International Journal for Novel Research in Economics , Finance and Management
www.ijnrefm.com
Volume 3, Issue 5, Sep-Oct-2025, PP: 01-17

Examining the Determinants of Maternal Mortality Rate in Kenya

Moses Onyango Otiangá, Yasin Kuso Ghabon
PhD School of Business and Economics Maseno University,
Kenya

***Abstract* – This study examines the determinants of maternal mortality rate in Kenya with a focus on health system variables and socio-economic factors. Using time-series, maternal mortality rate (MMR) per 100,000 live birth was modeled as a function of female literacy, hospital bed capacity per 1,000 persons, and the number of physicians per 1,000 persons. Diagnostic tests including the Jarque–Bera normality test, Breusch–Pagan–Godfrey, heteroskedasticity tests, Breusch–Godfrey serial correlation test and variance inflation factors (VIF) test and further R-squared test, t-statistic and F-statistic tests were deployed to check the robustness of the model. Results from the study indicate that female literacy has a strong negative and statistical significant effect on maternal mortality, this underscores the role of education in improving maternal health outcomes, conversely hospital bed capacity, shows a positive and significant association with maternal mortality, this suggests inefficiencies in resource allocation and utilization and equally, the quality of health infrastructure deployed. The number of physicians per 1,000 is negatively related to maternal mortality rate but with weaker significance. The overall model is significant (F- statistic, $p<0.01$), explaining approximately 71% of the variation in MMR. Despite this, the specification errors and evidence of heteroskedasticity points out the systemic challenges in health service delivery. Policy recommendations include expanding female education, improving the quality rather than quantity of hospital care, ensuring equitable deployment of health personnel, and strengthening community– facility linkages to reduce first-delay barriers. The findings suggest that increasing health expenditure geared towards increasing female literacy, hospital bed capacity and the number of doctors is not sufficient; efficiency, accountability, and integration of community interventions are critical to achieving sustainable reductions in maternal mortality in Kenya.**

***Keywords* – Maternal mortality rate, healthcare, education and health expenditure.**

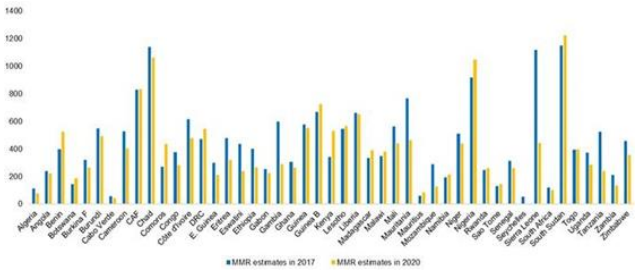
I. INTRODUCTION

This study examines Maternal Mortality Rate (MMR), this is one of the critical health care metrics in relationship to a given vector of health inputs in Kenya. MMR quantifies the number of maternal deaths per 100,000 live births resulting from pregnancy or pregnancy termination. MMR is a significant health risk associated with pregnancy for women. MMR measures the quality of maternal healthcare services with a major focus on maternal and reproductive health. Maternal death refers to the death of a woman during pregnancy or within 42 days after abortion regardless of the duration and place of pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or unintentional causes (WHO).

The figure 01 below shows the maternal mortality ratio per 100,000 live births for Kenya in comparison to other African countries.

From the figure 01 above, the maternal mortality ratio in Africa (year 2020) was estimated at 531 deaths per 100,000 live births against Kenya's recorded ratio of 184 death per 100,000 live births. The maternal mortality rate of 100 to 499 deaths per 100000 births is considered as high or moderate (WHO). This implies Kenya is not doing well in preventive of maternal mortality rate and this calls for more investment in maternal health care service.

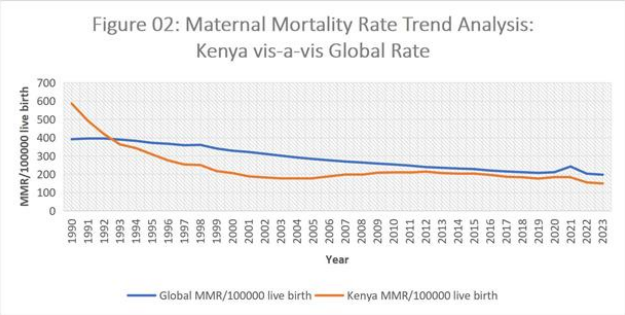
Figure 01: MMR per 100000 live births in Africa 2017 vis-à-vis 2020



Source: UN MMEIG, WHO, UNICEF, UNFPA, World Bank and UNDESA 2017-2020

It is important to underscore that maternal mortality remains a key factor affecting women reproductive in Sub-Saharan Africa. According to figure 02 above, the global MMR ratio declined to 34.2% between the years 2000 to 2020, however, MMR is remains a major concern in Africa, the continent recorded more than two-thirds (69%) of the maternal deaths (UN MMEIG, WHO, UNICEF, UNFPA, World Bank and UNDESA 2023). The higher MMR rates in Africa above the global index calls upon the major development partners and affected affected countries to focus on ways to reduce MMR to 70 maternal deaths per 100000 live births by 2030.

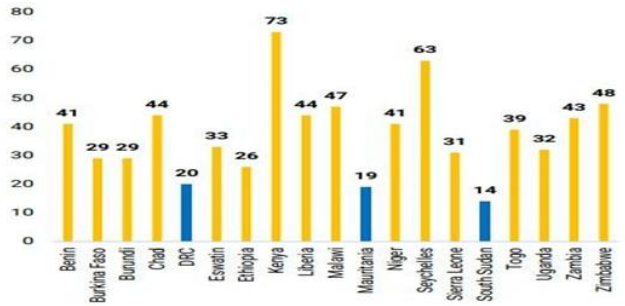
Kenya Maternal Mortality Ratio to Global Performance



Source: World Bank 2024

Medicine availability

The figure 03: Access to medicine by expectant women in Kenya relative to other African countries.



Source: WHO 2018

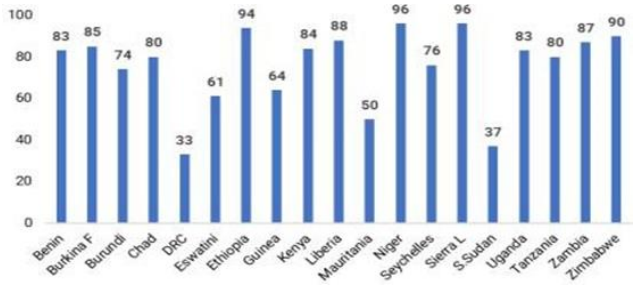
The figure 03 above shows the availability and readiness of medicine across sampled African countries by comparison. Kenya recorded the easy access to the medicine relative to peer countries by 73% (WHO 20218), more particularly the medicines to save lives of mothers such as heat stable carbetocin, oxytocin, misoprostol, tranexamic acid and magnesium sulfate. Increased access to medicine leads to improved maternal health and improved quality of live.

Availability of family planning

The family planning aims at ensuring universal access to health to a wide range of quality and affordable family planning commodities, information, and equitable health services and that ensures that the individuals achieve desired family size and improve overall health of mothers and children. The figure 04 below shows Kenya's achievement in family planning in comparison to other African countries.

Family planning empowers individuals and couples to make informed decisions about when and how many children to have. It can be noted that from the figure 04 above, underscores the strides Kenya has made in strengthening her health system through programs such as Linda Mama. Investment in maternal health through family planning, significantly makes Kenya feature among top African countries on family planning initiatives.

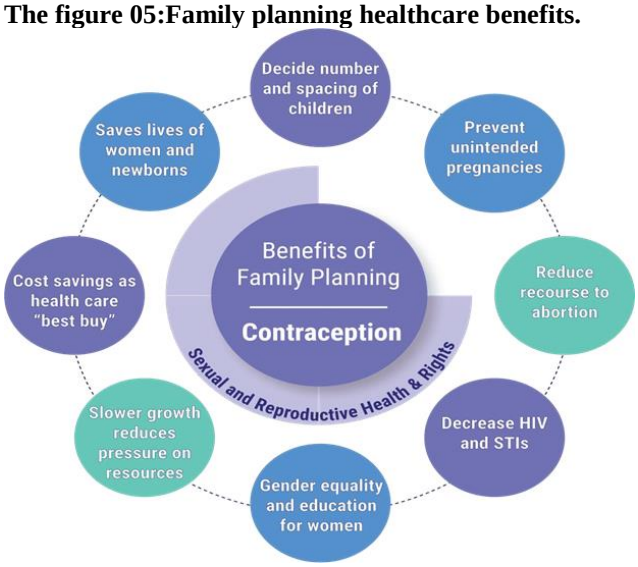
Figure 04: Family Planning



Source: WHO 2018

This study underscores the important role family planning method plays in enhancing the quality of lives for individuals, communities and countries and this in turn reduces MMR. The family planning approach helps to improves women's participation in the community, and promotes equality between women and men, improves the socioeconomic status of women and their families and further, allows allocation of more resources to each child. Family planning also increases education, and work, gender, and health and further relieves economic, social and environmental pressure and this increases resilience.

The figure 05:Family planning healthcare benefits.



Couple Year Protection (CYP)

The figure 05: above shows Kenya's national CYP from the period of 2015/2016 to 2019/2020. The CYP estimates the protection provided by use of contraceptive methods during one year, against the volume of all contraceptives sold or distributed during the period. The CYP approach is used to estimate overall coverage by family methods.

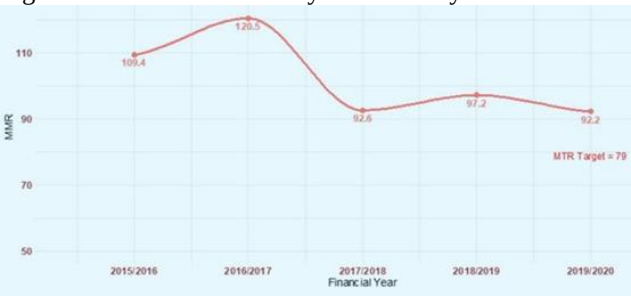
Figure 06: Family Planning Utilization

Source: MOH 2021

It can noted from the figure 06 above that CYP remained relatively steady, however, the counties within central and western as well as counties situated within the urban centers recorded high CYP coverage while counties in the ASAL regions recorded lowest CYP (MOH), the disparities could be due to socio- economies inequalities between the counties which undermines access to healthcare services.

Maternal deaths in health facilities per 100,000 deliveries in Kenya

Figure 07: Maternal Mortality Trend Analysis

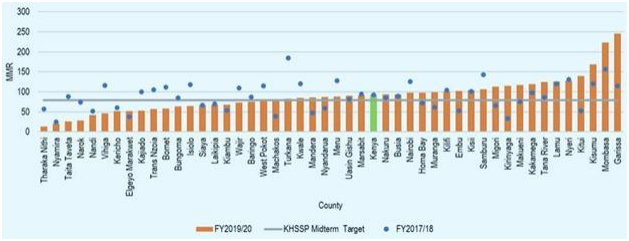


Source: Kenya MOH 2021

The figure 07 above shows the maternal mortality rate from 2015 to 2020 recorded in health facilities, with a general decline in maternal deaths per 100000 deliveries for the period of five years under review. The peak in MMR was recorded in 2016/2017 at the rate of 120.5 and the rise was attributed to the strikes by health workers during the period (MOH). It can be noted that attained mid-term rate (MTR) of 92.2 was still above Kenya's national target of 79 maternal deaths per 100,000 live births for year 2019/20.

The figure 08 above shows maternal mortality ratios at the County health facilities, it can be noted that Garissa, Mombasa and Kisumu recorded high facility maternal death rate of 246, 223 and 169 respectively for every 100,000 deliveries recorded in health facilities. The statistics recorded in the three latter counties was above the national average rate and equally above the MTR of 79 maternal deaths per 100000 set for the period 2015/2016 to 2019/2020.

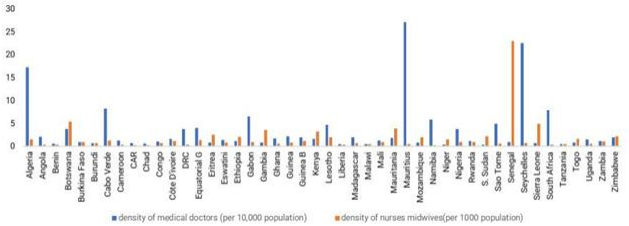
Figure 08: Maternal Mortality Rate at the County Levels



Source: Kenya MOH 2021

Access to health workforce

The figure 09: Density of doctors and nurses/midwives in selected African countries (WHO 2020).



Source: WHO 2020

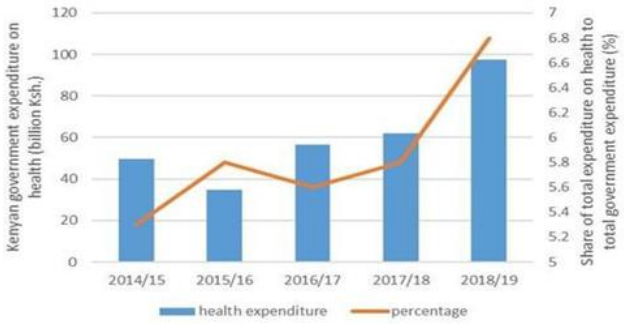
The density of doctors in selected African countries between 2012 and 2020 was estimated at 2.9 per 10000 population while nurses/midwives' density was estimated at 1.29 per 1000 population. Kenya recorded low density ratio both for the doctors and nurses/midwives of the doctor's density range between 0 to 5.9 and nurses/midwives' density of between 0 to 5 (WHO). This underscores Kenya's doctor's and nurse/midwives' low ratio which undermines access to quality health services and this increases the MMR rate.

Kenya Healthcare Expenditure

In Kenya, the healthcare services are mainly provided by different agents, these include: Ministry of Health (MOH), Faith Based Organizations (FBOs), Non-governmental Organizations (NGOs) and profit sector incentivized by profits. The MOH of health controls 52% of all health facilities while the private sector driven by profits 36% and FBOs control 10%, and while the remaining 2% of the health infrastructure is controlled by NGOs (Republic of Kenya 2016).

The public sector healthcare provision is heavily reliant on taxes, supplemented by user charges and National Health Insurance Fund (NHIF) while the NGOs and private for-profit providers are financed through user charges called out-of-pocket (OOP) expenditure (Kimani et al., 2016).
Health care financing model is examined in the context of total health expenditures by sources. The figure 10 below shows that the public expenditure on health increased from over Ksh 49.78 billion to Ksh 97.53 billion between 2014/15 and 2018/19. This expenditure relative to the overall government expenditure was approximated at 5.3% for the fiscal year 2014/15 and 6.8% for the fiscal year 2018/19.

Figure 10: Kenya public expenditure on health, 2014/15-2018/19



Source: KNBS 2019

The increase in healthcare expenditure can be attributed to government's interventions and implementation of Universal Health Coverage (UHC), this is a programme was intended to transform the country's healthcare system. The government healthcare initiatives aimed at improving the quality of healthcare services both in the public and private healthcare facilities and ensure that medical care services are affordable and efficiently delivered to all Kenyans. The increase in government healthcare expenditure was justified by increase in the per capita income from Ksh 1,082 during the financial year 2014/15 to Ksh 1,962 fiscal year 2018/19 (KNBS, 2019).

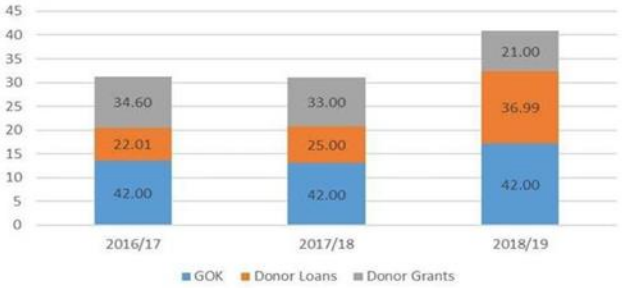
Composition of the healthcare development expenditure 2016/17-2018/19

The figure 11 below shows the sources of healthcare funding by source; this includes the internal and external sources. The government healthcare internal funding was estimated to an average of 42% (2016/17-2018/19 KNBS 2019) while funding from the external source which is a make-up of an average of 28% from the donor funding and an estimated average of 30% from grands (2016/17-2018/2019 KNBS 2019).

It can be further noted that Kenya over reliant on external funding to fund her healthcare system, donor loans and grands took nearly 58% during the fiscal year 2018/19 while the government contributed 42% during similar period.

Government needs to reduce external funding proportion; this will insulate the country's healthcare system from foreign policy shocks to the local economy for example the American to USAIDs services across the world caught many countries unaware and it awakened many developing nations of the need to internal finance the healthcare system.

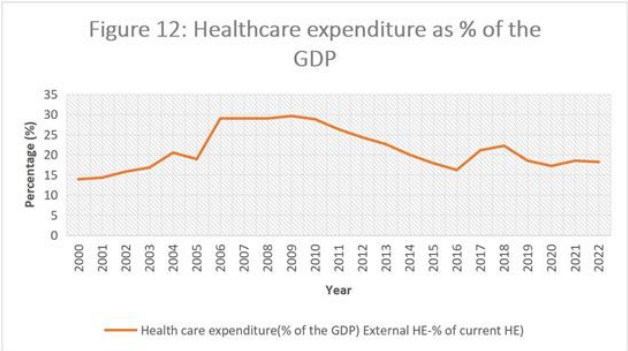
Figure 11: Composition of the healthcare development expenditure 2016/17-2018/19



Source: KNBS 2019

The external funding comes in terms of grants and loans. It is imperative to highlight that Keny's per capita expenditure on health is below the WHO recommended rate of Ksh 3400 required to provide critical healthcare packages such as diagnostic tests, preventive, hospitalization, health care infrastructure and ensure adequate supply of doctors and nurses.

Healthcare expenditure as % of the GDP



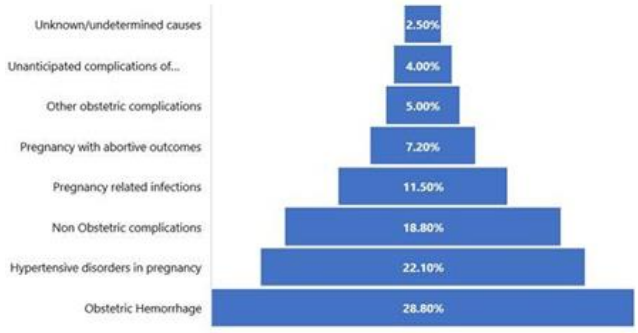
Source: World Bank 2023

The figure below shows the percentage of the Kenya's health expenditure to her GDP. The proportion of the health expenditure to the GDP rose from 20% during the year 2004, maintained a steady growth of average growth of 25% from 2005 to 2014) and started to decline gradually to 4.6% in 2023. The approximated expenditure of 4.6% of the GDP is significantly below the global average of 7.2% and short of the recommended Abuja Declaration of 15% of the national budget for health.

Maternal Mortality key drivers

The figure 13 below shows the major causes of maternal mortality deaths, obstetric hemorrhage leading with 28.80%. Obstetric hemorrhage leads to excessive bleeding related to pregnancy that can occur before, during or after childbirth and is one of the leading cause of maternal death worldwide. Hemorrhage is cause by uterine contraction, abnormal placentation and trauma.

Figure 13: Maternal Mortality by disease

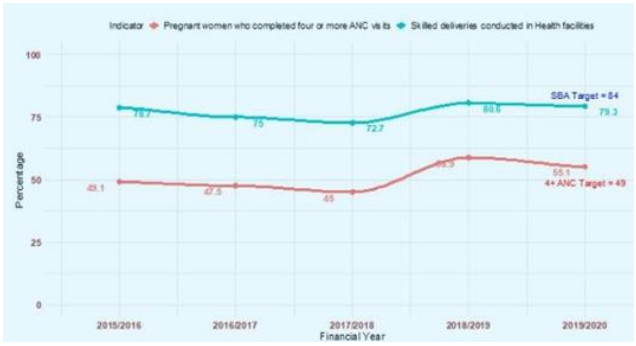


Hypertensive disorders in pregnancy contributes 22.10% of the maternal deaths, it is a condition that involves high blood pressure during pregnancy, includes chronic hypertension, preeclampsia and the disease can be managed through management of the blood pressure and seeking of medication.

Antenatal Care Attendance

The graph 14 below shows the percentage of women who received preventive and curative healthcare services from skilled health providers during pregnancy cycle. The blue line denotes the percentage of skilled birth attendance (SBA). The percentage of skilled deliveries carried out in health facilities was relatively steady and ranges between 72.7% and 80.6% over the period of 2015/16 to 2019/2020. The highest percentage (80.6%) was recorded in 2018/19 and this was close to the SBA target of 84%, but recorded marginal drop to 79.3% in 2019/20.

Figure 14: Antenatal care



Source: KHIS 2020

The red line shows the percentage of women who completed 4+ ANC visits. The year 2015/16 recorded 49.1% visits and dropped to 45% in 2017/18 but improved to 55.1% in 2018/19, this exceeded the national target of 49% and 2019/20 dropped to 55%. The cyclical drop among women completing four ANC underscores the barriers to accessing skilled deliveries such as unaffordable healthcare costs, distance and socio-cultural constraints. The increased proportion of women completing four or more ANC visits significantly shows the strengthening of the maternal health interventions and awareness.

The correlation between ANC and SBA indicates a positive relationship, when ANC completion rose sharply in 2018/19, the SBA coverage also peaked. This shows that improving ANC attendance may contribute to higher skilled birth deliveries and this aligns with the global evidence that ANC is a strong predictor of facility-based deliveries.
ANC analysis shows that more effort is needed to maintain and even improve further the realized gains in ANC coverage and further calls for strengthening of the maternal health services, reduce barriers to facility deliveries and link ANC to delivery planning can bridge the gap

Comparative County Health Input Performance

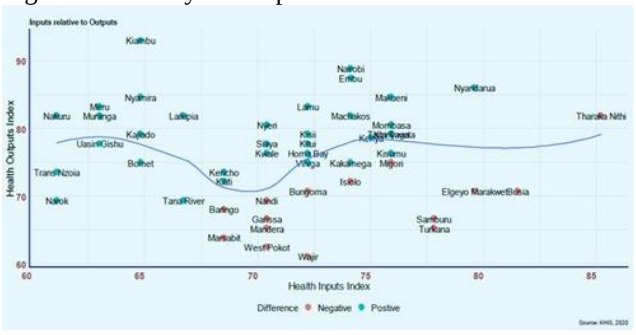
The figure 15 below shows the combination of health care inputs that yields better health outcomes in various counties in Kenya. The health inputs include: medical equipment, medical doctors/nurses, infrastructure and financing. The health outcomes include: good healthcare service delivery, child health outcomes and maternal utilization.

The blue markers show better health outcomes, demonstrates efficient allocation of inputs, implies, use of minimum input combination used to generate optimal health outcomes at relatively low cost and with minimum wastage of resources.

The following counties recorded high input-output: Tharaka Nithi, Nairobi, Nyandarua, Kiambu,Kiambu, Nyamira, Uasin Gishu and Meru. These counties invest and achieve relatively higher health outcomes with given low set of health inputs. These counties make good use of resource combination to achieve efficient outcome.

The red markers in the above figure 15 above shows inefficient combination of input vectors that leads to relatively low outcomes among the county health facilities. This indicates inefficient allocation of inputs to produce health outcomes, and leads to resource wastage and this eventually leads to increased the cost of health production.

Figure 15: County health production function



Source: KHIS 2020

According to the figure 15 above, the following counties: Turkana, Samburu, Busia, Elgeyo Marakwet, and Garissa used relatively higher combination of vector of inputs to product low output. This demonstrates inefficiency in resource use while counties such as Wajir, West Pokot,

Mandera have relatively low input allocation that leads to low output, this points out under investment and poor health outcomes and this requires health policy interventions for instance increased resource allocation.

The counties that produce low health outcome despite resource allocation calls for better management, accountable use of public resources and improved governance in the health sector. Counties such as Turkana, Wajir and West Pokot required increased health input and better health management in order to realize increased health outcomes. The counties that recorded better health outcomes should pursue health polices that ensures sustained efficient input combination in order to enjoy long term gains and sharing of better health practices. The noted socio-economic disparities in resource allocation among counties that degenerates to inequalities in access to healthcare services points out the need to align national health polices that ensures equity in resource allocation to close on the gaps.

The figure 15 above provides an efficiency diagnostic metric that shows which counties optimally utilize allocated resources and which ones under performed and this guides in evidence-based decision making by directing focus where resources should be increased, reallocated, or better managed.

II. LITERATURE REVIEW

Maternal mortality rate (MMR) remains a pressing public health concern more particularly in developing countries like Kenya. Despite global initiatives such as the Millennium Development Goals (MDGs) and the on-going Sustainable Development goals (MDGs) and Sustainable Development Goals (SDGs) interventions, maternal mortality rate in Kenya remains higher relative to global targets. Kenya Demographic and Health Survey (KDHS) underpins that maternal mortality rate is influenced by interplay of a myriad of factors that range from medical, socio-economic, demographic, and health system factors. To crystallize the determinants of the maternal mortality rate requires deep dive into both theoretical perspectives and empirical evidence that significantly lays the basis in appreciating how these facets shape health outcomes.

The literature on maternal health in this study is classified into two categories: theoretical framework and empirical literature. The theoretical frameworks provide conceptual instruments that aids in analyzing health outcomes while empirical literature examines studies that explain the causal relationship between variables such as female education for example female literacy, availability of physicians (doctors and nurses), per given population and infrastructure such as bed capacity per defined population.
This section therefore provides a review of the relevant theoretical and empirical literature that lays ground to this study. The section will begin with theoretical framework underpinning the analysis and proceeds to review empirical literature on determinants of maternal mortality rate in Kenya.

Theoretical Framework

The Health Behavioural Model

The Health Behaviour Model, this model is also called the Andersen Healthcare Utilization Model, this model was originally ideologized by Ronald Andersen (1968). This model explains why families use health services and it is premised on that fact that access and use of healthcare are shaped not only by medical need but also by individual, household and systemic factors.

This model classifies the determinants of healthcare into three domains: a) predisposing factors, b) enabling factors and c) need factors. The determinants of healthcare under this model is expounded below:

Predisposing factors: This examines the characteristic of individuals that influence their inclination to use healthcare services before even getting sick, such characteristics include the following: demographic factors and this encompasses: age, sex, marital status; while social structure determinants include: education, occupation and ethnicity and health beliefs include: attitude towards health, cultural norms and practices, perceived values of care.

Enabling factors: This examines conditions that make healthcare services available and affordable and is determined by resource constraint. The resources include: income, household wealth, access and affordability of health insurance cover, availability of health facilities, trained medical personnel, hospital beds, drugs and equipment, access infrastructure to health centers and distance. For maternal health, the access to hospitals with adequate beds, government expenditure on free maternity services, and density of physicians/nurses play a critical enabling environment.

Need factors: The underlying condition of an individual such as a woman's subjectivity to pregnancy risks, a medical professional's assessment for instance diagnosis of pre-eclampsia that requires urgent care. Pregnant women experience complications and this may call for urgency for skilled healthcare and on the contrary, those without symptoms may lead to under utilization of preventives services like antenatal care.

Andersen's Health Behaviour Model primarily explains why people use or fail to use healthcare, however, the model does not directly explain how healthcare utilization directly affects outcomes like maternal mortality. Further, the model assumes individuals act rationally, this may not be the case, since decisions may be shaped by norms, stigma or misinformation.

The Three Delays Model

This model was developed by Thaddeus and Maine (1994), helps in understanding maternal mortality by identifying three phases where delays hinder a woman's access to and receipt of timely care during a pregnancy related emergency. The Three phases include: Delay 1: is where an individual contemplates seeking medical care, Delay 2: is how an individual gets to appropriate health facility and Delay 3 is where now an individual receives care at the facility. This model emphasizes developing solutions that eliminate barriers at each of these critical stages to effectively reduce maternal related deaths.

Thaddeus and Maine postulates that delay in seeking medical care stems from a woman's health perception and limited knowledge of danger signs, misinterpretation of symptoms or cultural practices that influence when care can be sought. The model posits delay due to distance, lack of transportation, or poor infrastructure especially in rural areas to enable seemless mobility to a medical facility can lead to increased cases of maternal mortality rates. Thaddeus and Maine (1994) further posit that after a woman reaches the health facility, may still experience delay to receive treatment due to lack of trained medical staffs, essential drugs and equipment, poor facility management, or poor patient referral systems.

Thaddeus and Maine (`1994) model focuses on the three specific delays associated with an emergency, however, does not sufficiently account for the entire continuum of care, including the quality of antenatal and postnatal care, which can contribute to adverse outcomes. Poor quality of care during routine visits might create false sense of health security and hence, delay recognition of complications during pregnancy.

Human Capital Model (Becker)

Becker's Human Capital theory explains investments in education, training, and health as means of enhancing health productivity. Despite this, the model lacks the specific mechanism of health depreciation, investment, and demand for medical care that Grossman formalized. Hence, Grossman's health capital model provides a more direct theoretical link to maternal health outcomes.

Biomedical Models

This is a traditional biomedical framework that focus only on clinical risk factors for example haemorrhage, sepsis, hypertension and obstructed labour. This model however, does not explain why women delay or fail to access life-saving care, nor do they capture socio-economic determinants such as poverty, education, or cultural practices. Grossman's model integrates economic and behavioural dimensions, making it more comprehensive.

The Grossman Model

Michael Grossman's seminal paper of 1972 conceptualized health as a durable capital stock that produces healthy time which is a key input into both labor market productivity and overall utility. Unlike goods that are simply consumed, health provides ongoing returns over time. Individuals derive satisfaction from being healthy (consumption motive) and also benefit from fewer sick days, increased work capacity, and lower medical costs (investment motive) (Grossman, 1972). Concept of Health as a capital good in Grossman's model and its implications for long term behaviour and socioeconomic health disparities.

Assumptions of the Grossman's model

Health as a capital good: Health stock (H) yields ''healthy time'' and this implies health is considered as a valuable commodity. It imperative to highlight that health as a capital good, depreciates with age and also depreciates as a result of certain lifetime behaviour such as smoking and taking poor diet.

Health produces utility in two ways: The first is consumption good. This is about people well or of good health an individual is and the second is investment good, which is about having good health that reduces lost work time and this generates health benefits for example increased income; that is allocation of more time to work and reduced medical bills which will then lead to increased disposal income and hence, improved social welfare.

Individuals allocate time and resources: People allocate their available time budget between work, leisure, health production and being ill. The investment in health is attained through seeking medical care (M), doing routine exercises, eating healthy food and taking time off work to allow the body to relax and rest (time input, T). Its worthy to note that education leads to efficiency improvement in health production because more educated (E) individuals are more likely to seek better health services and even take medical insurance cover because they are more knowledgeable of good health practices and also are more likely to have reliable income streams from wages (W).

Depreciation and investment: Health capital depreciates with time at the rate δ, and that the individuals must invest (I) in order to maintain or increase their health stock. The depreciation and investment of health stock is shown by the equation below:

The health capital equation is denoted as follows:

$$H_{t+1} = H_t(1-\delta) + I_t$$

Where:

H_t is the health stock at time t

δ is the rate of deprecation and this increases with age

It is the investment in health for example time and medical inputs

Health production function

This assumes that health is produced using time and market goods. The production is given below: Ht = f (Mt, Tt, E)
Individuals maximize lifetime utility

Lifetime utility is maximized subject to the budget and time constraints. Utility derived from consumption (C), leisure (L) and health (H) is provided by the following utility function,
U = U (C, L, H)

Implications of the Model

Health is a choice variable, not just a result of medical care. In the Grossman model, health is an outcome of individual choices, not merely the result of healthcare services or medical interventions. Individuals decide how much to invest in their health based on their preferences, income, education, and time constraints.

Illustration:

People choose their levels of health by deciding how much time and resources to allocate to health- improving activities (e.g., rest, nutrition, exercise, medical treatment). This contrasts with the older biomedical view, which treats health as something determined primarily by doctors or hospitals. For example: A person might choose to exercise daily, avoid alcohol, and eat healthy foods to maintain or improve their health, even without seeing a doctor.
Health behaviours for example exercise, diet, seeking care are investments based on rational decisions. Grossman conceptualizes health-related behaviours like exercising, eating well, and seeking preventive care as investments rather than passive actions. Individuals are rational actors who weigh the costs and benefits of health investments. They decide whether the benefits of good health (like increased productivity and quality of life) are worth the costs (like time, money, or effort). This means health policy should consider how people respond to incentives. For instance, reducing the cost of gym memberships or healthy food can encourage better health investments. For example: A person might choose to stop smoking not just for current comfort, but because it reduces the risk of future illness and lost income from sick days.

a) Education improves health by increasing the efficiency of health production
Grossman's model suggests that education enhances an individual's ability to produce health more efficiently. More educated individuals have better of health information, are more likely to adopt preventive care, can make better lifestyle choices and navigate healthcare systems more effectively. Policies that improve access to education could have long-term health benefits, even if they are not health-specific. For instance, studies consistently show that higher educational attainment is associated with lower morbidity and mortality, independent of income.

b) Aging Increases Depreciation, requiring more investment to maintain health
Grossman introduces the idea that health "depreciates" with age, much like physical capital. As people age, their bodies naturally deteriorate, so more resources for example time, money, effort will be needed to maintain or improve health. This implies that older adults need to invest more for instance in more frequent check-ups and specialized care just to maintain the same level of health they had when younger. The country implore policy for the aging populations for example need policies tailored on healthcare strategies and investments, such as preventive screenings or age-specific interventions.

c) Socioeconomic Differences in Health Stem from Differences in Resources, Education, and Discount Rates
Grossman's framework can explain health inequalities using economic reasoning.

It is significant to point out that wealthier individuals can afford better nutrition, healthcare, and leisure time for exercise than the poor individuals for example education improves health production efficiency. Individuals with high discount rates for instance who value present satisfaction over future benefits are less likely to invest in long-term health. This implies that health disparities are not just due to access to hospitals but reflect deeper structural inequalities in income, education, and time preferences. Using a case example of a low-income individual might avoid preventive care due to immediate costs, even if it leads to worse outcomes in the future.
Explains why higher-income, more educated people tend to have better health.

Justifies investments in preventive care, public health, and education to improve population health.

The summary equation

Health capital accumulation is given as follows

$$\frac{dH}{dt} = I(t) - \delta H(t)$$

Where:

H(t) = health capital at time t
I (t) = investment in health
δ = rate of depreciation

Grossman's framework implies that individuals act rationally in maintaining or improving their health, depending on costs, benefits, and constraints
Preventive vs. Curative Choices: Individuals choose preventive investments for example exercise, immunizations if the marginal benefit reduced illness or increased longevity outweighs the cost in terms of time preference and money.

Studies show that preventive care is highly cost-effective and aligns with health capital investment. For instance, Cutler & Miller (2005) found that clean water investments in the early 20th century U.S. led to dramatic mortality reductions, reflecting health capital accumulation.

Education as a Health-Producing Input: Education increases the productivity of health investments by improving knowledge and decision-making. Lleras-Muney (2005) posits that each additional year of education led to a 1.7-year increase in life expectancy, controlling for income and occupation. Individuals with lower discount rates are more willing to trade off present consumption for future health. This explains why people with higher education/income often engage in healthier behaviour, such as routine checkups, dietary control, and avoiding harmful habits.

Grossman's model explanation of socioeconomic health disparities: Grossman's model provides a framework for understanding inequalities in health outcomes across income, education, and employment lines. Income and Resource Constraints: Low-income individuals often under invest in health because they lack both time and money, and face higher opportunity costs for investing in health (e.g., lost wages for clinic visits). Lubotsky & Paxson (2002) indicates that health status gradients by income appear as early as childhood and widen over the life course, even in systems with universal healthcare access.
Higher Health Capital Depreciation Among the Poor: Lower socioeconomic groups are more exposed to health risks for example poor housing, hazardous jobs, food insecurity, which increases health capital depreciation. For instance, research by Currie and Rossin-Slater (2015) showed that early-life exposure to pollution and poverty had long-lasting negative effects on adult health outcomes. Access to Health Information and Services: Inequities in access to health education and services constrain efficient health production among the poor.

In Kenya, a study by Muriithi (2013) found that wealthier households were significantly more likely to seek preventive care, while poorer ones delayed treatment due to costs or distance to facilities, resulting in worse long-term outcomes.

Justification of Grossman's model for the study

Other models focus narrowly on clinical risk factors (biomedical model, only describe utilization barriers (Three Delays) or lack of clear treatment of health as a capital stock (Becker, HBM). However, the Grossman's model factors precisely factor in socio-economic, behavioural drivers of maternal health care demand while framing maternal health as a long-term investment in human capital. This makes the Grossman's model more useful to this study by analyzing the determinants of maternal mortality in Kenya,

where economic barriers, unequal access, and under investment in health remain centric challenge in Kenya.

Empirical Literature Review

Both teenage mothers of below 20 and older mothers above 35 years show higher mortality risk in Kenyan hospital-based and population studies due to biological vulnerability and obstetric complications (F-Yego 2014). The body of the young teenage mother may not have fully developed for pregnancy and child birth, this leads to complications like obstructed labour and premature birth. Giving birth at the age of 35 years and above comes with a lot of risks such as hypertensive disorders for example preeclampsia and encampsia. Hypertensive disorders are the main cause of maternal mortality rate in older age.

Lower maternal and partner education correlate with higher maternal mortality and lower utilization of skilled care. Education elevates care-seeking, birth preparedness, and recognition of danger signs (F-Yego 2014). This further correlates with the Grossman's model that conceptualizes health as an investment good and provides returns overtime. Educated women are are more knowledgeable of health care needs and would therefore seek early preventative care and even take health insurance cover and this tends to lower the maternal mortality rate.
Poorer households face higher barriers cost and poor transport, leading to lower facility deliveries and higher risk of fatal outcomes in delayed care. Low per capita income is a barrier to healthcare access especially among the poor rural households in Kenya, where 80% rely on agricultural sector, this sector is highly susceptible to climate change and low input access that ends up providing low return to investment. This explains the prevalent poverty rates in rural Kenya. Low income hence, impacts negatively health care access (KNBS 2022).

Higher ANC attendance and quality for example timely visits, screening for hypertension, anemia and HIV are associated with lower maternal risk because they allow risk detection and birth planning.

However, mere contact does not guarantee impact if quality is poor (L Ikamari 2020).

Institutional deliveries with skilled attendants reduce mortality risk; increased facility delivery correlates with better outcomes, conditional on facility capacity and quality (L Ikamari 2020). Access to skilled doctors and nurses leads to reduced maternal mortality(MMR) risks.
Cultural norms, reliance on traditional birth attendance (TBAs), stigma, and failure to recognise danger signs contribute to first-delay problems in many Kenyan communities; community interventions that link TBAs to clinics have improved referrals in some counties. Lori, J.R., Ofware, P., Boyee, D., Barasa, A., A., Akwanalo 2016)

Facility readiness and quality of intrapartum care: Poor intrapartum care quality, late recognition of complications, lack of blood transfusion capacity, shortages of essential drugs, and inadequate emergency obstetric care (EmOC)

are key accelerate the causes of maternal deaths in facilities (F-Yego 2014).

User fees, insurance and financing: Changes in financing for example the user fee removal, NHIF expansion to low income stratum, Linda Mama maternal programs greatly influence health service utilization, however, their impact on MMR is mediated by whether facilities receive adequate compensatory funding and improve service quality. The improvement in financing reforms can increase facility births, but quality and supply-side constraints determine mortality gains (KDHS 2022).

Health expenditure, both at household and government levels, is a critical determinant of maternal health outcomes. Studies have consistently shown that increased public spending on health reduces maternal mortality by expanding access to essential services such as antenatal care, skilled birth attendance, and emergency obstetric care. For example, Bokhari, Gai, and Gottret (2007) posits that higher health spending significantly lowers mortality rates across developing countries. On the same breath, Anyanwu and Erhijakpor (2009) established that public health expenditure in Sub-Saharan Africa is negatively associated with maternal mortality, this is through improved service delivery and availability of drugs and equipment. In the Kenyan context, Kimani and Maina (2019) observed that maternal health indicators improved following the government's policy on free maternity services, though disparities remain across counties due to unequal allocation and inefficiencies in expenditure.

The availability of skilled health professionals is directly linked to reductions in maternal deaths. The World Health Organization (WHO, 2015) emphasizes that shortages of skilled birth attendants contribute significantly to maternal mortality in low-income countries. Anand and Bärnighausen (2004) found a strong inverse relationship between physician density and maternal mortality across 158 countries. In Sub-Saharan Africa, Speybroeck et al. (2006) highlighted that higher density of doctors and nurses improves access to skilled delivery and emergency care, thereby reducing maternal deaths. In Kenya, Wamalwa (2015) showed that counties with higher health worker-to-population ratios recorded significantly lower maternal mortality ratios, pointing to the critical role of human resources for health.

Education, particularly female literacy, is a key non-medical determinant of maternal health outcomes. Caldwell (1979) argued that maternal education influences health-seeking behavior, knowledge of pregnancy complications, and effective utilization of health services. Subramanian, Nandy, Irving, Gordon, and Davey Smith (2006) established that maternal education strongly predicts maternal survival across developing countries. In East Africa, Tura et al. (2013) found out that higher female literacy rates are associated with reduced MMR, as educated women are more likely to access antenatal care and skilled delivery, the converse is true for illiterate women. Gathoni and Muriithi (2020) in there study of female literacy effect to MMR in Kenya found out that female literacy significantly improves uptake of reproductive health services, leading to better maternal outcomes.

Infrastructure, proxied by hospital bed capacity, also plays a role in maternal survival. Adequate bed capacity reflects both facility readiness and the ability of the health system to handle obstetric emergencies. Gupta et al. (2003) established that higher hospital bed density is associated with improved maternal outcomes in developing countries, that is reduced MMR. In Sub-Saharan Africa, Kruk et al. (2016) argued that inadequate facility capacity contributes to delays in receiving care, leading to higher maternal deaths. In Kenya, Gitobu, Gichangi, and Mwanda (2018) established that regions with better hospital infrastructure, including higher bed-to-patient ratios, had significantly lower maternal mortality, particularly during obstetric complications requiring emergency interventions.

The relationship between health system inputs for example expenditure, skilled personnel, education, and infrastructure and maternal mortality outcomes. While global and regional evidence shows consistent patterns, Kenyan studies reveal persistent challenges of inequality across counties, inefficiencies in health spending, and shortages in health personnel and infrastructure. This underscores the need for further research examining how these determinants jointly influence maternal mortality in Kenya, providing a basis for evidence-based policy interventions.

Anyanwu & Erhijakpor (2009) carried out a study: utilizing cross-country panel data. Measures and processes of measurement of population health are varied and imperfect, resulting in many indicators of population health ranging from crude indicators such as birth and death rates, mortality and morbidity indicators to quality adjusted measures such as Quality Adjusted Life Years (QALYs) and Disability Adjusted Life Years (DALYs) (Mugo, 2004). However, Nixon and Ulmann (2006) in a review of several studies demonstrate that majority of studies use mortality rates for example age-specific or infant mortality and life expectancy (Barlow & Vissandjee, 1999) as measures of population health outcomes. This is consistent with the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) indicators (United Nations, 2015).

Studies analyzing the impact of public spending on health outcomes include some measure of health expenditure as one of the independent variables. Health expenditure as a share of GDP and per capita health expenditure are commonly used as independent variables. The range of socio economic variables varies across studies based on data availability, setting and relevance. However, most studies include health system variables such as medical personnel density (physicians and nurses per 100,000 population), hospital beds and cots, demographic and

economic variables (Cremiux et al., 2005; Cremiux et al., 1999), education index, proportion of health expenditure covered by government (Hitiris & Possnett, 1992), and dietary consumption. Other specific variables include decentralization coefficient (Robalino et al., 2001), political rights and proportion of white-collar workers (Or, 2000).

Studies on health expenditures and health outcomes show mixed findings, with some studies (Gupta et al., 2001; Gupta et al., 1999; Hojman, 1996; Bokhari et al., 2007; Gani, 2009; Aisa et al., 2014; Bein et al., 2017; Jaba et al., 2014; Akinci, et al., 2014) finding support for health expenditures reducing the mortality rates while others find no effect (Deolalikar, 2005). Most of these studies are cross- country studies with very few country-specific studies. The impact of government expenditure on health may vary from one country to another largely because countries have different levels of income, education, infrastructure for example: network of road, access to improved water sources and sanitation), among others (Bokhari et al., 2007).

III. METHODOLOGY MODEL SPECIFICATION

We examine the determinants of health inputs on health outcome, in this case, maternal mortality rate (MMR). The model is determined using time series data on Kenya. We use maternal mortality rate as a proxy of health outcome. The basic equation examines the direct impact of health expenditure, number of physicians per 1000 pregnant mothers, female literacy and hospital bed per 1000 patients. MMR refers to the number of maternal deaths during a given time period per 100,000 live births during the same period.

Model specification

MMR per 100,000 live births = B0 + B1 Female Literacy + B2 Hospital Bed Capacity per 1000 population
+ B3 Number of Physicians per 1000 population

Condensed model

MMR = B0 + B1FL + B2HBC + B3NP+ ε

Where:

MMR = Maternal mortality rate FL = Female literacy
HBC = Hospital bed capacity per 1000 population

NB = Number of physicians for example the number of doctors and nurses per 1000 population

ε = Error term

In the literature, maternal mortality rate is considered a better indicator of the health status of the population. Long term improvements in the health status of the population are best reflected in maternal mortality rate. Maternal mortality rate is regarded as a sensitive indicator of the availability, utilization and effectiveness of health care and is commonly used for comparing health care systems, monitoring, and designing population and health programmes. MMR generally reflects the level of mortality and the effectiveness of preventive care, and the attention paid to maternal and child health (Anyanwu & Erhijakpor, 2009).

The health outcomes are presumed to be primarily a function of public health expenditure, and other socio-economic control factors. The variables controlled for in many of the studies are as follows: national income, doctors per 1000 population and number of hospital beds and cots per 1000 population.

According to the literature, an increase in public health expenditure (an indicator of the volume of resource flowing into the health sector) is expected to have a negative effect on infant mortality rates. An increase in public health expenditure would imply broader access to health care and services, which helps to reduce maternal mortality rates. Literacy rate and especially female literacy is an important determinant of health status of infant mortality rates, and the population in general (Baldacci et al., 2004). In developing countries such as Kenya, women play an important role in family health and sanitation. In addition, female education is positively associated with improved infant health. Educated mothers are likely to be aware of nutrition and their children's health (Currie & Moretti, 2003). Thus, a mother's socio-economic status is believed to affect infant survival chances.

Table 01: Health Variable definition

Variable	Definition
Infant mortality rate	Number of maternal deaths during a given time period per 100,000 live births during the same period.
Public health expenditure	Total public expenditure on the health sector in Kenya shillings
National income	Real gross national income in Kenya shillings divided by the population
Doctors per 100,000 population	The total number of doctors per 100,000 population
Number of hospital beds and cots per 100,000	Number of hospital beds and cots per 100,000 population
Female literacy rate	Proportion of women who can read and write

Mortality rates are normally higher among rural, low-income households than in urban households. Also, urban households tend to access better health facilities than rural households. National income has been shown to be an important determinant of health outcomes. It is a proxy for socio economic status (standard of living) in a given country and an important proxy for human capital income (Roberts, 2003). A population's health status improves as national income improves, suggesting that increasing incomes would be associated with lower infant mortality rates. Higher incomes also lead to improved public health infrastructure such as water and sanitation, better nutrition, better housing and the ability to pay for health care (Cutler et al., 2006). According to basic economic theory, if everything else remains unchanged and if health care is a normal good, an increase in national income will lead to an increase in the demand for health care. Income also increases the capacity of the government and other players to supply more and better quality health care and to improve access to health care through better infrastructure. The number of physicians per 100,000 population is also important as a direct medical input, and indicates access to medical care. It is a vector of knowledge facilitating medical technology absorption and the adoption of best practices, and is expected to lower the mortality rates (Ricci & Zachariadis, 2006). The higher the density of doctors, the more likely that infant mortality rates would decline.

Kyalo and Kevin Munywoki (2013) established that public health expenditure recorded e negative and a significant relationship with both under-five mortality rate and infant mortality rate. They posit that life at birth increases, but infant and under-five mortality get worse as the public expenditure goes up. The worse health outcome as a result of increase in health public expenditure is phenomenal in Sub-Saharan Africa because of existence of extractional institutions (Acemoglu, D., & Robinson, J A. 2012).

Data Source

The data used in this study was collected from various sources which include: World Bank data base, UNICEF, Ministry of Health data base and KNBS. The time series data covering the period from 1990 to 2024 was constructed from the above sources and formed the basis of the study.

Applied Data Analysis Software

The study data for this study will be analyzed using EVIEWS statistical package software given the large number of study variables and the number of years of study and this can be tedious using convectional mathematical formulas for a multiple regression model.

Study Results

The regression results from the EVIEWS statistical software is provided in the table below. Table 02: Regression results

Dependent Variable: MMR_100K
Method: Least Squares
Date: 09/17/25 Time: 22:49
Sample: 1990 2024
Included observations: 35

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1129.942	175.2004	6.449425	0.0000
FEMALE_LITERACY	-13.58664	2.009401	-6.761539	0.0000
HOSPITAL_BED_CAPACITY_PER_1000	93.57929	28.54749	3.278022	0.0026
NUMBER_OF_PHYSICIANS_PER_1000	-656.6419	344.2916	-1.907226	0.0658

R-squared	0.708057	Mean dependent var	234.3714
Adjusted R-squared	0.679804	S.D. dependent var	97.54398
S.E. of regression	55.19608	Akaike info criterion	10.96687
Sum squared resid	94444.81	Schwarz criterion	11.14463
Log likelihood	-187.9202	Hannan-Quinn criter.	11.02823
F-statistic	25.06169	Durbin-Watson stat	0.674553
Prob(F-statistic)	0.000000		

The model specification from the above table is provided as follows:

$MMR100K = \beta 0 + \beta 1FL + \beta 2HBC + \beta 3NP + \varepsilon$

MMR100K = 1129.942-13.58664Female Literacy+93.57929 Hospital. Bed Capacity per 1000 population - 656. 6419.Number of Physician per 1000 population+ ε
MMR100K = 1129.942-13.58664FL+93.57929 HBC - 656.6419NP+ ε

Where;
MMR100K = Maternal mortality ratio per 100,000 live births, the dependent variable FL = Female Literacy rate (%)
HBC = Hospital Bed Capacity per 1000 population NP = Number of Physicians per 1000 population
ε = the error term.

Interpretation of the MMR model coefficients.

The constant (C) = 1129.942, implies that maternal mortality rate would be 100,000 when all the explanatory variables are all zero.

Female Literacy

Implies that 1% increase in the maternal mortality rate will lead to a reduction in maternal mortality rate by 13.6 deaths per 100,000 live births ceteris peribus. This results correlates with the literature review, where educated women have better health outcomes (Grossman Model) through reduced maternal mortality rates (MMR). Literate women have lower experience of lower MMR because of improved health literacy, have higher economic independence, increased autonomy in decision making and have better reproductive health practices.

Hospital Bed Capacity

An increase of 1 hospital bed per 1000 people is associated with an increase in MMR by 93.6 deaths per 100,000 live births. The results goes against the theoretical expectation and this could be as a result of resource allocation inefficiency or resource mismanagement leading to an increase in MMR with increase bed capacity. Increasing

hospital bed capacity is intended to reduce maternal mortality rate and increase maternal health care access. The results points ideal picture in Kenya where there is misallocation health expenditure to other unrelated health care services and high rate of corruption among the devolved units Kyalo, Kevin Munywoki (2013) and Linet. N Arisa (2012). Expanding beds without sufficient and skilled personnel leads to ineffective utilization of resources.

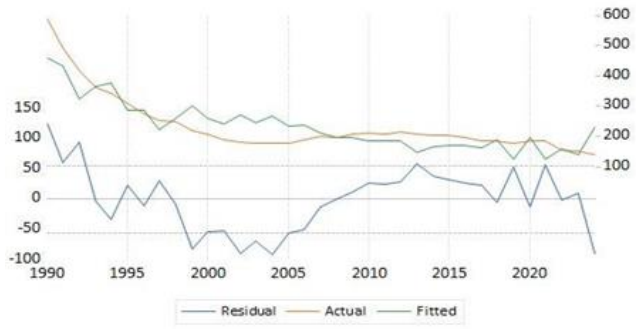
Number of physicians

An increase in the number of physicians per 1000 of the population is associated with a reduction in MMR by 657 deaths per 100, 000 live births. An increase in the number of medical doctors and nurses leads to lower MMR since the availability increases availability and access to skilled care throughout a woman's pregnancy and childbirth. More physician allocation leads to better prenatal and antenatal care, this allows for early detection and management of potential risks.

R - squared

R-squared is also called the coefficient of determination. This statistical metrics measures the proportion of the variance in the dependent variable, MMR per 100,000 live births that is explained by the independent variable: these includes Female Literacy, Hospital Bed Capacity per 1000 population, and the Number of Physicians per 1000 population. In this model, 0.7081 which is 70.81% of the variation in maternal mortality rate is explained by the three predictor variables. A 70.81% R-squared implies a strong correlation, this is a strong pointer to a model fitness. The remaining 29.19% of the variance in the dependent variable is explained by the study variables and are therefore, explained by other factors not included in the model that affect maternal mortality rate.

Figure 16: R-squared Explained graphically



The orange line which denotes the actual, the maternal mortality rate (MMR) per 100,000 births from 1990 to 2024. The green line, denotes the fitted values, shows the values of MMR predicted by the model and blue line, which denotes the residuals, shows the difference between the actual and the fitted values (Actual - Fitted). The difference explains how far off the model is from reality at each point.

The blue line fluctuates around zero, this is a desirable expectation, however, there are a times the residuals are above or below zero, this elucidates systematic influences not captured by the model such as health policy, infrastructure and maternal health programs. The residuals show short term deviations, but the long term pattern is well explained by 70.81%.

The t-statistic test

The t-statistic tests the individual significance of each coefficient in the model. This helps to check whether the given independent variable has a statistical significance effect on the dependent variable MMR after controlling the other variables.
Hypothesis test for each variable at 5%

H0 : $\beta 1=0$, the variable has no effect on MMR H1 : $\beta 1\neq 0$, the variable has effect on MMR

Given that t=-6.76 and p=0.0000,. We reject the null hypothesis , accept the alternative hypothesis and conclude that Female Literacy level significantly influences MMR.
H0 : $\beta 2=0$, the variable has no effect on MMR H1 : $\beta 2\neq 0$, the variable has effect on MMR
Given that t=3.278 and p=0.0026,. We reject the null hypothesis , accept the alternative hypothesis and conclude that Hospital Bed Capacity significantly influences MMR.
H0 : $\beta 3=0$, the variable has no effect on MMR H1 : $\beta 3\neq 0$, the variable has effect on MMR
Given that t=-1907 and p=0.0658,. We fail to reject the null hypothesis and conclude that the number of physicians marginally insignificantly influences MMR at 5% but significant at 10%.
It can be deduced from the t-statistic above that the female literacy and hospital bed are strong predictors of MMR while physicians have a weaker effect.

F-Statistic

F-statistic critically examines the overall fitness of the study model.

H0 : $\beta 1 = \beta 2 = \beta 3$, none of the variables are statistically significant in explaining the MMR H1 : $\beta 1, \beta 2, \beta 3\neq$, the three variables are statistically significant in explaining the MMR
Given that F = 25.06169 and p = 0.000000,and that $p<0.05$, we reject the null hypothesis and accept the alternative hypothesis and conclude that the model as a whole is statistically significant in explaining variations in MMR per 100,000 live birth.

Variance Inflation Factor

This is a test for multicollinearity
Table 03: VIF

Variance Inflation Factors
Date: 09/17/25 Time: 22:52
Sample: 1990 2024
Included observations: 35

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	30695.19	352.6322	NA
FEMALE_LITERACY	4.037691	279.2894	1.095613
HOSPITAL_BED_C...	814.9590	74.67951	1.038389
NUMBER_OF_PHY...	118536.7	36.48247	1.108754

Calculation alternative formula

$$VIF_j = \frac{1}{1 - R_j^2}$$

Where R2 is the R2 from the regressing predictor j on all other predictors Hypothesis for the overall VIFs
H0 : VIF ≈ 1-5 No evidence of of problematic multicollinearity in the model H1 : VIF >5There is a serious multicollinearity
Since the centered VIFs : Female Literacy ≈ 1.095, Hospital Bed Capacity ≈ 1.038, and the Number of Physicians ≈ 1.109 and all are below 5 or 10, we do not reject the null hypothesis Ho, and state that there is no evidence of problematic multicollinearity in the model.

Normality Test

This refers to the statistical procedure used to test if the data set follows a normal distribution.

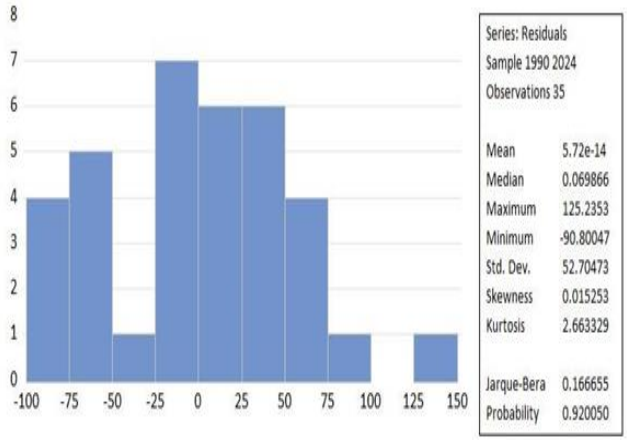
Hypothesis test

H0 : Residuals are normally distributed

H1 : Residuals are not normally distributed

Since 0.92>0.05, we fail to reject the null hypothesis and conclude that the residuals of the model are normally distributed.

The figure 17: The normality test



Breusch-Godfrey Serial Correlation LM Test

The hypothesis set-up

H0 : No serial correlation up to order 2-ρ1=ρ2=0

H1 : ρ1, ρ2 =≠ 0, serious correlation of order ≤ 2 exists

Given both ρ-values are less than 0.05, we fail to reject the null hypothesis and deduce that is a significant correlation in the residuals and this affirmed by Durbin-Watson statistic of 0.6745.

The MMR model shows presence of serial correlation and this could have been caused by: Omitted Variables
The omission of important variables such as per capita income, government health spending, the infrastructure in place, maternal health programs and fertility rates might have led to the serial correlation in MMR model specification for this study.

The table 04: Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	9.416087	Prob. F(2,29)	0.0007
Obs*R-squared	13.77997	Prob. Chi-Square(2)	0.0010

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 09/17/25 Time: 23:09
Sample: 1990 2024
Included observations: 35
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.779705	141.8097	0.019602	0.9845
FEMALE_LITERACY	0.388116	1.620261	0.239539	0.8124
HOSPITAL_BED_CAPACITY_PER_1000	-8.361457	23.68321	-0.353054	0.7266
NUMBER_OF_PHYSICIANS_PER_1000	-69.39371	277.8972	-0.249710	0.8046
RESID(-1)	0.399419	0.194605	2.052461	0.0492
RESID(-2)	0.340652	0.191839	1.775714	0.0863

R-squared	0.393714	Mean dependent var	5.72E-14
Adjusted R-squared	0.289181	S.D. dependent var	52.70473
S.E. of regression	44.43539	Akaike info criterion	10.58075
Sum squared resid	57260.61	Schwarz criterion	10.84739
Log likelihood	-179.1632	Hannan-Quinn criter.	10.67280
F-statistic	3.766435	Durbin-Watson stat	1.381564
Prob(F-statistic)	0.009475		

The possible causes to the serial correlation

Measurement error

The variables such as hospital beds per 1000 population and physicians per 1000 populations have interpolated data and this is phenomenal in developing countries, this might also cause serial correlation. This leads to errors that are systematically related over successive years → serial correlation.

Policy or external shocks

The changes in health policies for example free maternal care, donor programs like the recent withdrawal of USAID programs have multiple year impacts and need to be modelled using the dummy variables.

Heteroskedasticity Test: Breusch-Pagan-Godfrey

Table 05: Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	3.839428	Prob. F(3,31)	0.0190
Obs*R-squared	9.481567	Prob. Chi-Square(3)	0.0235
Scaled explained SS	6.186080	Prob. Chi-Square(3)	0.1029

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 09/17/25 Time: 23:13
Sample: 1990 2024
Included observations: 35

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	19856.96	10022.41	1.981256	0.0565
FEMALE_LITERACY	-263.1499	114.9486	-2.289283	0.0290
HOSPITAL_BED_CAPACITY_PER_1000	2507.937	1633.071	1.535718	0.1348
NUMBER_OF_PHYSICIANS_PER_1000	-23658.93	19695.34	-1.201245	0.2388

R-squared	0.270902	Mean dependent var	2698.423
Adjusted R-squared	0.200344	S.D. dependent var	3530.967
S.E. of regression	3157.514	Akaike info criterion	19.06017
Sum squared resid	3.09E+08	Schwarz criterion	19.23792
Log likelihood	-329.5529	Hannan-Quinn criter.	19.12153
F-statistic	3.839428	Durbin-Watson stat	1.825529
Prob(F-statistic)	0.019030		

Hypothesis Test
H0 : Homeskedasticity, the error variance is constant

H1 : Heteroskedasticity, the error variance is not constant

We reject the null hypothesis since both F-statistic ρ-value (0.0190) and the first Chi-square ρ-value (0.0235) are both < 0.05 and conclude that there is evidence of heteroskedasticity, the arror variance is not constant.

IV. CONCLUSION AND POLICY RECOMMENDATION

The government expand free and ensure equitable access to quality education, this is attained by ensuring primary and secondary education is fully funded by the government and accessible to all girls. The government come up with programs that fosters increased resource allocation to counties with the highest maternal mortality rates and low female literacy levels for example the counties in North Eastern region of Kenya.The Ministry of Education should integrate comprehensive health and family planning education into the school curriculum for both girls and boys. This intervention would increase awareness of the importance of family planning, antenatal care, and delivery with skilled health personnel. The government should further strengthen the adult literacy and programs especially for women in rural areas, where such initiatives should include modules on reproductive and maternal health and appreciate culturally sensitive methods of communication in teaching methodology.

The central and government units should increase access to healthcare facilities across the country, with focus to economically underprivileged rural and marginalized areas and enhance referrals of complicated health cases to higher level facilities. The recruitment and training of more primary healthcare workers and skilled birth attendants to serve in under-served areas would reduce significantly maternal mortality rate.

The central and devolved units of government should prioritize the expansion of hospital beds and maternal health infrastructure in rural and remote that suffer the highest maternal mortality rates.

The government investment in maternity waiting homes (MWHs) and strategic placement would lead to overcoming the geographical barriers and increase access to emergency maternal health services such as obstetric facilities and attendance by skilled attendants.

Tracking of bed utilization is critical and therefore, both levels of government should implement strategies that improve the operational efficiency of existing hospital beds, with much focus in rural areas that record low bed density, to enable them handle higher patient volume that comes with increased facility-based deliveries.Hospitals should implement hospital management information systems (HMIS) that will help track bed occupancy and streamline patient flow, this will in the long run reduce overcrowding. The implementation and strengthening of referral systems between lower-level health centers and equipped hospitals will ensure beds are reserved for the most critical and emergency health services.

Ministry of health and devolved units should provide competitive salaries, benefits, and hardship allowances to attract and retain health workers, especially in under-served rural areas. This helps mitigate "brain drain" and staff shortages. Harmonization of varied contractual arrangements for example permanent, contract, and locum will help to address inconsistencies that demotivate staff. This includes ensuring fair and consistent compensation across different counties. Creation of clear career development program for example mentorship opportunities, and promotion systems to improve job satisfaction and professional fulfillment for health workers will enhance health work productivity and improved healthcare service delivery. Enhancement of the capacity of county governments to manage their human resources for health, including resolving budget shortfalls and timely salary payments. This requires better coordination between national and county authorities.Further, establish and strengthen work councils for regular dialogue between health management and trade unions. This can help resolve disputes and prevent disruptive strikes that affect service delivery.

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