Title: Distribution of sources of household air pollution: a cross-sectional study in Cameroon

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Abstract

Background: Household air pollution (HAP) is a recognised risk factor for many diseases, including respiratory diseases, cardiovascular/circulatory disorders, adverse pregnancy outcomes and cataracts. Population exposure to biomass fuels, including wood, varies among countries and from one fuel source to the other. This study aimed to investigate the different sources of HAP in peri-urban and rural communities in Cameroon.

Methods: A cross-sectional survey was conducted in a representative sample of households from the Dschang Health District (DHD) region. This included 848 homes in which a range of fuels for

cooking including biomass (firewood, charcoal, sawdust), kerosene and liquefied petroleum gas (LPG) were used both indoors and outdoors.

Results: Of the study households, 651 (77%) reported exclusive use of firewood and 141 (17%) reported using more than one source of fuel. Exclusive use of firewood was greater in rural communities (94%) than in peri-urban communities (38%). In peri-urban communites, use of multiple fuels including LPG, wood, sawdust and kerosene, was more common (44.75%). A total of 25.03% of households in both peri-urban and rural communities reported using bottled gas (or liquified petroleum gas (LPG) for cooking. Motivations for choice of fuel included, price, availability (easy access), rapidity, tradition or culture related factors

Conclusions: Work to help households (especially those who are resource poor) to adopt LPG equipment for cooking, and use in a more exclusive way is required. Education could help address some of the concerns over the use of LPG.

Key words: Indoor air pollution, household air pollution, LPG, fuel type, Dschang-Cameroon.

Background

Over 3 billion people rely on biomass fuel (BMF) as their main source of domestic energy(1,2). BMF, including wood, charcoal, dung and crop residue, accounts as much as 95% in lower income countries(3,4). Studies have shown that there is an increase in the risk of respiratory morbidity and chronic obstructive pulmonary diseases among individuals using biomass fuels(1,5,6). The World Health Report (2002) estimates that acute lower respiratory infection (ALRI) is one of the leading causes of child mortality in the world, accounting for up to 20% of fatalities among children under five, almost all of them in developing countries. Household air pollution (HAP) is thought to cause about one-third of ARI cases(1). This makes solid fuels the second most important environmental cause of disease (6,7) and the fourth most important cause of overall

excess mortality in developing countries (6). In addition to impacts on mortality, HAP may have long lasting effects on general health and well-being: early exposure to IAP during childhood may stifle lung development, suggesting that the cost of this pollution may continue later in life. In fact, a growing literature indicates that environmental insults at early ages can have long lasting influences on human health and productivity(7).

According to the World Health Organization (WHO) report in 2008, 1.3 million deaths were estimated to be related to ambient air pollution globally. The figure became 3.7 million in 2012, which was nearly tripled. Two million deaths were attributable to the effects of household air pollution in 2008. This number also increased as nearly doubled (4.3 million) according to the latest report based on 2012 data by WHO recently. More than two million premature deaths each year were related to air pollution. Globally, seven million deaths were attributable to the joint effects of household and ambient air pollution in 2012(1).

The industrial sector is still developing in Cameroon, so ambient air pollution has not reached health-damaging levels, yet HAP caused an estimated 11,400 premature deaths in Cameroon. One of the highest contributors to ambient air pollution in Cameroon is therefore BMF for cooking and space heating.

In the absence of studies that describe the impact of different fuel sources on HAP in Cameroon, this study designed to demonstrate how various fuel types impact HAP in Cameroon in so as to provide real-life information that can guide specific interventions.

Methods

A piloted cross-sectional questionnaire was administered to heads of households or representatives in randomly selected urban and rural households in the Dschang Health District (DHD) in Cameroon from March to July 2018 to estimate the distribution of sources of household air pollution and characteristics. The DHD is a cosmopolitan district with an estimated population of 221,037 inhabitants in 2018. This district was chosen because of the diversity and big size of its population and ability to compare rural and urban household characteristics. It is made up of 22 Health Areas (HA) classified into urban and rural.

Our study sample size was estimated assuming 50% anticipated population proportion of biomass use (the prevalence of HAP in Cameroon is unknown to the best of our knowledge). We used a 95% confidence level, with 5% relative precision and doubled the sample size to take into account the clustering of households within HAs. To account for non-response, 20% was added to determine the final sample size.

Multistage stratified random sampling was performed among 22 HA to select 11 HA with equal representation of urban and rural health areas. Within selected health areas, villages/quarters were selected by simple randomisation from the list of clusters obtained from the National Institute of Statistics. The sample required from each health area was calculated with respect to their representation in the general population (2018). In villages/quarters, a guide was solicited from the local traditional authorities and the central spot was identified. On the left/right side of the street, one household was targeted after one was skipped till the end of the street. The process was repeated until the expected sample size of households for the village was reached.

A household was defined in this study as one or more persons living together, sharing the same roof and kitchen. Any building not respecting this definition was excluded and replaced by the one immediately next to it.

Data collection and management

In targeted households, data was collected from head of households after verbal/signed consent was obtained. Data was collected using a structured questionnaire administered in face to face interview by a trained surveyor. For each household, data was collected on socio demographic information and characteristics of indoor sources of air pollution including fuels used for cooking. Primary cooking fuel was defined as the fuel used mainly by a household for cooking(4). Secondary cooking fuel was defined as the fuel used as a backup for fuel-specific cooking activities by a household.

Resulting forms were verified daily to assess quality and completion. The resulting database was cleaned and analyzed by a statistician using Epi info version 7.2.2 software. Main analysis performed were proportions with a 95% confidence interval and tables were designed using MS-Excel 2013.

Ethical considerations

The proposal of this study was submitted and evaluated by the National Ethics Committee of Human Health Research of Cameroon and approval was given with the reference number **1030.** Prior to this evaluation, authorization was obtained in a signed document from local health authorities of the DHD. For each village/quarter, authorization was obtained from local traditional authorities. Data was collected from consenting households.

Results

Eleven health areas were selected - 2 in urban and 9 in rural setting - leading to a final sample of 848 households (98% response rate) within 85 villages/quarters. The study sample included 257 urban and 591 rural household. Approximately 80% of respondents were females. The mean age of respondents was 38 (SD:18.8) years, median age was 33 [range: 15 – 97] years. Average household size was 5 (Table 2). Nearly 15% of female respondents had never been to school and 60% of female participants reported peasant farming as their main occupation.

Table 1: Distribution of households reached in targeted health areas with population in 2018 by cluster and setting.

Targeted Health Areas of the study	*Urban or Rural*	*Population size in 2018 (inhabitants)*	*Clusters (Reached/Expected)*	*Households reached*
Fiala-Foreke (1)	Urban	34,760	20/20	197
Balevouni (2)	Rural	1,856	1/1	12
Nkeuli (3)	Rural	2,691	2/2	19
Fotetsa (4)	Rural	5,128	3/3	28
Maka (5)	Urban	10,804	6/6	60
Fonakeukeu (6)	Rural	5,149	3/3	30
Lepoh (7)	Rural	10,472	6/6	60
Ndoh-Djuttitsa (8)	Rural	13,663	9/9	93
Baleveng (9)	Rural	20,658	12/12	118
Doumbouo (10)	Rural	16,908	10/10	99
Mbeng (11)	Rural	20,508	13/13	132
TOTAL	**/**	**142,597**	**85/85**	**848**

Table 2: Socio-demographic presentation of the study sample.

Characteristics	*Modalities*	*Urban*	*Rural*	*Total*	*P value*
Reachedhouseholds (n)	/	257	591	848	
Response rate (%)	/	99.2	100	99.8	
Gender [n (%)]	Female	187 (72.8)	481 (81.4)	668 (78.8)	0.005
	Male	70 (27.2)	110 (18.6)	180 (21.2)	
Age of respondent (μ ± SD)	/	31.1 ± 12.9	41.5 ± 20.0	38.3± 18.8	< 0.0005
Average household size (μ ± SD)	/	5.4 ± 2.8	4.7 ± 2.4	4.9 ± 2.6	< 0.0005
Mother's level of education [n (%)]	No school	13 (5.5)	96 (16.3)	109 (13.2)	
	Primary	63 (26.7)	307 (52.0)	370 (44.8)	
	Secondary	112 (47.5)	181 (30.7)	293 (35.5)	< 0.0005
	Higher	48 (20.3)	6 (1.0)	54 (6.5)	
Father's level of education [n (%)]	No school	10 (4.4)	103 (18.0)	113 (14.1)	< 0.0005
	Primary	70 (30.6)	275 (48.2)	345 (43.1)	
	Secondary	92 (40.2)	168 (29.4)	181 (32.5)	
	Higher	57 (24.9)	25 (4.4)	6 (10.2)	
Mother's occupation [n (%)]	Housewife	47 (20.0)	29 (4.9)	76 (9.3)	
	Farming	55 (23.4)	452 (77.4)	507 (61.9)	
	Self-employment	69 (29.4)	73 (12.5)	142 (17.3)	< 0.0005
	Civil servant	29 (12.3)	23 (3.9)	52 (6.3)	
	Student	35 (14.9)	7 (1.2)	42 (5.1)	

Main sources of indoor air pollution in the DHD

From this study, 90% of households used firewood and about 75% (630 households) of them exclusively used wood. Nearly all households (98%) used wood to meet at least some of their cooking needs in rural HAs. Our results also reveal that 25% household have access to domestic gas for cooking, with a higher proportion in urban areas (55.6%) (Table 3).

Table 3: Fuel distribution in the households of the Dschang Health District

Cooking instruments	*Urban [n (%)]*	*Rural [n (%)]*	*Total [n (%)]*	*P value*
Firewood only	97 (37.7)	533 (74.3)	630 (74.3)	< 0.0005
Firewood	191 (74.3)	577 (97.8)	768 (90.6)	< 0.0005

Gas only	38 (14.8)	10 (1.7)	48 (5.7)	< 0.0005
Gas	143 (55.6)	69 (11.7)	212 (25.0)	< 0.0005
Kerosene stove	14 (5.5)	12 (2.0)	26 (3.1)	0.008
Charcoal	33 (12.8)	6 (1.0)	39 (4.6)	< 0.0005
Saw dust	26 (10.1)	6 (1.0)	32 (3.0)	< 0.0005

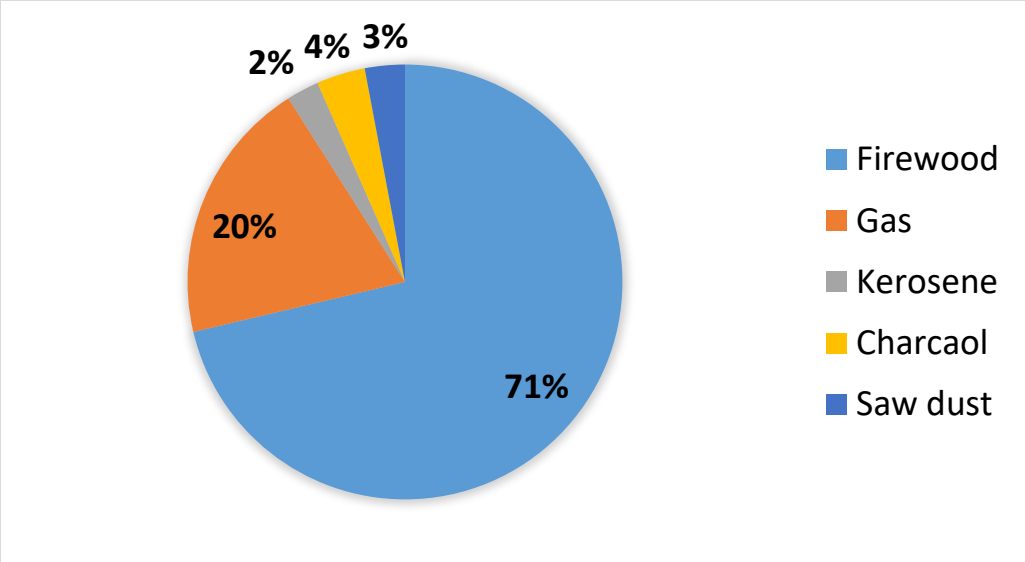

Figure 1: Fuel distribution in the households of the Dschang Health District.

Approximately 75% of households in the DHD use more than one source of fuel (Table 4). However, rural areas are significantly less likely to 'stack' fuels (11%).

Table 4: Distribution of multiple fuel type utilization in the Dschang Health District

Number of cooking fuel	*Urban [n (%)]*	*Rural [n (%)]*	*Total [n (%)]*	*P value*
More than one type of cooking fuel	114 (44.4)	67 (11.3)	630 (74.3)	< 0.0005
More than two types of cooking fuel	29 (11.3)	4 (0.7)	33 (3.9)	< 0.0005
More than three types of cooking fuel	8 (3.1)	0 (0.0)	8 (0.9)	< 0.0005

It is important to note that no one was found to use an electric cooker or a micro wave.

Factors influencing the choice of fuel type

Nearly 60% of households choose their fuel type based on affordability and only (18%) based on availability (Tables 5 and 6).

Table 5: Distribution of reasons influencing choice of fuel type in the Dschang Health District.

Reasons	*Urban[n (%)]*	*Rural [n (%)]*	*Total [n (%)]*	*P value*
Affordability	130 (50.6)	375 (63.4)	505 (59.5)	
Availability	27 (10.5)	122 (20.6)	149 (17.6)	
Rapidity	44 (17.1)	31 (5.2)	75 (8.8)	
Culture	8 (3.1)	40 (6.8)	48 (5.7)	< 0.0005
Easy to use	33 (12.8)	17 (2.9)	50 (5.9)	
Cleanliness	10 (3.9)	5 (0.8)	15 (1.8)	
Other reason	5 (1.9)	1 (0.2)	6 (0.7)	

Table 6: Distribution of main reasons of choice per fuel type in the Dschang Health District.

	Firewood [n (%)]				*Gas [n (%)]*				
Reasons	**U**	**R**	**T**	**P value**	**U**	**R**	**T**	**P value**	**U**
Affordability	118 (61.8)	373 (64.5)	491 (63.9)		52 (36.4)	37 (53.6)	89 (42.0)		16 (48.5)
Culture	8 (4.2)	40 (6.9)	48 (6.2)		4 (2.8)	3 (4.4)	7 (3.3)		0 (0.0)
Rapidity	22 (11.5)	28 (4.8)	50 (6.5)		36 (25.2)	9 (13.0)	45 (21.2)		5 (15.2)
Cleanliness	5 (2.6)	3(0.5)	8 (1.0)	<0.0005	8 (5.6)	2 (2.9)	10 (4.7)	0.08	4 (12.1)
Easy to use	12 (6.3)	13 (2.2)	25 (3.2)		25 (17.5)	6 (8.7)	31 (14.6)		7 (21.2)
Availability	24 (12.6)	120 (20.8)	144 (18.7)		15 (10.5)	11 (15.9)	26 (12.3)		1 (3.0)
Other reason	2 (1.1)	1 (0.2)	3 (0.4)		3 (2.1)	1 (1.4)	4 (1.9)		0 (0.0)

U= Urban; R=Rural; T=Total

Burden of exposure to sources household of air pollution.

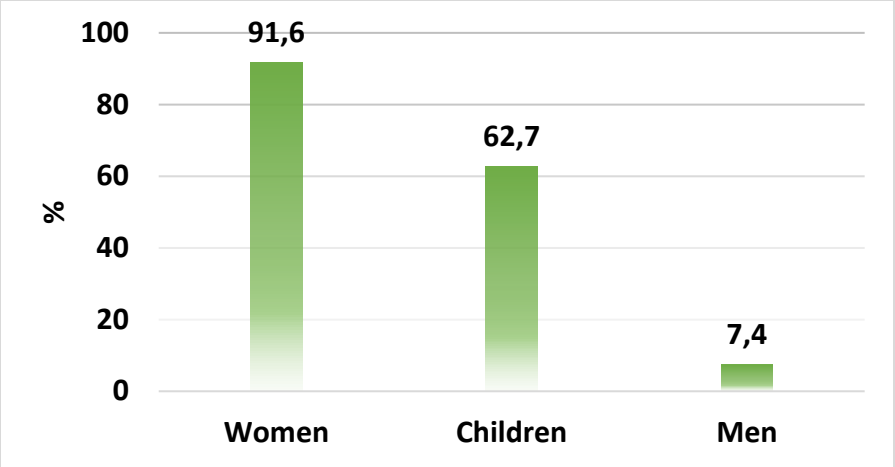

Figure 2: Distribution (%) of persons in charge of cooking in households of the Dschang Health District.

In 9 out of 10 households interviewed, women were reported to be the main cook. Children were involved in cooking in more than 60% of the households and men in only 7% of the households (Figure 2). It is to be emphasised that only the mothers in 270 (31.84%) and the children in 42(4.95%) were in charge of the cooking.

Food was cooked an average of one time (1.3± 0.5) per day in study households, with no variation between rural and urban areas. More than ¾ of households have been using their primary fuel type for more than five years (Table 7). Firewood has been used for the entire lifespan in almost all the households.

Table 7: Duration of utilization per main fuel types

Fuel types	*Duration*	*Urban*		*Rural*		*Total*	
		n (%)	**(95% CI)**	**n (%)**	**(95% CI)**	**n (%)**	**(95% CI)**
Firewood	<= 5 yrs	14 (7.3)	(4.1 – 12.0)	9 (1.6)	(0.8 – 2.9)	23 (3.0)	(2.0 – 4.5)
	> 5 yrs	177 (92.7)	(88.0 – 95.9)	569 (98.4)	(97.1 – 99.2)	746 (97.0)	(95.5 – 98.0
Gas	<= 5 yrs	40 (28.0)	(20.8 – 36.1)	10 (14.5)	(7.2 – 25.0)	50 (23.6)	(18.0 – 29.9
	> 5 yrs	103 (72.0)	(63.9 – 79.1)	59 (85.5)	(75.0 – 92.8)	162 (76.4)	(70.1 – 82.0

Charcoal	<= 5 yrs	6 (18.2)	(7.0 – 35.5)	1 (16.7)	(0.4 – 64.1)	7 (17.5)	(7.5 – 33.5)
	> 5 yrs	27 (81.8)	(64.5 – 93.0)	5 (83.3)	(35.9 – 99.6)	32 (82.0)	(66.5 – 92.5
Kerosene	<= 5 yrs	4 (28.6)	(8.4 – 58.1)	1 (8.3)	(0.2– 38.5)	5 (19.2)	(6.5 – 39.3)
	> 5 yrs	10 (71.4)	(41.9 – 91.6)	11 (91.7)	(61.5 – 99.8)	21 (80.8)	(60.6 – 93.4
Saw dust	<= 5 yrs	4 (15.4)	(4.4 – 34.9)	1 (16.7)	(0.4 – 64.1)	5 (15.6)	(5.3– 32.8)
	> 5 yrs	22 (84.6)	(65.1 – 95.6)	5 (83.3)	(35.9 – 99.6)	27 (84.4)	(67.2 – 94.7

Discussion

This study describes the different primary fuel types used by households in a highly populated district in Cameroon. The use of firewood turned to be more dominant comperatively to the useof other fuel, though available. The population preferred to use wood since they found it easy to get, that is either from their farms or comparatively cheaper (pay as you go) with respect to other sources of fuel such as gas since getting gas entails disbursing large amounts of money for an initial kit

Sources of household air pollution

Results of this study reveal that firewood is the main biomass fuel type used in the Dschang Health District (90%) with a significant difference between the rural and urban settings. Other fuel types including domestic gas, kerosene, charcoal and sawdust, are also found in households with slight disparities between rural and urban yet 75% of the population strictly rely on firewood for cooking. Approximately 75% of households of the DHD use more than one source of fuel however, this proportion was very low in the rural settings (11.3%).

A study published in Cameroon in 2018 showed 70% of households using solid fuel for cooking with 90% at rural level(10). Another published study conducted in another city of the same region (Bafoussam, which is the regional capital) had much lower reported solid fuel use (48%); the difference can be explained by the fact that it was conducted exclusively in an urban area with a smaller sample of household. It is therefore confirmed that rural households of the DHD in Cameroon have a higher reliance on solid fuels for cooking than urban households.

Other fuel types including domestic gas, kerosene, charcoal and sawdust are available but household access is still very limited (less than 5% at community level) for cooking; electricity is strictly used for purposes other than cooking and heating. So, almost all the people living in this area have permanent high risk of developing related diseases.

This is confirmed by data from the National Demographic Health Survey which presented a prevalence of 28.1 percent of acute respiratory infections in children under five in 2014. Interventions targeting increasing population access to non-solid fuel type with consideration of rural and urban disparities can reduce the risk of developing these diseases.

Factors influencing the choice of fuel type

Interviewed head of households or representatives cited a number of factors influencing the choice of their cooking fuel type; affordability (59.5%) and availability (17.6%) were the main reasons. Other concerns were speed of cooking, ease of use, tradition, cleanliness and health and safety. This is in agreement with other studies carried out in low-income areas of India (3–5,12). The population preferred to use wood since they found it easy to get, that is either from their farms or comparatively cheaper (pay as you go) with respect to other sources of fuel such as gas since getting gas entails disbursing large amounts of money for an initial kit.

To whom the burden of exposure to sources household of air pollution.

Mothers and children were mostly those under this heavy load of HAP. Because of their customary involvement in cooking, especially women's exposure is much higher than men's (3,12,14–16) with children either been carried on the back during cooking hours or laid to sleep on kitchen beds during the cooking process.

These women and children have been exposed to IAP almost all their lives, since almost every HH (92.7 for Urban vs 98.4 for Rural) has been using firewood as their cooking fuel for more than 5years and only 24% of households have used LPG as their source of cooking fuel for the same

duration. As such, studies to evaluate their effective degree of HAP exposure and interventions to aiding the population to switch from solid fuels to cleaner sources of fuel is imperative.

Strength and Limitations

Information bias which we encountered due to the fact that we relied solely on the information the participants gave. However, using stratified sampling enabled equal urban/rural representation of the communities.

Conclusion

This study brings out wood as the main source of energy for both urban and rural health areas. The choice of fuel type was mainly as a result of poverty. As such, we recommend more studies to be carried out on HAP in and Cameroon so that a true picture of the nation's state as concerns indoor air pollution be exposed, more studies to be carried out so as to bring out the relationship or association between indoor air pollution and respiratory related diseases and other health impacts, and a study to measure the degree of exposure to indoor air pollution.

List of abbreviations

DHD: Dschang Health District

HA: Health Area

HH: Household

HD: Health District

IAP: indoor Air Pollution

ARI: Acute Respiratory Infection

Declarations

Ethics approval and consent to participate

The proposal of this study was submitted and evaluated by the National Ethics Committee of Human Health Research of Cameroon (reference number **1030).** Prior to this evaluation,

authorization was obtained from local health authorities of the DHD and for each village/quarter, authorization was obtained from local traditional authorities. Data was collected from consenting households and personal data are not published in this study.

Consent for publication

Not applicable

- **Availability of data and material**

The database of this study is not available online but can be shared on request from the author.

- **Competing interests**

The authors declare that they have no competing interests.

- **Funding**

The study was funded by the principal investigator, who was involved in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

- **Authors' contributions**

Conception and design of the study and data collection tools: MBE and JA;

Data collection and entry: MBE, WB, HSYS, BDKA, OTMH, CDD, RSFN, MSTG

Data cleaning and analysis: APG

Drafting and editing the manuscript: EMB, APG, DP, BHNM, MPS

All authors red and approved the final manuscript.

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