Original Article

Cooking smoke (household air pollution) exposure status of households in Ethiopia: A further analysis based on 2016 DHS data.

Desta Debalkie Atnafu[1*], Asmamaw Ketemaw[1], Yonatan Menber[2], Yosef Wassihun[3], Habtamu Alganeh Guadie[1]

Abstract

Background: Although currently adoption of modern life style has resulted in reduction of consumption of solid fuels, the dependable source of household energy in developing countries still remain unclean and its incomplete combustion continue to be the most common source of cooking smoke in Ethiopia. As a result, 50-90 % of households emitted cooking smoke which intern leads to various public health concerns. The objective of this study was to describe the household level cooking smoke exposure practices in Ethiopia.

Methods: A cross-sectional study was conducted January 18 to June 27, 2016. From 16,650 households recorded in the 2016 Ethiopian demographic and health survey dataset, households (n=10,904 (weighted)) were included in the study. Proportions were computed and presented in tables and bar graph. Bi-variable analysis was performed using x^2 test to assess the existence of association and multivariable binary logistic regression also computed to identify the independent determinants of cooking smoke exposure status. A p-value of less than 0.05 was considered as a statistical significance cut off value.

Results: The study revealed that 6,695 (61.4%, 95% CI: 59.6-63.2) of households had cooking smoke exposure. The majority of cooking smoke exposure by households was attributable to the uneducated status of household head and rural residence (61.6% and 63.7% respectively). Sex (AOR =0.74, 95% CI: 0.64-0.85), age group of house hold head (AOR= 1.4, 95% CI: 1.49-1.81 and AOR= 1.39, 95% CI: 1.2, 1.63), residence (AOR= 0.55, 95% CI: 0.39-0.78), familiy size (AOR = 1.3, 95% CI: 1.16–1.53), poorest wealth index (AOR= 6.1, 95% CI: 4.5-8.2), and households with television (AOR= 4.9, 95% CI: 3.8-6.3) and electricity for source of room light (AOR=1.52; 95% CI:1.09-2.12) were independent determinants for cooking smoke exposure status.

Conclusion: Cooking smoke exposure in studied households in Ethiopia was a persistent problem. Socio-demographic and economic factors along with advancing of clean energy technologies and behavior intervention need to be implemented to address the problem of household air pollution. [*Ethiop. J. Health Dev.* 2021; 35(3):183-193]

Key words: Cooking, Smoke, Exposure, Household, Ethiopia, EDHS

Introduction

Solid cooking fuel is the primogenital reserve of energy next to the sun. For many years, societies have used biomass fuels to cook food, heat homes and lighting. Cooking smoke, which is the byproduct during incomplete combustion (mix of higher temperatures with lower oxygen) of household fuels, is a mixture of gas, liquid and particulate matter (1).

Safety management in cooking practices has emerged as a transformative opportunity to improve individual health, simplify livelihoods and maintain the cleanliness of the global environment. The value chain around cooking stoves, perhaps the simplest and oldest household technology, presents an opportunity to put the integrative idea of sustainable development into practice (2). In the process, however, cooking-related air pollution on the global climate has emerged with the usage of unclean stoves and jeopardized health(2). Annually, more than 2 million lives of women and children were lost due to exposure from household cooking smoke (2,3).

As of today, approximately half of the world likelihood was associated with cooking, using solid fuels such as cow dung, crop residues, stubble, wood pellets, sawdust, leaves, charcoal and a little bit of coal. It is documented that 2.5 to 3 billion household members' energy demand in the world was covered by such fuels(4). In Ethiopia's context, about 95% of households used solid fuel for cooking purposes with a greater difference between rural (99%) and urban (80%) (5,6).

Burning of household fuels using primitive, inefficient and traditional cooking stoves, as well as, open fires released toxic pollutants such as carbon monoxide, sulfur oxide, nitrogen oxide, benzene, and hydrocarbons. This pollutant emitted as a result of burning solid fuels is responsible for indoor air pollution on a global scale in general and in Sub Saharan Africa (SSA) in particular. Large numbers of household members in developing countries including Ethiopia are exposed on a daily basis to this kind of harmful emissions from the malpractice of indoor cooking (7). This was highly aggravated when cooking

[1*]Department of Health System Management and Health Economics, School of Public Health, Bahir Dar University, Bahir Dar, Ethiopia. *Corresponding author email: destad2a@gmail.com

[2]Department of Public Health Nutrition and Diet Ethics, School of Public Health, Bahir Dar University, Bahir Dar, Ethiopia

[3]Department of Health Promotion and Behavioral Science, School of Public Health, Bahir Dar University, Bahir Dar, Ethiopia

was done in households without separated kitchen and ventilation structure. A study conducted in Gondar for example corroborated that 80% of rural women had cooked food using biomass fuel inside a living room without windows for ventilation system (7).

Among household members, women, who spent much of their time at home preparing family food and to care for their children, were at risk of cooking fuel-related air pollution (8). Cooking smoke is responsible for about 3% of the global burden of disease (9). In lower-income countries, over 1.6 million children died of exposure to cooking fuel smoke annually(10). More than 2.6 million total deaths and 77.2 million disability-adjusted life years were also accustomed to this household air pollution (HAP) (10).

The most common factors contributing to higher exposure to cooking fuel smoke in SSA, including Ethiopia, were the use of unprocessed firewood, type of fuel used(11), type of stove installed(11,12), poor housing condition(11), being female , larger family size, being uneducated, low socio-economic condition(11), rural residency(8,12) and occupational exposure(13-16).

Ethiopia, the owners of many cultures and cooking practices, is one of the poorest countries in Sub-Saharan Africa, where more than 80% of the population resides in rural area (16). In the country, the stable source of cooking fuel was unclean which mainly comprises of biomasses. The common cooking place in most rural communities was inside the living room, without a separate kitchen (no chimney) and without any windows for ventilation. Whereas, the type of cooking stove used was unclean and made of traditional three stones and thus exacerbated the levels of household air pollution (17). Moreover, exposure to cooking-related smoke is common in Ethiopia and has larger public health importance (18). Although the rate of acceptance was unlikely in Ethiopia, cooking outside the living room in a separate kitchen with a ventilation system and installing a clean stove was fundamental in reducing indoor air pollution (18). Factors aggravating low uptake of such cooking technology include cultural barriers, cost and lower promotional activity (18). Being cognizant to the silent killer of indoor air pollution, it is mandatory to assess exposure levels of indoor air pollution among households in Ethiopia. Therefore, this study aimed to describe the cooking smoke exposure status of households in Ethiopia.

Methods

Study settings, design and period

This study was written based on the 2016 Ethiopia Demographic and Health Survey (EDHS) data. This study was a cross-sectional study and was implemented between January 18, 2016, to June 27, 2016. Ethiopia is the site of the Africa Union with nine regional states and two city administrations. It has a total population of 108,386,391 and only 21.2% of the total population resides in the urban areas (19).

Study participants and sampling

All households both rural and urban were included in this study. The 2016 EDHS used a multistage stratified cluster sampling method, with two stages. About 645 Enumeration Areas (EAs) were recruited in the first stage and the second stage by using the household listing, 28 households per cluster were selected with an equal probability systematic sampling technique. The household data set was used to extract studied variables (outcome and independent variables). The detailed sampling procedure was reported in the DHS country report(20). This analysis used information from 10, 904 households (weighted) whose families lived in it and had cooking experience before conducting the survey (figure 1). Households with a cigarette smoker were excluded from this study and not yet analyzed.

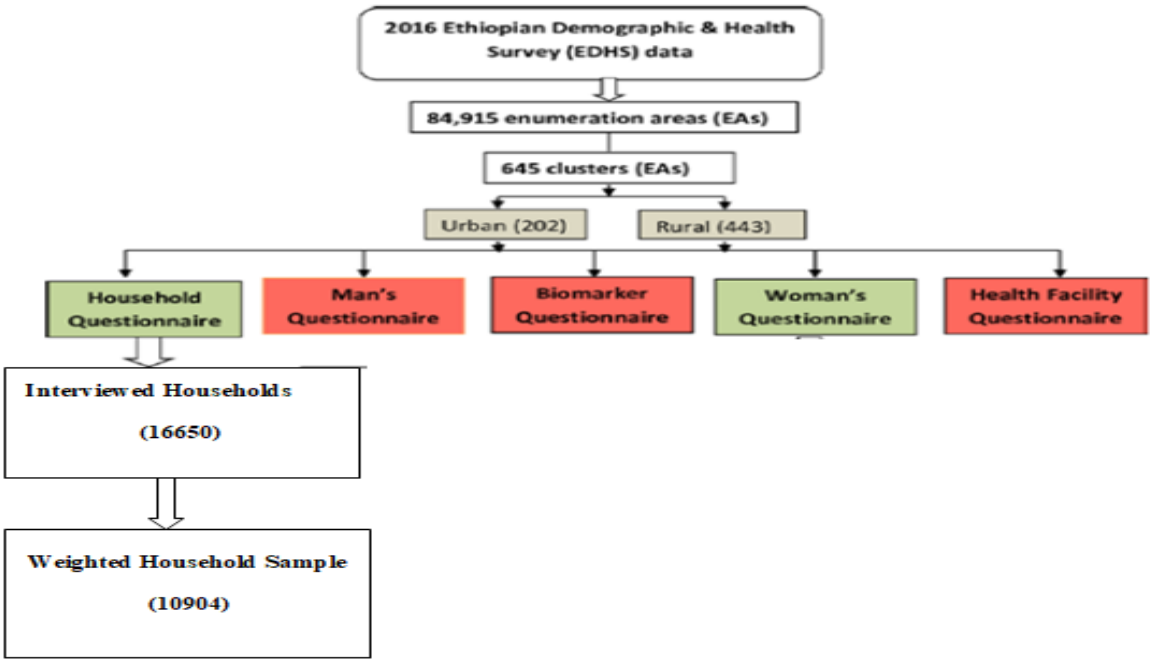

Figure 1: **Schematic presentation of the steps followed in identifying the study population, EDHS 2016.**

Measurement

The dependent variables for this study were cooking smoke (household air pollution) and exposure status (yes or no). When a household was accompanied by toxic emissions from cooking activities, it was considered to be exposed to cooking smoke (household air pollution). Whereas, a household that did not experience toxic emissions during cooking-time because of using clean fuel sources was referred to as not yet being exposed to cooking smoke. Toxic emissions in this study context means any form of indoor air pollution resulting from cooking, especially from the use and burning - of wood, dung, charcoal, kerosene and other cooking fuels. Socio-demographic, socio-economic, housing condition, ventilation system, kitchen characteristics, cooking fuel type and type of stoves were considered as explanatory variables.

Data analysis

Important variables associated with cooking smoke exposure status were identified through literature searches from previous studies. The selected variable was analyzed based on the original coding as it appeared in the EDHS household date set. However, some variables (number of rooms in household, type of fuel, type of stove, cooking place, type of living room and cooking smoke exposure) were extracted by combining and recoding the individual variables together. The variables type of stoves were recoded as open fire, traditional three clay cooked stove, improved cooked stove, electricity and others. Correspondingly, the variable cooking place was categorized based on previous studies, as inside living room, in separated kitchen and outdoor space. Type of cooking fuels was also categorized as electricity, LPG, charcoal and fire wood, biomass and others. A total of 19 variables including the outcome variable were analyzed in this study. Data extraction, editing and analysis were performed using SPSS version 23. Before any statistical analysis, the data were weighted using sampling weight, primary sampling unit, and strata to restore the representativeness of the study and compensate for the unequal probability of selection between the strata variables (20). Proportions were computed and presented in tables and bar graph. Bi-variable analysis using Chi-squared (x^2) test and multivariable logistic regression were computed to assess the existence and degree of association between explanatory variables and outcome variables respectively. A p-value of less than 0.05 was considered as a statistical significance cut off value.

Ethical Consideration

This study was a secondary analysis of publicly available datasets, where permission was obtained through registering with the DHS website and therefore the data set was accessed from "https://www.dhsprogram.com/data/dataset_amin/login_main.cfm". The data was collected by the Ethiopian Central Statistical Agency (CSA) and the Federal Ministry of Health (FMoH) by technical assistance of ICF through the DHS Program. The ethical clearance was provided by the Federal Democratic Republic of Ethiopia Ministry of Science and Technology and the Institutional Review Board of ICF International. Written consent to participate in the study was obtained from participants and the data was recorded anonymously.

Results

Socio-demographic characteristics of the respondents/ households

Out of households with history of cooking smoke exposure, the majority of participants were between 18 and 34 years of age 516 (66.8%). Among households with cooking smoke exposure status, approximately, two-thirds of household heads 3,189 (61.6%) were with no education. Most of the interviewed households were found in rural area 4,202(63.7%). Two-fifth of households with cooking smoke exposure status 3,853 (40%) were married and in the poorest 2,144(74.5%) wealth index. A significant amount of difference in cooking smoke exposure condition was also observed in the sex of household heads, female 2,032(65.3%) and male 3,465(40.1%). Overcrowding was one of the factors aggravating the problem of household air pollution, about 1,607 (58.6%) of households whose size greater than five were exposed to cooking smoke. Households which had no radio 4,340(64.8%) and TV 4,673 (63.4%) emitted a significant amount of smoke due to cooking practices inside the living room (Table 1).

Table1: **Socio-demographic characteristics of respondents (households) in Ethiopia, 2016 (N=10,904).**

Variables	Category	Exposure Level		X^2	P-Value
		Yes (n(%))	No (n(%))		
Age group of household's head	18-24	516(66.8)	345(33.2)	56.01	0.001
	25-34	1583(66)	1208(34)		
	35-49	1712(57.6)	1648(42.4)		
	>49	1989(60.3)	1903(39.7)		
Place of residence	Rural	4202(63.7)	3351(36.3)	104.899	0.001
	Urban	1753(48.5)	1598(51.5)		
Sex of household's head	Male	3465(40.1)	3768(59.9)	25.655	0.01
	Female	2032(65.3)	1639(34.7)		
Education of household's head	No education	3189(61.6)	2675(38.4)	54.546	0.006
	Primary	1380(35.5)	1595(64.5)		
	Secondary	542(48.2)	4881(51.7)		
	Higher	485(43.9)	511(56.1)		
	Do not know	22(45.3)	17(54.7)		
Current marital status of household's head	Never married	204(34.8)	431(65.2)	31.768	0.047
	Married	3853(40)	4008(60)		
	Widowed	32.4(32.4)	824(67.6)		
	Divorced	416(38.1)	537(61.9)		
Wealth status	Poorest	2144(74.5)	1412(25.5)	973.447	0.001
	Poorer	1159(73.5)	917(26.5)		
	Medium	1085(63.6)	916(36.4)		
	Richer	908(51.8)	817(48.2)		
	Richest	595(34.8)	951(65.2)		
Household size	1-5	3332(37.3)	4193(62.7)	16.605	0.043
	≥	1607(58.6)	1772(41.4)		
Has radio	Yes	1553(49.2)	1460(50.8)	167.154	0.001
	No	4340(64.8)	3551(35.2)		
Has TV	Yes	1321(52.6)	1127(47.4)	134.636	0.001
	No	4673(63.4)	3783(36.6)		

Housing condition, kitchen characteristics, cooking fuel type and type of stoves used by households

The absence of a chimney or hood in the kitchen, unavailability of electricity for lighting in the household, and cooking inside the living room on a daily basis showed significantly higher exposure to cooking smoke among interviewed households. However, the type of stove used to cook food was not a big problem that aggravates emissions because of cooking (Table 2).

Table 2: **Housing condition, kitchen characteristics, cooking fuel and type of stoves used among households in Ethiopia, 2016 (N=10904).**

Variables	Category	Exposure Level		X^2	P-Value
		Yes (*n* (%))	No (*n* (%))		
Type of living room	Rustic mat	85(52.1)	104(47.9)	2826.44	0.001
	Tukul (thatched)	154(58.8)	99(41.2)		
	Rudimentary	9(76.4)	7(23.6)		
	Corrugated iron sheet	3356(62.9)	2128(37.1)		
	Bamboo	383(31.5)	638(68.5)		
	Finished	1114(12.2)	2768(87.8)		
	Others	3(10)	56(90)		
Number of rooms	1 room	4855(67.8)	3519(32.2)	628.20	0.001
	2 rooms	1236(57.9)	782(42.1)		
	3 rooms	132(33.3)	275(66.7)		
	4 rooms	18(45.4)	52(54.6)		
	5 rooms	13(48.6)	8(51.1)		
	≥6 rooms	5(19.9)	9(80.1)		
Presence of separated kitchen	Yes	984(44.8)	1927(55.2)	457.997	0.001
	No	4816(67.0)	3177(33)		
Ventilation system for cooking smoke (presence of chimney)	Neither chimney nor hood	3178(63)	2662(37)	28.048	0.012
	Chimney	1301(39.4)	1418(60.6)		
	Hood	1141(48.66)	1204(51.34)		
Has electricity for source of room light	Yes	2051(52.8)	1733(47.2)	281.546	0.001
	No	4067(65.7)	3053(34.3)		
Frequency of cooking inside living room	Never	4204(39.8)	4820(60.2)	47.057	0.014
	Daily	4816(67.0)	533(33.2)		
	Weekly	280(27.1)	361(72.8)		
	Monthly	20(39.2)	34(60.8)		
	<Once a month	67(36.6)	64(63.4)		
Type of stove used food cooked	Open fire	3265(60.6)	2974(39.4)	5.57	0.745
	Traditional three clay cooked stove	1362(62.2)	1181(37.8)		
	Improved cooked stove	561(36.8)	732(63.2)		
	Electricity	206(38)	235(62)		
	Others	182(38.9)	206(61.1)		
Cooking fuel	Electricity	304(25)	641(75)	75.179	0.001
	LPG	95(20.6)	193(79.4)		
	Charcoal & fire wood	767(56.7)	886(43.3)		
	Biomass (cow dung)	4180(60.7)	3819(39.3)		
	Others	-	19(100)		

Cooking smoke (household air pollution) exposure status of households

From a total of 10,904 households included in this study, about 6, 695 (61.4%, 95%CI: 59.6-63.2) had been exposed to cooking smoke (households air pollution) (figure 2). The majority of cooking smoke by households 3,189(61.6%) and 4,202 (63.7%) were attributable to the uneducated status of household heads and rural residence respectively (Table 1). Additionally, significantly higher household air pollution was documented among married household heads, poorest household, larger family size, households without a radio and TV, rudimentary living room, households with one living room, households without a separated kitchen and cow dung used as cooking fuel (Table 1 and 2).

Figure 2: **Exposure level of cooking smoke by households in Ethiopia (N=10, 904)**

Factors associated with cooking smoke exposure status of households

In bi-variable logistic regression analysis; sex, age group of HH head (years), residence, family size, wealth index, and households with radio, television and electricity for source of room light were found to be statistically correlated with cooking smoke exposure status. All variables that were significantly associated with cooking smoke exposure had a 5% level of significance in bi-variable logistic regression analysis and were taken for multivariable analysis. After fitting for conceivable confounders, seven variables were found in the final model**:** the odds of cooking smoke exposure status was 26% less in households headed by males (AOR =0.74, 95% CI: 0.64-0.85). The exposure status of cooking smoke among households who had a family size greater than or equal to six was 1.3 times higher than the counter parts (AOR = 1.3, 95% CI: 1.16–1.53). Having no electricity for room light had 52% higher odds of exposure to cooking smoke as compared to households with electricity (AOR =1.52; 95% CI:1.09-2.12). Household heads aged between 18 to 24 years and 25 to 34 years were about 40% at higher odds of being exposed to cooking smoke as compared to greater than or equal to 50 years (AOR= 1.4, 95% CI: 1.49-1.81 and AOR= 1.39, 95% CI: 1.2, 1.63). Urban households had a 45% lower risk of exposure to cooking smoke compared to households from rural areas (AOR= 0.55, 95% CI: 0.39-0.78). In this study there is a strong association between cooking smoke exposure status and wealth index; poorest, poorer, middle and richer households had 6.1, 5.2, 3.3 and 1.76 times higher risk of exposure to cooking smoke compared to richest households (AOR= 6.1, 95% CI: 4.5-8.2, AOR=5.2, 95% CI: 3.93-6.83, AOR=3.3, 95% CI: 2.53-4.27, & AOR= 1.76, 95% CI: 1.4-2.22) respectively. Households which have no television had 90% higher odds of exposure to cooking smoke as compared to households with no television (AOR= 4.9, 95% CI: 3.8-6.3).

Table 3: **Bi-variable and multivariable logistic regression analysis of cooking smoke exposure status of households in Ethiopia, 2016 (N=10,904).**

Variables	Category	COR (95% CI)	AOR (95% CI)
Sex of HH head	Male	0.79(0.69-0.9)	0.74(0.64-0.85)*
	Female	1	1
Age group of HH head (years)	18-24	1.42(1.1-1.82)	1.4(1.49-1.81)**
	25-34	1.28(1.11-2.47)	1.39(1.2-1.63)*
	35-49	1.14(1.02-1.27)	1.03(0.92-1.16)
	≥50	1	1
Family size of HH	1-5	1	1
	≥6	1.33(1.18-2.51)	1.3(1.16-1.53)*
Place of residence	Urban	0.65(0.43-0.97)	0.55(0.39-0.78)*
	Rural	1	1
Wealth Index	Poorest	6.01(3.67-7.73)	6.1(4.5-8.2)*
	Poorer	5.07(1.4-6.42)	5.2(3.93-6.83).*
	Middle	3.37(2.17-4.26)	3.3(2.53-4.27)*
	Richer	1.83(1.48-2.26)	1.76(1.4-2.22)*
	Richest	1	1
Has electricity for source of room light	No	1.97(1.64-2.37)	1.52(1.09-2.12)**
	Yes	1	1
Has radio	No	1.99(1.75-2.27)	1.13(0.93-1.3)
	Yes	1	1
Has television	No	1.73(1.45-2.07)	4.9(3.8-6.3)*
	Yes	1	1

*Significant at P-value ≥ 0.001; ** significant at P-value ≥ 0.01

Discussion

This study confirmed that cooking smoke exposure condition could be higher in magnitude in the variable of interest of different socio-demographic and socio-economic factors, housing condition, kitchen characteristics; type of stove used and fuel type. However, the latest three characteristics had no definite relationship with cooking smoke status and were not found in the final model. This study also unveils that the level of household air pollution was 61.4%. Although this prevalence is higher, it is a little bit lower than the EDHS report of 2011 which exhibited nearly 64% of households in Ethiopia was exposed to cooking-related smoke. A study in Gondar Ethiopia also documented that 80% of households were exposed to cooking smoke which was higher than the current findings (7). This reduction of cooking smoke exposure levels from previous studies might be attributed to the implementation of health extension packages in the country in which one of its packages were emphasized mainly on improving housing conditions including kitchen characteristics.

Ethiopia is a resource-limited country located in the horn of Africa, where more than 84% of the population, are rural residents and have no access to clean energy sources for domestic utilization. According to the study findings, households in the rural area are without electricity for at least room light and had higher odds of exposure to cooking smoke, similarly reported in other studies(21-23). In the current study only 8.4% of rural households had access to electric power for room light and only about 34.7% of total surveyed households (both urban and rural) had electricity for source of room light which is very far apart from the national goals and with this pace were unable to address the goals targeted by sustainable development goals (SDG) for developing countries (5,8).

Exposure to household air pollution was higher among women who did most of the households cooking activities (3,24), similar to the results found in our study that documented 65.3% of the household heads with cooking smoke exposure condition were females and thus, being female is a statistical significant difference ($p<0.01$) in the exposure status for cooking smoke. Sex of the household head was also exhibited as an independent determinant for the outcome of interest as shown in the regression analysis (AOR=0.74; 95% CI: 0.64-0.85), comparable to studies conducted elsewhere (25, 28). This may be due to the fact that the tradition of Ethiopia left the cooking and feeding practices of household members mainly for women.

The odds of indoor air pollution exposure from unprocessed solid fuel use was higher among the young and increased the risk of respiratory infection (27,28). This was supported by the current study in that household heads who aged between 18-34 years were about 40% at higher odds of being exposed to cooking smoke as compared to the aged one (≥50 years).

Therefore the government of Ethiopia should strengthen and take collective action with a multi-sectorial approach targeting the young and females who spent more time in households with traditional structures.

Household air pollution affects the poorest households that were unable to afford clean and efficient cooking practices(29), similarly discovered by the multivariable analysis. Different literatures revealed that income status of households could play a pivotal role in the exposure condition of households for cooking smoke(29). This is corroborated by the current study in that three-fourth of households with cooking smoke exposure status were found in the poorest wealth index (74.5%) and the regression analysis also proved that a strong association between cooking smoke exposure status and wealth index was evident, similar to previous studies (30). This similarity could be explained by the fact that a significant proportion of respondents in Ethiopia relied on traditional cooking fuels as their primary cooking energy source due to various economic reasons. In addition to this, most of the households interviewed in this study were rural residents who were unable to afford clean energy sources for cooking even though the structure was not well installed. The level of urbanization, living standard, weather conditions and socioeconomic factors were also factors that influenced the household's cooking smoke exposure condition.

Given the large family sizes that generally characterize rural Ethiopia, it may not be surprising if many traditional households with larger family members were exposed to indoor air pollution particularly cooking smoke (12,16,31,33), similar to the current study. The implication of large family sizes in rural communities, due to the crowding of households, increased the consumption of fire wood which was gathered locally and burnt without a separated kitchen openly and the fact that induces the risk of exposure for cooking smoke.

Biomass solid fuel is the most common energy reserve for cooking, particularly in developing countries where the clean energy source is not well structured (1). As a result, about half of the people in the world and 90% of the rural households in the developing countries utilized solid fuel for cooking and heating using traditional stoves (4). In Ethiopia, about 95% of households used solid fuel for cooking purposes with a greater difference between rural (99%) and urban areas (80%) (5,6). Similarly, the study conducted in Sodo and Debre-Markos town (90%) showed that biomass and charcoal fuel were the chief sources of energy for cooking among surveyed households (30,32). It is highly exacerbated when households use an inefficient stove and without any ventilation system in the kitchens. This is consistent with the current study in that among the studied households which had been exposed to cooking smoke; about 56.7% and 60.7 % used fire wood and biomass respectively to cook food on a traditional stove made of three clay stands and about 63% of the households had neither a chimney nor a hood as a ventilation system. However, the type of stove used to cook food in this study was not a statistically significant factor that aggravated emissions because of cooking. Thus, decision makers should diversify cooking energy consumption patterns and adopt smokeless cooking technologies to have clean and safe households.

Though it was not statistically significant; there is a greater difference in the cooking smoke exposure practices of households that cooked food on open fire in the field. Among cooking smoke exposed households, about 60.6% had cooked food on open fire, which agrees to the findings in Sodo town that reported 73.3% of households had open fire stoves (33). The local government bodies should design promotes and makes available, improved cook stoves in order to minimize consumption of fuel and facilitate complete combustion to have zero waste emissions and hence, women who used this improved stove could be prevented from high exposure of cooking smoke.

Exposure to cooking smoke is greater when cooking takes place inside the house rather than in a separated building or outdoors. The study conducted in Butajira (34) and Sodo town (33), Ethiopia showed that half and two-third of the households respectively had a separated kitchen in which to cook food . Contrary to these studies, findings in the present study showed that more than two-third of households with cooking smoke exposure status had no separated kitchen. This deviation could be due to Butajira and Sodo town being urban areas and are likely to have improved standard of living including kitchen characteristics while in the current study more than 69.27% of households lived in rural areas and had little knowledge about the harmful health effects of cooking smoke, which attributed to the fact that having no separated kitchen for cooking. This explanation can be also strengthened by the fact that about 61.6% of the studied household heads, who were exposed for cooking smoke, was not yet educated. Additionally, only a small proportion of households (27.4% and 22.5%) had radio and television respectively. Similarly, the results obtained from the final regression model found that households without television had 90% higher odds of exposure to cooking smoke as compared to households with no television (AOR=4.9, 95% CI: 3.8-6.3). This was also supported by the study conducted in Ethiopia (35).

An appropriately structured ventilation system could improve households' atmosphere and is important in localities whose source of cooking energy is traditional solid fuels (36). The number of rooms, doors and windows is also pertinent in improving households' ventilation (36,37). It has been recommended that the presence of at least one or more windows in the kitchen is critical, including adequate size and cross ventilation to facilitate natural ventilation (37). Likewise, in this study being exposed to cooking smoke by households is statistically greater among those households with a small number of rooms. This was reported in the same way by other studies in Honduran (36). In addition, a study conducted in Butajira, Ethiopia showed that the availability and practice of ventilation in the cooking

room was poor and caused indoor air pollution(34). On the other hand, the availability of ventilating structures inside where the cooking place, could not guarantee reduction of cooking smoke exposure by mothers who practiced cooking. Thus, mothers who responsible for cooking must be sensitized in order to open existing windows regularly during the time of cooking. There was a limitation of conducting a study with survey data, since the variable of interest for the researcher may not be found in the dataset. Further studies should be performed with primary data s sources to supplement the evidence of households' air pollution in Ethiopia in different administrative contexts based on analytic study computations.

Conclusion

Cooking smoke exposure in studied households, Ethiopia was still a problem which is due to poor cooking energy consumption patterns, cooking practices and kitchen conditions by households. Cooking and heating with solid fuels on open fires and traditional stoves results in high concentration of indoor air pollution. As a result, most of the women who carried out cooking activities were exposed to cooking smoke. The use of unclean cooking energy, which was common in crowded households, induced indoor air pollution in the poorest households and affected the health of the women and the young. Thus, the cooking energy consumption pattern in Ethiopian households, particularly in the rural settings, should be diversified, clean and safe for health. Behavior intervention along with advertising of cook stove technologies and ventilation systems must also be given higher emphasis to address the problem of household air pollution.

Consent for publication: Non applicable

Ethics approval and consent to participate: This study is a secondary analysis of publicly available datasets, where permission was obtained through registering with the DHS website and therefore the data set was accessed from https://www.dhsprogram.com/data/dataset_amin/login_main.cfm. The data was collected by the Ethiopian Central Statistical Agency (CSA) and the Federal Ministry of Health (FMoH) by technical assistance of ICF through the DHS Program. The ethical clearance was provided by the Federal Democratic Republic of Ethiopia Ministry of Science and Technology and the Institutional Review Board of ICF International. Written consent to participate in the study was obtained from participants and the data was recorded anonymously.

Availability of data and materials: All relevant materials and data supporting the findings of this study are available without restriction. Contact: destad2a@gmail.com when needed.

Competing interest: The authors declare that they have no competing interests.

Funding: No financial support was gained to conduct this study.

Acknowledgements: The Central Statistical Agency and Ethiopian Demographic Health Survey (DHS) should be acknowledged for providing us the datasets on our request. The authors are also grateful for filtering and cleaning the dataset to bring important variables related to households cooking smoke exposure status.

Authors' contribution: DDA conceived and designed the study with additional inputs from AK, YM and YW. DDA, AK, YM and YW processed the data and produced the descriptive tables. DDA, AK, YM and YW analyzed the data. DDA prepared the first draft of the manuscript. All authors contributed to the critical revision of the manuscript for important intellectual content and approved the final version to be published.

References

1. Sepp S. Multiple-household fuel use – A balanced choice between firewood, charcoal and LPG. Federal ministry of economic cooperation and development technical report. Deutsche Gasellschaft fur International Zusammenrbeit (GIZ). GmbH, 2014: 49
2. The Environment Department (Climate Change) of the World Bank. Household cook stoves, environment, health, and climate change: A new look at an old problem; May 2011.
3. Muchiri, L. Gender and equity in bioenergy access and delivery in Kenya. Practical action eastAfrica,2008.Availableonline:http://www.csas.ed.ac.uk/__data/assets/word_doc/0007/24793/Gender_and_Equity_in_Bio_energy_Access_and_Delivery_in_Kenya_final.doc.
4. World Health Organization (WHO). Burden of disease from household air pollution for 2016 – Summary. Geneva: World Health Organization, 2018. Available from:www.who.int>data.
5. Central Statistical Agency, Ethiopia. Welfare monitoring survey: Addis Ababa, Ethiopia, 2011.
6. Central Statistical Agency [Ethiopia] and ICF International. Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International, 2012.
7. M Edelstein, E Pitchforth, G Asres, M Silverman and N Kulkarni. Awareness of health effects of cooking smoke among women in the Gondar Region of Ethiopia: a pilot survey. International Health and Human Rights. 2008; 8:10.
8. Sanbata H. Indoor air pollution and acute respiratory illness among children from household fuel use in Addis Ababa, Ethiopia: Addis Ababa University, 2012,p.98.
9. Zhang J, Smith KR. Indoor air pollution: a global health concern. British Medical Bulletin.2003; 67:209–225.
10. GBD 2016 risk factors collaborators. Global, regional, and national comparative risk assessment of 84 behavioral, environmental

and occupational, and metabolic risks or clusters of risks, 1990–2016: A systematic analysis for the global burden of disease study 2016. Lancet. 2017; 390: 1345–422. DOI: https://doi.org/10.1016/S0140-6736(17)32366-8.

11. D. G. Fullerton, N. Bruce, and S. B. Gordon. Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2008: 102(9): 843–851.
12. Chris Keil, Hailu Kassa, Alexander Brown, Abera Kumie, and Worku Tefera. Inhalation exposures to particulate matter and carbon monoxide during Ethiopian coffee ceremonies in Addis Ababa: A Pilot Study. Journal of Environmental and Public Health. Volume 2010. doi:10.1155/2010/213960.
13. Bede-Ojimadu O, Orisakwe OE. Exposure to wood smoke and associated health effects in Sub-Saharan Africa: A Systematic Review. Annals of Global Health. 2020; 86(1): 32, 1–27. DOI: https://doi.org/10.5334/aogh.2725
14. Food and Agricultural Organization. Incentiv-izing sustainable wood energy in Sub-Saharan Africa: A way forward for policy: Food and Agriculture Organization of the United Nations. Viale Delle Terme Di Caracalla 00153 Rome, Italy. 2017; Available from: www.fao.org.
15. Kar A, Rehman IH, Burney J, Puppala SP, Suresh R, Singh L, et al. Real-time assessment of black carbon pollution in Indian households due to traditional and improved biomass cook stoves. Environ Sci Techno. 2012; 46(5):2993-3000.
16. Asamene Embiale, Feleke Zewge, Bhagwan Singh Chandravanshi and Endalkachew Sahle-Demessie. Short-term exposure assessment to particulate matter and total volatile organic compounds in indoor air during cooking Ethiopian sauces (Wot) using electricity, kerosene and charcoal fuels.Indoor and Built Environment. 2019; 28(8): 1140–1154. DOI: 10.1177/1420326X19836453 journals.sagepub.com/home/ibe.
17. Bruce N, McCracken J, Albalak R, Schei MA, Smith KR, Lopez V, et al.: Impact of improved stoves, house construction and child location on levels of indoor air pollution exposure in young Guatemalan children. J Expo Anal Environ Epidemiol. 2004;14 (Suppl 1):S26-S33.
18. Khushk WA, Fatmi Z, White F, Kadir MM: Health and social impacts of improved stoves on rural women: a pilot intervention in Sindh, Pakistan. Indoor Air. 2005; 15:311-316.
19. Agency Ci. Ethiopia demographics profile 2019. Index mundi, 2019.
20. Central Statistical Agency (CSA) [Ethiopia] and ICF, Ethiopia demographic and health survey 2016 : Addis Ababa, Ethiopia, and Rockville, Maryland, USA: CSA and ICF.
21. Balakrishnan K, Ramaswamy P, Sambandam S, *et al.* Air pollution from household solid fuel combustion in India: An overview of exposure and health related information to inform health research priorities. Glob Health Action. 2011; 4(5638) [PMID: 21987631]
22. Patel AB, Meleth S, Pasha O, *et al.* Impact of exposure to cooking fuels on stillbirths, perinatal, very early and late neonatal mortality – A multicenter prospective cohort study in rural communities in India, Pakistan, Kenya, Zambia and Guatemala. Matern Health Neonatol Perinatol. 2015; 1(18): 18. [http://dx.doi.org/10.1186/s40748-015-0019-0] [PMID: 27057335]
23. Barría PRM. Indoor air pollution by particulate matter from wood fuel: An unresolved problem. Environ pollut climate change.2016; 1: 104. doi: 10.4172/2573-458X.1000104
24. Okello G, Devereux G, Semple S. Women and girls in resource-poor countries experience much greater exposure to household air pollutants than men: Results from Uganda and Ethiopia. Environ Int. 2018; 119: 429–437. DOI: https://doi.org/10.1016/j.envint.2018.07.002.
25. June Y T Po, Mark F G, Chris C. Respiratory disease associated with solid biomass fuel exposure in rural women and children systematic review and meta-analysis. Thorax. 2011; 66:232e239. doi:10.1136/thx.2010.147884
26. Saruna G, Shiva R.M, Abhishek Sh et al. Geographic and socio-economic variation in markers of indoor air pollution in Nepal: evidence from nationally-representative data. BMC Public Health.2019; 19:195. https://doi.org/10.1186/s12889-019-6512-z.
27. Hu G, Zhou Y, Tian J, et al. Risk of COPD from exposure to biomass smoke: a meta-analysis. Chest. 2010 Jul; 138(1):20-31. doi: 10.1378/chest.08-2114. Epub 2010 Feb 5.
28. Lee A, Adobamen PR, Agboghoroma O, et al. Household air pollution: A call to action. Lancet Respir Med. 2015; 3(1): e1-2. http://dx.doi.org/10.1016/S2213-2600(14)70288-7 [PMID: 25593091].
29. Kumlachew Geremew, Molla Gedefaw, Zewdu Dagnew, and Dube Jara. Current level and correlates of traditional cooking energy sources utilization in urban settings in the context of climate change and health, Northwest Ethiopia: A case of Debre-Markos town. BioMed Research International. 2014; Volume 2014. http://dx.doi.org/10.1155/2014/572473.
30. Prateek MS, Jamie L, Elizabeth J, et al. Impact of Outdoor Air Pollution on Indoor Air Quality in Low-Income Homes during Wildfire Seasons. Int. J. Environ. Res. Public Health. 2019; 16: 3535; doi:10.3390/ijerph16193535
31. Amha Admasie, Abera Kumie, and Alemayehu Worku. Children under five from

houses of unclean fuel sources and poorly ventilated houses have higher odds of suffering from acute respiratory infection in Wolaita-Sodo, Southern Ethiopia: A case-control study. Journal of Environmental and Public Health. 2018; Volume 2018. https://doi.org/10.1155/2018/9320603.

32. Amha Admasie, Abera Kumie and Alemayehu Worku. Association of Household Fuel Type, Kitchen Characteristics and House Structure with Child Size at Birth in Wolaita Sodo, Southern Ethiopia. The Open Public Health Journal. 2018; 11, 298-308.
33. Mulugeta Tamire, Adamu Addissie, Susann Skovbjerg, Rune Andersson and Mona Lärstad. Socio-Cultural Reasons and Community Perceptions Regarding Indoor Cooking Using Biomass Fuel and Traditional Stoves in Rural Ethiopia: A Qualitative Study. Int. J. Environ. Res. Public Health. 2018;15: 2035. doi:10.3390/ijerph15092035.
34. Habtamu S, Araya A and Abera K. Association of biomass fuel use with acute respiratory infections among under- five children in a slum urban of Addis Ababa, Ethiopia. BMC Public Health. 2014, 14:1122. http://www.biomedcentral.com/1471-2458/14/1122
35. Clark ML, Reynolds SJ, Burch JB, Conway S, Bachand AM, Peel JL. Indoor air pollution, cook stove quality, and housing characteristics in two Honduran communities. Environ Res. 2010; 110(1): 12-8. http://dx.doi.org/10.1016/j.envres.2009.10.008 [PMID: 19922911].
36. Mak, C.M.; Yik, F.W.H. A study of natural ventilation in a kitchen using computational fluid dynamics (CFD). Architect. Sci. Rev. 2002; 45: 183–190.