



Research Article

Improved Cooking Stove Usage Characteristics and Incidences of Respiratory Related Symptoms Among Women Adopters of ICS in Nakuru Town East Suburbs

Margaret Muchendu* , Daniel Muasya Nzengya

School of Education and Social Sciences, St Paul's University, Limuru, Kenya

Abstract

Traditional biomass stove indoor air pollution continues to be a serious public health concern, especially in low- and middle-income nations where cooking exposes women the most. Long-term smoke and particulate matter intake have been connected to respiratory symptoms such as wheezing, shortness of breath, and persistent cough, which increases morbidity in women. As a greener option, improved cooking stoves (ICS) have been developed with the goal of lowering emissions and increasing fuel economy. However, little is known about how usage factors, such as frequency of use affect respiratory related symptoms. The purpose of this study was to examine the Influence of ICS usage characteristics on incidences of respiratory related symptoms among women in Nakuru Town East suburbs. The study utilized mixed-method research design. Data collection tools included questionnaires for households and semi structured interview guides for FGDs and KIIs. 315 female heads of households were sampled and completed the questionnaire. Quantitative data was analyzed using descriptive statistics and logistic regression. Qualitative data was content analyzed. Findings indicates that 74.9% had used ICS on the day the research was conducted, while 25.1% did not use it that day. Eighty-three-point four percent of owners used an ICS prior to their current one, and 16.6% (52) did not. On Daily usage patterns, 51.1% were using ICS for all meals, 25.7% for two meals, 13.7% for dinner only, 4.4% for lunch only or other meals, and 0.6% for breakfast only. Further findings also showed that, Women who had not used an ICS prior to their current one was 1.66 times more likely to report a cough, though the result remains marginally insignificant ($p = 0.106$). Findings of the study suggest that experience with ICS use over time may lower respiratory symptoms, possibly due to increased familiarity and effective use.

Keywords

Improved Cooking Stoves Use Characteristics, Women, Respiratory Symptoms, Kenya

1. Introduction and Background

Indoor air pollution (IAP) arising from the continued use of traditional biomass remains one of the most pressing global public health challenges. Although access to modern energy services is recognized as a foundational requirement for health,

development, and gender equality, nearly one-third of the world's population still relies on polluting fuels and inefficient stoves for their domestic needs [19]. The consequence is per-

*Correspondence: Margaret Muchendu (margietich2@gmail.com)

Received: 4 February 2026; **Accepted:** 14 February 2026; **Published:** 27 February 2026



Copyright: © The Author(s), 2026. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

sistent household air pollution (HAP), which contributes significantly to the global burden of respiratory morbidity and mortality, especially among women, children, and marginalized populations who experience prolonged exposure in poorly ventilated settings [18].

The use of traditional cooking stoves characterized by incomplete combustion, low thermal efficiency, and high emissions continues to place millions at risk of acute and chronic respiratory illnesses. It leads to high concentrations of particulate matter, carbon monoxide, nitrogen oxides, and a range of harmful organic compounds. These pollutants exceed international indoor air quality thresholds, with peak concentrations of particulate matter in biomass-using households sometimes surpassing outdoor pollution spikes during major urban smog events [19]. Global analyses indicate that the main respiratory symptoms associated with poor indoor air quality resulting from the lack of improved cooking stoves as acute lower respiratory infections, persistent cough, wheezing, phlegm production, breathlessness, and increased susceptibility to pneumonia. Acute lower respiratory infections, particularly pneumonia, remain the leading cause of death among children under five years worldwide, and household air pollution is responsible for nearly half of these fatalities [18]. Adults exposed to prolonged biomass smoke also experience frequent episodes of cough, chest tightness, shortness of breath, and compromised lung function. These symptoms reflect both acute irritation of the respiratory tract and chronic inflammation associated with repeated exposure to smoke [11].

Chronic obstructive pulmonary disease (COPD) is one of the most significant long-term consequences of prolonged exposure to biomass smoke. Evidence demonstrates that women who cook with solid fuels for many years develop COPD at rates comparable to long-term tobacco smokers, even in the absence of smoking behavior [4]. The chronic exposure results in airway remodeling, persistent airflow limitation, and frequent exacerbations manifested as chronic cough and breathlessness. Furthermore, studies show that the risk of lung cancer is significantly elevated among individuals exposed to coal-based cooking fuels due to carcinogenic compounds emitted during combustion such as benzopyrene and other polycyclic aromatic hydrocarbons present in coal smoke [10].

Asthma and wheezing disorders are also widely documented among individuals in households using traditional stoves. Children are particularly vulnerable due to their higher inhalation rates per body weight and immature immune systems. Exposure to nitrogen dioxide and particulate matter from both biomass and kerosene stoves has been linked to increased asthma incidence and severity, with repeated exposure contributing to airway hyper-responsiveness and reduced lung growth [15]. Additionally, eye irritation, nasal congestion, headaches, and throat discomfort are common symptoms among individuals regularly exposed to indoor smoke, and although sometimes viewed as minor, they represent cumulative harm and contribute to reduced quality of life.

Traditional cooking stoves emit a complex mixture of pol-

lutants, the most significant of which include particulate matter, carbon monoxide, nitrogen dioxide, sulfur dioxide, volatile organic compounds, polycyclic aromatic hydrocarbons, and heavy metals. Among these, fine particulate matter is considered the most harmful due to its ability to penetrate deep into the alveolar region of the lungs and enter systemic circulation [10]. PM_{2.5} levels in biomass-using households routinely exceed WHO recommended limits by over 100 times during cooking periods, particularly in poorly ventilated dwellings. Carbon monoxide exposure reduces oxygen-carrying capacity in the blood, causing dizziness, fatigue, headaches, and in severe cases, loss of consciousness and death. Women and infants in households with long cooking sessions are at highest risk of its poisoning due to cumulative exposure over several hours per day [6]. Nitrogen dioxide, predominantly emitted from kerosene and gas stoves, has been linked to asthma exacerbations, airway inflammation, and reduced lung function among children [15].

Across Sub-Saharan Africa (SSA), the burden of respiratory symptoms associated with poor indoor air quality continues to be profound, particularly in households that rely on traditional biomass fuels for daily cooking. The region records some of the highest rates of household air pollution (HAP) globally because an estimated 82 percent of households still use polluting solid fuels such as firewood, charcoal, agricultural residues, and animal dung [2]. This level of dependence exposes millions of families to concentrated levels of particulate matter and carbon monoxide, creating household environments that are often far more hazardous than outdoor settings. The World Health Organization (WHO) has consistently noted that SSA countries account for a disproportionate share of morbidity and mortality from HAP-related respiratory symptoms compared to other developing regions [20].

It is estimated 8.5 to 9.5 million Kenyan households are chronically exposed to household air pollution from traditional stoves. Symptom-based studies corroborate this scale: a detailed survey in Trans Nzoia County found that 96.8 percent of households used wood fuel and more than 90 percent of women and 95 percent of young children experienced persistent cough within the preceding year, along with high levels of wheezing, sputum production, eye irritation, and breathing difficulties [5]. Further evidence from the Ministry of Energy's indoor air quality study in Sagalla (Taita Taveta) and Namanga (Kajiado) documented that before the adoption of improved cooking stoves, coughing and breathing difficulties were highly prevalent among household members, particularly women and children. Even after dissemination of improved cooking stoves, a substantial proportion of households recorded indoor carbon monoxide and particulate matter concentrations exceeding WHO guidelines, indicating the persistent nature of indoor air quality challenges despite technological improvements [7].

Kenyan women bear the greatest burden of exposure to indoor air pollution in the country due to gendered divisions of

labor. Cooking remains overwhelmingly a female responsibility, often taking place in poorly ventilated spaces, particularly in rural and peri-urban settlements [5]. Consequently, women experience longer daily exposure to harmful pollutants, increasing their risk for acute and chronic respiratory illnesses. The aforementioned Trans Nzoia study found that 92 percent of women had experienced coughing within the previous 12 months and more than 60 percent reported sputum production; nearly one-third reported wheezing associated with poor ventilation and indoor wood burning [5]. National-level estimates based on Global Burden of Disease data similarly show that Kenyan women account for a disproportionate share of annual deaths and lost healthy life years attributable to household air pollution [18]. The objective of the study was to analyze the influence of ICS usage characteristics on incidences of respiratory related symptoms among women adopters of ICS in Nakuru Town East suburbs.

2. Empirical Review

The duration and frequency of exposure to cooking smoke have emerged as important determinants of respiratory health, particularly among vulnerable groups such as women and young children. While the introduction of improved cooking stoves (ICS) is generally seen as a step forward in reducing household air pollution, the length and consistency of their use can significantly influence their actual health impact. A number of studies from different geographical contexts have explored this dynamic, although findings have not always been consistent. [1] carried out a study in rural central India focusing on children under six months old. The research found a clear association between frequent use of biomass stoves and an increased incidence of acute lower respiratory infections (ALRI) among infants. Children exposed to biomass smoke had significantly higher rates of ALRI (33.7%) compared to those in households using improved cooking stoves, where no ALRI episodes were recorded (21.8%; $p < 0.001$). While the study's age group was limited to infants under six months—thus narrower than the under-five population targeted in the proposed study—it nonetheless illustrates how repeated exposure to cooking smoke can sharply elevate respiratory risks even in very young children.

In Nepal, [3] examined daily stove usage in terms of hours spent cooking and its correlation with respiratory illness. Their findings showed that the longer a stove was used each day—particularly traditional biomass models—the higher the risk of ALRI among children. This study reinforced the conclusion that not just the type of fuel, but the intensity and duration of exposure, play a crucial role in shaping respiratory health outcomes. [16] Explored cooking practices in Sierra Leone. The found that the amount of time spent in kitchens using wood stoves was positively associated with respiratory infections among both women and children. Interestingly, this association was less clear in homes using charcoal stoves. The adjusted odds of acute respiratory infection rose significantly

with prolonged exposure in wood stove settings (OR = 2.03; 95% CI: 1.31–3.13). However, this study did not specifically consider access to or adoption of improved cooking stoves, which is a central focus of the proposed research.

Sharma, S., et al. [14] conducted a study in Rasuwa, Nepal. They highlighted that extended use of traditional cooking stoves was significantly linked to ALRI among children under five ($p = 0.040$). Although the findings align with global literature, differences in the policy context between Nepal and Kenya warrant careful interpretation, especially regarding ICS adoption programs and cooking culture. [8] Assessed the cumulative exposure to biomass smoke—measured in hour-years—and its health effects on rural women in southern India. Findings were that even in households that had access to both LPG and biomass stoves, increased biomass usage was linked to higher self-reported respiratory symptoms ($p < 0.001$). This phenomenon of “fuel stacking” (simultaneous use of multiple stove types) reduces the effectiveness of cleaner fuels and remains a significant challenge to realizing health gains from ICS adoption. Although the study focused on adult women, the exposure patterns it describes are highly relevant to children living in the same households. [12] Investigated indoor air pollution and children's respiratory symptoms in a semi-urban setting in Sri Lanka. Their study found that households using biomass fuels recorded significantly higher concentrations of PM_{2.5} ($p < 0.001$) and carbon monoxide ($p = 0.002$) than those using electricity or LPG. Moreover, there was a statistically significant correlation between elevated pollutant levels and the incidence of lower respiratory tract infections in children ($p < 0.001$ for PM_{2.5}; $p = 0.028$ for CO₂). The study concluded that the frequency of biomass stove use played a direct role in increasing household air pollution and, in turn, respiratory illness rates.

Taken together, these studies underscore an important nuance in the relationship between cooking stove type and health: it is not just what you cook with, but how often and for how long that truly matters. Prolonged exposure, even to moderate levels of indoor air pollutants, accumulates risk—especially for children whose respiratory systems are still developing.

3. Study Methods

This research employed a cross-sectional, concurrent triangulation mixed-methods design focusing on 219,200 households in Nakuru Town East, selecting a sample of 315 households using improved cooking stoves. The study also incorporated 11 interviews with key informants and two focus group discussions. Quantitative data collected through questionnaires were analyzed using SPSS (version 25), while qualitative data from semi-structured interviews were processed through NVivo (version 12) utilizing thematic analysis. Approval from the relevant ethical bodies was obtained, ensuring the confidentiality of participant data and anonymity. The results presented here are part of a broader study entitled “Influence of Improved Cooking Stoves, Biomass Solid Fuel Usage

on Respiratory Related Symptoms Among Women in Nakuru East Suburbs, Kenya."

Findings on from quantitative surveys with 400 women on use patterns of ICS amongst households are summarized in [Table 1](#). These results provide insights into the prevalence frequency and duration of use.

4. Results and Discussion

Household ICS use characteristics

Table 1. Descriptive statistics of household ICS use characteristics (N = 315).

Variable	Category	F (%) (Mean)
ICS use today	Yes	236 (74.9%)
	No	79 (25.1%)
ICS use prior to current one	Yes	262 (83.4%)
	No	52 (16.6%)
Duration of using ICS (in years)		Mean = 8; Median=7.0; Mode=5.0)
ICS use in a typical day	Breakfast only	2 (0.6%)
	Lunch only	14 (4.4%)
	Dinner only	43 (13.7%)
	Two meals	81 (25.7%)
	All the meals	161 (51.1%)
	Other meals	14 (4.4%)

Source: Author (2025)

[Table 1](#) shows the results of ICS use characteristics in households surveyed. Daily ICS use was reported by 74.9% (236 of 315 owners), while 25.1% (79) did not use it that day. Eighty-three-point four percent (262) of owners used an ICS prior to their current one, and 16.6% (52) did not. The mean duration of ICS use was eight years (median = 7.0, mode = 5.0), reflecting long-term adoption. Daily usage patterns

showed 51.1% (161) using ICS for all meals, 25.7% (81) for two meals, 13.7% (43) for dinner only, 4.4% (14) for lunch only or other meals, and 0.6% (2) for breakfast only. These findings are in agreement with results of [\[9\]](#) whose findings indicated that majority of the households had an average of 5.8 ± 4.6 cooking hrs./wk.

Table 2. Cross Tabulation of ICS use Characteristics and Self-Reported Incidences of Cough With/Without Phlegm Amongst participants sampled.

Variable	Category	YES F (%)	NO F (%)
ICS Use today	Yes	148 (72.5%)	88 (79.3%)
	No	56 (27.5%)	23 (20.7%)
ICS use prior to current one	Yes	176 (86.3%)	87 (78.4%)
	No	28 (13.7%)	24 (21.6%)
ICS use in a typical day	Breakfast only	1 (0.5%)	1 (0.9%)
	Lunch only	9 (4.4%)	5 (4.5%)
	Dinner only	26 (12.7%)	17 (15.3%)
	Two meals	57 (27.9%)	24 (21.6%)

Variable	Category	YES F (%)	NO F (%)
	All the meals	102 (50%)	59 (53.2%)
	Other meals	9 (4.4%)	5 (4.5%)

Source: Author (2025)

Table 2 presents a cross-tabulation analysis assessing the association between access to ICS and the self-reported incidence of Cough With/Without Phlegm among women in the three months preceding the survey.

Prior use of ICS before the current one was reported by 86.3% (176) of the women with cough symptoms and 78.4% (87) without symptoms. This suggests that women with longer experience using ICS were still susceptible, potentially due to cumulative exposure or partial use, highlighting that duration alone may not fully eliminate health risks unless accompanied by consistent and appropriate usage. The final variable considers ICS use per day by meal type. Among those reporting a cough, half (50%) used ICS for all meals, followed by 27.9% using it for two meals, and 12.7% for dinner only. Among women without the cough, 53.2% used ICS for all meals, slightly higher than symptomatic users. These findings imply

that more extensive daily ICS use correlates with fewer respiratory symptoms, reinforcing the importance of replacing traditional stoves for all cooking sessions, not just some. In Nepal, [3] reported similar findings where the results showed that the longer a stove was used each day—particularly traditional biomass models—the higher the risk of ALRI among children. The study by [9] showed that an additional hour per week spent cooking food with traditional cooking stoves was associated with cough (OR = 1.10, 95%CI 1.01–1.19) and that there was an association between one additional stir-fry dish in a week with an increased risk of cough (OR = 1.04, 95%CI 1.03–1.16). Although the findings were more specific on methods of cooking unlike in this study, the results demonstrated that more extensive daily ICS use correlates with fewer coughs. This study reinforced the conclusion that not just the type of fuel, but the intensity and duration of exposure, play a crucial role in shaping respiratory health outcomes.

Table 3. Cross Tabulation Table on ICS use Characteristics and Self-Reported Incidences of Wheezing Amongst participants sampled.

Variable	Category	YES F (%)	NO F (%)
ICS Use today	Yes	104 (79.4%)	132 (71.7%)
	No	27 (20.6%)	52 (28.3%)
ICS use prior to current one	Yes	112 (85.5%)	151 (82.1%)
	No	19 (14.5%)	33 (17.9%)
ICS use in a typical day	Breakfast only	0 (0%)	2 (1.1%)
	Lunch only	5 (3.8%)	9 (4.9%)
	Dinner only	20 (15.3%)	23 (12.5%)
	Two meals	41 (31.3%)	40 (21.7%)
	All the meals	61 (46.6%)	100 (54.3%)
	Other meals	4 (3.1%)	10 (5.4%)

Source: Author (2025)

Table 3 presents a cross-tabulation analysis assessing the association between ICS use and the self-reported incidence of wheezing among women in the three months preceding the survey.

The pattern of ICS usage on the survey day reveals a slightly higher use among women without wheezing (71.7%) compared to those with the symptom (79.4%). Interestingly, a greater percentage of women who did not use ICS that day

reported wheezing (20.6%) than those who did not wheeze (28.3%), suggesting that daily usage of ICS plays a role in reducing exposure to pollutants that contribute to wheezing, though the association appears modest.

Historical usage—prior to the current ICS—was also analyzed. Among women with wheezing, 85.5% (112) had previously used ICS, compared to 82.1% (151) of those without the symptom. These figures are relatively close, indicating that

past exposure may not be as significant as present-day usage patterns and stove condition when it comes to symptom prevalence. The final section looks at ICS use by meal frequency in a typical day, offering more granular insight into stove reliance. Among wheezing respondents, the largest proportion—46.6% (61)—used ICS for all meals, while 31.3% (41) used it for two meals and 15.3% (20) for dinner only. For those without wheezing, 54.3% (100) used ICS for all meals, with fewer relying on it for only two meals (21.7%) or dinner only (12.5%). This comparison indicates a clear trend: increased frequency of ICS use correlates with reduced wheezing, with

the lowest symptom prevalence among those using ICS for all meals. The results are in agreement with some of the previous studies. In a randomized controlled trial in rural Rwanda (n=1001 adults, mostly women) ICS users had lower respiratory symptom prevalence after three years, including trends toward reduced wheezing (2.7% vs. 5.4% in traditional cooks, $p=0.361$), alongside significant drops in cough and mucus [9]. The findings of this study therefore, reinforced the conclusion that not just the type of fuel, but the intensity and duration of exposure, play a crucial role in shaping respiratory health outcomes.

Table 4. Cross Tabulation of ICS use Characteristics and Self-Reported Incidences of Difficulties in Breathing Amongst Women Sampled.

Variable	Category	YES F (%)	NO F (%)
ICS Use today	Yes	97 (77.6%)	139 (73.2%)
	No	28 (22.4%)	51 (26.8%)
ICS use prior to current one	Yes	98 (78.4%)	165 (86.8%)
	No	27 (21.6%)	25 (13.2%)
ICS use in a typical day	Breakfast only	2 (1.6%)	0 (0%)
	Lunch only	8 (6.4%)	6 (3.2%)
	Dinner only	20 (16%)	23 (12.1%)
	Two meals	27 (21.6%)	54 (28.4%)
	All the meals	63 (50.4%)	98 (51.6%)
	Other meals	5 (4%)	9 (4.7%)

Source: Author (2025)

Table 4 provides a cross-tabulation analysis exploring the relationship between women's use of ICS and the incidence of difficulties in breathing—a key respiratory symptom linked to exposure to indoor air pollution. The analysis is based on self-reported data collected over the three months prior to the survey.

Current use of ICS on the survey day was reported by 77.6% (97) of women who experienced breathing difficulties, and 73.2% (139) of those who did not. The remaining 22.4% and 26.8% respectively did not use the ICS that day. This shows a slightly higher proportion of non-users among those without symptoms, suggesting that occasional use on its own may not be a strong determinant in preventing breathing problems unless accompanied by sustained, daily usage.

Regarding prior use of ICS before the current stove, 78.4% (98) of those reporting breathing difficulties had past experience using ICS, compared to 86.8% (165) among those without symptoms. This suggests that a longer history of ICS use may contribute to reduced respiratory symptoms, though the link is not strongly pronounced and likely influenced by other factors such as frequency and conditions of use. The final section of the table focuses on ICS use per day by meal frequency.

Among women reporting breathing difficulties, 50.4% (63) used the ICS for all meals, while the remaining distribution includes two meals (21.6%), dinner only (16%), lunch only (6.4%), breakfast only (1.6%), and other meals (4%). In comparison, 51.6% (98) of women without symptoms used ICS for all meals, followed by 28.4% for two meals, and lower figures for other categories. These patterns suggest that using ICS for all meals offers better respiratory protection, though the slight margin between symptomatic and asymptomatic groups highlights those other contextual factors, such as ventilation, type of fuel, and cooking environment, may also influence respiratory outcomes.

In summary, Table 4 shows a positive association between consistent use of ICS and reduced incidences of breathing difficulties among women. ICS usage, especially for all daily meals over a sustained period, appears to provide measurable health benefits. However, these results were in contrast with some previous studies. Findings of [11] showed a statistically significant negative correlation between the years spent cooking with biomass and the concentrations of PM, indicating that a longer exposure is associated with a greater decline in lung

function and increased breathing difficulties as PM levels rise. This indicates that there is a likely influence of the occurrence of difficulties in breathing by other factors such as frequency

and conditions of use which need to be looked into besides the frequency of ICS use.

Table 5. Cross Tabulation of ICS use Characteristics and Self-Reported Incidences of Runny Nose Amongst Participants Sampled.

Variable	Category	YES F (%)	NO F (%)
ICS Use today	Yes	77 (75.5%)	159 (74.6%)
	No	25 (24.5%)	54 (25.4%)
ICS use prior to current one	Yes	89 (87.3%)	174 (81.7%)
	No	13 (12.7%)	39 (18.3%)
ICS use in a typical day	Breakfast only	0 (0%)	2 (0.9%)
	Lunch only	4 (3.9%)	10 (4.7%)
	Dinner only	16 (15.7%)	27 (12.7%)
	Two meals	28 (27.5%)	53 (24.9%)
	All the meals	48 (47.1%)	113 (53.1%)
	Other meals	6 (5.9%)	8 (3.8%)

Source: Author (2025)

Table 5 presents a cross-tabulation analysis exploring the relationship between ICS use and the incidence of a runny nose—a common symptom of respiratory irritation caused by exposure to indoor air pollution. The data is based on self-reports from women over the three months prior to the survey.

When considering ICS use on the day of the survey, the usage rates were nearly identical: 75.5% (77) among those with runny nose symptoms and 74.6% (159) among those without. This similarity indicates that occasional or daily use alone may not be sufficient to prevent symptoms unless combined with consistent, long-term, and comprehensive use practices.

Looking at prior ICS use before the current stove, 87.3% (89) of women with symptoms had used ICS in the past, compared to 81.7% (174) of those without symptoms. This trend shows that longer-term ICS users may still experience symptoms, suggesting that factors such as inconsistent usage, exposure to other pollution sources, or poor ventilation may moderate the benefits of ICS. The final section of the table breaks down ICS use per day by meal frequency, revealing differences in intensity of stove use. Among women with a runny nose, 47.1% (48) used ICS for all

meals, compared to a higher 53.1% (113) among those without symptoms. A higher percentage of symptomatic women used ICS for two meals (27.5%) or dinner only (15.7%), compared to 24.9% and 12.7% respectively in the non-symptomatic group. This trend highlights the potential benefits of using ICS for all daily cooking activities, as partial usage may not fully shield users from smoke exposure.

In summary, **Table 5** supports the view that ICS comprehensive as well as consistent use—especially for all meals—correlate with reduced incidence of respiratory symptoms like runny nose. While owning a functioning ICS is a key factor, maximum health benefits appear to depend on using the stove for all cooking tasks. This is in consistence with findings of other previous studies conducted by [9] and [13]. Their studies results showed that every extra hour spent in a kitchen was associated with a higher incidence of runny nose. The persistence of symptoms among some ICS users suggests the need to address additional environmental and behavioral factors, such as kitchen ventilation, fuel type, and cooking location.

Table 6. Cross Tabulation of ICS use Characteristics and Self-Reported Incidences of Teary Eyes Amongst Sampled Participants.

Variable	Category	YES F (%)	NO F (%)
ICS Use today	Yes	63 (75%)	173 (74.9%)
	No	21 (25%)	58 (25.1%)
ICS use prior to current one	Yes	70 (83.3%)	193 (83.5%)

Variable	Category	YES F (%)	NO F (%)
ICS use in a typical day	No	14 (16.7%)	38 (16.5%)
	Breakfast only	0 (0%)	2 (0.9%)
	Lunch only	4 (4.8%)	10 (4.3%)
	Dinner only	14 (16.7%)	29 (12.6%)
	Two meals	21 (25%)	60 (26%)
	All the meals	38 (45.2%)	123 (53.2%)
	Other meals	7 (8.3%)	7 (3%)

Source: Author (2025)

Table 6 presents a cross-tabulation analysis examining the relationship between women's use of ICS and the self-reported incidence of teary eyes—a symptom commonly associated with eye irritation from smoke exposure due to indoor air pollution. The data represents reports from the previous three months before the survey.

The proportion of women who reported using ICS on the day of the survey was nearly identical between both groups: 75% (63) among those with teary eyes and 74.9% (173) among those without. This indicates that same-day usage does not vary significantly between groups and may not alone explain differences in symptoms. However, it suggests that day-to-day usage should be reinforced as part of a broader strategy for exposure reduction. Prior usage of ICS before the current one was also reported by a similar proportion of both groups: 83.3% (70) among those with teary eyes and 83.5% (193) among those without. This parity suggests that the duration of ICS exposure may not be a decisive factor in explaining symptom occurrence unless paired with consistent daily use and

correct cooking practices. The breakdown of ICS usage per meal reveals clearer trends. Among women who reported teary eyes, 45.2% (38) used ICS for all meals, compared to a higher 53.2% (123) among those who did not report symptoms. Those reporting teary eyes showed higher percentages of partial use: 25% (21) for two meals, 16.7% (14) for dinner only, and 8.3% (7) for other meals. The data suggests that inconsistent or limited ICS use may leave women more vulnerable to eye irritation, particularly if they switch between ICS and traditional cooking stoves or if cooking is conducted in poorly ventilated spaces. The study by [8] in Udupi, India found similar results as of this study. The study results indicated that there was a clear correlation between cumulative biomass exposure (measured in hour-years) and respiratory symptoms as well as cardiovascular and eye conditions among women. This calls for emphasis on consistent use of ICS which goes beyond just adoption to ensure maximum health benefits.

Table 7. Cross Tabulation of ICS use Characteristics and Self-Reported Incidences of Congested Chest Amongst participants sampled.

Variable	Category	YES F (%)	NO F (%)
ICS Use today	Yes	72 (81.8%)	164 (72.2%)
	No	16 (18.2%)	63 (27.8%)
ICS use prior to current one	Yes	78 (88.6%)	185 (81.5%)
	No	10 (11.4%)	42 (18.5%)
ICS use in a typical day	Breakfast only	0 (0%)	2 (0.9%)
	Lunch only	5 (5.7%)	9 (4%)
	Dinner only	9 (10.2%)	34 (15%)
	Two meals	26 (29.5%)	55 (24.2%)
	All the meals	45 (51.1%)	116 (51.1%)
	Other meals	3 (3.4%)	11 (4.8%)

Source: Author (2025)

Table 7 presents a cross-tabulation analysis assessing the relationship between women's ICS use and the self-reported incidence of congested chest—a common respiratory symptom caused by prolonged exposure to indoor air pollution, particularly from traditional biomass fuels. The data reflects the experiences of female respondents in the three months preceding the survey.

A slightly higher proportion of symptomatic women (81.8%, n=72) reported using ICS on the day of the survey, compared to 72.2% (164) among those without symptoms. Although this may seem counterintuitive, it could imply that daily ICS use does not immediately eliminate risk, especially if other household members use traditional stoves, or if the cooking area lacks proper ventilation. Another possibility is that some symptomatic individuals began using ICS recently after experiencing respiratory issues, suggesting reactive rather than preventive adoption. Among those with congested chest symptoms, 88.6% (78) had used ICS prior to the current one, compared to 81.5% (185) among those without symptoms. This suggests that long-term ICS exposure may not uniformly protect users unless accompanied by consistent use, correct maintenance, and other environmental health practices. The data might also point to variations in stove quality, usage discipline, or external smoke exposure affecting health outcomes even among prior ICS users. The frequency of ICS use

across daily meals offers more insightful distinctions. Among symptomatic women:

51.1% (45) used ICS for all meals, which is identical to the rate among non-symptomatic women (51.1%, n=116).

29.5% (26) of symptomatic women used ICS for two meals, slightly more than 24.2% (55) among those without symptoms.

Conversely, 15% (34) of asymptomatic women reported using ICS only for dinner, compared to just 10.2% (9) among those with symptoms.

These patterns suggest that while a higher frequency of ICS use is associated with lower symptom prevalence, the relationship is not strictly linear. The health benefits of ICS may depend not just on the number of meals but also on how well the stove is used, the kitchen's ventilation, and whether other sources of indoor air pollution remain in the household (e.g., kerosene lamps, charcoal use). These results are in contrast with the findings of the study by [17] which were explicit that there were higher crude odds of respiratory illness (COR: 6.40) including congested chest resulting from spending more than three hours in the kitchen. Besides frequency of ICS use, there is need to consider other factors at play like cooking location, stove usage technique, or the presence of other pollutants (e.g., kerosene lamps) that may influence respiratory symptoms outcomes and address them to mitigate respiratory symptoms.

Table 8. Cross Tabulation of ICS use Characteristics and Self-Reported Incidences of Sneezing Amongst Sampled Participants.

Variable	Category	YES F (%)	NO F (%)
ICS Use today	Yes	93 (78.8%)	143 (72.6%)
	No	25 (21.2%)	54 (27.4%)
ICS use prior to current one	Yes	97 (82.2%)	166 (84.3%)
	No	21 (17.8%)	31 (15.7%)
ICS use in a typical day	Breakfast only	0 (0%)	2 (1%)
	Lunch only	5 (4.2%)	9 (4.6%)
	Dinner only	10 (8.5%)	33 (16.8%)
	Two meals	30 (25.4%)	51 (25.9%)
	All the meals	71 (60.2%)	90 (45.7%)
	Other meals	2 (1.7%)	12 (6.1%)

Source: Author (2025)

Table 8 explores the relationship between women's ICS usage and the occurrence of sneezing—a common upper respiratory symptom linked to indoor air pollution. The data reflects self-reported experiences from the last three months before the survey and seeks to understand whether ownership and usage

patterns of ICS are associated with reduced respiratory symptoms. ICS use on the day of the survey was reported by 78.8% (93) of women who experienced sneezing and 72.6% (143) of those who did not. This counterintuitive result may reflect that symptomatic women are more consistent users due to prior experiences with smoke-related health issues, or that current

ICS use was adopted too recently to reverse accumulated exposure effects. It also suggests that daily use, while necessary, may not be sufficient if ICS is not used exclusively or in poorly ventilated environments. Among those who reported sneezing, 82.2% (97) had used ICS prior to their current one, while 17.8% (21) had not. Among those without symptoms, 84.3% (166) had previous ICS experience. These similar rates imply that long-term exposure to ICS alone does not fully eliminate respiratory symptoms, and additional variables such as cooking location, stove usage technique, or the presence of other pollutants (e.g., kerosene lamps) may influence outcomes. The pattern of ICS use across meals reveals meaningful differences. Among those who experienced sneezing:

60.2% (71) used ICS for all meals, compared to 45.7% (90) of those without symptoms—an unexpected trend that may point to incomplete transition away from traditional methods, or residual exposure from earlier practices.

25.4% (30) used ICS for two meals, nearly the same as 25.9%

(51) among those without symptoms.

Notably, only 8.5% (10) of symptomatic women used ICS for dinner only, compared to 16.8% (33) of non-symptomatic respondents. This could suggest that exclusive evening use may be less protective, possibly due to longer cooking durations or closed environments during nighttime.

Interestingly, “other meals” and “breakfast only” categories had low and inconsistent representation, making it difficult to draw strong conclusions from these groups. These results are in contrast with the findings of the study by [17] which indicated higher crude odds of respiratory illness (COR: 6.40) including sneezing resulting from spending more than three hours in the kitchen. Besides frequency of ICS use there is need to consider other factors in play like cooking location, stove usage technique, or the presence of other pollutants (e.g., kerosene lamps) that may influence respiratory symptoms outcomes.

Table 9. Logistic regression: influence of ICS Usage on Self-reported Incidences of Respiratory Symptoms among Women in the Last Three Months Prior to Survey.

Explanatory variable	Self-reported respiratory symptoms						
	Coughing with/without phlegm	Wheezing	Difficulties in breathing	Runny nose	Teary eyes	Congested chest	Sneezing
	OR	OR	OR	OR	OR	OR	OR
ICS Use today							
(Yes)							
No	0.671	0.575	0.810	0.782	0.759	0.562	0.853
ICS use prior to current one							
(Yes)					0.974		
No	1.664	0.789	1.856	0.612		0.572	1.117
<i>Note. Estimates represent the log odds of "Binary Indicator = No vs. Yes" Reference category in bracket</i>							
<i>*Significant at 0.1, ** significant at 0.05, *** significant at 0.01</i>							

Source: Author (2025)

Results of a logistic regression analysis examining how different aspects of ICS use influence the likelihood of reporting incidences of cough with or without phlegm—a common respiratory health symptom linked to indoor air pollution. The model estimates the log odds of reporting a cough (dependent variable), based on a series of independent ICS use-related variables. Respondents who did not use their ICS on the day of the survey were less likely to report coughing (OR = 0.671), but again, this result is not statistically significant ($p = 0.190$).

While counterintuitive, this may reflect variability in usage patterns or recall bias rather than a protective effect of non-use. Women who had not used an ICS prior to their current one were 1.66 times more likely to report a cough, though the result remains marginally insignificant ($p = 0.106$). This trend implies that experience with ICS use over time may lower respiratory symptoms, possibly due to increased familiarity and effective use.

Results of a logistic regression analysis examining the association between ICS use patterns and the self-reported incidence of wheezing among women within the three months prior to the survey. The dependent variable is binary (presence or absence of wheezing), and the explanatory variables relate to different aspects of ICS usage. The analysis estimates log-odds, standard errors (SE), p-values, and odds ratios (OR) to determine the strength and significance of associations. The results reveal Respondents who did not use ICS on the day of the survey had lower odds of wheezing (OR = 0.575), and this result is marginally significant ($p = 0.059$). This suggests a potential inverse relationship, where non-use of ICS on the survey day might be linked to reduced wheezing—possibly due to reduced overall cooking or exposure. However, this finding needs cautious interpretation due to borderline significance. Lack of prior ICS use was associated with slightly lower odds of wheezing (OR = 0.789), though this association is not statistically significant ($p = 0.468$). The direction of the effect contradicts expectations and may reflect unmeasured confounding factors or misreporting.

Results of a logistic regression analysis examining the influence of access to ICS on self-reported incidences of difficulties in breathing among women over the past three months were as follows. The outcome variable was binary, indicating whether the woman reported experiencing difficulties in breathing ("Yes" vs. "No"). The variable ICS use prior to the current one (No) shows a borderline statistically significant increase in odds of breathing difficulties (OR = 1.856, $p = 0.050$), suggesting that women not using a previous ICS before the current one might be more likely to report breathing difficulties. Other predictors, including ICS use today and typical ICS use during the day, do not show statistically significant associations with breathing difficulties (p -values > 0.05).

Results of a logistic regression analysis exploring the influence of ICS use on the self-reported incidences of runny nose among women over the past three months were that the dependent variable was binary, indicating whether the respondent experienced a runny nose ("Yes" versus "No"). The model included several predictors: ICS use today, ICS use prior to the current one, and ICS use in a typical day with multiple categories compared to the reference group of using ICS for all meals. The results show that none of the predictors reached statistical significance at the conventional 0.05 level, suggesting no strong evidence of association between these variables and the likelihood of reporting a running nose. Women who did not use an ICS prior to the current one appeared less likely to report runny nose symptoms (OR = 0.612), but again, this was not statistically significant ($p = 0.169$).

Results of a logistic regression analysis investigating the influence of ICS usage on self-reported incidences of teary eyes among women within the last three months had the outcome variable being binary, indicating whether women reported experiencing teary eyes ("Yes" vs. "No"). The predictors in the model include ICS use today, ICS use prior to the current stove, and ICS use during a typical day, with the reference

category being ICS use during all meals.

The analysis shows that most predictors do not have statistically significant associations with self-reported teary eyes. For instance, not using the ICS today or prior to the current one is associated with a lower but statistically insignificant odds of teary eyes (OR = 0.759 and 0.974, respectively). These results suggest that the current status and recent use of ICS do not strongly influence the likelihood of women reporting teary eyes. When examining ICS use in a typical day, most categories also show no significant impact. However, the category labeled "Other meals" stands out with a statistically significant positive association (OR = 3.892, $p = 0.026$), indicating that women who use ICS during meals other than the main ones (breakfast, lunch, or dinner) have nearly four times the odds of reporting teary eyes compared to those who use ICS during all meals. The "Breakfast only" category again shows an extreme coefficient with an enormous standard error, resulting in an unstable estimate close to zero, likely due to sparse data. In summary, this model suggests that while general ICS daily use does not appear to influence teary eyes significantly; there is a notable exception for those using ICS during "Other meals," who report higher odds of this symptom. This finding may warrant further investigation to understand potential exposure patterns or behavioral factors associated with these specific meal-use categories.

Results of a logistic regression analysis assessing the influence of ICS use on self-reported incidences of congested chest among women in the last three months show the outcome variable being binary, indicating whether the respondent experienced congested chest symptoms ("Yes" vs. "No"). The predictors included in the model are, ICS use today, ICS use prior to the current stove, and ICS use during a typical day, with the reference category being use of ICS during all meals. The findings suggest that most predictors do not have a statistically significant impact on the odds of reporting congested chest symptoms. Although the odds of congested chest tend to be lower for women who did not use ICS today (OR = 0.562) or prior to the current one (OR = 0.572), these effects are not statistically significant at the 0.05 level but indicate a potential trend ($p = 0.084$ and $p = 0.146$, respectively).

Results of a logistic regression analysis examining the influence of ICS use on self-reported incidences of sneezing among women in the last three months indicate that the outcome variable is binary, indicating whether women reported sneezing ("Yes" vs. "No"). The predictors include ICS use today, ICS use prior to the current stove, and ICS use during a typical day, with the reference category being ICS use during all meals. The results reveal that, whether ICS was used today or prior to the current one does not show significant associations with sneezing, with odds ratios close to one and high p-values, indicating no meaningful effect. This effect is likely influenced by other factors like fuel type, cooking area and other pollutants within the cooking space that needs to be taken into account to fully realize respiratory health.

Findings recorded in this study however contradict some

previous studies results. [9] found out that cooking frequency was associated with some respiratory symptoms. The findings recorded that every additional hour cooking food increased the risk of a runny nose (OR ¼ 1.05, 95%CI 1.01–1.09). An additional hour per week spent grilling food was associated with cough (OR ¼ 1.10, 95%CI 1.01–1.19) and runny nose (OR ¼ 1.08, 95%CI 1.01–1.16). One additional stir-fry dish in a week was associated with an increased risk of cough (OR ¼ 1.04, 95%CI 1.03–1.16). On the contrary, the study findings were supported by those of Tonche et al. 2024 which showed no statistical association between the duration of cooking and respiratory symptoms.

5. Conclusion and Recommendations

Conclusion

The findings confirm that ICS use substantially lowers household exposure to harmful pollutants, offering significant respiratory health protection. However, the persistence of substantial symptom prevalence even among ICS users underscores that ICS adoption, while valuable, is insufficient as a stand-alone intervention. Factors such as intermittent ICS use, fuel stacking, stove maintenance challenges, and insufficient ventilation continue to limit the full realization of potential health benefits. While ICS technologies utilizing solid biofuels do deliver important health benefits, their dependence on solid fuels inherently sustains residual pollutant emissions. Even among ICS users, significant proportions of women continued to report respiratory symptoms: cough (64.8%), wheezing (47.9%), and breathing difficulties (46.4%). These findings suggest that while ICS-based interventions represent meaningful progress, the ultimate resolution of IAP-related respiratory illness will require broader transitions toward cleaner cooking fuels and exclusive ICS utilization supported by proper user education.

Recommendations

There is need to promote exclusive and sustained use of ICS technologies. The findings of this study underscore that health gains from ICS adoption are significantly undermined by fuel stacking behaviors, where households revert to traditional cooking methods for certain meals or seasons. Public policy should therefore prioritize behavior change communication strategies aimed at discouraging the parallel use of traditional stoves. Community health workers, local leaders, and women's groups can serve as effective conduits for driving behavioral change and reinforcing the importance of exclusive ICS utilization for optimal health protection.

Future research should explore the longitudinal health impacts of ICS adoption through prospective cohort studies. While this study provided important cross-sectional evidence of reduced respiratory symptoms among ICS users, it remains unclear to what extent these reductions translate into long-term improvements in lung function, chronic disease prevention, and overall morbidity and mortality. Longitudinal studies

would allow researchers to track individuals over extended periods, providing a more comprehensive assessment of how sustained ICS use influences chronic respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), cardiovascular conditions, and child growth outcomes.

Abbreviations

ALRI	Acute Lower Respiratory Infections
COPD	Chronic Obstructive Pulmonary Disease
COR	Crude Odds of Respiratory Illness
CO ₂	Carbon Dioxide
HAP	Household Air Pollution
FGD	Focus Group Discussions
IAP	Indoor Air Pollution
ICS	Improved Cooking Stove
KII	Key Informants Interviews
LPG	Liquefied Petroleum Gas
OR	Odds Ratio
PM _{2.5}	Particulate Matter
SAA	Sub-Saharan Africa
WHO	World Health Organization

Author Contributions

Margaret Wambui Muchendu: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources

Daniel Muasya Nzengya: Supervision

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Arlington, L., Patel, B. A., Simmons, E., Kurhe, K., Prakash, A., Rao, S. R., & Hibberd, P. (2019). Duration of Solid Fuel Cookstove Use is Associated With Increased Risk of Acute Lower Respiratory Infection Among Children Under Six months in Rural Central India. *PLoS ONE*, 14(10), 1–12.
- [2] Azanaw, J., & Endalew, M. (2025). Solid fuel use and household air pollution in Sub-Saharan Africa: Analysis of Demographic and Health Surveys. *PLOS Global Public Health*, 3(1), e0002145.
- [3] Bates, M., Chandyo, R., Branth, P., Pokhrel, A., Mathisen, M., & Basnet, S. (2013). Acute Lower Respiratory Infection in Childhood and Household Fuel Use in Bhaktapur, Nepal. *Environ Health Perspect*, 121, 637–642.
- [4] Burney P, Jithoo A, Kato B, et al (2014). Chronic obstructive pulmonary disease mortality and prevalence: the associations with smoking and poverty—a BOLD analysis. *Thorax*, 69, 465–473.

- [5] Dida, G. (2022). Indoor air pollution, maternal health, and gender inequalities in Kenya. *East African Medical Journal*, 99(2), 33–44.
- [6] Fuller, Richard et al. (2022). Pollution and health: a progress update. *The Lancet Planetary Health*, 6(6), 535 – 547.
- [7] GOK. (2021). National Strategic Plan for Prevention and Control of Non Communicable Diseases 2021/22—2025/26. Department of Non-communicable diseases.
- [8] James, S. B., Shetty, R., Kamath, A., & Shetty, A. (2020). Household cooking fuel use and its health effects among rural women in southern India—A cross-sectional study. *PLoS ONE*, 15(4), 1–12.
- [9] Juntarawijit, Y, Juntarawijit, C. (2019). Cooking smoke exposure and respiratory symptoms among those responsible for household cooking: A study in Phitsanulok, Thailand. *Heliyon*, 5(5), 1-15.
- [10] Nandasena S, Wickremasinghe AR, Sathiakumar N. Indoor air pollution and respiratory health of children in the developing world (2013). *World J Clin Pediatr*. 2(2): 6-15.
- [11] Pathak, Utkarsha, Kumar, Rohit, Suri, Tejas M., Suri JC., Gupta NC., Pathak Sharmishtha. (2019) Impact of biomass fuel exposure from traditional stoves on lung functions in adult women of a rural Indian village. *Lung India* 36(5), 376-383.
- [12] Ranathunga, N., Perera, P., Nandasena, S., Sumal, N., Kasturiratne, A., & Wickremasinghe, R. (2019). Effect of household air pollution due to solid fuel combustion on childhood respiratory diseases in a semi urban population in Sri Lanka. *BMC Pediatrics*, 19(306), 1–12.
- [13] Sana, A., Meda, N., Badoum, G., Kafando, B., & Bouland, C. (2019). Primary cooking fuel choice and respiratory health outcomes among women in charge of household cooking in Ouagadougou, Burkina Faso: Cross-sectional study. *International Journal of Environmental Research and Public Health*, 16(6), 1040.
- [14] Sharma, S., et al. (2015). Traditional stoves and exposure to indoor air pollution. *Energy for Sustainable Development*, 25, 5-12.
- [15] Smith, K. R., & Pillarisetti, A. (2018). Household air pollution and health: A call for research. *Journal of Environmental Science and Policy*, 85, 30–38.
- [16] Taylor, E. T., & Nakai, S. (2012). Prevalence of Acute Respiratory Infections in Women and Children in Western Sierra Leone due to Smoke from Wood and Charcoal Stoves. *International Journal of Environmental Research and Public Health*, 9, 2252–2265.
- [17] Tonche M., Dawit D., Hunache B.(2024). The Association between Improved Cookstove Use and Respiratory Illness in Rural Southern Ethiopia Ethiop. *J. Med. Health Sci.*, 4(1): 356-367.
- [18] World Health Organization. (2021). Household Air Pollution and Health: Global Update 2022. World Health Organization.
- [19] World Health Organization. (2022). Household Air Pollution and Health: Global Update 2022. World Health Organization.
- [20] World Health Organization. (2024). Household Air Pollution and Health: Global Update 2024. World Health Organization.