Associations between Respiratory Health Effects and Allergens, Fungal and Endotoxin in Settled Dust: Relevant Units of Potential Exposure

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Rationale: Many indoor environmental studies analyze settled dust rather than airborne contaminants. These are often expressed per gram of dust. However, expressing concentration per unit area sampled is intuitively preferable as a metric of potential exposure. We investigated relationships between potential exposures to contaminants in settled dust reservoirs and lower respiratory symptoms to examine the relevance of these metrics. **Methods:** Floor and chair dusts were vacuumed from 23 locations in 2 hospitals. Dusts were analyzed for cat allergen (Feld1), extracellular polysaccharides (EPS) for *Aspergillus* and *Penicillium*, β-glucans, endotoxin, and culturable fungi. Two potential exposure metrics were used: contaminant per unit mass and per unit area. A respiratory symptoms questionnaire was offered to employees (70% participation rate; N=600). **Results:** There were moderate positive correlations (r=0.35-0.74) between the two potential exposure metrics for endotoxin, culturable fungi, β-glucans and EPS and a strong positive correlation (r=0.89) for Feld1. Feld1 per unit mass had very low correlation with total mass of dust while the other contaminants per unit mass were negatively correlated. In univariate logistic models, lower respiratory symptoms were more significantly associated with culturable fungi, β-glucans and EPS concentrations when expressed per unit area than when expressed per unit mass. Both metrics for Feld1 were significantly associated with lower respiratory symptoms. **Conclusions:** Our findings indicate that settled dust measures of potential exposure in relation to lower respiratory health effects should be expressed per unit area rather than per unit mass.

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Women's Peak Expiratory Flow Rate Variability Is Not Affected by Home Combustion Sources

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Rationale: In healthy, non-asthmatic subjects, an increase in diurnal variability of peak expiratory flow rate (peak flow) may occur as the result of bronchoconstricting effects of inhaled environmental substances. Methods: we studied a group of 648 non-smoking women living in non-smoking households in Virginia in the winters of 1995-96, who after training measured their own peak expiratory flow rate using a portable meter (three blows, twice daily) for two weeks. They kept diaries of the cumulative use of home heating combustion sources (kerosene heaters, fireplaces, wood stoves) which were most frequently used as supplemental heating sources, for the two week period, without records of daily use. Peak flows were expressed for each woman as the variablity per cent mean for the two weak measurement period : [daily higher peak flow - daily lower peak flow]/[mean of all values for two week period]. Results: Mean age of women was 30 years (range 18 - 42). 50 women had a physician diagnosis of asthma. For analysis, subjects with variability per cent mean <6.0 were contrasted with those > 6.0 in a logistic model, adjusting for educational level, race, and history of allergies.There was no significant association of variability in peak flow with the overall use of home combustion sources during the two week observation period. Conclusion: there was no effect of home combustion source use over two weeks on peak flow variability in these non-smoking women, although we cannot exclude a small effect that could be detected only by day-by-day comparisons.

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Indoor Air Pollution & Respiratory Function in a Rural, High Altitude Community in India

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Exposure to indoor air pollution has been linked with both acute and chronic respiratory disease. Exposure to airborne endotoxin can cause airway inflammation, asthma and decreased lung function. This research sought to provide experimental data on indoor air quality, and the resulting respiratory impact, for a high elevation (4800m), rural community in Ladakh, India. This community is of interest because residents burn biomass (dung and wood) inside the home for heating and cooking. Size distribution and mass concentration of particulate matter (PM), concentration of endotoxin and carbon monoxide (CO) levels were determined for six homes. Lung function data and induced sputum samples were collected for ten test-home Ladakhi natives, ages 18-69 years (mean = 41 yrs) and 4 researchers. PM concentration ranged from 2-5.5 mg/m3 with an MMAD of 0.4μm. Endotoxin concentration ranged from 4-580 endotoxin units/m3 (0.4-58 ng/m3). CO levels ranged from 50-120 ppm. FEV1/FVC for the ten subjects ranged from 75-96%, with FEV1> 95% of predicted in all cases. Induced sputum analysis revealed a significantly greater total inflammatory cell count (mean ± SEM, 10^5 cells/ml) in the Ladakhi natives as compared to the sojourner scientist (92.6 ± 27.3 vs 7.1 ± 4.4, $P < 0.01$). While the high levels of PM, CO and endotoxin did not correlate with significant decrements in lung function, induced sputum analysis revealed marked airway inflammation dominated by macrophages and neutrophils.

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Air pollution exposure is very dependent of personal activity and exposure pattern. This is the first ever study of personal exposure of pregnant women to air pollution. Personal exposure to CO, VOC's, lead in blood and microenvironmental exposure to PM-2.5 were studied in summer 2002 in 45 pregnant women in Trujillo, Peru. Trujillo is an urban city of 732600 people, at sea level, 80% of outdoor air pollution is from motor vehicles with emission rates similar to 1974 USA levels, 52% of people live in poverty. At the time of this study and out of 2330 single births, 32.1% of pregnant women reported anemia, 13.0% reported no pre-natal medical evaluation, 9.3% of new borns had low birth weight and 5.0% of new borns had very low birth weight. Method: Pregnan women were studied for one day during their normal daily activities from 8-13 hours. Questionnaires were used to collect data on demographics, time budget activity and exposure partern. Studied air pollutants were collected using passive and active monitors. Results: CO mean= 2.74 PPM/Hr (stdev=2.90); selected VOC's: benzene mean = 7.82 Ug/M3 (stdev=4.28), toluene mean= 1496.11 Ug/M3 (stdev= 1044.62), lead in blood mean= 2.72 Ug/Dl (stdev=1.05,) and PM-2.5 mean= 51.77 Ug/M3 (stdev=24.43). Conclusions: Results of this pilot study indicate that exposure to CO, selected VOC's and PM-2.5 are of concern in this subpopulation. Real time concentrations of CO as well as the rate of change of instantaneous and frequent CO concentration favor: high COHb concentrations, longer than normal elimination half time for COHb and could result in bioaccumulatrion of COHb.

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Anatomically Based Model of Airways To Simulate Respiratory and Particle Flow

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In order to study gas flow and particle deposition in the lung, we built a realistic three-dimensional model of the bronchial tree, extending to the segmental bronchi. We used a commercial Computational Fluid Dynamics (CFD) software to simulate gas and particle transport. **METHODS:** The model is based on the morphometrical data of Horsfield et al. [*J. Appl. Physiol., 31, 207-217, 1971*] and on bronchoscopic and CT images. From the data, we computed lengths, diameters and branching angles of the ducts while bronchoscopic and CT images gave their spatial orientation. The software was validated from cases where the solution is analytically known and from previously published simulations [*Respir. Physiol., 130, 201-221, 2002*]. The massflow at the inlet of the model was 0.314 l/s. The flow in each segmental bronchus was imposed as outlet boundary conditions. Particles of aerosol (diameter from 1 to 7 μm) were introduced during inspiration: their repartition inside the model was computed and analysed. **RESULTS:** The static pressure repartition was computed during inspiration: the largest pressure drop, around 15 Pa, occurs between the entrance of the model (the trachea) and the right upper apical exit, due to the largest flow in this duct. The simulations showed non-fully developed flows in the exit branches because of their short lengths. Preliminary results showed different repartition of the particles in the branches, dependent of the particle size which is mostly visible in ducts with large branching angles, due to the inertia of the particles. **CONCLUSION:** CFD allows the computation of flow and particle repartition in a realistic model of the first generations of the human bronchial tree. We found very large inhomogeneities of particle deposition in branches of the same generation.

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Effect of the Carrier Gas on Aerosol Deposition in the Human Lung

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Aerosol mixing resulting from turbulent flows is thought to be a major mechanism of deposition in the upper respiratory tract (URT). Since turbulence levels are a function of gas density, the use of a low density carrier gas should reduce deposition in the URT. We measured aerosol deposition in the lung of 4 healthy subjects using both air and a low density gas mixture (heliox: 80% helium - 20% oxygen) as the carrier gas. The subjects breathed 0.5, 1 and 2 μm-diameter particles from a reservoir at a constant flow rate (432 ± 2 ml/s) and tidal volume (866 ± 5 ml). Aerosol concentration and flow rate were measured at the mouth using a photometer and a pneumotachograph, respectively. When using heliox as the carrier gas, the data indicated that particle size (d_p) increased during transport in the lung, most probably because of condensation of water vapor onto the particles. There was no detectable increase in d_p when suspended in air. In spite of the increase in d_p when breathing heliox, deposition was significantly reduced ($p<0.01$) compared to air for all d_p we studied. Deposition decreased from 18.8±0.7% to 16.8±1.3% for 0.5 μm, from 22.4±0.8% to 20.7±0.8% for 1 μm and from 40.9±2.9% to 36.3±2.5% for 2 μm-diameter particles. While the decrease in gas density would be expected to decrease URT deposition, the increase in d_p would be expected to increase alveolar deposition due to increased sedimentation. These data suggest that the effect of the low density gas is larger than that of an increase in d_p. While it could not be directly measured from these data, it is likely that when breathing heliox instead of air, deposition is reduced in the URT and increased in the small airways and alveoli.

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