Biomass Fuel use Prevalent in the Zambian Population: Observations from the Zambia Demographic Health Survey 2018

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https://doi.org/10.56893/ajhes2024v03i01.10

Abstract

Background: Biomass fuels are used by half of the world's population, and are often the only source of domestic energy. Markers of lower socioeconomic status were related to greater use of dirty-burning fuels. This study aimed to measure the prevalence and determinants of biomass fuel use in the Zambian population.

Methodology: This cross-sectional study used secondary data from the Zambia Demographic Health Survey 2018. Descriptive statistics of individual characteristics, testing for associations using Pearson's chi-square test, and univariate and multivariate binomial regressions were performed using Stata 13.

Results: The prevalence of biomass fuel use was 91.7% (11,762), with the most notable usage observed among females (68.2%) residing in rural areas compared to males (63.4%). Factors indicating lower socioeconomic status, such as living in rural areas with a crude prevalence ratio of 1.13 (1.12-1.14) and cooking outdoors at 1.10 (1.09-1.10), were linked to the use of biomass fuels, while higher education served as a protective factor at 0.84 (0.83-0.85).

Conclusion: This study showed that rural residence, cooking from outside, and educational attainment could be important determinants of the use of biomass fuels. Education appears to be an effective preventive factor in reducing the likelihood of biomass fuel use.

Keywords: Biomass fuels; education; prevalence; determinants; Zambia demographic health survey

Introduction

The World Health Organization (WHO) has ranked indoor air pollution as the 10th most important preventable risk factor in developing countries and is the fourth most important preventable risk factor (Farmer, 2001). Approximately half of the world's population and up to 90% of households in rural areas of developing countries still depend on unprocessed biomass fuels, mainly wood, dung, and crop residues, for cooking and heating

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(Jaakkola & Jaakkola, 2006). Globally, almost two million deaths per year are attributable to solid fuel use, with more than 99% of these occurring in developing countries. Several billion hours are spent collecting firewood for cooking, primarily by women, which could be put to more productive use (Prasad et al., 2012). Globally, the region with the highest use of solid fuels for cooking is sub-Saharan Africa (Bonjour et al., 2013). Several studies in sub-Saharan Africa have shown that the levels of household particulate matter are high and far exceed the levels recommended by the World Health Organization to avoid detrimental health effects (Fullerton et al., 2009).

Biomass fuels are often the only domestic energy source for cooking and heating. Smoke emissions from these fuels are a major source of indoor air pollution, particularly in the rural communities of developing countries. These emissions contain pollutants that adversely affect health, such as suspended particulate matter and polycyclic organic matter, which include several known carcinogens, such as benzo[a]pyrene, and harmful gases, such as carbon monoxide and formaldehyde. There is evidence that exposure to these pollutants can lead to an increased risk of diseases, including respiratory infections (e.g., pneumonia, tuberculosis, chronic obstructive pulmonary disease, lung cancer, and asthma), low birth weight, cataracts, and cardiovascular events. A systematic review of 33 studies on tobacco smoke, indoor air pollution, and tuberculosis, including five on biomass fuel combustion, concluded that exposures increased the risk of tuberculosis. However, stronger evidence is needed to draw conclusions.

Markers of lower socioeconomic status, such as educational attainment and occupation, are related to greater use of dirty-burning fuels. This pattern is illustrated by a six-fold increase in the use of wood compared between the highest and lowest levels of education, with an inverse and similar magnitude of difference in the use of electricity across the education level spectrum (Piddock et al., 2014). Effective health education can result in acquiring knowledge and bringing about desired changes in practice (Vijayapushpam et al., 2010). There seems to be a need to design context-specific interventions based on evidence; however, the burden and socio-demographic factors associated with using biomass fuels are unknown. Therefore, this study aims to serve as a basis for future programs by assessing the prevalence and determinants of biomass fuel use in the Zambian Population..

Methodology

This study was based on information extracted from the 2018 Zambia Demographic and Health Survey [ZDHS]. The Zambia Demographic and Health Survey (2018) is a nationally representative sample of women aged 15-49 and men aged 15-59 who were residents of the selected households or slept in the households the night before the survey. ZDHS data collection took place from 18th July 2018 to 24th January 2019. The main objective of

the 2018 ZDHS was to provide up-to-date estimates of the basic demographic and health indicators. Specifically, the ZDHS collected information on fertility and childhood mortality levels; fertility preferences; awareness, approval, and use of family planning methods; maternal and child health; adult and maternal mortality; and knowledge and attitudes toward HIV/AIDS and other sexually transmitted infections. The information collected through the ZDHS is intended to assist policymakers and program managers in evaluating and designing programs and strategies to improve the health of the country's population.

Study Design

This was a population-based cross-sectional study. Secondary data were extracted from the 2018 Zambia Demographic Health Survey.

Study Selection

The sample size of this study was determined using the available data of 11,846 participants (aged 15 years or older) who were interviewed.

Extraction Criteria

Data was extracted from the existing Zambia Demographic Health Survey datasets. The extraction criteria are based on those that answered the "question on cooking method and sex." A coding matrix for the variables of interest was then created. A data extraction form was used to extract the values of the dependent and independent variables. Demographic and socioeconomic factors and cooking methods were extracted from the ZDHS dataset. The demographic factors of interest were gender and age. Three markers of socioeconomic status were considered: place of residence, highest level of education attained, and wealth index. The age of the participants was further categorized as 15-24, 25-29, 30-39, and 40+.

Data Management and Analysis

In this study, there was one dichotomous outcome variable: cooking method (use of biomass fuels: yes or no). The data collected from the extraction tool was sorted and imported into the statistical analysis tool Stata version 13 for further cleaning and analysis (Stata, 2009). Categorical variables were reported as numbers and percentages. Pearson's chi-square test assessed statistical differences between categorical variables with a significance level set at $p<0.05$ and a 95% confidence interval. Normally distributed continuous data were reported as means and standard deviations. The Shapiro-Wilk test was used to test for normality. In this study, only age was normally distributed (The Shapiro-Wilk test expressed a p-value greater than 0.05). Other continuous data were presented as medians and interquartile ranges. Univariate and multivariate analyses were performed using binomial regression. Associations between participant characteristics and cooking methods were evaluated using prevalence ratios and their associated 95% confidence intervals. A *p*-value lower than 0.05 is deemed significant.

Ethical Considerations

This study was based on a secondary analysis of publicly available ZDHS data that had already been collected. There was minimal to no risk to the participants, with benefits from modifiable ways of using cleaner fuels based on the identified determinants of biomass fuel use. There is also a potential benefit as data will be used to guide and design future implementation interventions and can be used to inform various programs such as tuberculosis programs. Data were anonymized, and the protocol was approved; therefore, confidentiality was maintained. A waiver was granted from the University of Zambia Biomedical Research Ethics Committee.

Results

Population and Distribution

Among the respondents (n=11846), there were 10057(84.9%) women and 1789(15.1%) men. The highest number of women respondents were in the 40+ age group, 5441(54.1%) women and 1045(58.41%) men. Most of the respondents resided in rural areas, 8117 (63.3%); 6457(64.2%) of these are women and 1076(60.1%) are men. The highest number of respondents are in the poor category (65.1 %), with more women in this category at 3524(35.1%) than men at 607(33.9%). Most respondents had a low (primary or lower) educational level at 6968(54.3%). The highest number of respondents used dirty fuels at 11762(91.7%), with men and women comparably using dirty fuels at 1651(92.3%) and 9274(92.2%), respectively. The highest number of respondents cook from indoors 7058(55.0%) with women more at 5667(56.4%) than men at 904(50.5%) (see Table 1).

Table 1

Sociodemographic and Proximate Characteristics of the Respondents

	Men	Women	All (Men and Women)
	n (%)	n (%)	n (%)
Electricity			
No	1291(72.2)	7166 (71.3)	9141(71.2)
Yes	498 (27.8)	2891 (28.7)	3690 (28.8)
Age group			
15-24	136 (7.6)	514(5.1)	765(6.0)
25-29	175 (9.8)	1197 (11.9)	1547(12.1)
30-39	433 (24.2)	2905 (28.9)	3530 (27.5)
40+	1045 (58.4)	5441(54.1)	6989 (54.5)
Residence			
Urban	713 (39.9)	3600 (35.8)	4714 (36.7)
Rural	1076 (60.1)	6457(64.2)	8117 (63.3)
Wealth			
Poor	1182 (66.1)	6533 (64.9)	8341 (65.1)
Rich	607 (33.9)	3524 (35.1)	4490 (34.9)
Education Level			
Low	1151(64.3)	5302(52.7)	6968 (54.3)
Higher	638 (35.6)	4755(47.3)	5863 (45.7)
Cooking fuel			
Clean fuels	138 (7.7)	783 (7.8)	1069 (8.3)
Dirty fuels	1651 (92.3)	9274 (92.2)	11762(91.7)
Cooking place			
Indoors	904 (50.5)	5667 (56.4)	7058 (55.0)
Outdoors	885 (49.6)	4390 (43.6)	5773 (45.0)
Total	1789 (15.1)	10057 (84.9)	11846(100.0)

*Low education=No education and Primary *Higher education =Secondary or Higher

Frequency Distribution of Biomass Fuel Determinants

Most respondents used biomass fuels, with 92.3% of men using biomass fuels, while 9274 (92.2%) of women used biomass fuels. Generally, the 15-24 age group had the highest number of respondents using biomass fuels 725(94.8%), which was consistent among women. However, men in the 40+ years age group reported more biomass fuel use at 993(95.0%). 7909(97.4%) residents using biomass fuels resided in rural areas, with 6328(98.0%) women using biomass fuels, compared to 1046 (97.2 %) men. The highest number of biomass fuel users had low education (no education or primary education, 98.9%), which was consistent across both men and women. Most of the respondents used biomass fuels cooked outdoors, 5741(99.5%), which is similar among both genders, at 882(99.7%) among men and 4364(99.4%) among women. The highest number of

biomass fuel users is in the poor category at 8338(99.96%), and this is similar across both genders (see Table 2).

Table 2

Frequency Distribution of Biomass Fuels Determinants

	Women (n=10,057)	Men (n=1789)	All(n=11846)
	n (%)	n (%)	n (%)
Total	9274(92.2)	1651(92.3)	11762(91.7)
Age group			
15-24	504(98.1)	122(89.7)	725(94.8)
25-29	1136(94.9)	143 (81.7)	1399(90.4)
30-39	2618 (90.1)	393 (90.8)	3157(89.4)
40+	5016 (92.2)	993(95.0)	6481(92.7)
Residence			
Urban	2946(81.8)	605 (84.8)	3853(81.7)
Rural	6328(98.0)	1046(97.2)	7909(97.4)
Education Level			
Low	5239(98.8)	1142(99.2)	6892(98.9)
Higher	4035(84.9)	509(79.8)	4870(83.1)
Cooking place			
Indoors	4910 (86.6)	769 (85.1)	6021(85.3)
Outdoors	4364(99.4)	882 (99.7)	5741(99.5)
Wealth			
Poor	6531 (99.9)	1181(99.9)	8338(99.96)
Rich	2743 (77.8)	470(77.4)	3424(76.3)

Determinants of Biomass Fuel Use

The prevalence of biomass fuel use was higher in women (84.9%) than in men (15.1%). The prevalence of biomass fuel use increased with age, with the highest prevalence being 55.1% in the 40+ age group. Of the respondents who used biomass fuel, 67.2% resided in rural areas. The highest number of respondents using biomass fuels attained a low educational level of 6892(58.6%). The highest number of biomass fuel users cook indoors 6021(51.2%). Most biomass fuel users were in the poor category, 8338(70.9%). Respondents living in rural areas, cooking outdoors and being female were associated with the use of biomass fuels as shown in Table 3, while being female was not related to the use of biomass fuels after adjusting for residence and cooking place (see Table 3).

Table 3

Determinants of Biomass Fuel Use

Variable	Prevalence (N)	Crude PR (CI)	Adjusted PR(CI)
Age group (years)			
15-24	725(6.2)	1	
25-29	1399(11.9)	0.95 (0.93-0.98)	
30-39	3157(26.8)	0.94 (0.92-0.96)	
40+	6481(55.1)	0.98(0.96-1.00)	
Residence			
Urban	3853(32.8)	1	1
Rural	7909(67.2)	1.20(1.18- 1.21)	1.13(1.12- 1.14)
Education level			
Low	6892(58.6)	1	
Higher	4870(41.4)	0.84(0.83-0.85)	
Cooking place			
Indoors	6021(51.2)	1	1
Outdoors	5741(48.2)	1.20(1.20-1.21)	1.10(1.09 -1.10)
Wealth			
Poor	8338(70.9)	1	
Rich	3424(29.1)	0.73(0.72-0.74)	
Gender			
Male	1651(15.1)	1	1
Female	9274(84.9)	1.01(0.98- 1.01)	0.94(0.94 – 0.94)

Determinants of Biomass Fuel Users by Gender

Among men, the highest number of biomass fuel users are in the 40+ age group at 60.1%, with the lowest being the 15-24 age group at 7.4%. Most men using biomass fuels resided in rural areas 1046(63.4%). The highest level of education attained by most men using biomass fuels is low at 1142(69.2%). Most men cooked outdoors at 882(53.4%). 71.5% of male biomass fuel users were poor. Men Respondents in the 30-39 age group and 40+ age group residing in rural areas and cooking outdoors were associated with using biomass fuels.

Among the women, the 40+ years age group had the highest number of biomass fuel users (54.1 %), and most women resided in rural areas at 6328(68.2%). The highest level of education attained by most female biomass fuel users was low (56.5 %). Most female biomass fuel users cook indoors 4910(52.9%). Most female biomass fuel users were in the poor category at 6531(70.4%). Residing in rural areas and cooking outdoors were associated with the use of biomass fuels among the women (see Table 4).

Table 4

Determinants of Biomass Fuel Use by Gender

	Men		Women	
	Prevalence	PR (CI)	Prevalence	PR(CI)
Age group (years)				
15-24	122(7.4)	1	504(5.4)	1
25-29	143(8.7)	0.91(0.83-1.00)	1136(12.2)	0.97(0.95-0.99)
30-39	393(23.8)	1.01 (0.95-1.08)	2618(28.2)	0.92(0.90-0.93)
40+	993(60.1)	1.06(1.00-1.12)	5016(54.1)	0.94(0.93-0.95)
Residence				
Urban	605(36.6)	1	2946(31.8)	1
Rural	1046(63.4)	1.15(1.11- 1.18)	6328(68.2)	1.20(1.18-1.22)
Education level				
Low	1142(69.2)	1	5239(56.5)	1
Higher	509(30.8)	0.79(0.76-0.82))	4035(43.5)	0.85(0.85-0.87)
Cooking place				
Indoors	769(46.6)	1	4910(52.9)	1
Outdoors	882(53.4)	1.21(1.18-1.25)	4364(47.1)	1.20(1.18-1.21)
Wealth				
Poor	1181(71.5)	1	6531(70.4)	1
Rich	470(28.5)	0.74(0.71-0.78)	2743(29.6)	0.73(0.71-0.74)

Discussion

This large cross-sectional study provides new insights into the demographics of biomass fuel use in the Zambian population. There is evidence of high biomass fuel use in this population, with a prevalence of 91.7%. This burden is generally most notable in females residing in the country's rural areas, in contrast to males, who seem to have a slightly smaller burden than those living in rural areas.

These findings are similar to a study in India where women are the primary cooks (Regalado et al., 2006). However, older men seem to have a higher burden than older women. We also found evidence indicating that the rate of biomass fuel usage is steadily increasing with an increase in age in both men and women. A similar trend was observed in a study conducted in Malawi, which reported an increase in age, greater use of wood, and less use of electricity (Piddock et al., 2014). The reason for this association is unclear, but we hypothesize that it could be attributable to the use of biomass fuels as a primary source of fuel in the older age categories. In support of our observed association between increased age and use of more dirty-burning fuels, a study by Fullerton et al. (2009) also found that participants who used wood were significantly older than those who used charcoal.

The finding that the prevalence of biomass fuels increased with age in both men and women is an interesting observation. This finding is supported by the fact that non-communicable diseases are much more frequently associated with individuals in older age groups (Prasad et al., 2012). This finding provides an opportunity to follow these individuals as health-promoting interventions by promoting early screening and detection of

associated Non Communicable Diseases and encouraging the use of alternative fuels to combat the progression of these NCDs or reduce the general prognosis of existing NCDs (de Koning et al., 1985). There is a lack of knowledge of the health risks associated with the use of biomass fuels, which could make them more prone to habit. This highlights the importance of targeting the older population in the overall efforts to use alternative fuels.

The link between markers of lower socioeconomic status and more dirty-burning fuels is consistent with two studies conducted in Malawi (Fullerton et al., 2009). A more extensive study in Ghana found that neighborhoods with a lower socioeconomic status used a greater amount of biomass fuels and had higher particulate matter levels in cooking areas (Munday et al., 2019). Markers of lower socioeconomic status, such as rural residence and cooking outside, were associated with the use of biomass fuels. At the same time, higher education had a negative association with the use of biomass fuels. Therefore, we state that biomass fuel use appears to be driven by socioeconomic factors such as residence, education level, and cooking place. Higher socioeconomic status seems to have a protective effect.

Consequently, the use of biomass fuels remains the highest among poor individuals and the lowest among the rich. The distinct division between the poor and rich may confer a risk for the persistent use of biomass fuels to make ends meet. These findings are supported by a population-level comparative risk assessment model used to assess the mortality effects of interventions on child nutrition and environmental risk factors stratified by economic status (Zhou et al., 2011). They found that implementing environmental changes, including cleaner fuels initially aimed at the poorest people, would result in a greater reduction in child mortality. The effects of education on biomass fuel consumption are unknown. However, a lower level of education was tracked with greater reported use of wood, and less use of electricity is a similar finding in a study conducted in Bangladesh (Baul et al., 2018). Economic and lifestyle changes that follow educational attainment may have been associated with behaviors that decreased the use of biomass fuels in those with higher (secondary or higher). Highly educated people may be the first to respond positively to preventive information on the use of biomass fuels, have more opportunities for alternative use of fuels, and therefore are more likely to understand the dangers of the use of biomass fuels. The association between education and biomass fuel use may be mediated by health knowledge. Education is a robust determinant of health awareness. Exposure to health education improves understanding of the association between health behaviors and outcomes, positively contributing to health behaviors. Furthermore, less-educated individuals may be less responsive to health promotion or may receive less information about the consequences of the use of biomass fuels.

Women generally use more biomass fuels than men in this population. The Zambian sociocultural characteristics might be a significant factor in the large discrepancy between men and women. Although Zambian society has been influenced by Western culture during the past decades, it remains conservative and rooted in traditional culture, especially in women. Women are most exposed to the use of biomass fuels because they do most of the domestic work, including cooking. Women with higher socioeconomic status may be more insensitive to social norms or have a chance to access alternative fuel sources. These findings are similar to those of a study in Malawi, where domestic activities were more commonly reported as occupations by women (16.2%) than men (0.9%), suggesting that women are likely to have greater exposure to household air pollution.

We also found geographical contrasts associated with the use of biomass fuels in this population. The highest number of respondents using biomass fuels resided in rural areas compared to urban areas. This finding is similar to that of a study that demonstrated that lower socioeconomic status and wood burning were significantly associated with living in a rural area (Fullerton et al., 2009). A more extensive study in Ghana found that neighborhoods with a lower socioeconomic status used a greater amount of biomass fuels and had higher particulate matter levels in cooking areas (Kruk et al., 2015). It is well recognized that the greatest burden of disease from household air pollution is found in less-developed areas of the world (Gakidou et al., 2007). There is also evidence that non-communicable diseases have a disproportionally large effect on those with a lower socioeconomic status (Mortimer et al., 2012). Sustainability, accessibility, and cost of alternative fuel sources may be among the factors contributing to the use of biomass fuels, especially in rural Zambia.

Overall, our findings highlight the need for comprehensive approaches to reducing the use of biomass fuels and their associated health effects. Documenting biomass fuel exposure is vital for addressing diseases associated with household air pollution, including COPD and pneumonia (Di Cesare et al., 2013). A greater understanding of biomass fuel use is also helpful in enabling us to tackle the emerging epidemic of non-communicable diseases as a whole. This will allow the planning of appropriate interventions and surveillance to monitor the link between changes in exposure and improved outcomes. The considerable variability in worldwide exposure to risk factors for non-communicable diseases, such as household air pollution, also reinforces the need for epidemiological studies of noncommunicable diseases in sub-Saharan Africa. Due to the negative association between the individual use of biomass fuel and higher education, policies should pay more attention to populations with a low level of education, as this is the cheapest and most sustainable way to reduce the use of biomass fuels to break the link between educational disadvantages and the use of biomass

fuels. Policies should focus on enhancing health literacy and implementing anti-biomass fuel education initiatives. Tailored interventions should target the biomass fuel use characteristics of different socioeconomic status groups. The tailored interventions may include improving awareness of social norms regarding the use of biomass fuels for low-income females and offering social support to rural residents. Therefore, biomass fuel control policies should address individual behaviors and mitigate broader inequalities in educational opportunities and cultural backgrounds.

Conclusion

This study showed that rural residence, cooking from outside, and educational attainment could be important determinants for the use of biomass fuels. This suggests that various socioeconomic and sociodemographic factors, singly or synergistically, could be key factors influencing biomass fuel use. It remains unresolved whether low education is a risk factor for the use of biomass fuels or whether educational disparities in biomass fuels are attributable to factors that confer risk for both low education and use of biomass fuels. Nonetheless, because education appeared to be an effective preventive factor in reducing the likelihood of biomass fuel use, this could mean that integrated approaches for primary preventive health strategies designed to reach such predominantly poor and hard-to-reach communities might be an answer to strengthening community health systems. Those with higher levels of education could be used as peer promoters or role models for intervention. Therefore, it is recommended that interventions be repackaged or shaped with appropriate messages and messengers to target at-risk populations with messages they can understand based on their level of education.

Acknowledgment

The authors wish to express their sincere appreciation and acknowledge the invaluable contribution made by the lecturers at the University of Zambia, the School of Public Health, in particular the TDR team, the central statistical office, and the DHS program, who provided the data source for this study, and the University of Zambia Biomedical Research Ethics Committee, that granted ethical approval.

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