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Modeling the impact of conflicts and socioeconomic factors on mortality rate in Somalia

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Abstract
Healthy quality has become a pressing issue for policymakers and researchers. The health indicators in Somalia are poor, such as high mortality rates and low life expectancy. This study ascertains the impacts of environmental pollution, energy consumption, economic growth, food production, and internal and external conflicts on the mortality rate in Somalia. The study employs a machine learning method, specifically the Kernel regularized least squares (KRLS) technique, on an annual unbalanced time series spanning 1985–2019. This method assesses the marginal effects of the sampled independent variables on mortality rate, unlike the traditional econometric methods that assume constant marginal effects. The empirical results revealed that economic growth and food production reduce the mortality rate in Somalia, whereas energy consumption and internal and external conflicts increase it. Environmental pollution does not have any significant effect on the mortality rate in Somalia. Based on the empirical findings, the study proposes shifting from fosil fuel energy use to renewable energy, which is clean and favorable to the environment and health. Furthermore, deescalating conflicts would help to reduce Somalia's mortality rate.

Keywords Conflicts · KRLS · Mortality rate · Socioeconomic factors · Somalia

1 Introduction

Conflicts cause tremendous suffering for people as well as significant costs to the economy and society [1]. Armed conflicts damage private and public infrastructure and have a profound impact on economic development. The destruction of schools and health infrastructure, as well as housing, has a direct impact on education and health for vulnerable communities [2]. It also causes the displacement of communities, families, and individuals, resulting in substantial populations of internally displaced persons and refugees [3]. Although conflict is commonly characterized as a collision of opposing parties, the concept has not been consistently defined. Reis et al. [4] classified conflict as internal or external. Conflict, specifically external conflict, refers to interstate occurrences (between countries), whereas internal conflict generally refers to conflict within a state (for example, civil war or terrorism) or people-to-people conflict (for instance, ethnic and religious conflicts, common violence, or crime).

The United Nations has identified armed conflict as a significant obstacle to the achievement and execution of the Sustainable Development Goals (SDGs), which encompasses enhancements in energy infrastructure, food security, and global health [5]. The nations mostly impacted by conflict worldwide are in the Middle East, specifically Palestine, Afghanistan, Iraq, and Syria [1]. On the other hand, Africa, being the most impoverished continent globally, also experiences the

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greatest number of conflicts and political instability [2]. For more than three decades, Somalia has experienced prolonged conflicts characterized by political strife, tribal divisions, and terrorism [6]. Hence, this impeded the health system of the country. In 2023, Somalia was ranked the most fragile state in the world [7]. The empirical literature on conflicts and health quality indicators nexus produced conclusive results. They observed that any kind of conflict undermine health quality outcomes. For instance, Kotsadam and Østby [8] noted that a rise in armed conflicts correlates with an increase in maternal mortality in Sub-Saharan African nations. Nonetheless, disparities exist in rural regions as well as in affluent and more educated communities. Furthermore, Ouili [2] emphasized that armed conflicts elevate child mortality in Ivory Coast by approximately 3% and diminish human capital by decreasing the likelihood of children's school enrollment. A similar result has been observed by Gates et al. [9] in a panel of countries. They reported that conflicts undermine the efforts of reducing poverty and child mortality of Millennium Development Goals (MDGs).

Besides the inhibiting impact of conflicts on health quality outcomes; greenhouse gas emissions (GHG), particularly in the form of air pollution, are the leading cause of health problems. Currently, environmental concerns about air pollution claim the lives of about 3.41 million people annually, with most of these fatalities occurring in developing countries [10]. In many low-income countries, indoor biomass combustion is the primary source of cooking energy, which is one of the most significant concerns for health quality indicators [11]. Further, energy security involves access to contemporary energy sources like renewable energy to generate electricity that decreases air pollution and health threats [12]. According to Rahman and Alam [13], energy use has a significant impact on people's health. They also discovered that energy use tends to increase life expectancy in South Asia from 2002 to 2017. On the contrary,, Arawomo et al. [14] found no significant effect of energy consumption on life expectancy in 11 Sub-Saharan African countries. In terms of renewable energy, it was discovered that renewable energy consumption enhances life expectancy in 155 global economies studied from 1990 to 2018 [15].

Sub-Saharan African (SSA) countries, including Somalia, have experienced unprecedented economic growth in recent decades [16, 17]. Economic expansion enhances financial capabilities and contemporary facilities that contribute to increased life expectancy [18]. Plenty of studies have documented that increased economic growth ensures longer life expectancy and reduced mortality rates. For instance, Warsame [18] noted that economic growth enhances life expectancy in Somalia using a Kernel machine learning method. Li et al. [1] found that the mortality from earthquakes decreases as the income of the countries increases in Asia. In a similar panel study, Zouine et al. [19] emphasized that economic growth improves health quality by reducing mortality rates from chronic and fatal diseases in MENA countries. Utilizing geo-referenced data, Kammerlander and Schulze [20] endeavored to analyze the impact of local economic growth on infant mortality in 46 developing nations. It was determined that a sustained increase in economic growth mitigates infant mortalities.

Food production, on the other hand, is essential to sustain and increase quality of life. Food security is the state in which every individual has constant and adequate access to nutritious, safe, and adequate food that satisfies their dietary requirements and preferences for an active and healthy lifestyle, encompassing physical, social, and economic aspects [21]. The availability of food has a substantial effect on health quality [22]. Many studies have shown that improving food security (nutrition) increase life expectancy and quality of life, while malnutrition and overnutrition reduce it [22]. Using time series data and an ARDL bound test, Halicioglu [23] assessed the determinants of life expectancy in Turkey. The empirical results indicated that nutrition and food availability enhance longevity in Turkey. Food availability provides key ingredients to the population that are necessary for their health. A similar result has been established by Bayati et al. [24] in a panel of Mediterranean countries. They discovered that food availability improves healthy quality outcomes. Food access and availability are crucial for sustaining healthy quality. However, high food prices could hamper health quality by shortening life expectancy and increasing the mortality rate [25]. In addition, the role of food availability in mitigating mortality rate is verified using various analysis methods. For instance, Comerford et al. [26] found the presence of higher maternal mortality of black mothers and their offspring compared to their white counterparts in the United States of America (USA), which is due to the low nutrition intake of black mothers and their kids.

Based on the literature review, we found that numerous studies have examined the determinants of health quality indicators in both single-country and cross-country settings. Nevertheless, there are limited studies in least-developed countries such as Somalia where the health outcome indicators are very poor. Moreover, most of the previous studies have used traditional econometric methods that produce constant marginal effects.

Life expectancy and mortality rates are frequently used as primary measures to evaluate the population's health quality [16]. A nation's level of social and economic development also strongly correlates with it [27]. Although life expectancy has increased at the global level in the last decades and this increase varies among countries. There is a high disparity between developed and developing countries. For example, based on a human development report published

in 2013, the gap between life expectancy in Japan, which is the highest in the world (86.6 years), and Sierra Leone, which is the lowest in the world (48.1 years), was 35.5 years [28]. Long-term changes in social, cultural, political, economic, environmental, and health system factors can explain the differences between countries. Health policymakers in both developed and developing countries are concerned about this discrepancy among countries, and they are interested in understanding the main factors that influence health outcomes. Long-term transformations in social, cultural, political, economic, environmental, and health system variables account for the variety of national characteristics. Concerned about this inequality among nations, health policymakers in both developed and developing countries are interested in the fundamental drivers of healthy quality [29]. However, in addition to disrupting food and energy consumption, conflicts worsen political instability and health systems and increase homelessness, poverty, and unemployment—all of which have adverse effects on the health quality [30].

The combination of prolonged conflicts, energy consumption, and food production systems in Somalia have dramatic cumulative impact on the mortality rate. Persistent conflicts have interrupted healthcare facilities, while restricted electricity accessibility and fragile food supply exacerbate health issues, all of which contribute to an increase in mortality rates among its population [31]. However, there are scant studies on the determinants of health outcomes in Somalia. The very few studies focused on the socioeconomic determinants of healthy quality indicators in Somalia have omitted several important variables [32]. For instance, Warsame [32] examined the impacts of environmental pollution, economic growth, renewable energy, and urbanization on life expectancy in Somalia. Therefore, Warsame's study employed life expectancy as a key health indicator. However, this study differs from its predecessors in several key areas. First, this study measures health quality indicators for the mortality rate, a significant concern in Somalia. Second, unlike most previous studies that have omitted conflicts, this study considers the effects of conflicts, energy consumption, and food production on mortality rate. Thirdly, this study adds to the existing literature by utilizing a machine-learning method based on the kernel regularized estimation technique [33]. This method is superior to the traditional econometric methods on the premise that it examines the marginal effects of the explanatory variables. Hence, this study examines the interconnected impacts of conflicts, economic growth, environmental pollution, energy consumption, and food production on the mortality rate in Somalia.

2 Theoritical framework

This research employed Grossman [34] health demand model. The premise of Grossman's [34] model is that "health is a capital good." Individuals possess an inherent stock of health that diminishes over time, and health can be enhanced via the utilization of medical care and enhancing environmental quality [35]. Majeed and Ozturk [35] expand this model to encompass the relationship between the environment and health, wherein environmental quality functions as an input for health outcomes. The function of the environment as an input is contingent upon conceptions of sustainable development and ecological modernization. The notion of sustainable development advocates for the use of finite resources in a way that preserves natural resources and does not jeopardize the needs of future generations. The sustainable utilization of natural resources predominantly relies on circular economy methods, which encompass the utilization of clean energy sources. Undermining health inventory leads to death. The health production function is specified as follows:

$$H = f(X) \tag{1}$$

In this context, H represents the health measure utilized as a proxy for health outcomes, whereas X encompasses a range of determinants influencing health, including income, education, healthcare expenses, and environmental factors. We can categorize the term x into three subsections for a macro-level analysis: economic, social, and environmental aspects [36].

$$H = f(Y, S, V) \tag{2}$$

In this study, Y represents a vector of economic variables (gross domestic product per capita and trade), S denotes a vector of social variables (food production), and V signifies a vector of environmental factors (energy consumption and environmental pollution). Moreover, we control the effects of conflicts on the mortality rate in Somalia, in addition to economic, social, and environmental factors. It is worth highlighting that Somalia had experienced more than three decades of prolonged conflicts, which damaged the economic sectors and caused human casualties.

3 Data and methods

3.1 Data

This undertaking evaluates the impacts of environmental pollution, energy consumption, internal conflicts, external conflicts, economic growth, and food production on the mortality rate in Somalia. The study utilizes unbalanced annual secondary time series data spanning from 1985 to 2019 to achieve its objective. We extracted environmental pollution, food production, and mortality rates from the World Bank. We sourced energy consumption data from Our World in Data. The International Country Guide Risk (ICRG) of the Political Risk Service (PRS) group provides information on internal and external conflicts. We convert all the sampled variables into natural logarithms to interpret the results as elasticities and mitigate the heteroskedasticity problem. Table 1 presents detailed explanations about the data sources and descriptions.

3.2 Method

To achieve the aim of the study, we employ the Kernel Regularized Least Square (KRLS) method to quantify the impacts of environmental pollution, economic growth, energy consumption, food production, internal conflict, and external conflict on the mortality rate in Somalia. This method has been developed by Hainmueller and Hazlett [33]. It is preferred over the traditional econometric methods for several reasons. First, this method examines pointwise derivatives and average marginal effects whereas the econometric techniques estimate constant marginal impacts. Second, The KRLS approach outperforms other machine learning methods in addressing the issue of incorrect statistical conclusions by offering interpretable and adjustable parameter outputs. Third, it produces unbiased results and does not need to pretest the sampled variables [37].

By utilizing the Grossman's health production model and previous studies of Gates et al. [9] and Majeed [15], we develop the model specification of the study as follows:

$$\ln MOR_t = \beta_0 + \beta_1 \ln EU_t + \beta_2 \ln IC_t + \beta_3 \ln EC_t + \beta_4 \ln CO_{2t} + \beta_4 \ln RGDP_{2t} + \beta_4 \ln FPI_{2t} + \varepsilon_t \quad (3)$$

MOR, EU, IC, EC, CO_2, RGDP, and FPI stand for mortality rate, energy use, internal conflict, external conflict, carbon dioxide emissions, real gross domestic product, and food production index respectively. ε is the error term.

4 Empirical analysis and discussion

Preliminary analysis of the data such as mean, median, and standard deviation are reported in Table 2. It was observed mean values of mortality rate (102), economic growth (9.93E+08), internal conflict (− 3.5), energy use (378), external conflict (− 5.4), food production (98), and environmental pollution (659). Energy use and environmental pollution have the highest standard deviation values of 162 and 139 respectively. All the series are independently and identically distributed except energy use, food production, and environmental pollution. Besides, the correlations of the sampled

Table 1 Variable description

Code	Indicator name	Source
MOR	Mortality rate	World Bank
RGDP	Real GDP (constant, 2010)	SESRIC
CO_2	Carbon dioxide emissions (thousand metric tons)	World Bank
IC	"It is assessment rating contains three components: (a) civil war/coup threat, (b) terrorism/political violence, (c) civil disorder"	ICRG
EC	"It is assessment rating contains three components: (a) war (b) cross-border conflict, (c) foreign pressures"	ICRG
FPI	Food Production Index (2004)	World Bank
EU	Energy Consumption Per Capita	Our World in Data

variables are also displayed in Table 2. It was established that economic growth, external conflict, and food production are negatively associated with the mortality rate whereas internal conflict, energy consumption, and environmental pollution are positively related to the mortality rate in Somalia.

The empirical result of the KRLS estimation method is displayed in Table 3. This method outperforms the econometric methods in that it examines the pointwise marginal coefficients of the predictors. It was determined that all the interested explanatory variables are statistically significant except environmental pollution which is inconsequential. Somalia emits a tiny fraction of the global carbon emissions [38]. Economic growth and food production significantly reduce the mortality rate whereas internal and external conflicts, and energy consumption increase the mortality rate in Somalia.

On average, a 1% increase in economic growth contributes to the mortality rate decrease by about 0.17%. In the 25th and 50th (median) percentiles, economic growth improves health quality in Somalia by reducing the mortality rate in Somalia, but in the 75th percentile, the effect of economic growth turns positive by increasing the mortality rate by about 0.013%. Hence, the effect of growth on the mortality rate is heterogeneous and has decreasing marginal effects. This result is in line with ample previous studies that found economic growth improves health outcomes such as Rahman and Alam [39] in panel countries and Warsame [32] (in Somalia).

In the same vein, an average increase in food production mitigates the mortality rate by about 0.065% for a 1% increase in it. Food production, similarly, enhances health quality in the 25th and 50th percentiles but turns positive in the 75th percentile, which implies that it increases the mortality rate. Food production has heterogeneous and decreasing marginal effects on mortality rate. Food production has a paramount importance in improving health quality by providing nutrients and calories. On the contrary, energy consumption increases mortality rate by about 0.054% for an average increase in energy utilization. In the 25th, 50th, and 75th percentiles, energy utilization also significantly inhibits health quality by increasing the mortality rate. Energy utilization has homogeneous and increasing marginal effects on the mortality rate in Somalia. This result is consistent with the previous study of [17] who found that nonrenewable energy consumption hampers health quality indicators. Finally, internal and external conflicts both hamper health quality by increasing the mortality rate in Somalia. On average, a 1 unit increase in internal conflict leads to a mortality rate increasing 0.0026%. In the 25th percentile, internal conflict reduces mortality rate but it turns positive in the 50th and 75th percentiles. External conflict increases the mortality rate by about 0.0033% for a 1 unit increase in external conflict. In the 25th percentile, it turns negative but in the 50th and 75th percentiles, external conflict results in the mortality rate decrease.

To implement the empirical results of the study as policy implication, we have conducted several diagnostic tests such as loolossas, tolerance, goodness-of-fit, and lambda as reported in Table 3. An adjusted R-squared of 0.99 implies that

Table 2 Preliminary analysis of the data

	MOR	RGDP	IC	EU	EC	FPI	CO_2
Mean	102.209	9.93E+08	−3.519	378.744	−5.436	98.495	659.107
Median	104.5	1.01E+09	−4.00	320.322	−4.955	100.335	630.000
Maximum	115	1.29E+09	0.000	856.191	−2.130	111.600	1008.425
Minimum	81.4	7.47E+08	−6.000	253.762	−10.000	71.400	490.000
Std. Dev	8.357	1.55E+08	1.611	162.027	1.920	9.349	139.388
Skewness	−0.977	−0.051	0.935	1.849	−0.918	−0.994	1.370
Kurtosis	3.405	2.058	3.201	5.282	3.211	3.879	3.937
Jarque–Bera	5.313	1.197	4.718	25.181	4.562	6.302	11.185
Probability	0.070	0.549	0.094	0.000	0.102	0.043	0.004
Correlation							
MOR	1						
RGDP	−0.518	1					
IC	0.374	−0.279	1				
EU	0.685	0.094	0.095	1			
EC	−0.046	0.374	−0.017	−0.113	1		
FPI	−0.138	0.487	−0.625	0.195	0.224	1	
CO_2	0.384	0.470	0.061	0.814	−0.012	0.322	1

Table 3 Estimation of KRLS result

	Avg	SE	T-statistics	P > t	P25	P50	P75
lnRGDP	−0.1723	0.0118	−14.582	0.000	−0.3931	−0.1057	0.0132
lnFPI	−0.0653	0.0225	−2.898	0.008	−0.1722	−0.078	0.0496
$lnCO_2$	−0.00047	0.0147	−0.032	0.975	−0.034	−0.0061	0.0359
lnEU	0.054	0.005	10.571	0.000	0.0126	0.0544	0.0894
IC	0.0026	0.001329	1.962	0.061	−0.00054	0.0031	0.0054
EC	0.0033	0.0011	2.998	0.006	−0.00054	0.0044	0.0086
Lambda = 0.06176							
Tolerance = 0.032							
Sigma = 6							
Eff. df = 17.72							
$R^2 = 0.994$							
Looloss = 0.08704							
Robust							
Pr (Skewness) 0.2309							
Pr (Kurtosis) (0.6276)							
Adj chi^2 (2) 1.80							

the explanatory variables explain 99% of the variations occur in the mortality rate in Somalia. The data of the study has a normal distribution as shown in Fig. 1. Further, Fig. 2 indicates there is no structural break in the data, and the model of the study is stable.

Robustness analysis

To find out unbiased and robust results, we used fully modified ordinary least square (FMOLS) as a robustness analysis. Its results, reported in Table 4, revealed that economic growth significantly reduces mortality rates in Somalia. On the contrary, energy consumption and external conflicts significantly raise the mortality rate in the country. The rest of the variables are statistically insignificant. Nevertheless, most of the variables are in line with the results of the KRLS estimation method.

Discussion of the results

The empirical findings regarding internal and external conflicts on mortality rates support our hypothesis that such conflicts negatively impact health outcomes by elevating mortality rates and reducing life expectancy. It is clear that conflict directly contributes to the mortality rate. Furthermore, conflict undermines essential infrastructure and critical economic sectors of the economy. Since 1991, Somalia has undergone various types of conflicts. These conflicts resulted in human casualties and property damage [40]. This result is supported by previous studies such as Da'ar and Gele [6] in Somalia and Kotsadam and Østby [8] in Sub-Saharan African countries, which found that conflicts undermine healthy quality outcomes. Moreover, the empirical results of economic growth indicate that it significantly contributes to the reduction of mortality rate in Somalia. Increased income offers vital resources that contribute to better health outcomes. Somalia is classified as

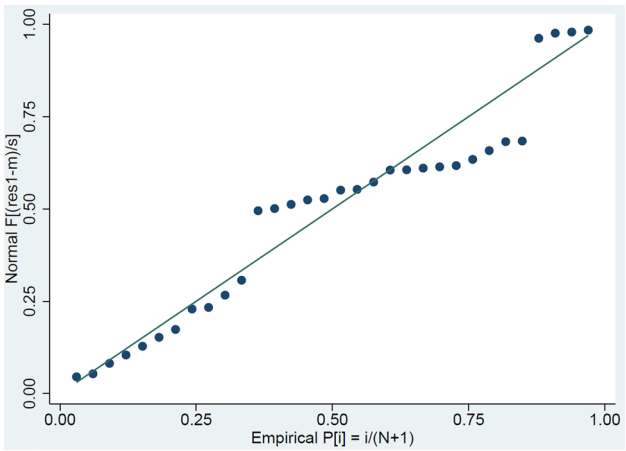

Fig. 1 Normal distribution of the estimated residuals of the model

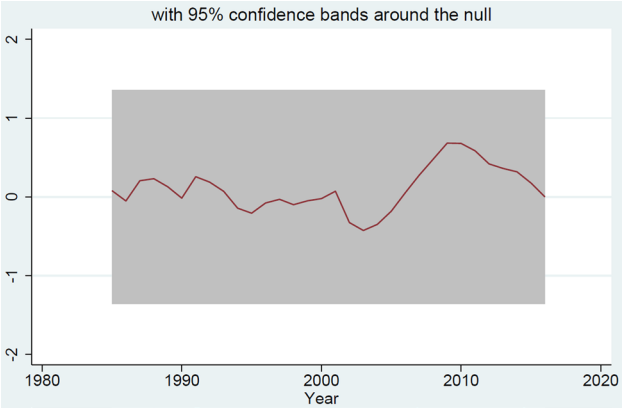

Fig. 2 Parameter stability of the estimated residuals of OLS CUSUM

Table 4 Fully modified ordinary least squares (FMOLS)

Variable	Coefficient	Std. Error	T-Statistic	Prob
lnRGDP	−0.498	0.072	−6.822	0.000
lnFPI	0.104	0.078	1.323	0.198
lnEU	0.129	0.041	3.106	0.004
$lnCO_2$	0.142	0.084	1.682	0.105
IC	0.007	0.004	1.479	0.152
EC	0.017	0.003	5.025	0.000
Constant	12.89	1.221	10.551	0.000
R-squared	0.916591	Mean dependent var	4.619660	
Adjusted R-squared	0.895739	S.D. dependent var	0.084221	
S.E. of regression	0.027195	Sum squared resid	0.017749	
Long-run variance	0.000814			

a low-income nation. A rise in income results in a continuous enhancement of health quality. However, the CO_2 emissions impact on the mortality rate in Somalia appears to be minimal. This could be explained by the fact that Somalia produces a minimal share of CO_2 emissions due to its lack of manufacturing industries [11].

Food production reduces the mortality rate in Somalia. This result could be justified for several reasons. First, food production ensures the availability of various and sufficient nutrients that are essential for human health. On the contrary, limited food availability results in higher food prices, which could cause chronic diseases and high death rates. Somalia is an agrarian-based economy. The agriculture sector plays a pivotal role in covering food needs. More food production implies more nutrients, improved health, and lower mortality. This result agrees with the previous studies of Shahbaz et al. [28] who found that food supply enhances health outcomes in Pakistan.

5 Conclusion and policy implications

Healthy quality has become a pressing issue for policymakers and researchers. In Somalia, health outcomes are poor, such as high mortality rates and low life expectancy. This study investigates the effects of environmental pollution, energy consumption, economic growth, food production index, and internal and external conflicts on the mortality rate in Somalia. This research employed the theoretical framework of Grossman's health demand model. The premise

of the Grossman model is that "health is a capital good." People have a natural health reserve that depletes over time, and they can improve their health by seeking medical care and improving environmental quality. In order to accomplish the study's objective, we employ a machine learning method based on the KRLS technique, utilizing unbalanced annual time series from 1985 to 2019. Unlike the traditional econometric methods that assume constant marginal effects, this method assesses the marginal effects of the sampled independent variables on the mortality rate.

The empirical results showed that factors such as economic growth, food production, energy consumption, and internal and external conflicts significantly influence the mortality rate, while environmental pollution has no significant impact. Increased income offers vital resources that contribute to better health outcomes. Somalia is classified as a low-income nation. A rise in income results in a continuous enhancement of health quality.Similarly, food production improves health quality by lowering the mortality rate. It ensures the availability of various and sufficient nutrients that are essential for human health. On the contrary, limited food production results in higher food prices, which could cause chronic diseases and high death rates.Moreover, increased energy consumption raises the mortality rate, thereby reducing the quality of health outcomes. Energy utilization has a uniform and growing impact on the mortality rate in Somalia. Finally, internal and external conflicts both hamper health quality by increasing the mortality rate in Somalia. The empirical findings regarding internal and external conflicts and mortality rates support our hypothesis that such conflicts negatively impact health outcomes by elevating mortality rates and reducing life expectancy. It is clear that conflict directly contributes to the mortality rate. Furthermore, conflict undermines essential infrastructure and critical economic sectors of any economy. Since 1991, Somalia has undergone various types of conflicts.

The empirical results revealed an increase in the mortality rate due to energy consumption and conflicts. Nonrenewable energy constitutes a large proportion of the total energy consumption in Somalia. Hence, the study proposes shifting from nonrenewable energy use to renewable energy, which is clean and favorable to the environment and health. Further, de-escalating conflicts would contribute to the reduction of the mortality rate in Somalia. The study suggests the importance of resolving and rectifying various types of conflicts, including both internal and external ones. The investigation shows how important it is to reduce conflicts like wars, cross-border disagreements, civil unrest, pressure from outside Somalia, and terrorism, as these things have a terrible effect on the country's health. Conversely, the establishment of economic growth and food production aims to reduce mortality rates. Therefore, we propose the implementation of policies that encourage the increase in domestic production, such as attracting investments in agriculture, fishing, and manufacturing.

Numerious factors affect health quality indicators, such as socioeconomic and non-socioeconomic indicators. Hence, we recommend that future studies explore the impact of non-socioeconomic factors on health outcomes in Somalia, as this study solely focuses on socioeconomic determinants of mortality rate in Somalia.

Author contributions Abdimalik: conceptualization, methodology, formal analysis, writing the original draft. Abdukadir Mohamed: Writing The Introduction Hassan Abdikadir: Reviewing & Editing.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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