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Assessing the Impact of Indoor Air Quality on Respiratory Health- Some Prescriptions

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ABSTRACT

The aim of this review article is paper is to bring out the challenges of measuring impact of indoor air quality of urban domestic and commercial kitchens on the respiratory health of the exposed individuals especially the cooks. It highlights the importance of devising detailed experimental protocols for quantifying the exposure; assessing the short and long term morbidities to general respiratory symptoms through a properly designed questionnaire; measuring lung function parameters to represent short and long term effects of exposure; and applying appropriate statistics to establish cause-effect relationships.The main aim of this paper is to promote studies across the country linking indoor air quality and health through standard protocols to generate data pertinent to our environment and help evolve an appropriate management strategy.

1. Introduction

Air quality of all the megacities of India has seen sharp deterioration in recent yearsdue to unbridled industrialization, unprecedented growth in the number of vehicles, huge energy consumption and indiscriminate burning of stubble and waste. Many people associate air pollution,only with urban outdoor environment, however, extremely high concentrations of pollutants, commonly occur in the indoor environment. Studies have shown that daily particulate doze to the urban Indian women from domestic cooking is comparable to the doze resulting from outdoor particulate exposure in places perceived as highly polluted (Varghese et al., 2005).

2. Indoor Air Pollution

Indoor air pollution (IAP) describes the generation and transport of pollutants inside a variety of interior environments, in which people live and work. These pollutants may be particles or gases that are released in the air inside buildings, due to tobacco smoke, paints, cleaning solvents, fuel combustion etc. Cooking is an important source of IAP. In urban India, LPG is predominantly used as a cooking fuel. On combustion, LPG emits significant amount of fine particles, NO_x, and several other pollutants. Indian cooking involves frequent frying and roasting, which also generates large quantities of inhalable vapors and aerosols.Emission of pollutantsin a kitchenis a function of type of food cooked, quantity of food cooked (in domestic kitchens or in commercial kitchensof restaurants/ hotels/ hospitals/hostels etc.), and cooking practices followed. Kaul*et al.* (2014a) have reported that commercial kitchens are important source of exposure due to prolonged concentrations of high PM and NO_x. They observed average concentrations of $PM_{1.0}$, $PM_{2.5}$, PM_{10} and NO_x as 130 ± 24, 250 ± 53, 557 ± 206 and 619.3 ± 336.5 μg/m^3, respectively, in the domestic kitchens monitored. It is desirable to remove these pollutants from the kitchen as soon as they are emitted. Flushing out of pollutants depends on location of the kitchen and ventilation provisions. The pollutants may accumulate in the kitchen in absence of adequate ventilation and may also disperse to other areas of the building(Tarun et al., 2003). Considering the high pollution load generatedfrom fuel and cooking practices as well as the long duration an individual spends indoors, IAP from LPG based cooking may have a significant effect on the health of themillions of exposed individuals.

3. Effect of Cooking

Large quantity of oil is used in Indian kitchens for preparation of various food items.The oil is normally used at high temperature or is applied on a very hot pan, which produces substantial concentration of fine particles. The concentration of Poly aromatic hydrocarbons (PAHs) in fumes from hot cooking oil is high and these may pose a serious cancer risk for exposed persons as reported by many researchers(Siegmann& Sattler, 1996;IARC, 2006; K*et al.*, 2000). This is of significant relevance in a country like India where deep frying forms a large component of daily cooking activity. This may also be of great concern for commercial

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kitchens with insufficient ventilation as large quantity of oil is heated for long durations. During roasting of chapattis/naan/tandoori rotis, especially in commercial kitchens, the cooks are continuously exposed to emissions from the stove for a long duration. Kaul*et al*. (2014a) have reported that making of *chapattis* in tandoorcauses the NO_x concentration to gradually elevate to 2957.2 μg/m^3 (1573 ppb).The concentration may be higher in absence of adequate ventilation. Peak concentrations of this magnitude may adversely affect the health of especially the susceptible individuals like asthmatics, and old personsFine PM from LPG combustion may carry toxins like Volatile Organic carbon (VOC) and PAH deep into the alveolar region of the lungs (Kleinman*et al.*, 1999; Espinosa *et al.*, 2001; Purvis *et al.*, 2003). It therefore, may exacerbate respiratory disorders like coughing and wheezing in exposed individuals. Large PM concentration in the indoor air is characterized by substantial organic fractions, which originate from both fuel and cooking practices.High CO levels may also persist due to incomplete combustion owing to the poor condition of the gas stove.

Provision of adequate ventilation in kitchens is very important as the dangers of prolonged or repeated exposure to elevated concentration of pollutants are high. Inadequate ventilation substantially increases the particle, NO_x and other gaseous pollutant concentrations during cooking period. These pollutants can readily diffuse to other indoor areas, thus affecting the health of the persons not directly exposed to such pollutants. The concentration of pollutants has been observed to vary widely with type of ventilation (natural/forced viz exhaust fan; chimney etc.), habits of using forced ventilation (used throughout the cooking activity or only when there is visible buildup of pollutants), efficiency/capacity of the ventilation, placement of the stove/burners with respect to the ventilation system provided (Kaul et al, 2016).

4. Consequences of Exposure to Kitchen Pollutants

Arbex et al. (2007) have suggested that 10 years of work as a cook using gas stoves may result in 20% decrease in lung functions.Their study has been conducted in hospital kitchens where no frying is done. In India, cooks are exposed to emissions from the burning of fuel as well as from cooking fumes and thus entail a possible risk of deleterious health effects in relatively shorter durations of exposure.

The deposition of particles is reported to be greater in persons with asthma than in healthy people (Chalupa*et al.*, 2004). High concentration of fine PM as observed in Indian kitchens, can be thus critical, in particular for compromised individuals.

5. Tools for Carrying out Health Studies

5.1 Questionnaire Survey

Questionnaires are the most commonly used subjective instrument of measurement in respiratory epidemiology. They represent a convenient tool of investigating large population samples, due to low cost, ease of employment for the investigator and good compliance of the investigated subject (Belliaet al., 2003). ATS-DLD (1978)is widely used for carrying out health survey to assess the impact of IAP on respiratory system. The questionnaire includes questions on prevalence of symptoms like cough, phlegm, wheezing and dyspnea and their persistence. The ATS-DLD has comprehensively designed the questionnaire for assessing the impact of air pollution on human respiratory system. It has provisions for eliminating the effects of predisposition to respiratory diseases, smoking history etc. to bring out the impact of pollution distinctly. Causal linkages are established through appropriate statistical manipulation of the data in terms of significance testing.A modified Hindi (Indian language) version of ATS-DLD 1978 has been designed and used byKaul*et al.*(2014b). It has been reported that IAP due to cooking has effects similar to those of smoking and it exacerbates one or more of the respiratory symptoms in cooks, irrespective of age, gender or place of work.It has also been suggestedthat lung impairment associated with indoor pollutant exposure may be asymptomatic for a prolonged period, masking the extent of ill health from this cause and contributing to under reporting of respiratory symptoms.

6. Spirometer

The most widely used non-invasive test of ventilatory functions is used to assess the properties of pulmonary system of the exposed individuals by measurement of the dynamic or respired lung volumes and capacities. The measurements taken during the spirometry are FVC, FEV1 and FEV1/FVC ratio. Spirometric measurement is critical to the diagnosis and management of asthma, COPD and restrictive lung disease, developed as a result of environmental pollution, smoking or occupational exposure (Pierce, 2005). All the lung function parameters can be measured among the two populations, cooks (affected) and non cooks (control), to assess the effects on human physiology due to exposure. Using spirometry,Kaul (2011) has observed that higher exposure to fine particles in indoor environment among cooks in urban and rural areas results in increase in prevalence of respiratory symptoms as well as impairment of pulmonary function parameters compared to their non-cook counterparts. The lung function parameters of cooks and non-cooks show a significant difference in the two populations with non cooks showing better values. Average values of FVC % predicted, FEV_1% predicted and FEV_1/FVC % are 82.6±17.2, 90.6±20.0 and 89.4±9.2, respectively for cooks and 86.2±17.9, 93.7±18.8 and 90.9±7.2, respectively for non-cooks. Spirometry should be conducted for workers, who are above 40 years of age, on a regular basis for diagnosis and early detection of chronic obstructive pulmonary disease (COPD). Measurement of PEFR before and after short exposures to pollutants and assessing its variability may help diagnose susceptible individuals and enable them devise a plan for prophylactic doses for their health management(Singh et al, 2003).

7. Data handling

Statistical handling of data on human subjects is tricky as the physiological response involves high individual variability. Choosing an appropriate data size, removal of outliers from the populations to be compared, conducting lung functions tests on children and old subjects etc are especially challenging. Adopting proper significance testing procedures and fitting data to develop cause-effect relationships are equally difficult as the human response to any exposure is generally non linear and hence a multi disciplinary team of doctors, environmental scientists and statisticians is required to derive meaningful output from such studies.

8. Conclusion

The magnitude of IAP in urban kitchens is largely under-perceived. Normally, exposure to only solid fuels like wood, dung etc. is believed to be deleterious to health butactually, the pollutants emitted duringLPGcombustion also represent a significant source of daily exposure to the workers. Further, cooking practices and inadequate ventilationcontribute to elevated concentrations of pollutants in the indoor air. The exposed individuals suffer from increased respiratory disorders due to prolonged exposure and high concentrations of pollutants. Thus,for understanding the preventive aspects of air pollution, a proper knowledge of sources, generation of pollutants from them, as well as the ventilation that helps pollutant dispersion have to beassigned their due importance.

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