Household air pollution and lung function in Indian adults: a cross-sectional study

Mona Dave [1], Anand S Ahankari [1, 2], Puja R Myles [1], Perianayagam Arokiasamy [3], Uttamacharya [3], Pranali Khobragade [3], Kevin Mortimer [4], Andrew W Fogarty [1]

Affiliations

1 Division of Epidemiology and Public Health, University of Nottingham, Clinical Science Building, Nottingham, NG5 1PB

2 Halo Medical Foundation, India

3 International Institute for Population Sciences, India

4 Liverpool School of Tropical Medicine, Liverpool, UK

Corresponding author

Dr Andrew Fogarty, Division of Epidemiology and Public Health, University of Nottingham, Clinical Science Building, Nottingham, NG5 1PB
Andrew.Fogarty@nottingham.ac.uk

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Summary

Exposure to air pollution produced by cooking is common in developing countries, and represents a potentially avoidable cause of lung disease. Cross-sectional data were collected by the WHO-SAGE study in India between 2007 and 2010. Exposure to biomass cooking was also associated with a decrease in FEV_1 in one second (-70ml; 95% CI: -111 to -30) and FEV_1/FVC ratio (-0.025; 95% CI: -0.035 to –0.015) compared to those who were not exposed. These associations were predominantly observed in males ($p < 0.05$ for interaction analyses). Intervention studies using non-biomass fuels in India are required to ascertain potential respiratory health benefits.

Background

Three billion people around the world use dirty-burning fuels to provide energy for their day-to-day cooking, heating and lighting needs [1]. Four million people die every year from diseases caused by household air pollution from the burning of these fuels in or around the home environment. The major adverse health effects attributed to household air pollution are pneumonia in children and cardiovascular and chronic pulmonary diseases in adults. The Global Burden of Disease Study estimated that household air pollution is the second highest risk factor for the total burden of disease in India. However, there are few population-based studies of the association between exposure to household air pollution and lung function in India. There is a particular need for information about household air pollution and the risk of chronic lung disease in rural India which is where 68% of the 1.3 billion population live and most are dependent on the use of biomass fuels for cooking [2].

Methods

We used cross-sectional data that were collected from India as part of the World Health Organization's Study on Global Ageing and Adult Health (WHO-SAGE [3]) to test the hypotheses that exposures to biomass fuel, poor ventilation or cooking in a communal living space are associated with decreased lung function. Data were used from 'Wave 1' collected in India by 2007 [4 5]. Briefly, study participants were randomly selected and data were collected on a range of health and well-being indicators at both individual and household levels, from adults aged ≥18 years. Forced Expiratory Volume in one second (FEV_1) and Forced Vital Capacity (FVC) were measured using a Medical International Research SpiroDoc Diagnostic Portable Spirometer. Measurements were taken with the participant sitting down, and after one trial involving maximal inhalation and exhalation, three lung function measurements were recorded, and the highest value selected for

analysis. Linear regression was used to investigate the associations adjusting for potential confounding factors using robust standard errors to allow for clustering by household using Stata Statistical software (v13.1, Texas, USA). The study received approval from an Ethics Committee and all participants gave informed consent.

Results

The response rate was 92% for the individual questionnaires and 88% for the household level questionnaires. Of the 12128 individuals surveyed, 7639 (63%) provided lung function data for analysis (Table). The population is predominantly rural (74%), and female (61%), with the commonest cooking fuels being wood (58%) and gas (25%). 12% of the population cooked in the living space and 82% had no hood or chimney to vent emissions.

The use of biomass fuels (Table 1) was associated with a decrease in FEV_1 in one second (-70ml; 95% CI: -111 to -30) and FEV_1/FVC ratio (-0.025; 95% CI: -0.035 to – 0.015) compared to those who used electricity or gas. This association was predominantly observed in males ($p < 0.05$ for interaction for both analyses). There was no association between the use of biomass fuels and FVC. There was no association between the presence of ventilation or cooking in the living space with lung function.

Discussion

This large study conducted in six Indian States found that exposure to biomass fuel is associated with a decrease in lung function with an obstructive pattern that is larger in males than females. These data are broadly consistent with another study from Maharashtra State, India, which reported the association between cooking fuels and respiratory health in 1156 individuals [6]. In this study a higher risk of respiratory symptoms was observed in females who used agro-waste compared to baseline, and lower FEV_1 and FVC in women who lived in houses that used agro-waste and wood, and men who lived in wood-using houses. A study of 760 non-smoking women from Maharashtra State reported higher prevalences of chronic bronchitis and lower peak expiratory flow rates in those who cooked using biomass fuels compared to those who did not [7].

Data from outside India are consistent with our data. In rural women who live in Mexico, the use of biomass fuels was associated with increased rates of phlegm production and reduced FEV_1/FVC ratio compared with gas cooking [8]. An intervention study in Guatemala used chimney woodstoves, and reported a decrease in wheeze and respiratory symptoms,

but not lung function after 18 months [9]. The introduction of a biomass stove intervention in rural Mexico was associated with fewer respiratory symptoms and lower decline in lung function over the following year [10].

The strengths of our data are the systematic data collection with lung function from a relatively large population of adults in six Indian States. The high proportion of individuals who live in a rural community is informative, as these constitute a difficult to reach population, who represent those most at risk from air pollution secondary to cooking. The limitations of these data include the availability of lung function data in 63% of the sample, and hence we are unable to exclude the possibility of self-selection bias such as females with worse lung function not providing data. However, with the exception of a higher number of females who provided lung function data compared to males, the population of those who provided lung function data was similar to those who did not. We did not have validated reference values of lung function in this heterogenous population, and the high prevalence of exposure to biomass fuels would make definition and interpretation of normal values challenging. In addition, the impact of biomass fuels on respiratory health will vary across populations as the composition of biomass fuels can be expected to vary according to location, as may the susceptibility of both individuals and hence populations to air pollution.

In conclusion, these data demonstrate an association between the use of biomass fuels and decreased lung function with an obstructive pattern. The association is greater in men, which was surprising, as in Indian culture the cooking is generally done by women suggesting that other lifestyle factors associated with biomass cooking may also be important. This requires closer observation using prospective studies of change in lung function in similar populations.

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Table 1. Association between cooking fuel, ventilation and location with lung function

Descriptive variables	**No lung function data N=4489**	**Lung function data available N=7639**	
Number of Males (%)	1512 (34)	3167 (41)	
Mean age (years)	50.9 (17.8)	49.4 (16.1)	
State of residence (%)			
Assam	387 (9)	802 (10)	
Karnataka	790 (18)	954 (12)	
Maharashtra	912 (20)	1303 (17)	
Rajasthan	784 (17)	1590 (21)	
Uttar Pradesh	814 (18)	1577 (21)	
West Bengal	802 (18)	1413 (18)	
Rural area of residence	3345 (75)	5651 (74)	
Height, m (sd)	1.54 (0.10) N=3298	1.57 (0.09) N=7620	
FEV_1, L, (sd)	-	1.57 (0.75)	
FVC, L, (sd)	-	2.16 (1.08)	
FEV1/FVC	-	0.75 (0.18)	
Ever used tobacco, %	1416 (40) N=3521	2370 (43) N=7638	
Main cooking fuel	N=4486	N=7637	
Gas	1047 (23)	1937 (25)	
Electricity	5 (0.1)	6 (0.1)	
Kerosene/paraffin	43 (1)	94 (1)	
Coal/charcoal	89 (2)	188 (2)	
Wood	2653 (59)	4340 (57)	
Agricultural residue	348 (8)	552 (7)	
Animal dung	348 (5)	402 (5)	
Shrubs, grass	231 (1)	113 (1)	
Other	3 (0.1)	5 (0.1)	
Association of exposure to air pollution with lung function			
	Biomass fuel* for cooking (95% CI)	No chimney/hood (95% CI)	Cooking in living space (95% CI)
No. exposed (%)	5689 (75)	4669 (83)	631 (11)
FEV_1 (ml)			
All	**-70 (-111 to -30)**	-19 (-76 to +37)	+33 (-30 to +97)
Males	**-145 (-210 to -79)****	-43 (-136 to +49)	+39 (-64 to +141)
Females	-13 (-63 to +37)	-6 (-73 to +61)	+34 (-42 to +111)
FVC (ml)			
All	-10 (-70 to +49)	+7 (-86 to +100)	+38 (-55 to +130)
Males	-56 (-138 to +26)	-71 (-201 to +58)	+12 (-125 to +150)
Females	+29 (-50 to +107)	+62 (-64 to +189)	+56 (-68 to +179)
FEV_1:FVC			
All	**-0.025 (-0.035 to -0.015)**	-0.007 (-0.023 to +0.008)	-0.001 (-0.017 to +0.014)
Males	**-0.038 (-0.053 to -0.024)****	+0.004 (-0.016 to +0.025)	+0.001 (-0.023 to +0.024)
Females	**-0.015 (-0.029 to -0.002)****	-0.016 (-0.038 to +0.005)	-0.001 (-0.022 to +0.021)

Bold = p <0.05

* Biomass fuel defined as all fuel except gas and electricity.

** $p < 0.05$ for interaction between sex and exposure.

CI = confidence intervals

Biomass fuels compared with gas and electricity as reference group.

Linear regression model beta co-efficients adjusted for age in categories, sex, Indian State of residence, height and tobacco usage with robust standard errors used to allow for clustering by household

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