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RESPIRATORY HEALTH EFFECTS DUE TO USE OF SOLID BIO FUELS IN RURAL AREAS OF RAJASTHAN

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ABSTRACT

The use of unprocessed solid bio fuels and inadequate natural ventilation in rural households gives rise to high levels of indoor air pollutants. The cooks, mainly women are discriminately affected due to exposure to this. In this study, we report an analysis of incidence of respiratory disorders of cooks (n=90), in comparison to non cooks (n=94) based on the data collected from rural areas of Jaipur district, Rajasthan, India. The diagnostic and symptomatic tools were conjunctively used to assess the respiratory disorders. The cooks have been found to have reduced pulmonary response and higher symptomatic respiratory dysfunctions.

KEYWORDS: Female Cooks, Respiratory Health, Solid Bio Fuels, Spirometry

INTRODUCTION

In India 166 million households (67%) use solid bio fuels for their cooking needs (Census of India 2011; Global alliance for clean cook stoves,2013) and in Rajasthan 76% households use solid bio fuels . The combustion of solid fuels produces smoke, which is potentially harmful as it contains a mixture of hazardous pollutants like particulates, CO, benzo[a] pyrene, formaldehyde, nitrogen-di-oxide (NO2), polycyclic organic compounds and metals such as arsenic (Lissowska et al., 2005). Domestic cooking is an important source of house hold air pollution and is associated with significant respiratory morbidity and mortality (ICMR, 2001; Boman et al., 2003).

In rural households there is a predominant use of unprocessed non commercial solid bio fuels mainly comprising crop residue , dung cakes , wood etc. (Laxmi et.,al,2003). The elevated household air pollution due to combustion of such fuels is well established (Balakrishnan, 2004). The close linkages of pollutant exposure and its ill effect on health have been reported in many studies. Respiratory symptoms like cough, phlegm, breathlessness are more frequent among the people who live or work near the emissions source and are exposed to higher concentration of pollutants (Jain et. al., 2003). The parameter of lung capacity, peak expiratory flow rate (PEFR) has also shown significant reduction in exposed individuals due to short term exposures to indoor or outdoor pollutants (CSE, 2004; Jain et al., 2003). Greater risk of developing asthma exists due to genetic changes brought on by pollution and acquired in the womb (Perera et al., 2009).

The Global Burden of disease study (WHO, 2012) has identified 15 risk factors for the most disease burden. In India the household air pollution (HAP), mainly due to use of solid fuels and ambient particulate matter are the 2nd and 7th causative factors respectively. Further lower respiratory infection is amongst the top three factors for disability adjusted life years (DALY).

The respiratory health of cooks in rural areas has mostly been reported based on symptomatic studies; however the literature on physiological diagnostic studies is limited. The present study was therefore carried out to assess the respiratory status using spirometry as the diagnostic tool and conjunctively collecting the responses in a structured

questionnaire adapted from American Thoracic Society (ATS) as a symptomatic tool for both cooks (n=90) and non cooks (n=94) to bring out the differences due to pollutant exposure arising due to solid bio fuels during cooking activity using statistical techniques.

MATERIALS AND METHODS

Study Locale and Description of the Rural Houses

The study was carried out in rural areas of Jaipur district, Rajasthan at places with least intervention of extraneous pollution. The rural houses kitchen configuration fall in following four distinct categories. (Balakrishnan,2004); a) Houses with kitchen inside the main living area ;b) Kitchen partitioned from the main living area though a part of the main living room; c) separate kitchen outside the house; and d) open type kitchen.

The study has been carried out in all the above categories of houses except partitioned kitchen as the same were not found in the study local.

Symptomatic Assessment

Questionnaires based assessments are the most commonly used subjective instrument in respiratory epidemiology studies. They provide an easy analytical framework tool for investigating large population samples, with comparatively marginal cost, and provide an ease of employment by the investigator and simultaneously good compliance of the investigated subject (Bellia et al., 2003). The modified Hindi language version of questionnaire adapted from American Thoracic Society (ATS), Division of Lung Disease (DLD) categorised as ATS-DLD-1978 has been designed and used for carrying out health survey of the subjects. The ATS-DLD has comprehensively designed the questionnaire for assessing the occupational aspects and impacts 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 on respiratory disorders.

Diagnostic Assessment

Recorder & Medicare Systems (RMS), India, Portable Spiro meter Model 701 was used for measuring the pulmonary functions. It is a portable diagnostic machine, which can measure the Forced Vital capacity (FVC), Peak exhilaration flow rate (PEFR), Flow exhilaration volume during 1 sec of manoeuvre (FEV1) and the ratio of FEV1 to FVC besides other pulmonary parameters. The subject's anthropometric measurements such as height, weight and smoking habits are first configured in the instrument and after conduction of the spirometry test the instrument indicates the values as predicted values of the above critical parameters. The analysis of the parameters is done based on the recommended values of the parameters by American Thoracic Society.

Spirometry is a physiological test that measures inhalation and exhalation volumes of air as a function of time. (Miller et.al., 2005). Spirometry is a valuable screening test for general respiratory health assessment used internationally (Global initiative for COPD, 2013). Spirometric measurement is essential for the diagnosis and management of impaired lung functions due to environmental pollution, smoking or occupational exposure. (Pierce, 2005).

One of the most important aspects of spirometry test is the forced vital capacity (FVC) which is the maximum volume of the air delivered during expiration with a forceful manoeuvre and completely as possible after full inspiration. The forced expiratory volume (FEV1) is the volume of air exhaled in 1 second of an FVC manoeuvre. The ratio of FEV1 to FVC is another important assessment parameter for the lungs capacity as reduction of this ratio from expected values is specific for obstructive rather than restrictive respiratory diseases.

Statistical Analysis

The Statistical Package for Social Science (SPSS) version 18.0 has been used to ascertain that causal linkages are established through appropriate statistical analysis of the data in terms of significance testing between the symptomatic and the diagnostic parameters for corroborating the incidence of respiratory disorder amongst cooks due to higher exposure to pollutants during cooking activity using unprocessed solid bio fuels.

RESULTS AND DISCUSSIONS

The respiratory health symptomatic questionnaire was administered on cooks (n=90) and non cooks (n=94). The spirometry was consecutively carried out on all the subjects. Table 1 gives the distribution of the subjects according to the age.

Table 1: Frequency Distribution of Subjects According to the Age

Age Group (Years)	Cooks	Non-Cooks	Total
< 25	28	28	56
25-40	29	39	68
>40	33	27	60
Total	90	94	184

The percentage distribution of the four significant symptoms; wheezing, coughing, phlegm and dyspnoea as per age and within cooks and non cooks is summarised in Figure 1.

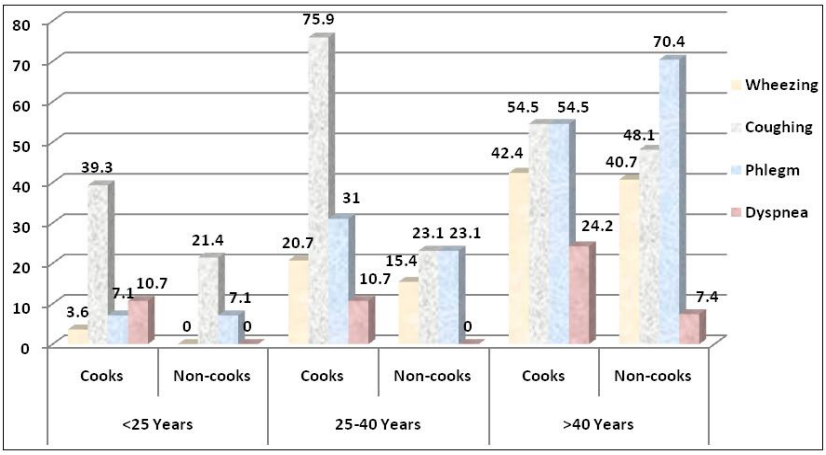

Figure 1: Incidence of Respiratory Disorders in Different Age Groups

In the subject group of the study all the cooks were females. The incidence of cough is the highest in case of cooks in the age group 25-40 years. In all the four respiratory symptoms the incidence is more among cooks in all age groups compared to non cooks except for the prevalence of phlegm in the age group above 40 yrs in case of non- cooks. The higher percentage of incidence of reported symptoms clearly reflects the adverse effects of pollutants on cooks compared to non cooks. The use of unprocessed solid fuels produces a large fraction of fine particles (PM2.5-1) besides the coarse particles (PM10-2.5). The fine fraction of particulate matter (PM) has the capability to penetrate in the lower region of the respiratory system. The coarse particulate matter is also significantly produced with the use of unprocessed solid bio-fuels, the deposition of such particles is mainly in the extra thoracic region of the respiratory system and coughing is one of the outcomes, which have been found at a very high percentage in cooks. The deposition of fine particles and their manifestation in respiratory disorders comparatively relates to long term exposure effects due to such pollutants. Table 2 A shows the statistical analysis of all the subjects in different age groups based on reported respiratory symptoms, while Table 2 B shows the analysis based on lung function parameters.

Table 2 A: Comparison of Cooks and Non-Cooks Based on Respiratory Symptoms

Respiratory Symptoms	<25 Years			25-40 Years			>40 Years		
	Cooks (N=28)	Non-Cooks (N=28)	P Value	Cooks (N=29)	Non-Cooks (N=39)	P Value	Cooks (N=33)	Non-Cooks (N=27)	P Value
Wheezing	3.6	0	0.50 (NS)	20.7	15.4	0.40 (NS)	42.4	40.7	0.55 (NS)
Coughing	39.3	21.4	0.12 (NS)	75.9	23.1	0.00** (S)	54.5	48.1	0.40 (NS)
Phlegm	7.1	7.1	0.69 (NS)	31.0	23.1	0.32 (NS)	54.5	70.4	0.16 (NS)
Dyspnea	10.7	0	0.12 (NS)	10.7	0	0.12 (NS)	24.2	7.4	0.08 (NS)

NS = Non Significant, Significant at 0.01 level**

Table 2 B: Comparison of Cooks and Non-Cooks Based on Lung Function Parameters

Lung Function Parameter	<25 Years			25-40 Years			>40 Years		
	Cooks (N=28)	Non-Cooks (N=28)	P Value	Cooks (N=29)	Non-Cooks (N=39)	P Value	Cooks (N=33)	Non-Cooks (N=27)	P Value
FEV1/FVC	85.79	91.09	0.00**	83.73	91.07	0.00**	77.80	87.11	0.00**
FVC%	82.02	87.69	0.08 (NS)	78.67	87.07	0.04*	70.12	72.42	0.56 (NS)
FEV1%	90.65	89.47	0.66 (NS)	87.56	92.07	0.10 (NS)	82.93	77.75	0.13 (NS)

NS = Non Significant, Significant at 0.01 level**

Though the percentage of incidence of all respiratory symptoms is more in case of cooks compared to non-cooks (Figure 1), the difference is significant in case of cooks only for coughing symptom. The difference of lung function parameter FEV1/FVC is also significant amongst cooks in all age groups. The factor FEV1/FVC if less than 70% of the predicted value, indicates prevalence of distinctive obstructive respiratory disorders. There is a significant difference between the cooks and non cooks based on the comparison of values in respective age groups. The lower values though not critical at this stage however indicate effects of long term exposure of pollutants on the cooks compared to non cooks and need for corrective action to prevent severe respiratory disorders. In a case study (Sumer et.al., 2004) a highly significant reduction was observed in cooks in all lung parameters for a comparison between dung cake users and modern LPG users belonging to non smoker category.

The comparison between cooks and non cooks is mostly statistically insignificant at 95% CI for respective comparisons between different sub categories such as smokers-non smokers, respective symptoms; wheezing, coughing, phlegm, dyspnoea and type of houses. However the difference is significant in the diagnostic parameters. Table 3 depicts the comparison of lung function parameters of the complete group of cooks and non cooks.

Table 3: Average Value of Lung Function Parameters of All Subjects

Lung Function Parameters	Cooks(N=90)	Non-Cooks(N=94)	Z Value
FVC% Predicted	76.58±12.25	83.05±15.84	0.84(NS)
FEV1% Predicted	86.82±7.31	87.18±15.91	0.00**
FEV1/ FVC (%)	82.19±7.48	89.94±8.26	0.00**

NS = Non Significant, Significant at 0.01 level**

There is a high level of significance between the lung function parameters FEV1 and the ratio FEV1/FVC. The average values of these parameters of cooks are lesser than those of non cooks. The average values difference clearly

indicates the difference due to short term and long term exposure due to pollutants. In themselves, these values are not critical at this stage however on persistent exposure these may result in severe chronic respiratory disorders.

CONCLUSIONS

Our study showed that the incidence of respiratory disorders is more in cooks as compared to non cooks in rural households that use unprocessed solid bio fuels for cooking practices. The percentage of the symptomatic factors; wheezing, coughing, phlegm and dyspnoea is more in cooks. The measured lung function parameters through spirometry of all subjects also indicate significantly lower values in case of cooks compared to non cooks. It is also recommended that necessary interventions at this stage to reduce pollutant exposure due to solid bio fuels can prevent further deterioration of the pulmonary functions of the cooks.

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