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Lung Function Among Improved and Traditional Cooking Stove Users

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Lung Function Among Improved and Traditional Cooking Stove Users

Abstract

Introduction: Indoor air pollution is a major cause of respiratory problems in developing countries. Cooking stoves in the kitchen could be an important factor. This study compares the effect of the traditional cooking stove and the improved cooking stove on the respiratory health of women.

Methods: A comparative evaluation was done among traditional cooking stove (TCS) users and improved cooking stove (ICS) users. Lung function parameters such as FEV_1, FVS, PEF were measured using a portable spirometer. The findings were correlated with the type of cooking stove used.

Results: Among 123 participants, 67(54.5 %) were ICS users and 56 (45.5 %) were TCS users. The mean age of TCS users was 34.7 years and that of ICS users was 32.9 years. Eleven (19.5%) TCS users and seven (12.4%) ICS users had abnormal lung function. The mean FVC was 3.25±0.46 litres for ICS users and 3.24±0.51 liters for TCS users. Likewise, FEV_1 was 2.69±0.36 litres for ICS users compared to 2.61±0.46 liters for TCS users. FEV_1/FVC was 0.83±0.06 for ICS users compared to 0.80±0.06 for TCS users. Overall, there was no significant difference between the two groups.

Conclusions: There was no substantial difference in the lung function of ICS and TCS users.

Introduction

Indoor air pollution (IAP) is rated as a major risk factor for morbidity and mortality after malnutrition, unsafe water and sanitation in the developing countries.1 Usually, women and children are exposed more to kitchen smoke, which has been linked with many health problems.2,3 Studies have shown that smoke exposure due to incomplete combustion of solid biomass fuel use is associated with chronic obstructive pulmonary disease (COPD) and lung cancer in women, and acute lower respiratory infections (ALRI) in young children.4-6 It is estimated that globally, 22% of COPD cases can be attributed to indoor smoke from solid fuels. The number of cases rises to 40-45% for women in developing countries.7

Most rural populations in Nepal still use solid fuels for daily cooking and heating, making them more vulnerable to the adverse effect of indoor smoke. Improved cooking stoves (ICS) promoted by the Alternative Energy Promotion Centre/Energy Sector Assistance program (AEPC/ESAP) is a healthier biomass energy technology in Nepal.8 ENPHO's research, which monitored ICS for AEPC/ESAP, showed significant reduction in Indoor air pollutants (Particulate matter less than 2.5 micrometer in diameter (PM2.5) and carbon monoxide (CO). The health survey indicated a low prevalence of key respiratory symptoms among women users. But accurate evaluation of the health impact requires quantitative assessment of health indicator, associated with the change in smoke exposure. To strengthen the evidence for a health impact relating to Indoor smoke, this cross section study measured lung function among women using both traditional and those using improved cook stoves.

Methodology

This experimental study is a small module of the main study "Follow-up Monitoring of Environmental and Health Benefits and Performance of ICS" conducted by the Environment and Public Health Organization8. The main objective of the follow up monitoring was to estimate pre-post ICS concentration of PM2.5 and CO. The 24 hour monitoring was conducted once during TCS use and again one year after the installation and use of ICS, in three districts of Nepal from January to March 2009.

The three study areas include Mabhu Village development committee (VDC) Ilam, Rampur VDC Dang and Boch VDC Dolakha, representing mid-hill, Inner Terai and the high hill geographical region as well as with varying ethnography. Mabhu VDC in Ilam has a mostly Gurung and Sherpa women only, in contrast to Chaudhari women in Rampur VDC in Dang and Tamang in Boch VDC Dolakha. The Social Mobilizer from the Regional Renewable Energy Support Centre (RRESC) of AEPC/ESAP in each site assisted in selecting TCS and ICS users meeting the

selection criteria. Since the sampling is based on the maximum possible number available, the sample number in each site is not equal.

Two groups were identified for the study. Current ICS users that have used ICS for at least one year or more were categorized as cases. Current ICS users below one year of use were excluded from this study. Current TCS users with no ICS intervention yet and using biomass fuel only were categorized into controls. Users with existing health problems were excluded from the study. The criteria also include users involved in regular cooking activities. All the participants including past or present smokers were included in the study. The lung function test was carried out one time in each of the case and control group.

For the lung function test, women were asked to forcefully exhale at least three times to get acceptable and reproducible data. All subjects were tested in the standing position. Women who had smoked one hour prior to the test, or consumed alcohol within 4 hour of testing, or had recently performed rigorous exercise or had eaten a heavy meal were excluded from taking the test. The test was carried out mainly during morning hours, just before the morning meal in an enclosed surrounding. Before taking the test, the lung function team shared their objective for the test with the participants, showed the ways to perform the test and responded to the user's querries about the test. Only after sharing the information and getting the verbal consent, the test was carried out.

The lung function parameters were measured using a portable spirometer, Easyware V2.2 (NDD, Zurich Switzerland) and tests were conducted referencing the guidelines of the American Thoracic Society.9 Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1) and Peak Expiratory Flow (PEF) were the key parameters measured and compared between the cases and the control. The lung function test was accompanied by a brief questionnaire relating to the respondents' respiratory history and prevalence of respiratory symptoms. The Spirometer was in a calibrated state prior to the test, and consequently daily calibration was not conducted.

FEV1, FVC less than 80% of predicted and FEV1/FVC more than 80% of that predicted were taken as suggestive of restrictive lung disease. Likewise, FVC more than 80% of that predicted with FEV1, FEV1/FVC less than 80% of that predicted suggested obstructive lung disease. Mean difference of different FVC, FEV1 and PEF were also conducted.

Analysis was conducted using statistical tool SPSS 13.0. General central tendencies, cross tabulation, and T-tests were conducted to detect any significant differences among cases and control.

Results

A total of 123 women were tested from three study sites. There were 67 ICS (54.5 %) and 56 traditional cooking stove (TCS) (45.5 %) users. Out of 123 women, 54 (43.9 %) were from Ilam, 40 (32.5 %) were from Dolakha and the remaining 29 (23.6 %) from Dang. Among ICS users, 47 (70%) of the women had been using ICS for a year. Likewise 12 users (17.9%) were found who had used ICS for 2-4 years and the remaining had been using ICS for 4-6.5 years. Similarly, 23 (41.1 %) of the TCS users had been using TCS for more than 20 years, 19 (33.9 %) for between 10-20 years and the remaining less than 10 years.

The majority of the participants were between 20-29(32.5%) and 30-39 (26.5%) years of age. The mean age of TCS users was 34.7 and that of ICS users was 32.9 years. Likewise, the groups were similar in terms of literacy status and age group distribution (not reported here). The TCS and ICS users had a Body Mass Index (BMI) of 20.7±2.8 and 21± 3 kg/m2 respectively.

Besides differing in their socio-economic condition, cultural and traditional practices, there was a distinct difference in kitchen structure and ventilation status in the kitchens in three of the research sites and consequent IAP measurements in both ICS and TCS were influenced by that8. Better ventilation was a key aspect of the kitchens in Ilam in contrast to the relatively poor ventilation in Dolakha. As a result, the study reported higher 24 hr mean Indoor air pollutants (IAP) levels for ICS and TCS in Dolakha compared to Ilam and Dang.

Eleven cases were eliminated from further analysis among the ICS group due to mixed ICS and TCS for daily use (termed as mixed users) leaving the total sample to n=112. The majority of the ICS (49, 87.5%) and TCS (45, 80.4%) users were found to have normal lung function. A single case (1.8 %) of restrictive lung function was found in each stove type category. However, 10 TCS users (17. 9%) were identified with obstructive lung function, as compared to 6 ICS users (10.7 %).

The number of smokers in the cases (previous, current) were 25 out of 123 (20.3 %) thus, excluding these, the total sample size was reduced to 87, with 43 ICS and 44 TCS users.

The number of smokers in the cases (previous, current) were 25 out of 123 (20.3 %) thus, excluding these, the total sample size was reduced to 87, with 43 ICS and 44 TCS users.

Table 1 shows a very similar number of instances of higher obstructive lung function in TCS (7, 15.9 %) in comparison to ICS users (3, 7.0 %) after eliminating smokers. Users in both categories have same prevalence of restrictive lung function, but normal lung function is relatively higher in ICS.

The analysis of lung function parameters (FEV, FVC) also excluded the mixed user and smokers cases. The result of the analysis after eliminating smokers and mixed users are shown in Table 2.

Overall, the difference in most of the parameters, between ICS and TCS users, is marginal. Independent T tests showed that there is no significant difference (P>0.05) in mean values of FVC, FEV1 and PEF at 0.05 levels of significance. The mean value in FVC and FEV1 is 6 and 81 ml higher in ICS users respectively. A significant difference was found in the mean FEV1/FVC ratio (P<0.03). This is the only indicative parameter showing better lung function in ICS than TCS users. PEF was better in ICS users by 363 L/S. Higher values in FVC, FEV1 and PEF could be a possible indication that their lung function is comparatively better than TCS users. A typical exhalation showing volume against the flow rate test of ICS and TCS user is shown in Figure 1 and 2. The figure also indicates higher FEV1 for ICS users.

Overall, a total of 34 cases (27.6%) of COPD and 47 cases (38.2%) of asthma was identified from the total sample size of 123. Eliminating the cases of mixed users and smokers (previous and current), the results showed a total of 19 cases (21.8 %) of COPD and 26 cases (29.9%) of asthma from a total population of 87. Nine cases (20.9 %) of COPD and 11 cases (25.6%) of asthma were identified among the ICS users, and 10 cases (22.7 %) of COPD and 15 cases (34.1%) of asthma were identified among the TCS users.

A non-significant (p>0.05) odds ratio for COPD and Asthma was estimated between TCS and ICS users. The odds ratio was 1.2 and 1.9 times higher in TCS users than ICS users for COPD and Asthma respectively.

Discussion

Except for FEV1/FVC, the comparison of lung function parameters such as FVC, FEV_1, and PEF showed no significant differences between the ICS and TCS users. The characteristically similar lung function parameters between the two groups may also indicate that either improvement in the lung function requires a longer duration than a year or the damage to the lungs due to the history of high smoke exposure has rendered irreversible damage to the lung among the current ICS users.[10]

Comparative studies on lung function in international studies have found no significant change or slight change in the lung function parameters between traditional biomass and non-biomass users[10-12]. Similarly, the Patasari stove intervention study in Mexico has also shown the decline in the value of lung parameter was less in users as compared to non-users, with reduction only in FEV_1.[13]

All of these lung function studies indicate that the reduction of Indoor air pollution levels brought about by ICS intervention does not necessarily correlate with a significant change in the lung function of the users. Also, absolute values in the IAP level even after intervention including[8] are still higher than the guideline values of the World Health Organization (WHO) in many of the studies.[14] This may have rendered the reduction in lung function to a non-significant value.[11] The IAP value of ICS reported after one year of intervention in the ENPHO study was 762 µg/m^3 for $PM_{2.5}$ which was significantly lower (p=0.000) than the TCS of 2068 µg/m^3.[3, 8] But still this value is substantially higher value than the WHO guideline value of 25 µg/m^3.[14] This may limit the detectable difference among women.[11] Another point of argument is the variation observed in the kitchen and personal exposure in an indoor kitchen environment. It is suggested that a wide variation between the type of kitchen and degree of personal exposure might play a different role according to a particular intervention.[15, 16, 17] Therefore, personal exposure might play a clarifying role in many studies conducting respiratory assessment related to healthier biomass intervention.

To strengthen the evidence and quantify the health benefits accruing from use of ICS in Nepal, a more rigorous and long term study is necessary. IAP data on personal exposure in addition to kitchen concentration needs to be estimated to consolidate any possible correlation between IAP reduction by ICS and improvement in lung function parameters. Likewise, use of bio-markers can be another effective tool for showing a meaningful relation between IAP reduction and a change in health impact. As of now, such biomarkers have not been tried in the Nepalese population.

Conclusions

The improved cooking stove promoted by AEPC/ESAP has been a successful intervention in reducing the kitchen indoor concentration of $PM_{2.5}$ and

CO significantly, but still it is far from the WHO guideline values. This cross-sectional examination of lung function of TCS and ICS users did not find a substantial difference in key lung function parameters besides the FEV_1/FVC ratio.

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Illustrations

Illustration 1

Table 1. State of Lung Function in TCS and ICS users

Table 1

	Normal	Restrictive	Obstructive
ICS	39	1	3
	90.70%	2.30%	7.00%
TCS	36	1	7
	81.80%	2.30%	15.90%
Total	75	2	10
	86.20%	2.30%	11.50%

Illustration 2

Table 2: Mean Values Lung function parameters after excluding smokers and mixed users

Table 2	ICS (N=43)				TCS (N=44)				Difference in means	P value (t-test)
	Mean (*)	Median	95 % Cl. interval	Min.-Max.	Mean	Median	95 % Cl. interval	Min.-Max.		
FVC (lts)	3.25 (0.46)	3.13	3.11-3.40	2.36-4.47	3.24 (0.51)	3.08	3.09-3.40	2.33-4.25	6 ml	>0.05
FEV_1 (lts)	2.69 (0.36)	2.61	2.59-2.81	2.0-3.70	2.61 (0.46)	2.58	2.47-2.75	1.48-3.49	81ml	>0.05
Ration(FEV_1/FVC)	0.83 (0.06)	0.85	0.81-0.85	0.72-0.95	0.80 (0.06)	0.81	0.78-0.82	0.64-0.92	30	<0.05
PEF (L/S)	6.46 (1.00)	6.71	6.21-6.79	4.78-8.19	6.09 (1.27)	6.22	5.70-6.48	3.20-9.20	363 L/S	>0.05

(*)Standard deviation, Lts: liters

Illustration 3

Figure 1

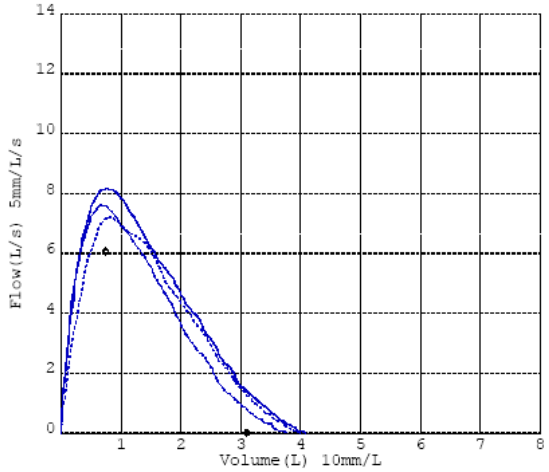

Figure 1. A Typical Volume Vs Flow rate from Lung function in the ICS user

Illustration 4

Figure 2

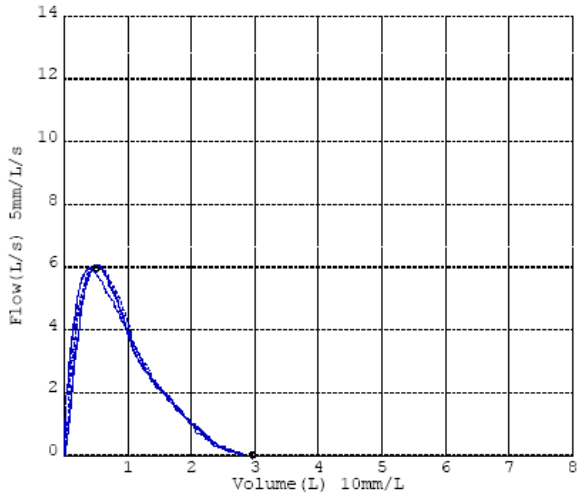

Figure 2. A Typical Volume Vs Flow rate from Lung function in TCS user

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