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Impact of Air Pollution and Health Expenditure on Under-Five Years Mortality Rate in Kenya: Application Of Air Pollution on Under-Five Years' Mortality Rate

Engede, Moreen[1], Kiganda, Evans[2], Otsyulah, Joseph[3]
[1]*Kaimosi Friends University, School of Business and Economics, P.O. Box 385 Kaimosi.*
[2]*Kaimosi Friends University, School of Business and Economics, P.O. Box 385 Kaimosi.*
[3]*Kaimosi Friends University, School of Business and Economics, P.O. Box 385 Kaimosi.*
Corresponding Author: Moreen, Engede[1]

ABSTRACT: - Health is undeniably diligently associated with economic and sustainable advancement whereby raising life expectancy of a new born by 10% increases the economic progress by 0.35% annually. In developing countries nearly 29,000 children below five-years die per day. Although there has been progress with respect to child mortality rates in Kenya which have decreased from 96.6 in 1970 to 30.6 per 1,000 live births in 2018, this value remains below the Sustainable Development Goals target of below 25 for every 1000 live births by 2030.The specific objectives was to determine the effect of air pollution on under-five years' mortality rate in Kenya. This study was based on the Grossman health demand model. The study employed correlational research design to establish the relationship between study variables. Time series data for a period of 49 years from 1970 to 2018 was collected from World Bank Development indicators using a data collection sheet. Inferential data analysis techniques that include unit root test, correlation analysis and Granger causality were used to establish short-run and long-run effect of air pollution on under-five years' mortality rate in Kenya. The unit root test indicated that the variables of interest were stationary. The correlation analysis established a positive association between under-five years mortality rate and air pollution. The Johansen cointegration established a long run relationship among the variables of under-five years mortality rate and air pollution with coefficient of 12.007 such that a unit increase in air pollution by 1metric ton of CO_2 increases mortality by approximately 12 deaths per 1000 live births. Vector error correction in the short-run indicated that previous year's air pollution does not significantly affect under-five years' mortality rate in Kenya. Granger causality test results showed a unidirectional causality from air pollution to under-five years mortality rate. In conclusion, air pollution affects under five years' mortality rate in Kenya. The study therefore recommends that the government of Kenya should ensure full implementation of enacted national air quality by targeting activities aimed at cutting down on the metric tons of CO_2 per capita emitted into the air. The research findings form useful material of knowledge to academia by expanding on existing literature and provide information to policy makers in identifying what needs to be done to reduce the burden of under-five years' mortality rate in Kenya.

Keywords: impact of air pollution and health expenditure on under-five years' mortality rate in Kenya

I. INTRODUCTION:

Health is undeniably diligently associated with economic and sustainable advancement. Evidence has shown that investment in health conveys a considerable paybacks for the economy. World Health Organization (WHO) notes that raising life expectancy of a new born by 10% increases the economic progress by 0.35% annually (Anyanwu & Erhijakpor, 2007). UNICEF has indicated a death rate of nearly 29,000 per day for children below five-years translating to approximately 21 per minute with majority occurring in developing countries. For instance, in Africa the probability of dying before attaining 5 years is 30% for children in relation to those in European countries (Dhrifi, 2018). The likelihood of passing on earlier age one stated per 1000 live births, is relied upon as a measure and gauge for children's wellbeing, accessibility, consumption and efficacy of healthcare (Anyanwu & Erhijakpor, 2007).

The death toll in 2017 for children below 5 years was 5.4 million despite sustainable development goal 4 (SDG) calling for an end to avert death of kids below 5 years by specifying that nations must target reducing under-five death rate to less than 25 for every 1,000 live deliveries by 2030 (UNIGME, 2018). With the existing burden of mortality, survival of children has become an alarm and majority of countries continue striving to reduce under-five years' mortality rate, Asia-Pacific, Latin-America and the Caribbean nations are nearly to attaining the target nonetheless headway remains sluggish in Sub-Saharan Africa, where under-five year's death rates were 163 per 1,000 live births in 2019 far-off the target of 62 (UNIGME, 2018; World Bank, 2007; Anyanwu & Erhijakpor, 2007).

The biggest contributors to the under-5 mortality is related to a wide range of socioeconomic factors for underdeveloped nations; most frequently identified causes include mother education, per-capita incomes, environmental factors and health expenditures (Issa & Ouattara, 2005; Kiross et al., 2020).

Over 46% of children whose mothers are not educated and come from developing nations are probably going to pass on before attaining 5years (Anwar *et al.*, 2019). Investigation and experiences have shown that for the nearly 11 million children who pass on annually, 6 million can be avoided through modest actions, such as vaccination, improved health care financing and maintaining clean environment amongst others. For that reason, decreasing the burden of death amongst those with low incomes is commonly observed as the prime public-health challenge globally and has turned out as a key concern for the global community, as mirrored by SDGs (Dhrifi, 2018).

Statement of the problem

Although there has been progress with respect to under-five years mortality rate in Kenya which have decreased from 96.6 in 1970 to 30.6 per 1,000 live births in 2018 (Manda, Mugo, & Murunga, 2020). This value is below the SDGs target 4 of reducing the under 5 years' death rate to below 25 for every 1000 live births by 2030 (Mugo, Agho, Zwi, Damundu, & Dibley, 2018). The target has not been met because it has been documented that air pollution levels have increased in Kenya by 182%. Children being more susceptibility with exposure to air pollution there might be increasing chances of under-five years mortality rate linked to pollution (ASAP, 2019; Anwar *et al.*, 2019).Although there has been a global research interest on air pollution and under-five years mortality rate, it is clearly noted that majority of the studies focused on neonatal and infant mortality rather than children under-five years and specifically for the link between air pollution and child mortality, making it difficult to generalize the results to the Kenyan scenario. Therefore, the purpose of the study will be to investigate the effect of air pollution on under-five years' mortality rate in Kenya to generate new knowledge from the Kenyan perspective.

Objectives of the study

General Objective

To establish the effect of air pollution on under-five years 'mortality rate in Kenya.

Specific Objective

To determine the effect of air pollution on under-five years' mortality rate in Kenya.

Theoretical Review

Health Demand Model

The model was advanced by Michael Grossman in 1972. Grossman, (1972) argued that health is a long-lasting capital-stock producing output of healthy time and people inherit the early health-stock which declines with age and may be improved through investment. When each person is born, he or she gets gifted with a minimum quantity of health. But, even at birth, health is unequally distributed amongst people as a result of variances in socioeconomic status of parents and the safety of environment under which the person is brought up (Murunga *et al*., 2019). As children grow to become adults, their health status is dependent on social, economic, environmental and political aspects that encompass parental income, mother's education level, general environmental cleanliness, expenditure on health and residence amongst other unobservable aspects (Muthaka, 2016; Murunga *et al*., 2019). To complement Michael Grossman, Wagstaff (1986) in his demand for health model argued that health-care is purely a resource in the health production function. Therefore, as noted by Nyamuranga (2016) healthcare is recognized as a vital component that determines low mortality rates besides higher lifespan such that health spending is a resource in the health production function. Any country needs to avail healthcare amenities and human resources for people's health outcomes to be improved.

II. LITERATURE REVIEW

Anwar *et al*., (2019) by exploring the link between neonatal deaths and air pollution used a panel of 12 highly exposed Asian nations from over 2000 to 2017. Results showed that air pollution was positively association with neonatal deaths. On another front, Kotech *et al*. (2020) investigating if pollution is connected with neonatal or post-neonatal mortality between 2001 and 2012 in England and Wales noted that the odds ratios for infant deaths rose significantly due to air pollution.

Andréa, et al. (2009) using a case study, connect traffic pollution and perinatal mortality of 14 districts Sao Paulo, Brazil. Logistical regression results showed increased threat of premature neonatal death due to greater exposure to traffic air pollution. In their study, Eva and Hanna (2012) examined the marginal influence of pollution on infant mortality using data from Mexico. Findings showed that increased carbon monoxide (CO) by a single part per billion resulted in 0.0032 deaths per 100,000 births which were greater than those in the U.S. By examining influences of neonatal mortality in South Sudan for a period of 5 years using generalized linear latent and mixed models Mugo et al. (2018) showed that air pollution significantly influenced neonatal mortality.

Critique of Existing Literature

There has been a global research interest on the air pollution and under five year's mortality rate for instance, Anwar *et al*., (2019), Kotech *et al*. (2020), Andréa, et al. (2009), Eva and Hanna (2012) showed a positive influence of air pollution on under-five years mortality rate and a bias towards the Latin America, Asia and USA for a study by Mugo *et al*., (2018) conducted in South Sudan. However, it is clearly noted that majority focused on neonatal and infant mortality rather than children under-five years and specifically for the link between air pollution and mortality in Kenya, therefore, making it difficult to generalize the results to the Kenyan scenario.

III. RESEARCH METHODOLOGY

Research design

The research adopted a correlational research design. According to Fraenkel and Wallen (2009) correlation research design helps to establish a relationship between variables. In this study the correlational research design was useful in establishing a relationship, between air pollution and under five years mortality rate in Kenya.

Study Area

Kenya is located on Africa's east coast at latitude 10 North and longitude 380 East. According to the World Bank (2020), Kenya has a land area of 582650 square kilometers and a population of 53.77 million. According to (Manda, Mugo, and Murunga, 2019) the under-five mortality rate in Kenya gradually decreased from 96.6 deaths per 1,000 live births in 1970 to 30.6 deaths per 1,000 live births in 2019, which is less than the SDGs' aim of bringing the rate to 25 years per 1,000 live births by 2030 (Mugo, Agho, Zwi, Damundu, and Dibley, 2018)

Model Specification

The study's time series model was specified as a functional form model (3.1) and mathematical form model (3.2).

$$M_t = f(A_t, GE_t, PE_t, \varepsilon_t) \quad (3.1)$$

$$M_t = \alpha_0 + \alpha_1 A_t + \alpha_2 GE_t + \alpha_3 PE_t + \varepsilon_t) \quad (3.2)$$

Where;

M_t – Under-five years' mortality rate

A_t - Air pollution,

GE_t - Public health expenditure

PE_t - Private health expenditure

ε_t -Error term denoting other factors

t- Time from 1990-2020

$\alpha_i, i = 0,1,2,3$ -Parameters to be estimated

Variable Measurement

Under-five years' mortality rate (Mt) is calculated by multiplying by 1000 the number of children under five years who die in a given year by the amount of live births in that same year.

Air pollution (At.): The Air Quality Index, or AQI, is used to gauge air quality. The AQI functions similarly to a thermometer with a range of 0 to 500 degrees. The AQI, on the other hand, displays variations in the amount of pollution in the air in terms of metric tons of CO_2 per capita of the quantity of carbon dioxide present in the air rather than changes in temperature.

Target Population

The targeted population was study's macroeconomic factors, including air pollution, and the under-five mortality rate for children under five, covered a 49-year period from 1970 to 2018.

Data Collection

Time series data on the variables of under-five years mortality rate and air pollution was collected from World Development Indicators from 1970-2018. The data was collected using a data collection sheet.

Descriptive Statistics

Table 1 shows the descriptive statistics analyzed to establish whether the variables of air pollution (A) and under-five years mortality rate were normally distributed.

Table 1: Variable descriptive statistics

Aspect	A	M
Mean	0.277	95.145
Maximum	0.383	150.800
Minimum	0.188	44.600
Std. Dev.	0.058	28.724
Jarque- Bera Probability	0.129	0.527
Observations	**49**	**49**

Note. *A-air pollution M-under-five years mortality rate*

Table 1 results shows that air pollution averaged 0.277 metric tons of CO_2 per capita of the amount of carbon dioxide present in the air. The maximum value of air pollution was 0.383 metric tons of CO_2 per capita which was reported in the year 1981. This led to under-five years' mortality rate to stand at 107.1 per 1000 livebirths in the same year. The minimum value of air pollution was at 0.188 metric tons of CO_2 per capita. This value was reported in the year 2003 with the under-five year's mortality rate reducing to 85.5 per 1000 live births. The standard deviation for air pollution was 0.058 metric tons of CO_2 per capita which was less than the mean implying that there were no outliers in the data set variables. The standard deviation value for the air pollution was low indicating that the value was clustered close to its mean. The Jarque-Bera p-value for air pollution was 0.129 more than 0.05 at 5 % level of significance an indication that the null hypothesis that variables were normally distributed was not rejected.

Under-five years mortality rate averaged 95.143 per 1000 live births way above the targeted 25 per 1000 live births. The maximum value for under-five years mortality rate was at 150.8 per 1000 live births recorded in the year 1970 because of very high pollution levels which stood at 0.358 metric tons of CO2 per capita. The minimum value of under-five years mortality rate was at 44.6 per 1000 live births in the year 2018 due very low pollution levels which stood at 0.273 metric tons of CO2 per capita. The standard deviation value of 28.724 for the under-five years mortality rate was low indicating that the value was clustered close to its mean and there were no outliers. The Jarque-bera p-value for under-five years mortality rate was 0.527 more than the 0.05 indicated that the variable was normally distributed at 5 % level of significance.

Unit Root Test

Phillips Peron (PP) tests and augmented Dickey Fuller (ADF) were conducted to see whether the variables of under-five mortality, air pollution and were jointly stationery as indicated in Table 2.

Table 2: Group unit roots for Series

Method	Statistic	Prob.**
ADF - Fisher Chi-square	1.500	0.993
PP - Fisher Chi-square	2.119	0.977

From Table 2 results indicated ADF statistics for the variables as a group with the probabilities of under-five years mortality rate and air pollution. The Fisher Chi-square statistic for the ADF and PP were 1.50 and 2.12 respectively that were less than the chi square critical value of 5.99 while the probability values for both ADF and PP were more than 0.05. This was an indication that the null hypothesis that the variables were jointly not stationary at significance level of 5 % was rejected i.e. the variables of under-five mortality and air pollution were stationery at significance level of 5%. This indicated that the time series variables were suitable for econometric analysis according to Gujarati (2003). Both the Augmented Dickey Fuller (ADF) and Phillips Peron (PP) tests were employed because they differ in the way they treat serial correlation in the test regressions.

Correlation Analysis

Pearson correlation was adopted to establish the association between variables in the study as outlined in Table 3

Table 3: Correlation analysis results

Correlation Probability	M	A
M	1.000 -----	
A	0.027* (0.043)	1.000 -----

**- indicate statistically significant, values in brackets () are p-values while values not in brackets are correlation coefficients.*
Note. *A-air pollution, M-under-five mortality*

The study's specific objective was to investigate the effect of air pollution on under-five years 'mortality rate in Kenya. Results summarized in Table 3 shows a correlation coefficient of 0.027 with a probability value of 0.043. The p-value was smaller than 0.05. This implies that there was a significant positive association between air pollution and under-five years' mortality rate at 5% level of significance. That is as air pollution increases under-five years mortality rate in Kenya also increases. The findings showed that, at the 5% level of significance, the null hypothesis of no correlation for the relationship between air pollution and Kenya's under-five death rate was rejected. The findings on air pollution and mortality were consistent with researches on air pollution and under-five years 'mortality rate like those done by, Anwar *et al*., (2019) who by exploring the link between air pollution and neonatal deaths used a panel of 12 highly exposed Asian nations from over 2000 to 2017. Results showed positive association between air pollution and neonatal deaths. On another front, Kotech *et al*. (2020)who by investigating if pollution is connected with neonatal or post-neonatal mortality between 2001 and 2012 in England and Wales noted that the odds ratios for infant deaths rose significantly due to air pollution.

Andréa, et al. (2009) associated traffic pollution and perinatal mortality using a case study of 14 districts Sao Paulo, Brazil. Logistical regression results showed increased threat of premature neonatal death due to greater exposure to traffic air pollution. In their study, Eva and Hanna (2012) examined the marginal influence of pollution on infant mortality using data from Mexico. Findings showed that increased carbon monoxide (CO) by a single part per billion resulted in 0.0032 deaths per 100,000 births which were greater than those in the U.S. By examining influences of neonatal mortality in South Sudan for a period of 5 years using generalized linear latent and mixed models Mugo et al. (2018) showed that air pollution significantly influenced neonatal mortality.

Cointegration Analysis

Johansen cointegration test was employed to determine whether the independent variable of air pollution had a long-term effect on under-five years mortality rate in Kenya. This was based on unrestricted Maximum Eigenvalue test as shown in Table 4. with normalized cointegration coefficients in Table 5.

Table 4: Unrestricted Cointegration Rank Test (Maximum Eigenvalue) results

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.794	66.447	27.584	0.000
At most 1 *	0.661	45.437	21.132	0.000
At most 2	0.268	13.131	14.265	0.075

Max-eigenvalue test indicates 1 cointegrating equation at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Results in Table 4. showed that the Maximum Eigen statistics for hypothesized number of cointegrating equations for none as 66.447, at most 1 as 45.437 and at most 2 as 13.265. The Maximum Eigen for none and at most 1 were greater than the critical values of 27.584 and 21.132 respectively while Maximum Eigen for at most 2 cointegrating equations was less than the critical value of 14.265. This implied that based on the Johansen cointegration analysis, there was one cointegrating equation an indication that there was a long run relationship between variables of air pollution (A) and under-five years mortality rate in Kenya (M).

Table 5: Normalized cointegration coefficients

Normalized cointegrating coefficients (standard error in parentheses), [t-statistics in parentheses]			
M	**A**	**GE**	**PE**
1.000000	-12.007	6.898	1.462
	(2.023)	(1.132)	(0.671)
	[-5.935]	[6.093]	[2.178]

M_t-12.007A_t=0 ………………………………………….(4.1)

M_t=12.007A_t ……………………………………….….(4.2)

From equation (4.2) cointegration coefficients of 12.007 for air pollution (A), were extracted with results discussed as per specific objectives in section 4.5.1.

Air Pollution and Under-five Years Mortality Rate

The number one specific objective of this study was to establish the effect air pollution on under-five years mortality rate in Kenya. The Johansen cointegration equation (4.2) showed coefficient of 12.007 and standard error of 2.024 and a t-statistic of 5.935 at 5% level of significance as in Table 4.6 between air pollution and under-five years mortality rate. Since the standard error (2.024) was less than half the value of the coefficient (12.007) and t-statistic (-5.935) was smaller than a critical value of 2 then air pollution had a significant positive long run effect on under-five mortality in Kenya such that an increase in air pollution by 1 metric ton of CO_2 per capita leads to an increase in under-five mortality in Kenya by approximately 12 children per 1000 live births. The findings on air pollution and mortality were consistent with with researches on air pollution and under-five years 'mortality rate like those done by, Anwar *et al*., (2019) who by exploring the link between air pollution and neonatal deaths used a panel of 12 highly exposed Asian nations from over 2000 to 2017. Results showed positive association between air pollution and neonatal deaths. On another front, Kotech *et al*. (2020)who by investigating if pollution is connected with neonatal or post-neonatal mortality between 2001 and 2012 in England and Wales noted that the odds ratios for infant deaths rose significantly due to air pollution.

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Vector Error Correction Model

Vector error correction (VEC) analysis was conducted to establish short-run effect of the independent variable of air pollution (A) on the dependent variable of under-five years' mortality rate in Kenya.

Table 6: Vector Error Correction Analysis Results

Error Correction:	**D(M)**
VECT	-0.083*
	[-2.681]
D(M(-1))	0.417*
	[2.241]
D(M(-2))	0.523*
	[2.128]
D(M(-3))	-0.104
	[-0.292]
D(M(-4))	0.342
	[0.971]
D(M(-5))	-0.177
	[-0.724]
D(A(-1))	-0.157
	[-0.082]
D(A(-2))	1.106
	[0.523]
D(A(-3))	1.756
	[0.705]
D(A(-4))	0.816

	[0.404]
D(A(-5))	-0.109
	[-0.060]
R-squared	0.869
F-statistic	6.313

Results in Table 6 indicated a vector error correction term (VECT) of -0.083 with a t-statistic of -2.681. A negative VECT whose absolute value of its t-statistic is greater than a critical value of 2 confirms that there existed a significant long run relationship between the independent variable of air pollution (A) and the dependent variable of under-five years' mortality rate(M) in Kenya such that any disequilibrium in the under-five years' mortality in the short-run is corrected at the rate of 8.3% in the next year in Kenya. Further, a coefficient of determination (R^2) value of 0.87 indicated that 87% of variations in under-five years mortality rate in Kenya is explained by changes in air pollution.

Past values up to the second lag of under-five years' mortality rate also influence mortality rate in Kenya. Short-run analysis coefficients of 0.417 and 0.523 at 1st and 2nd lags respectively with t-statistics greater than a critical value of 2 at 5% implied that under-five years mortality rate in the last year but one had significant positive influence on the current year under-five years mortality rate such that a unit increase in the mortality in the specified years increases under-five years mortality in the current year by approximately 1 death per 1000 live births.

Air Pollution and Under-Five Years Mortality Rate

In the short run as in Table 6 the vector error correction coefficients are -0.157, 1.106, 1.756, 0.816 and -0.109 at lags 1, 2, 3, 4 and 5 respectively with t-statistics less than 2 an indication that previous years air pollution does not significantly affect under-five years mortality rate in Kenya. These results were contrary to researches on air pollution and under-five years 'mortality rate like those done by, Anwar *et al*., (2019) who by exploring the link between air pollution and neonatal deaths used a panel of 12 highly exposed Asian nations from over 2000 to 2017. Results showed positive association between air pollution and neonatal deaths. On another front, Kotech *et al*. (2020)who by investigating if pollution is connected with neonatal or post-neonatal mortality between 2001 and 2012 in England and Wales noted that the odds ratios for infant deaths rose significantly due to air pollution.

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Granger Causality

Pairwise Granger causality was conducted to examine the direction of causality between the independent and the dependent variable. This was meant to examine whether air pollution cause under-five years' mortality rate i.e. unidirectional causality or they both cause each other i.e. bidirectional causality as in Table 7.

Table 7: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
A does not Granger Cause M	44	2.80244	0.0263*
M does not Granger Cause A		0.70918	0.6209

The specific objective was to determine the effect of air pollution on under-five years mortality rate in Kenya. Granger causality test results relating air pollution (A) and under-five years' mortality rate (M) indicated a probability value of 0.0263 which was less than 0.05 for the null hypothesis that air pollution does not Granger cause under five years' mortality rate while for the null hypothesis that under-five years' mortality rate does not

Granger cause air pollution a p-value of 0.6209 greater than 0.05. This implied that the null hypothesis that air pollution does not Granger cause under five years' mortality rate in Kenya at 5% significance level of significance an indication that there was unidirectional causality from air pollution to under five years' mortality hence air pollution influenced under-five years' mortality rate in Kenya and not under-five years' mortality rate causing air pollution.

Summary of Findings

The study's objective is determining the effect of air pollution on under-five years' mortality rate in Kenya. This was based on the null hypotheses that air pollution had no significant effect on under-five years' mortality rate in Kenya. Unit root, correlation and Granger causality analyses were employed to examine variable stationarity and effect of air pollution on under-five years' mortality rate in Kenya. The study variable was stationary an indication that it was suitable for time series analysis.

A positive significant association between air pollution and under-five years mortality rate in Kenya was established, there was a significant long run effect of air pollution on under five years' mortality rate in Kenya such that an increase in air pollution by 1 metric ton of CO_2 per capita leads to an increase in under-five years mortality rate in Kenya by approximately 12 children per 1000 live births. In the short-run it was noted that an indication that previous years air pollution does not significantly affect under-five years' mortality rate in Kenya. Granger causality test results showed a unidirectional causality from air pollution to under five years' mortality rate in Kenya.

IV. CONCLUSIONS

In conclusion, the study established that the independent variables of air pollution significantly affected under five years mortality rate in Kenya. More specifically, an increase in air pollution increases under-five years' mortality rate. The effect is significant in the long run for air pollution. However, air pollution has no short-run effect on under-five years' mortality rate in Kenya.

Recommendations

To ensure that the government of Kenya realizes the objective of reducing under-five years' mortality rate in Kenya from the average of 95 per 1000 live births to the targeted 25 per 1000 live births, the study makes the following recommendations.

Since a significant positive association between air pollution and under-five years mortality rate in Kenya was established, there was a significant long run effect of air pollution on under five years' mortality rate in Kenya such that an increase in air pollution by 1 metric ton of CO_2 per capita leads to an increase in under-five years mortality rate in Kenya by approximately 12 children per 1000 live births. The government of Kenya in order to ensure full implementation of enacted national air quality policies should target activities in the industrial sector, transport sector, energy sector, waste disposal operations and domestic cooking that cause air pollution. This will reduce the level of air pollution by cutting down on the metric tons of CO_2 per capita emitted into the air and in turn reduce under-five years' mortality rate in Kenya.

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Corresponding Author: Moreen, Engede[1]
[1]Kaimosi Friends University, School of Business and Economics, P.O. Box 385 Kaimosi.