HEALTH EFFECTS OF BIOMASS FUEL COMBUSTION ON WOMEN AND CHILDREN AND INTERVENTION OF IMPROVED COOK STOVE AND HAND WASHING PRACTICES (PHASE – I)

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Abstract*: For the purpose of this study 450 intervention and 150 control households (HHs) were selected. Among the intervened HHs improved cooking stoves and soap were provided. Qualitative information was collected through FGDs. The pre-intervention FGD focused, particularly on understanding how local women perceive the problems associated with fuel burning, exposure period, fuel usages, and their willingness to respond to the project interventions. The post intervention FGD focused on the acceptance of the intervention, how the women perceive the benefits, problems with improved stoves, any modification they feel needed in case of operation, etc. Twenty four (24-h) hours air samples for particulate matter (PM) were collected by using an air filter. The data gathered during sampling were fed into computers, checked, cleared and used for subsequent analysis. Detail will be delivered in Phase II report. This report contains baseline information. Above 67% of respondents of the studied HHs belong to age group between 19-29 years. A 59.5% of the studies HHs do not purchase fuel for cooking and about 83% HHs use cow dung and crop residues/dry leaves as fuel during dry season, while 16.92% use wood; however, they also use crop residues and dry leaves. Average cooking experience is 10.25 years and every day the respondent mothers spend 3.34 hours in the kitchen. Above 82% women reported to take their children to kitchen during cooking, while 9.25% women reported to take their children to kitchen almost always and 7.27% respondent told that they usually do not take their children to kitchen during cooking. A large proportion of the respondent women (234) suffer from some sorts of respiratory troubles. Of them, 28 women have known COPD history. About 19% children of studied HHs suffer from ARI, of them 61.6% (11.5% of total) have known pneumonia history.*

Keywords*: Indoor Air Pollution, Health impact of Bio-mass fuel combustion.*

Introduction

Biomass fuel refers to any solid plant or animal based material burnt by humans. Wood is the most common biofuel, but use of animal dung and crop residues is also widespread[1]. Around 50% of people, almost all in developing countries, rely on coal and biomass in

the form of wood, dung and crop residues for domestic energy[2]. Without a substantial change in policy, the total number of people relying on solid fuels will remain largely unchanged by 2030[3]. Biomass smoke contains thousands of substances, many of which damage human health. Most important are particulate matters, carbon monoxide, nitrous oxides, sulphur dioxide, formaldehydes and polycyclic organic matter which include carcinogens, such as benzopyrene. Small particles ($PM_{2.5}$) are `able to penetrate deep into the lungs and appeared to have the greatest health damaging potential[4]. In most of the traditional stoves, combustion is very incomplete and results in high emissions which combine with poor ventilation to produce very high levels of indoor pollution. According to USEPA guidelines, the recommended exposure value for 24-h average PM_{10} and $PM_{2.5}$ concentrations are 150µg/m^3 and 65µg/m^3, respectively and 8-h average carbon-monoxide standard is 9 ppm or 10mg/m^3. However, in rural households, the use of biomass fuel for cooking purpose exceeded the level on a daily basis by a factor of ten, twenty and sometimes more[4]. Approach was taken to assess the health hazards associated with biomass fuel use in kitchen by comparing the respiratory illness. Similarly, effect of use of soap in reducing diarrhoea and respiratory tract infection was assessed by comparing the incidences of these diseases between household practicing hand washing with soap and household not practicing hand washing.

The objective of the study was to develop cost effective solution to reduce health hazards associated with biomass fuel combustion in kitchen which will ultimately help to devise a framework for energy policy linking health and development of the country.

Materials and Methods

The study site is located at about 85 km west of Dhaka City. A cluster of 5 villages for the intervention area and another 2 villages from nearby non-intervention areas (control), having similar socio-economic attributes were selected for the study purpose. The GPS coordinates for study area are $23^0$45'47''N and $89^0$51'53'' E. A total of 450 HHs from intervention area and 150 HHs from control area were identified following the criteria of use biomass fuel for cooking in traditional stoves, at least one child under the age of five; and no cigarette or *biri* smoking in the house.

Interventions implemented: Improved cooking stoves were supplied among 300 HHs. Hand washing was promoted among 300 HHs, either singly or in combination with improved stoves. Every selected HH for hand washing was provided with 2 pieces of soap every month. Health workers were used to make checks by interview whether respondent HHs practice hand washing during their routine health monitoring work.

Data Collection: Eight (8) health workers were selected from local community. They are secondary school degree holder and were further trained in respiratory and diarrheal disease diagnosis by the project physician. Household characteristics, kitchen conditions, types and amount of fuel used, disease incidence of the respondent and her child, particularly that are related to respiratory diseases, etc. were collected through interview of respondents using pre-designed data collection format.

Collection of air samples for personal exposure data: Twenty four (24) hours air samples were taken by using an air filter for respirable Particulates Matters ($PM_{2.5}$ and PM_{10}).Respiratory dysfunction was collected using spirometry and monitoring of health of woman and child was carried out by the project health workers and an MBBS doctor. The data gathered during sampling were fed into computers, checked, cleared and used for subsequent analysis. Statistical comparisons was done between control and intervention data by simple t-test. Eight (8) Focus Group Discussions (FGDs) meetings were conducted, four (4) during pre- and four (4) during post intervention period. The pre- intervention FGD focused, on understanding how local women perceive the problems associated with fuel burning, exposure period, fuel usages, about the hazards associated with use of traditional stoves, acceptance of improved stove, aptitude towards hand washing, their suggestive remedies, and their willingness to respond to the project interventions. The post intervention FGD mainly focused on the acceptance of the intervention, how the women perceive the benefits, problems with improved stoves, any modification they feel needed, ease of operation.

Result

Table 1: Age Distribution of respondent mother:

Treatment group	Age groups in years										
	19-24 years		25-29 years		30-34 years		35-39 years		40-45 years		Total
		%		%		%		%		%	
Group 1	51	34	49	32.66	36	24	11	7.33	3	2.00	150 (100)
Group 2	44	29.33	52	34.66	38	25.33	15	10	1	0.66	150 (100)
Group 3	50	33.33	56	37.33	22	14.66	17	11.33	5	3.33	150 (100)
Group 4	45	30	58	38.66	26	17.33	20	13.33	1	0.66	150 (100)
Average	**190**	**31.66**	**215**	**35.83**	**122**	**20.33**	**63**	**10.50**	**10**	**1.66**	**600(100)**

About 36% respondent mothers belong to 25-29 age group, followed by 19-24 (31.66%) and 30-34 (20.33%) year age groups. Very few respondent mothers belong to age group 40 or above. There are not many variations among the intervention groups either in family size or in mother's age. Table 1 further shows that 67% of mothers belong to age group between 19-29 years.

Table 2: Source of family income:

Treatment group	Sources of income (%) HHs				
	Day Labor	**Farmer**	**Service**	**Trading**	**Others**
Group 1, N = 150	64 (42.66)	38 (25.33)	21 (14.00)	17 (11.33)	9 (6.00)
Group 2, N =150	45 (30.00)	15 (10.00)	6 (4.00)	50 (33.33)	35 (23.33)
Group 3, N =150	60 (40.00)	36 (24.00)	13 (8.66)	24 (16.00)	18 (12.00)
Group 4, N = 150	33 (22.00)	44 (29.33)	10 (6.66)	45 (30.00)	18 (12.00)
Average	**202 (33.66)**	**133 (22.16)**	**50 (8.33)**	**136 (22.66)**	**80 (13.33)**

Table 2 shows that income source for most of the HHs is day labor (33.66%), followed by local level small business (22.66%) and marginal farming (22.16%).

Table 3: Type of fuel used by the study HHs

Treatment	Fuel type (%) of total HHs		
	Cow Dung/Leaf	Wood	Others
Group 1, N = 150	120 (80.00)	30 (20.00)	0.00
Group 2, N = 150	138 (92.00)	12 (8.00)	1 (0.66)
Group 3, N = 150	126 (84.00)	24 (16.00)	0.00
Group 4, N = 150	113 (75.33)	37 (24.66)	0.00
Average	**497 (82.83)**	**102 (17.00)**	**1 (0.16)**

About 83% study HHs use cow dung and crop residues/leaf as fuel for kitchen burning, particularly during dry season, while 17% use wood; however, they also use crop residues and dry leaves (Table 3). Very negligible number of HHs uses other fuel types such as kerosene.

Table 4: Family expenditure for fuel

	Purchase fuel	
Treatment	**yes %**	**No %**
Group 1, N=150	25.85	74.15
Group 2, N =150	59.42	40.58
Group 3, N= 150	23.08	76.92
Group 4, N = 150	52.38	47.62
Total N = 600	40.18	59.82

Above table shows that 59.8 % of the study HHs do not purchase fuel for cooking. A 40.18% HHs purchase fuel in addition to fuel collected locally by family members. Responding to our query the participants informed that fuel is usually purchased from neighboring HHs or from local markets.

Table 5: Time spent by women for cooking in different meals and length of cooking experiences

Treatment	Average cooking time in hour/day					Average cooking length in year
	Morning	Noon	Dinner	Other	Total	
Group 1, N = 150	1.55	0.47	1.31	0.02	3.35	10.90
Group 2, N = 150	1.55	1.24	0.70	0.04	3.53	10.80
Group 3, N = 150	1.69	0.28	1.52	0.04	3.53	9.38
Group 4, N = 150	1.44	0.59	0.97	0.02	3.02	9.93
Average	**1.55**	**0.64**	**1.12**	**0.03**	**3.34**	**10.25**

All respondent women cook for the family. Sometimes other female members of the family help them in cooking. Above table shows that in average, they spend 3.34 hours/day in cooking. They spend more time for cooking in the morning. The cooking

experiences of the individual respondent women of the study area vary greatly ranging from 1 to 30 years. In average, respondent women have been cooking for about 10.25 years.

Table 6: Information on the practice of taking children to kitchen during cooking

Treatment	Numbers (%) HHs			
	Almost always	Often	Winter	Never
Group 1, N = 150	19 (12.66)	114 (76.00)	0.00	17 (11.33)
Group 2, N = 150	11 (7.33)	136 (90.66)	2 (1.33)	3 (2.00)
Group 3, N = 150	28 (18.66)	107 (71.33)	1 (0.66)	15 (10.00)
Group 4, N = 150	3 (2.00)	139 (92.66)	1 (0.66)	8 (5.33)
Total, N = 600	**61 (9.16)**	**496 (82.66)**	**4 (0.66)**	**43 (7.16)**

Above 82% women often take their children to kitchen during cooking. while 9.16% women told that they almost always take their children to kitchen and some 0.66% women take their children to kitchen only during winter. On the other hand, 7.16% respondent told that they usually do not take their children to kitchen during cooking.

Table 7: Information about eye burning experiences during cooking by the respondent women

Treatment groups	Eye burning experiences during cooking by respondents in (%)			
	Always	Some time	Never	Not Now
Group 1, N = 150	14 (9.33)	98 (65.33)	37 (24.66)	1 (0.66)
Group 2, N = 150	9 (6.00)	79 (52.66)	61 (40.66)	1 (0.66)
Group 3, N = 150	13 (8.66)	74 (49.33)	63 (42.00)	0.00
Group 4, N = 150	4 (2.66)	104 (69.33)	42 (28.00)	0.00
Total, N = 600	40 (6.66)	360 (60.00)	203(33.83)	2 (0.33)

Only 6.66% respondent women told that they always experience eye burning and tearing during cooking, while 60% women reported that they sometimes feel eye burning. On the other hand about 34% respondent women told they do not feel such problems during cooking.

Table 8: Perception of women on the harmful effects of cooking on health

Treatment	Numbers (%) respondent women		
	Yes	Do not Know	Others
Group 1, N = 150	102 (68.00)	48 (32.00)	0.00
Group 2, N = 150	61 (40.66)	88 (58.66)	1(0.66)
Group 3, N = 150	39 (26.00)	111 (74.00)	0.00
Group 4, N = 150	59 (39.33)	91 (60.66)	0.00
Total, N = 600	**261 (43.5)**	**338 (56.33)**	**1 (0.16)**

Responding to our query regarding harmful effect of smokes 43.5% women reported that cooking with fuel is harmful to health, while 56.33 % respondent women are not aware about the adverse health effects of smokes from cooking (Table 8).

Table 9: Results on the health examination of children by the physician

Treatment	Cyanosis Number (%)	Dyspenoea Number (%)	Wheeze Number (%)	Stridor Number (%)	Anaemia Number (%)
Group 1, N = 150	1 (0.66)	1 (0.66)	5 (3.33)	1 (0.66)	89 (59.33)
Group 2, N = 150	0.00	2 (1.33)	6 (4.00)	1 (0.66)	83 (55.33)
Group 3, N = 150	0.00	1 (0.66)	5 (3.33)	2 (1.33)	98 (65.33)
Group 4, N = 150	0.00	0.00	4 (2.66)	2 (1.33)	76 (50.66)
Total, N = 600	1 (0.11)	4 (0.66)	20 (3.33	6 (1.00)	346 (57.54)

Children were examined for certain diseases. A 57.54% of the children examined had varying degree of anaemia, 3.33% had wheezing problem, 1.00% stridor and 0.11% children had cyanosis.

Table-10: Health problem in children (under 5 years) as was reported by the respondents during health check up.

Treatment	Cough (%)	Breathing (%)	Cold (%)	Fever (%)	Nothing (%)
Group 1, N =150	39 (26.00)	4 (2.66)	19 (12.66)	13 (8.66)	75 (50.00)
Group 2, N = 150	54 (36.00)	2 (1.33)	29 (19.33)	4 (2.66)	61 (40.60)
Group 3, N = 150	34 (22.66)	4 (2.66)	6 (4.00)	4 (2.66)	102 (68.00)
Group 4, N = 150	67 (44.66)	2 (1.33)	29 (19.33)	2 (1.33)	50 (33.33)
Total, N = 600	**194 (32.33)**	**12 (2.00)**	**83 (13.83)**	**23 (3.83)**	**288 (48.00)**

During health check up, A 32.33 % reported that their children have cough problems, 13.83% children had cold, 3.83% had fever and 2.00% had breathing problems, while 48.00% women reported no problems with their children (Table 10).

Table 11: Respiratory disease incidences among women and children of the respondent HHs.

Treatment Groups	ARI-mother		COPD-mother		ARI-Child		Pneumonia-Child	
	Number	%	Number	%	Number	%	Number	%
Group 1, N = 150	68	45.33	5	3.33	33	22.00	18	12.0
Group 2, N = 150	56	37.33	7	4.66	23	15.33	10	6.66
Group 3 N = 150	55	36.66	11	7.33	36	24.00	14	9.33
Group 4, N = 150	54	36.00	5	3.33	20	13.33	27	18
Total, N = 600	**234**	**38.83**	**28**	**4.66**	**112**	**18.66**	**69**	**11.5**

A large proportion of the respondent women (234) of the project area suffer from some sorts of respiratory troubles. Of them, 28 women have known COPD history. About 19% children of study HHs suffer from ARI, of them 69 i.e. 11.5% of total have known pneumonia history, although only 4 cases were instantly identified during health check up.

Qualitative Information: There was a 100% agreement among the participants about the bad effects of smokes on their health. The major problems identified by the participants included eye burning and tearing, coughing, suffocation, sore throats, dirtiness of the kitchen and clothes. The major causes for the problems, according to them, include smokes, heat from flames and poor ventilation in the kitchen. The respondents stated that, cooking outside of the kitchen, provision for adequate ventilation in kitchen, spending less time in kitchen, use of LG or good quality fuel could reduce exposure to smokes.

The participants informed that they use wood chips, cow dung, agricultural residues e.g. straw, rice husks, dry leaves and herbs as HH fuels. Hard wood chips are preferred fuel among the locals as it gives less smoke and burns well, and causes less eye burning and tearing. However, wood chips are less available, costly and poor people cannot afford it. On the other hand, dry leaves and agriculture residues burns quickly, gives lot of smokes and ashes, and causes problems in eyes and makes the kitchen and clothes dirtier. Cow dung fuel burns slowly and gives bad odor and huge smokes, and causes comparatively more eye burning and suffocation. It was further reported that, ashes cause coughing and disturb inspiration. The participants informed that cooking for longer time makes them feel sick and discomfort due to excessive heat, sweating and smokes.

Discussion

The study area is densely populated and heavily relies on plant, dry leaves and cow-dung based bio-fuel for household (HH) energy needs. The area is inhabited by poor community, marginal farmers, fisherman, day labour and marginal local traders. The socio-economic conditions of respondent women reveals typical features of rural Bangladesh. The girls of rural Bangladesh usually get married at the age of early 18 and it is ritual that the new daughter in law takes the responsibility of preparing food for her husband's family members. Age analysis of respondent women reveals that 88% respondent mothers belong to age group between 19 to 34 years and only 12% are above 34 years.

About 83% respondent HHs use dung/dry leaf for fuel purpose and about 60% reported not to purchase fuel for cooking purpose. Most of the rural people belong to low marginal income group; therefore they collect bio-mass fuel from different sources as they cannot spare money for purchasing fuel. World Health Organization (WHO) country office for Bangladesh 2007 reports that almost 92% of the population in Bangladesh use bio-mass as cooking fuel[5]. Without substantial change in policy, the total number of people relying on bio-mass will increase 2.8 billion by 2030[6]. WHO Fact sheet 2014 reported that globally around 3 billion people cook and heat their homes using open fires and simple stoves burning biomass and coal[2]. Our study revealed that above 99% respondents use bio-mass fuel and use traditional stoves. Carlos Dora, coordinator for the WHO Interventions for Healthy Environments unit stated that the home with a dirty cook stove using coal can reach 2,000 or 3,000 $\mu g/m^3$ of particles that is 200 to 300 times the

WHO's average daily standard for maximum concentration of the fine particles[16]. Study report of WHO Environmental Health Unit, Bangladesh has identified the highest concentration of Suspended Particulate Matters (SPM) 39192 µg/m^3 air in fuel used as dung with little paddy straw[10, 11]. High concentrated SPM 10102 µg/m^3 air was also found in fuel of paddy straw and wood scraps[10, 12]. This indicates that 83% respondents of our study are exposed to very high concentrated SPM which makes them vulnerable for developing respiratory tract infection.

The respondent mothers spend average 3.34 hours/day in kitchen and their average cooking length is 10.25 year. Engler *et. al*, states that in developing countries, individuals are typically exposed to very high levels of pollution for between 3 and 7 hours each day over many years[13]. Particularly for women exposure is much more than the men and also women often carry their children with them while they cook and spend considerable time in the kitchen and inhale smoke[14]. This exposure of respondent mothers is a risk factor for developing lung diseases. About 83% mothers reported to take their children to kitchen often during cooking and 9.16% mothers take their children to kitchen almost every time. Children lung are vulnerable and is more subsist-able for developing respiratory infection. WHO Bulletin 2000 states that exposure to indoor air pollution may be responsible for nearly 2 million excess deaths in developing countries and for some 4% of the global burden of disease. Among them adult women are the most vulnerable and are three times more likely to suffer from Chronic Obstructive Pulmonary Diseases (COPD) and where coal is burned they are twice as risky to contract lung cancer.[15] Bruce et al reported that there is consistent evidence that indoor air pollution increases the risk of COPD and of acute respiratory infections in childhood. Evidence also exists of associations with low birth weight, increased infant and perinatal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer and cataract[15]. About 48% respondents of this study informed that their children are suffering from different type of respiratory diseases. Project physician confirmed wheezing and stridor in 3.3% and 1.00% children respectively and clinically diagnosed 43 ARI cases among children and 28 COPD cases among mothers. Based on evidence of health risks from air pollution WHO estimates that 34% stroke; 26% ischaemic heart disease; 22% COPD; 12% - acute lower respiratory infections in children; and 6% lung cancer are associated with Indoor Air Pollution (IAP)[2,16]. . The adverse health effect of bio-mass fuel use among children and women are not restricted on air pollution. Each part of the fuel cycle has its hazards e.g. fecal –oral infection during processing of dung fuel, bites from venomous snakes, spiders, leaches, insects, allergic reaction, and fungus infection during wood and straw collection[2,7,8,9].

Research carried out in Bangladesh has shown that during cooking hours concentration of SPM may increase several thousand µg/m^3 in short pollution 'spike' and pollution levels in the living rooms are only slightly lower[10,11,12.] Thus family members that are indoors but not in kitchen are also exposed to harmful pollution. This finding has significance for women and children; when examining the hours spent in indoors according to the gender and age group. Infants and children under five spent about an hour in the kitchen and between 18-20 hours in the living room per day. Adult women spend about 3.8 hours per

day in the kitchen[2, 5, 7, 8,9]. Thus Bangladeshi women and children exposed to high levels of IAP and are highly probable that this contributes to the under-five mortality due to ARI and COPD deaths in women. Over half of deaths among children less than 5 years old from acute lower respiratory infections (ALRI) are due to particulate matter inhaled from indoor air pollution from solid fuels and exposure to HH air pollution almost doubles the risk of childhood pneumonia[2, 16]. Approximately 17% of annual premature lung cancer deaths in adults are attributable to exposure to carcinogens from household air pollution caused by cooking with solid fuels. The risk for women is higher, due to their role in food preparation[2,16,17].

Conclusion

Community of this study has cordially accepted intervention of improved cooking stoves and hand washing practices. Most of the mothers take their children in the kitchen during cooking time although they are aware about adverse health effect of indoor air pollution. WHO new researches show that improved stoves can indeed significantly reduce acute respiratory infections in children and COPD, lung cancer and ALRI deaths in adults. WHO department of Public Health and Environment further states that improved house hold fuel technologies can support climate change mitigation in terms of 'carbon trading'[18]. After completion of phase two, the study will help to devise a framework for energy policy linking health and development of the country.

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