EFFECT OF WOODFUEL CONSUMPTION ON UNDER FIVE AND INFANT MORTALITY IN SUB SAHARAN AFRICAN COUNTRIES: SYSTEM GMM APPROACH

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ABSTRACT
This study aims to investigate the effect of woodfuel consumption on under-five and infant mortality in Sub-Saharan African countries by using a panel data set of 44 Sub-Saharan African countries spanning from 2011 to 2019. System Generalized Method of Moments (GMM) was used in analyzing the data. The estimated GMM result revealed that woodfuel consumption is positively associated with both under-five and infant mortality. This implies that a 1% increase in woodfuel consumption increases under-five and infant mortality by .0000579% and .0000304%, respectively. The study further reveals that per capita income, government health expenditure, and food availability were significant determinants of under-five and infant mortality in Sub-Saharan African countries. The findings of this study revealed concern for population health and the future of the labor force in the region. The study recommends that Sub-Saharan African governments, non-governmental organizations, donor agencies, and foundations make clean cooking energy, such as electricity, gas, and solar, available and affordable to households; this would facilitate the transition from wood fuel to cleaner fuel.
Keywords: Woodfuel, Under-five, Infant, Mortality, Sub-Saharan Africa, GMM.
JEL Codes: 0150, 112

1. INTRODUCTION
The under-five mortality rate (U5MR) and infant mortality rate (IMR) have been identified as major public health indicators and the ultimate among several health outcomes, resulting in their inclusion as a core target of internationally agreed development agendas such as the International Conference on Population and Development (ICPD) in 1994, the Millennium Development Goals (MDGs) in 2000, and the Sustainable Development Goals (SDGs) in 2015. However, Sub-Saharan Africa (SSA) fell short of U5MR targets in both the ICPD and the MDGs, and it is unlikely to meet the SDGs targets of reducing U5MR to 25 per 1,000 live births by 2030 unless a concerted effort is made to address the root cause of the problems. The United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) (2024) reported that 4.9 million children died globally before turning five in 2021, with 13,800 daily deaths due to preventable causes.

Despite a decrease in the global U5MR and IMR, SSA remains the leading region globally in both, with 86 and 50 deaths per 1,000 live births, respectively (UN IGME, 2024). U5MR and IMR in the region are more than 19 and 11 times, respectively, higher than the region of Australia and New Zealand. The SSA region alone accounts for more than half (58%) of global U5MR and IMR, or 2.7 million deaths. The UN IGME report further reveals that of the 54 countries that are off track in achieving the SDG target of reducing U5MR to 24 per 1,000 live births, 75% (40 countries) are in SSA. Failure of these countries to meet the target would result in the deaths of 43 million under-five and infant children, with SSA accounting for more than half of the deaths (54% or 25 million). On current trends, however, more than 43 million

children under the age of five will die before 2030, with half of those deaths occurring during the infancy period. SSA would account for 58% of these deaths (25 million). Meeting the SDG target would prevent 10 million under-five deaths by 2030 and reduce the annual number of under-five deaths in the 54 countries that are falling behind to 2.5 million in 2030 (UN IGME, 2021).

To address this issue, the root cause of both under-five and infant mortality needs to be investigated. This study proposes that wood fuel consumption may serve as a contributor to U5MR and IMR in SSA. Around 2.4 billion people worldwide use inefficient stoves or open fires, fueling kerosene, biomass, and coal, causing harmful household air pollution (Oyedele & Oluwalaiye) (2023). A report from the International Energy Agency (IEA) (2024) reveals that SSA, comprising half of the access gap to clean energy, has 29 countries with access rates below 20%, resulting in a significant increase in people without access to clean energy for cooking, reaching around 960 million in 2023, though expected to reduce to 940 million by 2030, which is still considered unacceptably high. In 2022, 70% of households in the region relied on wood fuel for cooking and heating (FAO, 2022). The use of biomass fuel such as wood is regarded as the primary source of indoor air pollution (Fasoye & Olayiwola, 2023). The combustion process of wood fuel produces smoke, which is a complex mixture of various particles and substances made up of organic and inorganic compounds (WHO, 2023). These compounds pose a significant threat to human health due to their toxic nature, including carbon monoxide, nitrogen and sulfur oxides, aldehydes, particulate matter, volatile organic compounds, chlorinated dioxins, free radicals, and polycyclic aromatic hydrocarbons. Wood fuel emits 1-2.4 Gt of CO_2 equivalent annually, accounting for 2.7% of anthropogenic GHG emissions (FAO, 2017). The FAO further posited that inhaling rapped particles during cooking exposes people to up to 30,000 g/m³ of PM10, whereas an acceptable concentration of PM10 throughout the day is only 300-5000 g/m³. Flammin et al. (2023) reported 2019 annual wood fuel emissions of 745×106t, with uncertainty ranging from -63% to +64%, primarily driven by SSA. Children under 5 years and women face various health issues, including respiratory infections like pneumonia, CORP and lung cancer, adverse pregnancy, and eye diseases, which are equally prevalent (IEA, 2024). The combustion of wood fuel is estimated to cause 3 million deaths annually (IEA, 2021; WHO, 2021).

The high rates of under-five and infant mortality in the SSA may not be unconnected with the high wood fuel consumption in the region. Identifying the empirical relationship and effect of the woodfuel usage on the death of under-five and infant children in the region becomes imperative to guide the policy makers and stakeholders in expediating actions toward reducing under-five and infant mortality to the SDGs' targets by 2030. This study therefore seeks to investigate the effect of wood fuel consumption on under-five and infant mortality in SSA. The remainder of this paper is organized as follows: Section two contains the theoretical and empirical literature. Section three contains the methodology. Section four presents and discusses the results, and finally, section five contains the summary, conclusion, and policy recommendations.

2. LITERATURE REVIEW

2.1 Theoretical Literature

This subsection reviews health theories, which include the Grossman Model for the Demand for Health, the Health Belief Model (HBM), and the behavioral model for health care utilization (BMHU).

Grossman model for the demand for health

Grossman's demand for health theory, developed in 1972, suggests that individuals demand health for two main reasons: as a consumption commodity and as an investment good. Health depreciates over time and can be improved through investment, proportional to the number of challenges. Investment in human capital depends on medical care, personal time, and the ability to convert health inputs into investment in health. Health investment impacts labor productivity, production time, education investment reward, effective working time, and labor supply by affecting mortality and life expectancy, impacting production function (Senke et al., 2023). Eze (2018) suggests using illness to measure health status, highlighting the limitations of Grossman's model. He argues that severe illnesses require larger medical resources to cure, unlike Grossman's model.

Health Belief Model

The Health Belief Model (HBM), developed in the 1950s by US social psychologists, is an early theory of health behavior (Anderson & Bartkus1973). It has been used to predict health behaviors like early screening for asymptomatic disorders and immunization. The model has also been used to understand vaccination intentions and disease response. The HBM suggests that health-related activity is influenced by an individual's perception of perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. Perceived threat refers to an individual's vulnerability to a disease and its alleged repercussions. HBM has faced criticism for its lack of clear guidelines for mixing defined variables and its inability to state their relationship explicitly (Armitage & Conner, 2000). However, this flaw can also be seen as positive, as it allows for flexibility, making HBM suitable for various populations and health behavior types.

The behavioral model for health care utilization (BMHU)

The Behavioral Model of Health Care Utilization (BMHU), developed by Ronald M. Anderson in 1968, is a conceptual model that aims to explain factors leading to healthcare utilization. It explores individual attributes that facilitate health service use from a broader perspective and aims to predict and explain why families use healthcare services. The model has also been lambasted for emphasizing need rather than social aspects. Another limitation identified by Bradley et al. (2007) is that the model viewed health care utilization as a variable that could be present or absent, which is far from reality because the model did not account for the entire range of health-seeking behavior.

Based on the theories discussed, the study adopts the Grossman health model to serve as the theoretical foundation for this investigation. This is because the theory emphasizes the importance of environmental factors in determining health outcomes like indoor air pollution from woodfuel consumption.

2.2 Empirical Literature

Empirical studies have shown a strong association between polluting fuel and health outcomes. Basu et al. (2024) evaluated the effect of cooking fuel choice on under-five mortality in India and found that using solid fuels for cooking considerably increases child mortality. The study by Adejoh et al. (2023) examined the impact of public health spending on post-neonatal mortality in 15 South African countries. The study found significant reductions in mortality rates per extra unit of public health expenditure across all income categories. Popoola and Mohammed (2023) studied the impact of measles outbreaks on under-five mortality in Nigeria from 1986 to 2021. The co-integration technique revealed that measles outbreaks had positive effects on under-five mortality in Nigeria. Rana et al. (2021) investigated the link between household air pollution and under-five mortality in Myanmar using data from a 2016 survey. They found that infant and under-five mortality risks were higher in children from households using solid fuel compared to those using clean fuel for cooking. Nisha et al. (2018) corroborated

this position by investigating the link between household air pollution from polluting cooking fuels and perinatal mortality in Bangladesh and discovered that polluting fuels are associated with increase in child mortality.

Akinyemiet et al. (2016) found that maternal smoking and solid fuel use in sub-Saharan Africa increase infant and child mortality rates. The highest infant mortality rate was recorded in children exposed to both, with a 71% higher risk of infant death in full multivariate models. Chillrud et al. (2021) studied the impact of a fan-assisted biomass-burning cookstove and a liquefied petroleum gas (LPG) stove intervention in rural Ghana. They found a 47% reduction in mean 48-hour CO exposure and a 32% reduction in mean maternal PM2.5 exposure in the LPG stove compared to the control arm. Cesur et al. (2017) found that the widespread adoption of natural gas in Turkey significantly reduced infant mortality rates. A 4% increase in natural gas intensity could save approximately 348 infant lives in 2011, indicating a significant impact of natural gas infrastructure. A study by Ogunro and Alimi (2024) uses the 2013 Demographic and Health Survey in Nigeria to investigate gender-specific environmental effects on child mortality. The research shows that both male and female children face mortality risks from traditional and transitional cooking methods, with females showing higher risks from traditional energy sources. The study also found that girls face an 81% increased risk of under-5 mortality using traditional fuels, compared to a 62% increased risk for boys. A study by Xue et al. (2021) examined the impact of landscape fire smoke (LFS) on the health of children. The study found that each 1 $\mu g/m^3$ increment of fire-sourced $PM_{2.5}$ was associated with a 23% increased risk of child mortality. The association was robust to different models, and the exposure-response function was super linear, suggesting per-unit exposure to larger fires was more toxic.

It is critical to identify gaps in the reviewed literature. The literature nearly unanimously agrees that biomass and other polluting fuels have a strong association with health outcomes such as mortality and other diseases. However, the association between woodfuel consumption and under-five and infant mortality in SSA has not been thoroughly studied. This omitted crucial information about the role of woodfuel consumption in explaining under-five and infant mortality in Sub-Saharan African countries. Existing empirical studies use various fuel sources like PM 2.5 and solid fuel obtained from the demographic and health survey databases, which may increase recall bias. PM 2.5 is a general measure of fine particulate matter but doesn't specifically identify polluting fuel sources, making it difficult to attribute health effects to specific sources. Additionally, PM 2.5 measurement may not accurately represent the spatial distribution of emissions. Variations in reporting methods for solid fuel use also make it difficult to compare results across studies or populations. Woodfuel consumption has more advantages over PM 2.5 and solid fuel, as it directly measures indoor air pollution, capturing the source of emission (woodfuel combustion) rather than just one of its consequences (PM 2.5 emission). To fill this gap, this study distinguished itself by using standard household woodfuel consumption data, obtained from the United Nations database, to explore the effect of woodfuel consumption on under-five and infant mortality in SSA counties by using the System Generalized Method of Moment.

3. METHODOLOGY

3.1 Theoretical Framework

The Grossman model of human capital, developed in 1972, is used as the theoretical foundation for this research. It suggests that household investment in health capital is influenced by consumer time and commodity markets, depreciating with age, disease, and time. However, Eze (2018) suggests using illness to measure health status, arguing that severe illnesses require more medical resources to cure, and those without cure or control are not sick. The choice of the Grossman model is based on the fact that woodfuel consumption is an environmental factor

that can impact health outcomes, which is the key aspect of the Grossman model, while under-five and infant mortality are health outcomes that can be influenced by various factors, including under-five and infant mortality. The model is specified as:

$H_t = f(Z_t)$ …….. (1)

Where H is a metric for individual health output and a function of Z, which is also influenced by nutrient consumption, income, utilization of public goods, education, time spent on health, and personal and societal endowments.

3.2. Empirical Model

Following the empirical work of Grossman (1976), the health outcome model is specified as follows:

$MORT = f(WFC, Y, GHE, FA, EDU, SAN, IMM, CFT, DR)$ …… (2)

Where MORT represents under-five and infant mortality. The abbreviation WC stands for wood fuel consumption. Whereas Y, GHE, FA, EDU, SAN, WAT, IMM, CFT, and DR represent income, health expenditure, food availability, education, sanitation, water, immunization, clean fuel, technology, and dependency ratio, respectively. Using a panel framework to express the functional relationship as an econometric model, we arrive at the following:

$MORT_{it} = \alpha_0 + \alpha_1 WFC_{it} + \alpha_2 Y_{it} + \alpha_3 FA_{it} + \alpha_4 EDU_{it} + \alpha_5 SAN_{it} + \alpha_6 IMM_{it} + \alpha_7 CFT_{it} + a_8 DR_{it} + \eta_t + \lambda_i + \Pi_{it}$ ……..(3)

Where i represents the number of Sub-Saharan African countries included in this study, and t represents time expressed in years. η_t represents the time-invariant country-specific effect that accounts for variations among the panel nations, while λ_i is the country-specific time variation effect. While Π_{it} is a time-variant error term representing all other factors that might have an impact on the under-five mortality rate in developing nations but are not considered by the model. The study used the Generalized Method of Moment (GMM) model developed by Arellano and Bond (1991) and Arellano and Bover (1995). The GMM model specification is expressed in equation 4:

$MORT_{it} = \alpha_0 + \ell MORT_{it-1} + \alpha_1 WFC_{it} + \alpha_2 Y_{it} + \alpha_3 FA_{it} + \alpha_4 EDU_{it} + \alpha_5 SAN_{it} + \alpha_6 IMM_{it} + \alpha_7 CFT_{it} + \alpha_8 DR_{it} + \eta_t + \lambda_i + \Pi_{it}$ ……(4)

Since MORT in this study stands for both U5M and IMR, estimating them in the same equation could result in a misspecified model due to probable endogeneity; hence, we specified them in separate models as in equations 5 and 6:

$U5M_{it} = \alpha_0 + \ell U5M_{it-1} + \alpha_1 WFC_{it} + \alpha_2 Y_{it} + \alpha_3 FA_{it} + \alpha_4 EDU_{it} + \alpha_5 SAN_{it} + \boldsymbol{\alpha_6} IMM_{it} + \alpha_7 CFT_{it} + \alpha_8 DR_{it} + \eta_t + \lambda_i + \Pi_{it}$ …… (5)

$IMR_{it} = \alpha_0 + IMR_{it-1} + \beta_1 WFC_{it} + \beta_2 Y_{it} + \beta_3 FA_{it} + \beta_4 EDU_{it} + \beta_5 SAN_{it} + \beta_{76} IMM_{it} + \beta_7 CFT_{it} + \beta_8 DR_{it} + \eta_t + \lambda_i + \Pi_{it}$ ……(6)

In equations 5 and 6, the dependent variables for the study are represented by $U5M_{it}$ and IMR_{it}, in SSA which stand for under-five mortality and infant, respectively. While $U5M_{it-1}$ and IMR_{it-1} are lagged dependent variables, they are accountable for the panel GMM model's dynamic behavior. The coefficients of all the log form-independent variables in model equation 5 are α_1, α_2, α_3, α_4, α_5, α_6, α_7, and α_8 while β_1, β_2, β_3, β_4, β_5, β_6, β_7, and β_8 for model 6, respectively.

3.3 Estimation method and justification

The panel estimation model was utilized for data analysis, as various techniques like pooled, fixed effects, and random effects were ineffective when a country-specific effect and lagged dependent variable were present, making them ineffective (Waziri et al., 2018). Arellano and Bond (1991) introduce the Generalized Method of Moments (GMM) estimator, which eliminates country-specific impacts, time-invariant variables, and correlation between lagged

dependent variables and disturbance components. The GMM estimator has a weakness in addressing level connection and linkages between levels and first differences. Arellano and Bover (1995) propose a system-GMM estimator to estimate level and first-difference regressions. This approach outperforms first-difference estimators in persistent dependent variables, limited time periods, and large cross-section data.

3.4 Variable Description and Expected Signs

Under-five mortality and infant mortality were used as dependent variables. The under-five mortality rate is the number of children who die before reaching the age of five and is stated in terms of 1,000 per live birth. Infant mortality rate is the death between birth and 11 months per 1,000 live births. Wood fuel consumption was employed as an independent variable. It is measured in cubic meters per thousand and is predicted to be positive in relation to both under-five mortality and infant mortality. Income is measured using GDP per capita expressed in constant US dollars. Its coefficient is expected to have a negative sign. Government health expenditure, measured as the ratio of health expenditure to GDP, is expected to have a negative sign in relation to under-five and infant mortality. Additionally, food availability was used to measure the food production index, which is expected to show a negative sign.

3.5 Data sources

The data for woodfuel consumption were sourced from the United Nations Statistics Division 2021, while the data for under-five and infant mortality, income, government health expenditure, food availability, education of a parent or household, sanitation, immunization, clean fuel and technology, and dependency ratio were sourced from the World Development Indicator 2022. The study covered 46 Sub-Saharan African countries from the year 2011 to 2019. These countries were chosen based on data availability and a nine-year period that fell within the parameters of an acceptable panel data rule.

4. RESULTS AND DISCUSSION OF FINDINGS

We conducted preliminary tests, including descriptive statistics, before estimating the main model. Table 1 shows the descriptive statistics of the study variables.

Table 1: Descriptive Statistics

VARIABLE	MEAN	STD. DEV.	MIN	MAX	OBS
U5MR	71.84928	30.88255	14.3	154.5	414
WFC	13203.48	27798.79	3.16	173313	414
IMR	49.18551	18.75552	12.3	104.2	414
Y	2277.145	2997.103	270.1373	16992	414
GHE	5.445525	2.461513	1.263576	20.4134	414
FA	101.0918	11.16548	67.67	155.8	414

Source: Authors' computation with data using Stata Version 16 (2024)

Statistics from Table 1 show the overall annual mean of U5MR is 71.84928, indicating that 72% of children in SSA countries die before reaching the age of five for the period 2011-2019. The overall annual mean of IMR is 49.18551, indicating that 49% of children in SSA countries die between birth and 11 months per 1,000 live births during the study periods. The table further shows that WFC has an overall annual mean of 13203.48 m^3. This implies that on average, households in SSA consumed about 13203.48 m^3 of woodfuel for the period 2011-2019. Y, measured by GDP per capita, has an average of $2277.145. This implies that SSA households have an annual income of $2277.145 on average during the period 2011-2019. GHE expressed as a percentage of current health spending is 5.445525. This means that SSA countries spent roughly 5% of their total budget on health during the study periods.

The FA, which measures food availability, has an annual mean of 101.0918. This implies that SSA households consumed approximately 101 tons of food on average for the periods 2011-2019. Each of the variables has 414 observations. This clearly shows that there is a significant difference within and between countries. This lends support to the use of the panel estimation method.

The estimated model results using system GMM with under-five mortality as the dependent variable are presented in Table 2. The specification tests validated the suitability of the GMM estimators. The Hansen J-test, for example, does not reject over-identifying restrictions as 0.726 > 0.005. This suggests that the identifying restrictions are valid and that the GMM model is correctly specified and consistent with the data. Similarly, the Diff-in-Hansen test rejects the null hypothesis (0.730 > 0.005). This suggests that the instruments used in the model are correctly specified and consistent with the data. The number of groups (44) is greater than the number of instruments (40) in the model. The lagged dependent variable is both positive and significant, indicating the dynamic nature of the model. These tests supported the use of system GMM estimation.

Furthermore, the estimated system GMM model on the effect of woodfuel consumption on infant mortality is also shown in Table 2. The specification tests validated the suitability of the GMM estimators. The Hansen J-test, for example, does not reject over-identifying restrictions as 0.748 > 0.005. This suggests that the identifying restrictions are valid and that the GMM model is correctly specified and consistent with the data. Similarly, the Diff-in-Hansen test rejects the null hypothesis (0.401 > 0.005). This suggests that the instruments used in the model are correctly specified and consistent with the data. The number of groups (46) is greater than the number of instruments (40) in the model. The lagged dependent variable is both positive and significant, indicating the dynamic nature of the model. These tests supported the use of system GMM estimation.

Table 2: GMM estimation on the effect of woodfuel consumption on under-five and infant mortality in Sub-Saharan African countries

Variables	System GMM	Variables	System GMM
	Coefficient		Coefficient
$lnU5MR_{it}$	.913 (.024)***	$lnIMR_{it}$	.926 (.039)***
$lnWFC_{it}$	.0000579(.0000282)***	$lnWFC_{it}$	.0000304(.0000118)***
lnY_{it}	-.0008771(.0005296)*	lnY_{it}	-122(.065)*
$lnGHE_{it}$	-285(.146)**	$lnGHE_{it}$	-040(.019)***
$lnFA_{it}$	-072(.025)***	$lnFA_{it}$	-.045(.022) ***
AR (2)	0.663	AR (2)	0.871
Hansen test of ORR	0.726	Hansen test of ORR	0.748
Difference-in-Hansen	0.730	Difference-in-Hansen	0.401
Number of observations	352	Number of observations	352
Number of groups	44	Number of groups	46
Number of instruments	40	Number of instruments	40

Note that values in parenthesis represent the standard error, while ***, ** and * represent significant level at 1%, 5% and 10% respectively.
Source: Authors' computation with data using Stata version 16 (2024)

The estimated results in Table 2 confirmed the hypothesis of the study that woodfuel consumption increases under-five deaths in sub-Saharan Africa. The elasticity of woodfuel consumption is positive and statistically significant at 1%. This indicates that a 1% increase in woodfuel consumption results in a 0.0000579% increase in under-five mortality. The GMM estimator reveals that under-five mortality increases with increasing wood fuel consumption in SSA. Similarly, the estimated results on the effect of woodfuel consumption on infant mortality also confirmed our earlier expectation that woodfuel consumption increases infant mortality.

The elasticity of woodfuel consumption is positive and statistically significant at 1%. This indicates that a 1% increase in woodfuel consumption results in a .0000304% increase in infant mortality. The findings of this study suggest that woodfuel consumption is found to increase both under-five and infant mortality, though the magnitude is more on under-five than infant mortality. Though the magnitude of the effect of woodfuel consumption on under-five and infant mortality as revealed by the study seems minimal, the strong significance shows that a policy that reduces woodfuel consumption could be leveraged on to drastically reduce under-five and infant mortality in the region. The findings of this study has serious implication on the availability of future labour force and the overall health of the under-five and infant children in the studied countries. The result also have implication on achieving the SDG target of reducing under five mortality to 25 per 1,000 live births by 2030.

The result of this study validates the finding of Basu et al. (2024), who reveal that using solid fuels for cooking considerably increases child mortality in India. The finding of this study is also in agreement with the findings of Nisha et al. (2018), polluting fuels are found to be positively associated with child mortality in Bangladesh. Lastly, the findings of this study are in consonance with the findings of Rana et al. (2021) and Ogunro and Alimi (2024), who found that infant and under-five mortality risks were higher in children from households using solid fuel compared to those using clean fuel for cooking. Income per capita, one of the control variables, has statistically significant negative coefficients at 10% in both under-five and infant mortality. This implies that an increase in income per capita of 10% reduces under-five and infant mortality by .0008771% and 122%, respectively. This is consistent with the finding of Irfan et al (2023) that income per capita reduces child mortality. The coefficient of government health expenditure is statistically significant at 5% and 10% and negatively related to both under-five mortality and infant mortality. Its elasticity of 285 and 040 indicated that an increase in government health expenditure in Sub-Saharan African countries will reduce under-five and infant mortality by 285% and 040%, respectively. The estimated coefficient of food availability in both the under-five and infant mortality models is statistically significant and negative at 1%. This suggests that in Sub-Saharan Africa, a 1% increase in food availability results in a reduction of under-five and infant mortality by 0.72% and 0.45%, respectively. This supports our earlier expectation that food availability reduces mortality among children under five and infant.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study showed a positive relationship between woodfuel consumption and under-five and infant mortality. This implies that increasing woodfuel consumption leads to increased under-five and infant mortality. The study concludes that woodfuel consumption is a significant driver of under-five and infant mortality in the studied countries. Therefore, addressing woodfuel consumption and promoting alternative energy sources is crucial for sustainable development. The study recommends Sub-Saharan African governments through ministries works and energy commissions, non-governmental organizations such as Clinton Health Access Initiative (CHAI), donor agencies, and foundations such as Bill and Malinda Gates to make clean cooking energy, such as electricity, gas, and solar, available and affordable to households, facilitating the transition from wood fuel to cleaner fuel. However, this requires significant financial investments and measures. To achieve this, the study suggests a result-based financing project and broad participation from both public and private sectors. This can be done by forming a coalition of governments, local and international investors, international donor agencies, and foundations to raise funds for clean cooking fuel in the studied countries. This may significantly lessen households' over-dependence on wood fuel for cooking. The study also recommends a step-down training and awareness campaigns, involving government

officials, international organizations, community leaders, and traditional rulers on the danger of using woodfuel for cooking. This can help to reduce overdependence on wood fuel.

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