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Deriving Optimal Mean Indoor Concentration Threshold Levels of $PM_{2.5}$ and VOC for Detecting Respiratory Symptoms among Pregnant Women in Ndola and Masaiti, Zambia

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Abstract

The burden of air pollution-related morbidity and mortality in developing countries will continue if limited air monitoring and lack of air quality standards continue. This paper focuses on deriving optimal mean indoor threshold concentration levels of particulate matter ($PM_{2.5}$) and volatile organic compounds (VOCs) for detecting respiratory symptoms among pregnant women in Ndola and Masaiti, Zambia.

The study involved 1,170 consenting pregnant women in a cross sectional study using a standard questionnaire. Lung function tests were conducted and indoor $PM_{2.5}$ and VOCs monitored in houses.

Biomass was the main cooking fuel. Indoor air quality monitoring results during cooking and daily average were 501(411, 686) µg/m^3 and 393 (303,578) µg/m^3 respectively for $PM_{2.5}$ and 340(318,360) ppb and 343(320, 363) ppb respectively for VOCs. Significant difference in the distribution of $PM_{2.5}$ (p-value = 0.001) and VOC (p-value = 0.017) between rural and urban area were observed. Mean indoor $PM_{2.5}$ and VOC varied significantly by cooking activity in both rural (p-value < 0.001) and urban (p-value < 0.001) areas. Similarly, fuel type for $PM_{2.5}$ at p-value = 0.005 but no significant difference for VOC at p-value = 0.779. However, there was a significant association between mean indoor VOC and forced vital capacity (FVC). Mean indoor $PM_{2.5}$ was significantly higher in households that presented with respiratory symptoms than those without respiratory symptoms for both rural (p-value = 0.011) and urban areas (p-value < 0.001). Exposing a pregnant woman to mean indoor $PM_{2.5}$ of 418µg/m^3 in rural areas and 372.3µg/m^3 in urban areas increased the risk of having at least one respiratory symptom. Statistical significant associations were observed between mean indoor $PM_{2.5}$ and respiratory symptoms.

Household air pollution levels in Zambian homes are high. Therefore, systematic PM and VOCs monitoring is critical in order to develop strategies and policies relating to improvement of air quality and respiratory health.

Keywords: Air pollution, Biomass, Particulate matter, Volatile organic compounds, Spirometry

1. INTRODUCTION

Currently, developing countries are increasingly experiencing a double burden of infectious and chronic diseases (Boutayeb, 2006) partly due to environmental conditions (Sclar et al. 2005; Zulu et al. 2011) which are compromised by the increasing presence of poor air quality resulting from the use of unprocessed cooking fuels such as wood, charcoal, cow dung and crop residues. These cooking fuels produce pollutants such as respirable suspended particulate matter (RSPM) that is of major significance as it significantly affects the cardiovascular and respiratory health of individuals (Pope and Dockery, 2006). Animal studies have shown that wood smoke causes immune suppression in the respiratory system (Thomas and Zelikoff 1999; Zelikoff 1994) and several previous studies elsewhere have also documented an association between exposure to biomass (wood smoke) and incidence of tuberculosis,

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