoor and outdoor treatments by both residents and commercial applicators and also as a termiticide during residential construction. The effect of urbanization level (i.e., characterization of participant's community as urban, suburban, or rural) on chlorpyrifos exposure was investigated using mixed-effects regression models to accommodate longitudinal data and to estimate variance components. Three surrogates of exposure, namely, indoor air concentrations ( $n = 97$ ), surface dust loading ( $n = 123$ ), and creatinine-adjusted urinary metabolite (3,5,6-trichloro-2-pyridinol) concentrations ( $n = 341$ ), were considered separately. The effect of the specified covariance structure was explicitly evaluated to determine if the pooling of variance components, as is often performed by default, is appropriate. Likelihood ratio tests comparing possible covariance structures suggested that the pooling of within- and between-person variance components among urbanization levels may not be appropriate for indoor air concentrations ( $p < 0.001$ ). The variance estimates indicated that indoor air concentrations were far more variable among households in rural communities than in urban or suburban communities. Furthermore, since maximum likelihood estimates of the means depend upon the variance components, the choice of covariance structure exerted a large effect upon the estimates of indoor chlorpyrifos concentrations. Mean indoor air concentrations for urban, suburban, and rural households in this study were estimated to be 7.3, 20.2, and 23.0  $\mu\text{g}/\text{m}^3$ , respectively, when allowing for distinct variance components, but were estimated to be 11.9, 16.6, and 11.7  $\mu\text{g}/\text{m}^3$ , respectively, when pooling the components. Similar analyses, on the other hand, indicated that variance components may be pooled among urbanization levels when evaluating surface dust and urinary metabolite concentrations. These preliminary results, albeit based on relatively small sample sizes, indicate that the choice of covariance structure can have a large effect on the results of an analysis and must be given appropriate consideration.

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## **10980- Using the BRFSS to collect population-based exposure information: 10 years of experience in Washington**

Jim VanDerslice, Ph.D. and Denise Laflamme, M.S.

### **ABSTRACT**

The Behavioral Risk Factor Surveillance System (BRFSS) was established by CDC in 1984 to collect population-based state-level data on health-related behaviors and health conditions through telephone interviews. Washington State has used the BRFSS to collect data on behaviors, attitudes and perceptions regarding environmental health issues since 1990. However, the value of these efforts has been questioned. The goal of this project was to: 1) analyze and assess the usefulness of all BRFSS environmental health items since 1990; and 2) assess the use of BRFSS by other states as a means of collecting exposure assessment information. The purpose of this presentation is to discuss the use of the BRFSS as a means of collecting exposure information, present the strengths and limitations of this data collection tool, and review the results from the questions asked in Washington State over the last 11 years.

Weighted frequencies and proportions were computed using STATA. Weights accounted for the number of households per strata, the number of phone lines and adults per household, and were also used to adjust for over-sampling certain sub-populations. Program personnel were interviewed to document the use of the data in program planning and policy development.

Some of the most useful data came from simple questions regarding the source of drinking water and type of wastewater treatment. About 10% of the households are using private wells as their source of drinking water. Over 80% of these had tested their well water and over sixty percent had tested their well within the last 3 years. Six percent of the tests indicated the presence of some contaminant. Thirty six percent of households reported having a septic tank.

While program managers have apparently been very interested in the public's perceptions of the magnitude or seriousness of various environmental problems, there is no evidence that the results have actually been used to influence programmatic activities, policies or funding priorities. The environmental issues which were most often thought to be a community problem included ambient air quality (22%), drinking water (15%), and workplace hazards (14%). Only 4% of those surveyed thought that indoor air quality was a problem.

At least 30 state health departments have included environmental health questions in the BRFSS. Food handling, lead poisoning and radon exposure items were used most frequently.

Survey instruments like the BRFSS can be valuable tools for estimating exposure levels when the exposure is highly influenced by some identifiable behavior, such as time spent in a micro environment, or the frequency or amount of a food consumed. The

BRFSS may be advantageous to conducting a specialized survey in that the marginal cost per question is low, the sample is representative of households with phones, sample sizes are generally large enough to conduct simple stratification, survey and analytical methods (e.g., weighting) have been standardized across the nation, and data collection takes place over the entire year. The main limitations are inherent in the use of a telephone survey to collect unbiased observations of past or current behaviors.

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11004- Development of an Exposure Assessment Targeted to an Environmental Epidemiological Study:  
The FACES Study

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Relatively little is known about how two classes of agents, air pollutants and bioaerosols, affect the long-term progression of disease among asthmatic children. FACES is a 5 year prospective study of 300 children, age 6 to 10 at enrollment, who have asthma and live in Fresno, CA. Because the health outcomes include symptoms, medication use, and pulmonary function, and the consequent disease progression, FACES is evaluating daily exposure to air pollutants and bioaerosols (pollen grains, fungal spores, and endotoxin). To accomplish this, daily measurements are made at the EPA Supersite. In addition to the daily variability, spatial variability throughout Fresno and between indoor and outdoor air is being evaluated with 2 trailers that will collect daily samples, routine measurements in all homes, and detailed measurements indoors and outdoors in a subset of homes. These data will be used to develop and test models to predict the variability among neighborhoods and inside homes. The agents have been classified into three groups on the basis of the principal determinants of their concentration: regional pollutants (vary over distances > 20 km, but little variability expected within the study area, e.g., PM<sub>2.5</sub> sulfate, nitrate, and ammonium ions), neighborhood pollutants (e.g., those with traffic sources such as diesel exhaust), and home-specific agents (e.g., tobacco smoke). Similarly, the principle determinant of the concentrations of bioaerosols may be regional, as in the case of long range transport of pollen grains and submicronic particles related to pollen from plants not common in Fresno; neighborhood, as for pollen grains, fungal spores and submicronic particles from sources which are in Fresno; or home-specific, e.g., endotoxin and dog, cat, dust mite and cockroach allergens. Even within the same season a large temporal variability in concentration has been observed for both air pollutants (e.g., PM, elemental carbon, ozone) and bioaerosols (pollen grains and fungal spores). Similarly, those agents which were hypothesized to vary from home to home (e.g., allergens in house dust) in fact have been found to exhibit several orders of magnitude variation; second hand smoke concentrations, as measured by a two week passive sampler for nicotine, were low and much less variable, perhaps because parents of asthmatic children avoid smoking in the home. Broad ranges in the concentrations of these agents, both spatially and temporally, should be reflected in the responses of the children as measured both on a daily basis (during two week panels three times a year) and during semiannual assessments. The close match of exposure analysis and health assessment should enhance the ability of the epidemiological study to detect the effects of air pollutants and biological agents in the progression of asthma.

11041- TITLE: EXPOSURES TO RESPIRABLE PARTICULATES IN RURAL HOUSEHOLDS OF ANDHRA PRADESH, INDIA

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OBJECTIVES: Indoor air pollution associated with combustion of solid fuels seems to be a major contributor to the national burden of disease in India but few quantitative exposure assessment studies are currently available. This study quantified daily average concentrations in three different household microenvironments and recorded time-activity data to reconstruct daily average exposures of household-members, in 420 rural homes selected through stratified random sampling from three districts in the state of Andhra Pradesh, India.

METHODS: All households were monitored in kitchen and living area locations, for periods between 22-24 hours. Outdoor area samples (one-per-every-five households) were typically collected for periods between 6-12 hours and included at least one cooking-window. Area samples for respirable dusts were collected and analyzed gravimetrically according to NIOSH protocol 0600. In addition, ~ 10 % of the households were monitored using real-time data-logging particulate monitors. This allowed calculation of ratios of 24- hour concentrations to average concentrations during cooking vs. non-cooking windows. Time activity data were collected from 1365 household members based on a 24-hour recall. Daily average exposures were reconstructed on the basis of micro-environmental concentrations and the time activity data.

RESULTS: Mean 24-hr average concentrations ranged from  $70\mu\text{g}/\text{m}^3$  ( $\text{GM} = 56\mu\text{g}/\text{m}^3$ ) to  $850\mu\text{g}/\text{m}^3$  ( $\text{GM} = 570\mu\text{g}/\text{m}^3$ ) in gas versus solid fuel using households respectively. Concentrations were significantly correlated with fuel type, kitchen type and fuel quantity. Mean 24- hour average exposure concentrations ranged from  $80\mu\text{g}/\text{m}^3$  ( $\text{GM} = 75\mu\text{g}/\text{m}^3$ ) to  $376\mu\text{g}/\text{m}^3$  ( $\text{GM} = 291\mu\text{g}/\text{m}^3$ ) in gas and solid fuel using households respectively. Amongst solid –fuel users mean 24-hr average exposure concentrations were the highest for women cooks (Mean=  $448\mu\text{g}/\text{m}^3$ ;  $\text{GM} = 319\mu\text{g}/\text{m}^3$ ) and were significantly different from exposures for men (Mean =  $244\mu\text{g}/\text{m}^3$ ;  $\text{GM} = 170\mu\text{g}/\text{m}^3$ ) and children (Mean= $267\mu\text{g}/\text{m}^3$ ;  $\text{GM} = 191\mu\text{g}/\text{m}^3$ ). Women between the ages of 15-40 (most likely to be involved in cooking or assisting cooks) experienced the highest exposure concentrations although among men, they were highest for those between the ages of 65-80 (most likely to be indoors). Also, although exposure concentrations for women cooks were not correlated with kitchen type, exposure concentrations of all other household sub-groups were significantly different across kitchen types, with members in households with indoor kitchens without partitions from the living area receiving the highest levels. Exposure concentrations were not significantly different for various household sub-groups amongst gas users.

CONCLUSIONS: The results obtained in this study are being used in conjunction with detailed household level information to develop a model to predict quantitative categories of exposure based on housing and fuel characteristics. This would facilitate the development of a regional exposure database and enable better estimation of health risks.

11075- Visualization of US Army military unit locations in relation to herbicide spraying during the Vietnam War.

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**INTRODUCTION.** Over 3 million men and women served in Southeast Asia during the Vietnam War. Between 10 and 15% were potentially exposed to toxic herbicides, some of which were contaminated with dioxins. Under a contract from the National Academy of Sciences, we have been developing exposure assessment methodologies based on military records for use in epidemiological studies of possible health consequences of exposure. Still unknown is the extent to which US troops were directly exposed to herbicide spray. One problem is that precise locations (to within 0.5 km, say) of military units may not be available. Based on existing records and knowledge of military tactical maneuvers, probable locations can be assigned where data are missing. The process of assigning locations to which exposure opportunity scores can be attached is greatly facilitated by visualization. **METHODS.** We used our Geographic Information System (GIS) for Vietnam to coordinate the visual display of the locations of US Army combat units with the locations of application of Agent Orange and other herbicides during the Vietnam War. The locations are contained in a database of troop movements in III Corps Tactical Zone that was created by the US Army and Joint Services Environmental Support Group, now the Center for Research on Unit Records, and which contains data for 276 headquarters and line companies in 55 infantry, artillery, cavalry, and engineering battalions. Over a quarter of a million locations were abstracted, frequently at daily intervals. Herbicide data are from the HERBS file which contains detailed flight path and herbicide application data for over 9,000 Ranch Hand aerial and base perimeter spray missions. We have extensively cleaned and updated both the HERBS and battalion databases using original sources from CRUR and the US National Archives. **RESULTS.** We can assign probable locations and estimate exposure opportunities for these military units, representing more than 300,000 troops in the 1969-1969 period. These are the basic underlying data necessary for a cohort study of health effects of herbicides on Vietnam veterans. The GIS has made it possible to link troop locations with herbicide locations during specific time periods and to provide exposure profiles of individual units. A novel feature of the visualization is use of QuickTime animation based on IgorPro (WaveMetrics, Inc.) graphical software. This permits real-time observation of both the troop movement and herbicide spraying, and graphically documents many instances of military units being directly sprayed. This will be illustrated with a video presentation.

## **11112- Associations between Particulate (PM) Gaseous Co-Pollutant Exposure Levels For COPD And MI Cohorts in Atlanta, GA**

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Epidemiological studies indicate that daily ambient particulate matter (PM<sub>2.5</sub>) concentrations are associated with increased mortality, hospital admissions, and respiratory and cardiovascular effects. It is possible that the observed significant associations are the result of confounding by ozone, nitrogen dioxide, or sulfur dioxide, as ambient concentrations of these pollutants are often correlated with those of PM<sub>2.5</sub>. This paper presents some of the results from an exposure and health conducted during fall 1999 and spring 2000 in metropolitan and suburban Atlanta, GA. In this study, repeated personal, indoor, and outdoor PM<sub>2.5</sub>, PM<sub>10</sub>, sulfate, carbon monoxide, elemental and organic carbon measurements were made, together with air exchange rate and cardiac health measurements for persons with chronic obstructive pulmonary disease (COPD) or who had a recent heart attack (MI). In the fall and spring, 24 and 22 individuals participated in the study, respectively. During each season, measurements were made for each participant over seven consecutive 24-hr periods using a multi-pollutant sampling device.

This paper uses the PM<sub>2.5</sub> and gaseous pollutant data to assess the potential for confounding of observed associations between PM and adverse health. Preliminary mixed modeling regression analyses indicate that personal PM<sub>2.5</sub> levels were significantly associated with corresponding outdoor levels, as the slope of the regression line equaled 0.8 (s.e.=0.07, p<0.0001) in the fall and 0.27 (s.e.=0.09, p=0.004) in the spring. The regression of personal ozone levels on outdoor ozone levels yielded regression lines with small but statistically significant slopes, equaling 0.12 (s.e.=0.02, p<0.0001) and 0.08 (s.e.=0.02, p=0.0005) in the fall and spring respectively. In both seasons, outdoor PM<sub>2.5</sub> and outdoor ozone have associations that are marginally significant at the 0.10 level. Personal PM<sub>2.5</sub> levels were not significantly associated with personal or outdoor ozone levels in either season.

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## **11124- Relating Personal PM and PM-Associated Elemental Carbon Exposures to Cardiovascular and Pulmonary Symptoms in a High-Risk Subpopulation**

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Sensitive subpopulations such as COPD patients have been shown to be especially susceptible to the effects of PM exposure. Proximity to traffic has been shown to be a predictor of PM effects in susceptible populations. Elemental carbon (EC) has been demonstrated to be a good indicator of combustion emissions, and in urban PM is a useful indicator of the diesel traffic contribution to PM concentrations. Extremely few personal EC exposure data exists, even though diesel exhaust exposure has been linked to cancer and the exacerbation and even onset of asthma.

In this study, the personal exposures of COPD patients to PM<sub>10</sub> and EC were monitored over 12 days during winter and summer. Simultaneous measurements of cardiovascular and pulmonary change indicators (pulse rate, blood oxygen content and lung function) were also made in order to relate particle concentrations with cardio-respiratory disease symptoms. A group of eight individuals were monitored during summer and winter sampling campaigns in 2000-2001. Personal exposures to PM<sub>10</sub> and EC were measured using both personal sampling pumps to monitor 24 hour means on Teflon filters, and personal photometer (DataRAMs [pDRs], MIE Inc.) to identify short-term PM peaks. Co-located pDRs compared very favorably to central station TEOM monitors in identifying short-term peak concentrations. Teflon filters were subsequently analyzed using a light reflectance method (EEL reflectometer) to identify personal elemental carbon concentrations, following construction of a reflectance-absorption coefficient calibration curve. Time activity and symptom diaries were also filled in by all participants in order to identify micro-environments in which participants spent the majority of time, and to identify where peak PM concentrations coincided with specific activities or locations. Indoor and outdoor PM<sub>10</sub> concentrations were also measured.

Personal PM<sub>10</sub> concentrations were higher than indoor micro-environmental PM<sub>10</sub> concentrations. EC was a significant proportion of the personal PM samples. Filter and pDR sampler results were correlated, but correlations varied from subject-to-subject and depended on specific activities. pDR samplers identified specific peak exposures during the sampling periods, which, in some cases, could be related to specific activities. Relationships between PM concentrations and health indicators were complex and no clear pattern emerged within this group.

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## 11125- Indoor-Outdoor PM<sub>2.5</sub> and PM<sub>10</sub> in New York City

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PM health effects have been reported to be highest in sensitive subpopulations such as COPD patients. Since such individuals spend higher proportions of their day indoors, the relationship between indoor and outdoor concentrations is therefore particularly important. The identification of the determinants of indoor concentrations – e.g., outdoor PM and indoor sources – is therefore also a priority for these individuals. In this study, the indoor-outdoor PM<sub>2.5</sub> and PM<sub>10</sub> concentrations of eight COPD patient homes in NYC were monitored over two 12 day periods during winter and summer. Simultaneous measurements of indoor-outdoor PM<sub>2.5</sub> and PM<sub>10</sub> concentrations were made at a central monitoring site (CMS) at 1<sup>st</sup> Ave. and 26<sup>th</sup> St. in Manhattan. Sampling locations were within a five mile radius of the CMS. Time-activity diaries were filled in by all study participants.

The 24 hour mean indoor PM<sub>2.5</sub> concentration was 27.8 µg m<sup>-3</sup> in summer and 20.1 µg m<sup>-3</sup> in winter for the group. PM<sub>2.5</sub> concentrations were higher indoors compared to outdoors, and higher in summer than in winter. The mean PM<sub>2.5</sub> indoor-outdoor ratio was 1.2 for winter and 1.5 for summer. PM<sub>2.5</sub> indoor-outdoor ratios ranged between 0.9-1.4 for winter and 0.4-2.5 in summer. On average, the indoor PM<sub>2.5</sub> concentration represented 77% and 76% of indoor PM<sub>10</sub> concentrations in winter and summer, respectively. PM<sub>2.5</sub> concentrations indoor and outdoors were more closely correlated than the corresponding PM<sub>10</sub> indoor and outdoor measurements.

Peak PM<sub>10</sub> concentrations also occurred indoors and during summer. Mean PM<sub>10</sub> indoor-outdoor ratios were 1.4 for winter and 1.8 during summer. PM<sub>10</sub> indoor-outdoor ratios ranged between 1.0-1.9 for winter and 1.0-3.4 in summer. PM<sub>10</sub> indoor-outdoor ratios were higher than PM<sub>2.5</sub> indoor-outdoor ratios in both winter and summer.

The relationship between the 24 hour mean PM<sub>2.5</sub> and PM<sub>10</sub> concentrations over the 12 day sampling period varied between subjects. In some cases, PM<sub>2.5</sub> was a good predictor of PM<sub>10</sub>, a poor predictor in others. R<sup>2</sup> values of correlations between indoor and outdoor concentrations over time varied subject to subject, with an overall mean of r<sup>2</sup> = 0.52 for PM<sub>2.5</sub> and r<sup>2</sup> = 0.34 for PM<sub>10</sub>. The relationships between the indoor and outdoor concentrations were assumed to be a function of the home micro-environment, since a high correlation between PM<sub>2.5</sub> tended to predict a good correlation between PM<sub>10</sub>.

Comparison of central and distributed sampling locations demonstrated good agreement between outdoor PM concentrations. PM<sub>2.5</sub> concentrations (in and outdoor) were more correlated than the corresponding PM<sub>10</sub>. However correlations between PM<sub>2.5</sub> and PM<sub>10</sub> concentrations over the sampling period varied. On average, indoor PM<sub>2.5</sub> accounted for approximately 80% of indoor PM<sub>10</sub> in both summer and winter. Maximum intra-PM sample type concentrations were consistently recorded in summer. Indoor-outdoor ratios of both PM<sub>2.5</sub> and PM<sub>10</sub> were also higher in summer than in winter.

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11138- Investigation of transfer of fluorescent tracers from surfaces to skin.

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Under the provisions of the Food Quality Protection Act (FQPA), aggregate exposure assessments must be conducted for pesticides proposed for registration. Many aspects of dermal exposure assessment remain poorly quantified. For purposes of assessing surface-to-skin transfers relevant to FQPA, a series of trials have been conducted using fluorescent tracers as surrogates for pesticides. In these trials, adult volunteers contacted surfaces loaded with tracers with their fingertips. Factors investigated included contact duration, contact pressure, surface tracer loading, surface type, contact scenario, skin moisture, and tracer aqueous solubility. Each variable was limited to two possible states. A hand press station (force plate) linked to a personal computer was utilized to control and record duration and pressure. Target conditions for those variables were 3 or 10 seconds and 30 or 100 g/cm<sup>2</sup>. Initial average tracer surface loadings were 0.2 or 0.5 µg/cm<sup>2</sup>. Alternative surfaces were glass and a textured vinyl fabric. Contact was either static (press) or dynamic (swipe). Skin moisture on pre-moistened or dry fingers was assayed with a corneometer. One relatively hydrophilic and one relatively hydrophobic tracer were utilized. Digital images of both the fingers and the surfaces were captured under UV illumination before and after activity to attempt assessment of mass balance. Tracer loading vs. fluorescence calibration curves were produced for each individual volunteer to minimize potential effects of varying skin tones. Based on finger imaging, transfers of 0-1.5 µg of tracer to roughly 2-3 cm<sup>2</sup> of finger surface were observed. Analysis of the relative importance of the experimental variables by multi-factorial anova is currently underway.

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