ABSTRACT

Introduction: Indoor and outdoor air pollution are major environmental health problems affecting both developed and developing countries. Global estimates suggest that urban air pollution contributes to approximately 800,000 deaths and 4.6 million life years lost worldwide each year. The burden is not equally distributed and two-thirds of deaths and life years lost occur in the developing countries of Asia. WHO estimates that 4300 and 1000 deaths are attributable to indoor and outdoor air pollution in Sri Lanka in 2009, respectively.

Rapid urbanization of several regions of Sri Lanka has resulted in heavy traffic congestion, the establishment of various factories, power plants and many other sources of outdoor air pollutants. However, air quality monitoring is limited and inadequate for interpreting and correlating outcomes at the individual level. Indoor air quality data are non-existent.

The few epidemiologic studies on air pollution and health in Sri Lanka have demonstrated positive associations between air pollution and adverse health outcomes. Most of these studies have not measured air pollutant concentrations.

Objectives: To determining the association between air pollutants in the home environment and respiratory health among children aged 7 to 10 years.

Methodology: The study commenced in March 2009. Three panels of children from 2 settings were followed up over a 1-year period. The study settings were located in the Colombo Municipal Council (CMC) area (setting 1) and in the Panadura Medical Officer of Health (MOH) area (setting 2). Two panels of children were selected in setting 1 based on the type of housing unit (panel 1: children living in semi permanent/ improvised houses, and panel 2: children living in flats and permanent single houses). The third panel was selected from children living in the Panadura MOH area.

Six hundred and twelve 7-10 year old children (204 children in each panel) were recruited from the two settings. Recruitment of children was confined to as small a geographic area as possible to ensure uniform outdoor exposures. Three air pollutants ($PM_{2.5}$, SO_2 and NO_2) were measured both outdoors and indoors (indoors only in 1/3 of households).

A baseline questionnaire was administered to obtain data on respiratory health status and socio-demographic and other factors. Each child maintained a respiratory symptom diary to monitor respiratory symptoms on a daily basis. Lung functions were assessed at the beginning and at the end of the follow up. Height and weight were measured using standard techniques. A follow up questionnaire was administered at the end of the study.

Results: The mean ages of children at recruitment were 8.39 (SD = 0.89) years, 8.49(SD = 0.89) years and 8.49 (SD = 0.90) years, in panel 1, 2 and 3, respectively; the total number of children comprised 323 males and 289 females. Five hundred and sixty eight children remained in the study at the end of 1 year. The majority of children were from families having an income of SLR 10,001 to 20,000 (46%, 45% and 51% in panels 1, 2 and 3, respectively).

The prevalence of wheezing (wheezing within the last 12 months) at baseline was significantly higher in setting 1 (20.8%) as compared to setting 2 (10.8%) (p=0.002). Persistent cough was reported by 10% of children in setting 1 and 3.4% children in setting 2 (p = 0.004). There was no difference in the proportions of children ever having asthma between the 2 settings (18.9% in setting 1 and 12.7% in setting 2) (p=0.066).

The annual outdoor average NO_2 concentration (41.7 $\mu g/m^3$), 24-hour average SO_2 concentration (35.7 $\mu g/m^3$), the 24-hour average $PM_{2.5}$ concentration (39.1 $\mu g/m^3$) and the 24-hour average PM_{10} concentrations (60.1 $\mu g/m^3$) of setting 1 exceeded the recommended WHO threshold values. In setting 2, the concentrations were within the WHO recommended values.

The average indoor SO_2 concentrations (setting 1= 28.7 $\mu g/m^3$ and setting 2=10.9 $\mu g/m^3$), NO_2 concentrations (setting 1=34.5 $\mu g/m^3$ and setting 2=12.6 $\mu g/m^3$) and $PM_{2.5}$ concentrations (setting 1 median = 57.5$\mu g/m^3$ and setting 2 median =36.8 $\mu g/m^3$) were significantly higher in households of setting 1 as compared to those of setting 2.

The incidence rates of days of symptoms and episodes of symptoms were, in general, significantly higher in children of setting 1 as compared to those of setting 2. There was difference in the incidence rates of days of wheezing and throat irritation between children of panels 1 and 2; children of panel 3 had significantly lower risk of all symptoms as compared to children of panels 1 and 2.

FVC, FEV_1 and $FEV_{25-75\%}$ of children were not significantly different between the two settings after adjusting for age, sex, height, weight and ethnicity. The average daily growth

related increases of FVC and FEV_1 of children were not significantly different between the two settings after adjusting for age, sex, height, weight and ethnicity.

An estimate of the total NO_2 and SO_2 exposure during the entire study of children resident in houses in which indoor air quality was measured was obtained. The incidence rates of days and episodes of wheezing and cough were significantly higher in children who had high exposure to NO_2 and SO_2 after adjusting for other risk factors. Exposure to high NO_2 (based on estimates of total exposures) and high indoor $PM_{2.5}$ concentrations were risk factors of cough and wheezing after adjusting for each other and other confounding factors.

Conclusions: Children in setting 1 were exposed to concentrations of $PM_{2.5}$, NO_2 and SO_2 that exceeded WHO recommendations; these children also had significantly higher incidence rates of respiratory symptoms as compared to children of setting 2 where the air pollutant levels did not exceed the WHO recommended values. Methods to mitigate the adverse impacts of air pollutants on health have been suggested.