






Assessing the Respiratory and Eye Effects of Biomass for Healthy Adult Populations in Mogadishu, Somalia

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ABSTRACT

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Biomass burning, primarily involving wood and charcoal, is a prevalent source of energy in Mogadishu, Somalia. This study assesses the impact of exposure biomass fuel smoke on Respiratory and Eye symptoms for Healthy Adult Populations in Mogadishu, Somalia. A hospital-based cross-sectional study was conducted from January to March 2024 with 220 participants. Data were gathered using a structured, pretested questionnaire. Logistic regression analysis, including multivariate logistic regression, was performed to assess the association between independent variables and respiratory symptoms. Key findings include that 37.3% of respondents have respiratory symptoms, while 62.7% did not experience any respiratory symptoms. Additionally, 78 participants (35.5%) experienced eye irritation, whereas 142 participants (64.5%) did not. Wood biomass use significantly increased the risk of respiratory symptoms with an adjusted odds ratio (AOR) of 4.635 (95% CI: 1.663-12.919, $p=0.012$). Prolonged exposure of 1-2 hours (AOR=0.246, 95% CI: 0.101-0.598, $p=0.001$) and 3-4 hours (AOR=0.114, 95% CI: 0.044-0.294) significantly lowered the risk of ARI compared to 5-6 hours. Indoor biomass exposure showed higher odds of respiratory symptoms (AOR=2.201, 95% CI: 0.762-6.355), although not statistically significant ($p=0.145$). The study concludes that biomass burning significantly contributes to health outcomes, underscoring the need for sustainable energy alternatives and health awareness campaigns tailored to local needs.

1. INTRODUCTION

Approximately half of the world's population relies on biomass and coal as their main energy sources for cooking, heating, and lighting [1]. Around 2.3 billion people globally use open fires or inefficient stoves fueled by biomass, creating harmful pollutants that in 2020 caused an estimated 3.2 million deaths, including over 237,000 children under 5 [2, 3]. Combined with ambient air pollution, this results in 6.7 million premature deaths annually and is linked to severe noncommunicable diseases like stroke, heart disease, COPD, and lung cancer [4, 5]. Somalia, with one of the lowest electrification rates in Africa, relies heavily on biomass fuels such as wood and charcoal as the predominant sources of energy for its households [6, 7]. The production of charcoal in Somalia is driven not only by domestic consumption [8], which accounts for about 20% of total production but also by significant foreign demand [9], which constitutes the remaining 80% [10]. The combustion of biomass fuels such as charcoal and wood in inadequately ventilated environments releases hazardous pollutants including particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs) [11, 12]. These pollutants are known to contribute to adverse respiratory and ocular health outcomes

[13, 14], yet their specific impact on the adult population in Mogadishu remains underexplored [15, 16]. Understanding these effects is crucial in regions where biomass use is prevalent and where respiratory conditions such as chronic obstructive pulmonary disease (COPD), asthma, and acute respiratory infections are common [17, 18]. These health conditions contribute to increased morbidity and mortality rates and place a significant burden on Somalia's already strained healthcare infrastructure [19, 20]. Exposure to biomass smoke, particularly from wood used in cooking, has been identified as a significant risk factor for chronic obstructive pulmonary disease (COPD) in developing regions [21]. Inhaling wood smoke for 4.5 hours is comparable to smoking around 20 packs of cigarettes per day [1]. Studies from Latin America and Asia consistently demonstrate a strong association between exposure to solid fuel smoke during cooking and the prevalence of COPD and chronic bronchitis, particularly among women [18]. Previous studies demonstrated that biomass smoke exposure leads to higher carbon dioxide partial pressure and lower lung function measurements compared to cigarette smoke, indicating the severe impact of biomass smoke on respiratory health [22]. Similarly, individuals exposed to biomass smoke were 1.38 times more likely to be diagnosed with COPD, with a

significant association found in women living in both rural and urban areas [17]. Globally, the prevalence of COPD varies significantly, with research indicating a concerning trend, particularly in Africa [23]. In Sub-Saharan Africa COPD prevalence rates in Africa ranging from 1.7% to 24.8%, with a pooled prevalence of 8%. The prevalence was notably higher with increasing age, smoking, and biomass smoke exposure [24]. Similarly, in Systematic review and Metanalysis in East Africa found an overall pooled COPD prevalence of 13.322% in East Africa, with variations across countries such as Ethiopia, Uganda, Tanzania, Malawi, Sudan, and Kenya [25]. The study emphasized the high burden of COPD, with approximately one in seven individuals in East Africa affected by the disease [25]. Wood smoke exposure from biomass cooking can lead to inflammation of the bronchial epithelium, accumulation of anthracotic particles in the lung parenchyma, and fibrotic thickening of the alveolar septa [26]. The subchronic exposure to wood smoke results in damage similar to that caused by tobacco smoke, including inflammatory lesions resembling emphysema, increased matrix metalloproteinase activity, and apoptosis [27]. These enzymes contribute to the degradation of the basement membrane and interstitial extracellular matrix in the lungs [28]. Additionally, oxidative stress and neutrophilic inflammation are central to the lung injury caused by biomass smoke exposure [29]. Despite the recognition of biomass smoke as a critical environmental health hazard, there is a notable lack of research on its effects on healthy adult populations in Somalia [30, 31]. This study aims to fill this research gap by assessing the respiratory and eye health of adults exposed to biomass smoke in Mogadishu. It will gather baseline data on the prevalence and severity of symptoms related to biomass exposure to help guide public health interventions and policies. The findings from this study could help advance environmental health efforts in Somalia, where indoor air pollution is a growing issue [32]. This research not only addresses immediate health concerns but also tackles broader issues like health equity and sustainable development [33]. Somalia's heavy reliance on biomass fuels, such as charcoal and wood, is tied to socio-economic challenges, making it crucial to improve access to clean energy and strengthen public health systems [34]. Therefore, this study aims to contribute to global efforts in improving environmental health, particularly in resource-limited settings facing similar challenges.

2. RESEARCH METHODOLOGY

2.1 Study design and setting

A hospital based cross-sectional study was conducted from September to October 2022 among adults living in the Hodan district of Mogadishu, Somalia. Data were collected from three different hospitals in Mogadishu, chosen based on their accessibility and patient load: Mogadishu Somali Türkiye Training and Research Hospital, Somali-Sudanese Hospital, and Kalkaal Hospital. Patients attending these selected hospitals within the study area were included in the study, while those who declined to participate were excluded.

2.2 Sample size

The study employed a single population proportion formula to determine the sample size due to the lack of previous

publications about the effect of biomass exposure on respiratory health in this region [35]. Therefore, to estimate the impact of biomass exposure on respiratory health, the study relied on prevalence data from a previous study conducted in Sri Lanka, where the prevalence (p) was found to be 17.3% [13]. A margin of error of 5% and a confidence level of 95% were considered.

$$N = \frac{Z^2 pq}{d^2}$$

$$N = \frac{(1.96)^2 * 0.173 * 0.827}{0.05^2}$$

$$N = 220$$

The participants were randomly selected using a random number generator.

2.3 Data collection

The data were collected through structured questionnaires distributed to the selected participants. The questionnaire used in this study was an adapted version of the adult questionnaire from the European Community Respiratory Health Survey II (ECRHS II), which has been extensively used in previous research [36]. It comprises three sections: the first section collects personal and sociodemographic information from the participants; the second section gathers details on the types and determinants of household fuel usage; and the third section focuses on identifying risk factors for health-related complaints and symptoms experienced in the residential environment over the past three months.

2.4 Data analysis

The collected data from the questionnaires was analyzed using quantitative analysis techniques. Descriptive statistics such as frequencies and percentages were used to summarize demographic characteristics, biomass exposure factors and respiratory symptoms. Logistic regression analysis, including multivariate logistic regression, was performed to assess the association between biomass exposure variables and respiratory symptoms.

2.5 Ethics approval and consent to participate

This study was approved by the Research Ethics Committee of Jamhuriya University of Science and Technology. Additionally, permission was obtained from the relevant hospital authorities, and informed consent was collected from each participant prior to data collection.

3. RESULTS

3.1 Sociodemographic characteristics of study participants

A total of 220 participants took part in the study. The sample included 122 males (55.5%) and 98 females (44.5%). Most participants were aged 26-35 years (70.9%), with fewer in the 36-45 years (14.1%), over 45 years (10.5%), and 18-25 years (4.5%) age groups.

Family size varied, with 85.5% living with more than 5 people. Income levels were distributed as follows: less than

\$100 (35.9%), \$100-\$300 (36.8%), \$300-\$600 (21.8%), and more than \$600 (5.5%). Educational attainment included no formal education (28.2%), primary school (5.0%), secondary school (12.3%), and college/university (54.5%). Smoking

habits at home were reported as no one smokes (27.7%), one smoker (24.1%), and two or more smokers (48.2%), as shown in Table 1.

Table 1. Sociodemographic characteristics of participants

Variable	Frequency	Percent
Sex		
Male	122	55.5
Female	98	44.5
Age Group		
18-25	10	4.5
26-35	156	70.9
36-45	31	14.1
Over 45	23	10.5
Family Members		
5≤persons	32	14.5
6> persons	188	85.5
Income		
Less than 100\$	79	35.9
Between 100-300\$	81	36.8
Between 300-600\$	48	21.8
More than 600\$	12	5.5
Education Level		
No formal education	62	28.2
Primary school	11	5.0
Secondary school	27	12.3
College/University	120	54.5
The Number of Smokers at Home		
No one smokes	61	27.7
One	53	24.1
Two or more	106	48.2

Table 2. Prevalence of symptoms among respondents due to biomass use

Symptoms	Frequency	Percent (%)
Respiratory Problems (e.g., coughing, wheezing, asthma)		
Yes	82	37.3
No	138	62.7
Eye Irritations (e.g., redness, tearing)		
Yes	78	35.5
No	142	64.5

Table 3. Association of biomass fuel use with acute respiratory infections

Exposure Variable	Category	No. of People with Respiratory Symptoms (n=220)		COR (95%CI)	AOR (95%CI)	P-Value
		Yes	No			
Smoking exposure (pack-years)	1-2	21	40	0.980 (0.504-1.902)	1.280 (0.570-2.872)	0.254
	2-3	25	28	0.576 (0.294-1.129)	0.588 (0.253-1.365)	
	>3	36	70	1	1	
Type of biomass	Wood	45	115	5.679 (2.406-13.405)	4.635 (1.663-12.919)	0.012
	Charcoal	17	14	1.830 (0.635-5.271)	1.970 (0.418-9.289)	
Frequency of using Biomass	Cardboard	20	9	1	1	0.003
	1-2	20	12	1.800 (0.312-10.390)	0.603 (0.080-4.544)	
	3-4	51	120	7.059 (1.378-36.154)	3.271 (0.534-20.045)	
	5-6	5	4	2.400 (0.303-19.041)	3.414 (0.314-37.181)	
Exposure Range (hours)	>6	6	2	1	1	0.001
	1-2	30	22	0.154(0.075-0.318)	0.246 (0.101-0.598)	
	3-4	31	16	0.108 (0.050-0.233)	0.114 (0.044-0.294)	
Location of Biomass	5-6	21	100	1	1	0.145
	Outdoor	54	109	1	1	
	Indoor	28	29	1.949 (1.056-3.598)	2.201 (0.762-6.355)	

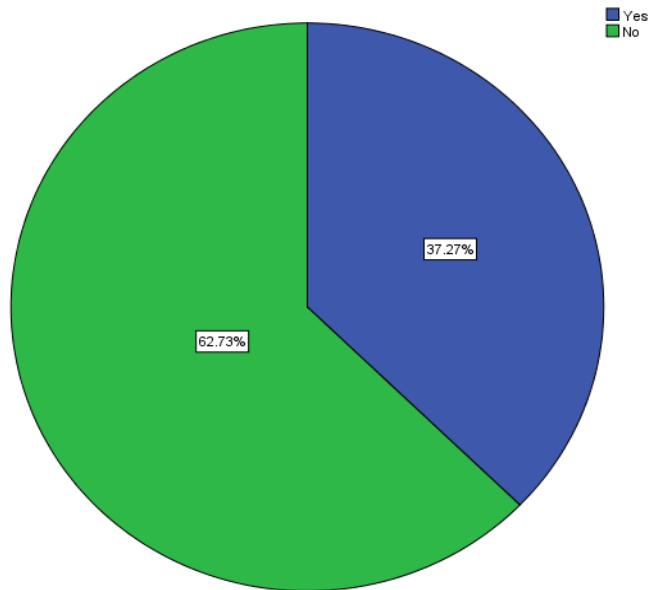


Figure 1. Prevalence of respiratory symptoms among participants

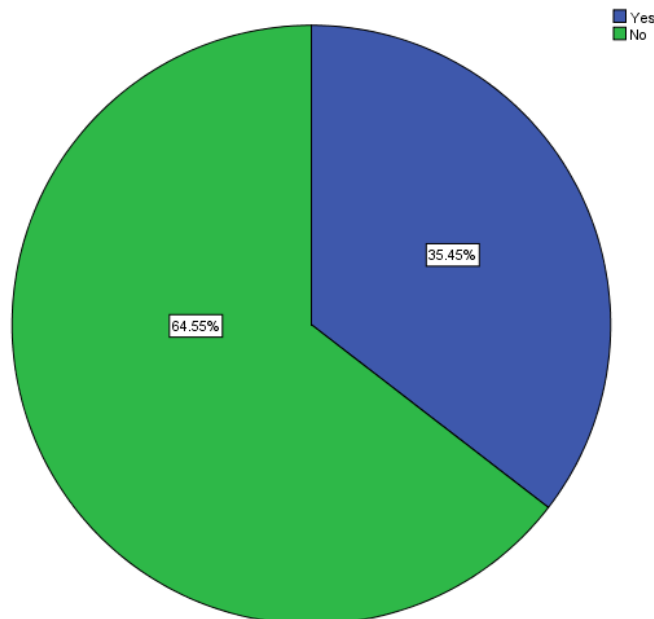


Figure 2. Prevalence of eye irritations among participants

3.2 Prevalence of respiratory symptoms and biomass fuel smoke exposure

The prevalence of respiratory symptoms among the participants was as follows: 82 individuals (37.3%) reported experiencing respiratory problems such as coughing, wheezing, or asthma, while 138 individuals (62.7%) did not report any such symptoms. Additionally, 78 participants (35.5%) experienced eye irritation, whereas 142 participants (64.5%) did not, as shown in Table 2, and Figures 1 and 2. Wood biomass use significantly increased the risk respiratory symptoms with an adjusted odds ratio (AOR) of 4.635 (95% CI: 1.663-12.919, $p=0.012$). Prolonged exposure of 1-2 hours (AOR=0.246, 95% CI: 0.101-0.598, $p=0.001$) and 3-4 hours (AOR=0.114, 95% CI: 0.044-0.294) significantly lowered the

risk of ARI compared to 5-6 hours. Indoor biomass exposure showed higher odds of ARI (AOR=2.201, 95% CI: 0.762-6.355), although not statistically significant ($p=0.145$), as shown in Table 3.

3.3 Discussion

Somalia is confronted with various challenges due to the high population density in urban areas, particularly in displacement camps where living conditions are frequently substandard. Recent reports indicate that a majority of individuals in these areas have a monthly family income less than 300 US dollars, highlighting the widespread poverty, unemployment, and dependence on unskilled labor. These factors, along with the prevalent use of biomass and charcoal

for cooking, are believed to have a significant impact on the health of those residing in these circumstances.

Biomass burning is not only an environmental concern but also a significant public health issue, contributing to a wide range of adverse health effects [29]. The pollutants released during the combustion of biomass fuels, such as particulate matter, carbon monoxide, and various toxic organic compounds, are known to cause serious health problems [15]. In both developed and developing nations, these pollutants have been linked to respiratory and cardiovascular diseases, as well as increased mortality rates [37]. The use of traditional, inefficient cookstoves exacerbates these risks, particularly in low-income households where biomass is the primary source of fuel. Studies have shown that exposure to smoke from biomass burning is strongly associated with respiratory infections, chronic obstructive pulmonary disease (COPD), lung cancer, and other respiratory issues [29]. The health risks are particularly severe for vulnerable populations, including women and children, who are often more exposed to indoor smoke due to their roles in household cooking [29]. Research indicates that improved biomass cookstoves can significantly reduce the health risks associated with biomass burning [12]. However, the health consequences of biomass are likely to be even more severe, mirroring findings from other developing countries where the use of biomass fuels is prevalent [38]. These risks include increased incidences of childhood acute respiratory infections, chronic bronchitis, and other serious health conditions [15]. Furthermore, the perception of health risks associated with biomass burning can vary within the community, often differing from global health initiatives [39]. This highlights the need for culturally sensitive awareness programs that address local beliefs and practices, particularly women and children. Therefore, understanding the health impacts of biomass burning in Mogadishu is crucial for implementing effective interventions to mitigate its adverse effects.

Our findings reveal that a notable proportion of participants experienced respiratory and eye-related symptoms. Specifically, 82 individuals (37.3%) reported respiratory issues such as coughing, wheezing, or asthma, while 78 participants (35.5%) experienced eye irritation. These results align with previous research indicating that exposure to biomass smoke is associated with an increased prevalence of respiratory symptoms and eye irritation [15].

In our study, the risk of respiratory symptoms was notably higher among those exposed to wood biomass, with an adjusted odds ratio (AOR) of 4.635 (95% CI: 1.663-12.919, $p = 0.012$). This finding supports the work of previous studies [18, 40, 41], which also highlighted the elevated health risks associated with wood biomass exposure. Moreover, the duration of exposure played a critical role in determining the risk. Prolonged exposure of 1-2 hours (AOR = 0.246, 95% CI: 0.101-0.598, $p = 0.001$) and 3-4 hours (AOR = 0.114, 95% CI: 0.044-0.294) was associated with a significantly lower risk of respiratory symptoms compared to 5-6 hours. This is in contrast to the findings of a studies [15, 18], which suggested that longer exposure times generally correlate with higher risks of respiratory issues.

While indoor biomass exposure was linked to higher odds of respiratory symptoms (AOR = 2.201, 95% CI: 0.762-6.355), this association was not statistically significant ($p = 0.145$). This is different to previous studies [29, 38], which suggested that indoor biomass exposure associated with higher risks of respiratory issues. This discrepancy might be attributed to

variations in indoor air quality or ventilation practices in different settings.

Overall, the results of this study emphasize the health risks associated with biomass fuel smoke and highlight the need for effective interventions to reduce exposure and mitigate its adverse effects. Continued research and public health efforts are essential to address these issues and improve respiratory health outcomes in regions heavily reliant on biomass fuels.

This study is hospital-based, which may introduce bias as it predominantly includes individuals already experiencing health issues. This could limit the generalizability of the findings to the broader, healthier population. To obtain a more representative assessment, future research should consider community-based studies conducted in households with larger sample sizes.

4. CONCLUSION

This study highlights the significant impact of biomass fuel smoke on respiratory symptoms and eye irritation among healthy adults in Mogadishu, Somalia. Notably, 37.3% of participants reported respiratory issues, and 35.5% experienced eye irritation. Exposure to wood biomass significantly increased the risk of respiratory symptoms, with prolonged exposure linked to higher risks.

To reduce these health risks, improving ventilation in homes, promoting the adoption of cleaner cooking technologies, and increasing public awareness about the health impacts of biomass smoke are essential. Raising awareness through community education programs can empower individuals to make informed decisions about their cooking practices and ventilation methods. Additionally, encouraging further research to explore effective interventions and policies is crucial for enhancing respiratory and eye health outcomes and reducing the adverse effects of biomass smoke exposure.

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