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Gender Disparities in Mortality Rates and Environmental Hazards across Selected Sub-Saharan Africa Countries

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Abstract: Enhancing female health stands as a paramount global public health concerns, necessitating a comprehensive understanding of the factors influencing female mortality. Among these factors, environmental hazards have gained significant attention, emerging as pressing issue for numerous nations. Despite the extensive literature on this subject, empirical evidence linking female mortality to environmental hazards remains scarce. Therefore, this study aims to fill this gap by examining the association between female mortality and environmental hazards in selected Sub-Saharan Africa countries. Leveraging secondary data from the World Bank for the year 2023, a recursive model was constructed. The functional equation incorporates variables such as cooking fuels, energy use, water shortage and air pollution as significant environmental risks exacerbating female mortality. The findings underscore the detrimental impact of environmental hazards on female health, highlighting the urgent need for policy interventions. Consequence, the study advocates for concentrated efforts to mitigate environmental risks and proposes actionable strategies to address female health vulnerabilities.

Keywords: Female Mortality, Environmental Hazards, Cooking Fuels, Energy Use, Water Shortage, Air Pollution, Sub-Saharan Africa.

1. INTRODUCTION

Environmental hazards, such as air pollution, water pollution and inadequate cooking fuel, pose significantly threats to human health globally. Pollution stand as a leading environmental cause of diseases and premature deaths, with air pollution alone estimated to have caused 6.5 million fatalities worldwide in 2015, representing 16 percent of all deaths (European Commission, 2018; World Bank, 2022). Biomass fuels encompass fuels derived from plants or animals, such as charcoal, wood, dung and crop residues, emit harmful smoke containing pollutants like carbon monoxide and particulate matter (Desai et al., 2004), contributing to ambient air pollution and associated health risks. Particularly in Sub-Saharan Africa, where access to energy remain a challenge, the utilization of biomass for cooking is prevalent, exacerbating health hazards (United Nations, 2023; Mlambo et al., 2023).

Despite progress in some areas, the World Health Organization (WHO) asserts that substantial gaps persist in access to basic services like water, sanitation and clean cooking fuels across the region. In Sub-Saharan Africa, only 23% of the population has access to basic sanitation, and nearly 970 million lack access to clean cooking fuels, resulting in dire health consequences, particularly for women and children (WHO, 2022). These challenges hinder economic and social progress and have significant environmental ramifications, further compounded by the aspiration to achieve net-zero greenhouse gas emissions by 2050.

The Lancet Commission on pollution and health highlighted that pollution accounted for 9 million premature deaths in 2015, establishing it as the foremost environmental risk factor for disease and premature mortality worldwide. Subsequent updates in 2022, using data from the Global Burden of Diseases, Injuries, and Risk Factors Study 2019, reaffirm these findings. Pollution continues to be responsible for approximately 9 million deaths annually, representing one in six deaths globally. Despite reductions in deaths attributed to types of pollution associated with extreme poverty, such as household air and water pollution, these improvements are offset by increased deaths due to ambient air pollution and toxic chemical pollution, notably lead. Deaths resulting from these modern pollution hazards, unintended consequences of industrialization and urbanization, have increased by 7% since 2015 and by over 66% since 2000 (Richard et al., 2022).

Health impact assessments reveal that Sub-Saharan Africa bears a significant burden of disease and premature mortality due to environmental pollution, which could impede efforts to achieve Sustainable Development Goals (SDGs) and foster economic development (Coker and Kizito, 2018; Fisher et al., 2021). In response, various regulations have been implemented globally to mitigate pollution, yet challenges persist, with the vast majority of the global population still exposed to air that exceeds WHO quality standards (WHO, 2022).

Women in Sub-Saharan Africa, face disproportionate challenges due to gender inequality and marginalization, including early marriage, violence and lack of legal protections. The COVID-19 pandemic has further exacerbated these issues, hindering progress in addressing them. Unintentional poisonings accounted for more than 84,000 deaths in 2019, with approximately 73% (around 62,000 deaths) deemed preventable through effective chemical management. While the number of deaths from unintentional poisonings has been decreasing since 2000, mortality rates remain relatively high in low-income countries, exceeding the global average by more than two times. A third of all deaths from unintentional poisonings occurred in Sub-Saharan Africa alone. Unintentional poisoning can result from various sources including household chemicals, pesticides, kerosene, carbon monoxide, and medicines, as well as environmental contamination or occupational chemical exposure. Notably, lead recycling serves as a significant source of environmental contamination and human exposure.

Despite the significant health impacts, studies focusing on pollution and female health in Africa remain limited, with women often bearing the brunt of exposure to environmental hazards due to gender-based domestic roles (Meh et al., 2019). Therefore, this study aims to enhance local knowledge on female health by examining the impact environmental hazards in developing countries, particularly in Sub-Saharan Africa. By quantifying the health impacts of environmental hazards, the study seeks to inform policy and contribute to the existing literature, emphasizing the need for improved policies targeting specific sources of environmental pollution. Specifically, the research explores how environmental factors such as unclean cooking fuels, energy use, water shortage and air pollution affect the health of females in selected countries in Sub-Saharan Africa, aiming to uncover the nuanced associations between environmental hazards and female health outcomes in the region.

Regarding the association between females' health and environmental risks, ongoing debates regarding its hypothesis, with researchers and policy-makers continuously providing recommendations. Therefore, the researcher proposes the following working hypothesis: female mortality, as a proxy for females' health, is functionally related to key environmental hazards such as cooking fuels, energy used, water shortage and air pollution. A corresponding null hypothesis will also be discussed. This research aims to investigate and evaluate these hypotheses to contribute to better understanding of the relationship between females' health and environmental risks.

The research primarily focuses on 21 countries in Sub-Saharan Africa, namely Botswana, Burkina Faso, Cote d'Ivoire, Ethiopia, Kenya, Lesotho, Madagascar, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Uganda, Zambia and Zimbabwe. This selection is based on the rationale that Sub-Saharan Africa represent a region with a high prevalence of underdeveloped countries. By studying these specific countries, the research aims to gain insights into the environmental health challenges faced by populations in underdeveloped regions, particularly focusing on the impact on females' health.

To investigate the association between females' health and environmental risks, secondary data from the most recent year available on the World Bank Open Data website (2024) will be utilized. The findings and conclusion of this study aim to contribute to understanding the link between female health and environmental risks. The significance of this study lies in the urgent attention require for environmental problems. Environmental risks not only harm human health but also diminishing economic productivity (World Summit on Sustainable Development, 2002). Therefore, addressing these issues is crucial for promoting both public health and socioeconomic development.

This article is organized as follows: Section one: Introduction provides introduction to the association between female mortality and environmental risks, problem statement, objective of the study, hypothesis, scope of the study and the significance of the study. Section two: Literature review provides a description of the features, population, female demographics in Sub-Saharan Africa and overview of the state of the environment in the region. Section three: Methodology, explanation of the research methodology employed in the study. Section four: Results and discussions, presentation and analysis of research findings. Section five: Conclusions and policy recommendations, summary of conclusions drawn from study and policy recommendations based on research findings.

2. LITERATURE REVIEW

According to the World Bank Open Data region website (2024), Sub-Saharan Africa composed of 42 countries on the mainland and 6 island nations, a with total population of 1.21 billion in 2022. The annual population growth rate is 2.5%, with a poverty headcount ratio at US$2.15 a day (2017 PPP) in 2019, affecting 35.4% of population. The GDP is recorded at US$ 2.05 trillion, with a GDP per capita of $1,690.4 in 2022 and an annual GDP growth rate of 3.6%. The adult literacy rate stands 68% for year 2022. Carbon dioxide emissions per capita were 0.7 metric tons in 2020 and the forest area constitutes 26.1% of the total land area as of 2021.

Between 2015 and 2020, Sub-Saharan Africa experienced the highest population growth rate at 2.7%, compared to the global average of 1.1% and the North African and Middle Eastern average of 1.8% (United Nations, 2019).

The population of Sub-Saharan Africa is anticipated to nearly double over the next three decades, increasing from 1.15 billion in 2022 to 2.09 billion in 2050. Globally, the population is projected to rise from 7.94 billion currently to 8.51 billion by 2030 and 9.68 billion by 2050. The population of the WHO African Region was estimated to be 1,120,161,000 in 2020, accounting for approximately 14.4% of the world's population of 7,758,157,000. It is the third-largest population among the WHO regions, following South-East Asia and the Western Pacific regions.

Population explosion can pose significant challenges in providing education, health and employment services. The current population density of 36 inhabitants per km^2 for the entire continent is relatively low on average, but significant disparities exists. Many areas are uninhabitable, while in others the population density is very high, for example in Nigeria, population density is very high, reaching 190 inhabitants per km^2. This high concentration of population exposes individuals to numerous health risks without ensuring access to basic rights (Juginovi´c et al., 2021).

The demographic dividend for African countries will stem from accelerated economic growth resulting from a decline in fertility rates and shift in the change pyramid structure. The active population, typically aged 18–65 years, will become more prominent, reaching an optimal level where the ratio between those capable of financing health and education systems and those benefiting from them becomes positive (WHO, 2022).

The Region is vulnerable to natural disasters, which exact a toll on human lives, economics and psychological well-being. Moreover, the energy sources and technologies employed in the Region, particularly in the rural areas, are neither modern nor sustainable, posing challenges to environmental health and sustainability. WHO defines air pollution as the contamination of the indoor or outdoor environment by any chemical, physical or biological agent that alters the natural characteristics of the atmosphere (WHO, 2022; Chen et al., 2018). Exposure to air pollution exacerbates and contributes to a variety of negative health effects. While particulate matter and nitrogen dioxide are commonly discussed pollutants in air quality management, air pollution is a complex mixture of gases and other pollutants may also significantly impact on health.

The Global Alliance on Health and Pollution (GAHP) has underscored the critical nature of air pollution as a significant public health issue around the world (Chen et al., 2018; GAHP, 2019; WHO, 2022, European Environmental Agency, 2023; Mlambo et al., 2023). Moreover, it has been highlighted that environmental exposures notably worsen female health challenges in Africa (Dauda et al., 2022).

The disease burden from solid fuel use is particularly significant in populations with inadequate access to clean fuels, especially among impoverished households in rural areas of developing countries. Women and their youngest children are disproportionately exposed due to their household roles. Solid fuel use is strongly linked to acute lower respiratory infections, including pneumonia, in young children, and to chronic obstructive pulmonary disease and lung cancer in women (and to a lesser extent in men). Each of these three health outcomes represents a major disease category in most societies, indicating that household solid fuel use is likely a significant contributor to the disease burden in communities where it is prevalent. Globally, 2.6% of all ill-health is attributable to indoor smoke from solid fuels, with the vast majority occurring in impoverished regions (Desai et al., 2004).

In 2019, air pollution was responsible for 1.1 million deaths across Africa. Household air pollution accounted for 697,000 deaths, while ambient air pollution was responsible for 394,000 deaths. The number of deaths related to ambient air pollution increased from 361,000 in 2015 to 383,000 in 2019, with the most significant increases observed in the most highly developed countries. The majority of deaths due to ambient air pollution are attributed to non-communicable diseases.

In terms of economic impact, the loss in economic output in 2019 due to air pollution-related morbidity and mortality was significant: $3.02 billion in Ethiopia (1.16% of GDP), $1.63 billion in Ghana (0.95% of GDP), and $349 million in Rwanda (1.19% of GDP). $PM_{2.5}$ pollutions was estimated to be responsible for a staggering 1.96 billion lost IQ points in African children in 2019 (Fisher et al, 2021).

Exposure to air pollution has been consistently linked to a wide array of negative health consequences, spanning from subclinical effects and physiological alterations in pulmonary functions and the cardiovascular system, to clinical symptoms, outpatient and emergency-room visits, hospital admissions, and ultimately premature death. Health impact assessments highlight that sub-Saharan Africa bears a significant burden of disease and premature deaths attributable to environmental pollution, ranking among the highest globally. The escalating pollution levels pose grave health and economic risks, potentially undermining African endeavors to bolster economic development, build human capital, and attain SDGs (Mlambo et al., 2023).

3. METHODOLOGY

3.1 Data source and description of variables

The methodology of this study is based on the utilization of secondary data obtained from the World Bank Open Data website for the most recent year available (2024). Specifically, the study focuses on variables related to female mortality and environmental hazards. Female mortality (FM) is quantified in terms of the rate attributed to unintentional poisoning per 100,000 female population.

The environmental Hazard variables encompass cooking fuels, energy used, water shortage and air pollution. These variables serve as both dependant and explanatory variables within the empirical model. Below are the definitions for each variable employed in the study:

- Female Mortality (FM): The rate of female deaths attributed to unintentional poisoning per 100,000 female population.
- Cooking Fuels (CF): The types and sources of fuels used for cooking purposes, including but not limited to biomass, coal, gas and electricity.
- Energy Used (EU): The consumption of energy resources, such as electricity and other forms of power, within the population.
- Water Shortage (WS): The extent of shortage or inadequacy in the availability of clean water for various purposes, including drinking, sanitation and hygiene.
- Air Pollution (AP): The presence of harmful substances or pollutants in the air, typically resulting from human activities such as industrial emissions, vehicles exhaust and agricultural practices.

These variables are integral to the empirical model, facilitating an analysis of the relationship between female mortality and environmental hazards across selected Sub-Saharan Africa countries.

3.2 Empirical model

An empirical model has been constructed using a recursive regression approach to analysing the data and derive results, findings and conclusions regarding the association between female mortality and environmental hazards. The decision to utilize a recursive model was made to mitigate potential issues encountered with the Ordinary Least Squares (OLS) method, such as bias, inconsistency and interdependence among explanatory variables.

The model is designed to examine the relationship between female mortality (FM) and environmental hazards, including cooking fuels (CF), energy use (EU), water shortage (WS) and air pollution (AP). It is hypothesized that there exists a positive relationship between female mortality as the dependent variable and the environmental hazards factors as independent variables. In other words, higher levels of CF, EU, WS and AP are expected to correlate with increased FM, and conversely, lower levels with decreased FM. Thus, the equation takes the following structure:

$$FM = F\,(CF, EU, WS, AP)$$

The Ordinary Least Squares (OLS) method is employed as the estimation model, utilizing SPSS software for analysis. The significance of the relationship between the dependent and independent variables is assessed using the t-test.

To evaluate the model's effectiveness, the magnitude of R^2 utilized as a measure of explanatory power and goodness of fit. R^2 values range between 0 and 1, with a value closer to 1 indicating a better fit of model to the data.

4. RESULTS AND DISCUSSION

The results of the present study, as provided for by the econometric estimation of the Equation, has previously discussed in Section 3. This Equation constitutes the empirical model used to test the hypothesis of the study. The SPSS output for the Equation has been tabulated in the Appendix. The Equation models female mortality as a function of a set of environmental hazards variables. Definitions for the dependent, as well as for explanatory variables, were provided in Section 3. The estimation of Equation is presented as follows:

$$FM = -\,0.440 + 0.007CF + 0.001EU + 0.026WS + 0.005AP$$

$$(-0.852) \quad (1.565) \quad (1.847) \quad (4.419) \quad (1.641)$$

$$R^2 = 0.826 \qquad D\text{-}W = 2.620$$

The Equation demonstrates a strong fit and high explanatory power, as evidenced by an R^2 value of 0.826 and a significant F-value of 0.000. All coefficients of the explanatory variables are statistically significant at the 0.05 level, differing from zero, as indicated by the t-values in parentheses. All regressors exhibited a significant functional relationship with the dependent variable, as indicated by the F-value, which measures how well the data fit into the equation as a model and is positively related to female mortality. The results validate the hypothesis of the study: female mortality as a proxy of females' health, is functionally related to key environmental hazards such as cooking fuels, energy use, water shortage and air pollution.

Similar findings by (fisher et al., 2021; Bickton et al., 2022) that air pollution in Africa is a major threat to health. The findings align with Bickton et al. (2022) study, which examined the association between household air pollution exposure and under-five mortality. They revealed a notable correlation between air pollution exposure and risks of child health, in elucidating the differences based on study population characteristics and cooking fuel types. Notably, other forms of biomass were the most commonly utilized cooking fuel (72.1%), followed by charcoal (16%) and clean fuel (11.9%).

The detrimental effects of unclean cooking fuels, unclean energy consumption, water shortage and air pollution on female mortality are evident, as indicated by the positive coefficients of the variables. These results suggest that females in developing countries are particularly vulnerable to environmental hazards. Moreover, environmental problems are notably significant in developing countries. In alignment with the United Nations' stance on the energy issue in 2023, the low levels of access to energy and the adverse effects of the predominant types of energy supply necessitate collaborative efforts from all stakeholders to pursue sustainable solutions aimed at enhancing access to modern energy services. For instance, leveraging the abundant renewable energy sources available on the continent could offer an opportunity to shift away from heavily polluting fuels that currently dominate the energy mix towards low-carbon or zero-emission energy sources (United Nations, 2023).

Rapid population growth alongside widespread industrialization has led to cities characterized by poor air quality, posing substantial health risks. This health and social crisis is undermining individuals' ability to manage their health and well-being effectively (WHO, 2022; Zhao and Su, 2023). By 2050, demographic changes and rapid urbanization will lead to more than 1.1 billion Africans living in cities. However, Africa will still grapple with significant challenges, as approximately 160 million urban dwellers will reside in informal settlements and slums. Nearly a third of the population will lack access to clean water, sanitation, energy or mobility facilities.

Without active intervention, environmental hazards will worsen mortality rates, reduce economic productivity and hinder development. To facilitate strategy interventions in Sub-Saharan African countries, extensive researches is needed to craft and adopt policies aimed at mitigating environmental health problems and advancing national development priorities and climate goals.

5. CONCLUSIONS AND POLICY RECOMMENDATIONS

This study concludes that female mortality, as an indicator of females' health, is significantly influenced by environmental hazards variables at the macro level. Factors such as cooking fuels, energy used, water shortage and air pollution play a crucial role in shaping this relationship and pose significant risks to females' health. Consequently, it is evident that there exists strong interconnection between females' health and environmental hazards. These findings suggest that investigating the correlation between females' health and environmental risks at the macro level is essential for sound policy formulation and intervention strategies. Attention should be paid to the reduction of environmental risks by intensify the use of renewable energy and electricity and enhancing access to water sources and sanitation facilities. This necessitates concerted efforts from policy makers, stakeholders and communities to address these issues effectively and improve the overall well-being of females and society as a whole.

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Data availability:

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Authors declare that they have no competing financial, professional, or personal interests from other parties.

Authors' contribution

The Author is the major contributor in writing and correcting the manuscript, determined the methodology for study, provided assistance in its implementation, and reviewed and approved the final manuscript.

Appendix

SPSS output of the Equation

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
FM	2.0524	.77241	21
CF	22.6667	24.03608	21
EU	4.2833E2	250.32506	21
WS	45.0143	21.63923	21
AP	1.7262E2	46.89562	21

Correlations

		FM	CF	EU	WS	AP
Pearson Correlation	FM	1.000	-.148	-.046	.876	.743
	CF	-.148	1.000	-.413	-.183	-.450
	EU	-.046	-.413	1.000	-.215	-.078
	WS	.876	-.183	-.215	1.000	.756
	AP	.743	-.450	-.078	.756	1.000
Sig. (1-tailed)	FM	.	.260	.422	.000	.000
	CF	.260	.	.031	.213	.020
	EU	.422	.031	.	.174	.368
	WS	.000	.213	.174	.	.000
	AP	.000	.020	.368	.000	.
N	FM	21	21	21	21	21
	CF	21	21	21	21	21
	EU	21	21	21	21	21
	WS	21	21	21	21	21
	AP	21	21	21	21	21

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	AP, EU, CF, WS[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: FM

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.909[a]	.826	.783	.35981	.826	19.042	4	16	.000	2.620

a. Predictors: (Constant), AP, EU, CF, WS

b. Dependent Variable: FM

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.861	4	2.465	19.042	.000[a]
	Residual	2.071	16	.129		
	Total	11.932	20			

a. Predictors: (Constant), AP, EU, CF, WS

b. Dependent Variable: FM

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.440	.516		-.852	.407
	CF	.007	.004	.215	1.565	.137
	EU	.001	.000	.225	1.847	.083
	WS	.026	.006	.736	4.419	.000
	AP	.005	.003	.301	1.641	.120

a. Dependent Variable: FM

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.2652	4.1196	2.0524	.70217	21
Residual	-.65902	.56352	.00000	.32182	21
Std. Predicted Value	-1.121	2.944	.000	1.000	21
Std. Residual	-1.832	1.566	.000	.894	21

a. Dependent Variable: FM

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