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Sub-National Disparities in Indicators of Maternal Mortality in Kenya: Insights from Demographic Health Surveys Towards Attaining SDG 3

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Abstract

Maternal mortality is a global public health concern associated with one in four deaths among females of reproductive age. In Kenya, the maternal mortality ratio (MMR) stood at 375 in 2021. The disparities in the Kenyan sub-population's economic, cultural, and social demographics call for targeted interventions and resource allocation to fast-track SDG-3.1 attainment. Robust data collection methodology, comprehensive understanding of multifaceted factors influencing maternal health, and targeted interventions are necessary to identify and formulate policies that address disparities in MMR across diverse communities. Our study leverages uniformly sampled, retrospective data from Kenya's demographic and health survey (DHS), which was collated in 2014 and 2022; complemented by data from other national surveys carried out in the same period. We employed data visualisation techniques, and Wilcoxon Rank Sum Test to display and quantify the disparities in the prevalence of MMR and its covariates at the national and subnational level. Our findings suggest a wide spectrum of disparities in direct, indirect, cultural and socio-economic factors contributing to the diverse landscape of MMR within Kenya. We propose targeted interventions and customized resource allocation at the sub-national level to accelerate the attainment of SDG-3 targets in Kenya.

Keywords: Demographic and health survey, Maternal mortality, Maternal mortality ratio, Kenya, Indicators of maternal mortality, Sub-national.

Abbreviations: DHS: Demographic and Health Survey; SDG: Sustainable Development Goal; MMR:Maternal Mortality Ratio; ANC: Antenatal Care Clinic; PNC: Postnatal Care Clinic; FGM: Female Genital Mutilation

Introduction

Maternal mortality refers to deaths of mothers as a result of complications during pregnancy, delivery, and up to 42 days after childbirth or abortion; and is a major global health concern, which is associated with the death of one in every four women of reproductive age [1, 2]. The maternal mortality ratio (MMR) at a given time provides estimates of the number of deaths among women per 100,000 live births and is a proxy indicator of the quality of healthcare and well-being [2]. The global MMR for the year 2020 was reported at 223 deaths per 100,000 live births [2, 3]. Modelled estimates suggest a decline to 158.8 deaths per 100,000 live births in 2021 [4] with a projected further reduction to 140 deaths per 100,000 live births by 2030 [1, 5, 6]. However, this trajectory indicates a potential failure to achieve the global Sustainable Development Goal (SDG) 3.1 target of 70 deaths per 100,000 live

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Mwaura HM, et al., J Women's Health Dev 2024
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births by 2030 [4], [7]. Developing countries contribute 95% of these maternal deaths, with Sub-Saharan Africa contributing 80% of these deaths [2, 8, 61], and robust interventions in these settings are require to enable the attainment of this SDG target. In Kenya, the average MMR in 2021 was more than double the global estimate at 378 deaths per 100,000 live births [9], which is an increase from the 2019 national census estimate of 355 deaths per 100,000 live births [10], and the 2014 DHS estimate of 362 deaths per 100,000 live births [11]. There are likely to be sub-national variations in MMR, calling for tailored mitigation interventions for different geographically dispersed communities [2, 9, 12]. The current national policies, in Kenya, use a blanket approach to reduce MMR, and these include; waiving fees for maternal and child health services in public hospitals, increased use of mobile clinics, recruitment of more primary healthcare workers, establishment of new healthcare facilities to increase access to vulnerable women [12, 13]. However, MMR still remains high implying there are unmet gaps. A data-driven approach that takes into account disparities due to socio-economic status, cultural practices, disease prevalence, climatic and environmental differences, and other factors may explain sub-national MMR variations, and in turn, allow optimization of interventions that improve healthcare outcomes. We suggest implementing targeted interventions and better-informed resource allocation at the sub-national level in Kenya would lead to substantial enhancements in maternal health, thereby reducing MMR. This approach has the potential to expedite the achievement of the SDG-3.1 target, in contrast to the broad-brush approach deployed in national strategies [14].

We used four broad classes of WHO-defined indicators (direct, indirect, cultural, and socio-demographic) of maternal mortality to highlight targeted interventions required for different sub-national regions, in Kenya [7]. Direct indicators have an immediate link to clinical complications resulting in death and include eclampsia/preeclampsia (high blood pressure), infectious diseases, induced abortion [7, 15, 16]; and are associated with severe complication conditions such as haemorrhage, obstructed labour, and ruptured uterus. Examples of infectious diseases that are endemic to developing countries and significantly increase MMR are: malaria, which causes up to 10,000 maternal deaths annually, and has more severe outcomes during pregnancy [17]. HIV accounts for up to 20% of global maternal deaths, and TB is a common opportunistic infection of immunocompromised patients [18-20]. Indirect indicators increase the likelihood of death as a result of direct indicators and include prevalence of antenatal and postnatal clinics attendance, prevalence of skilled birth attendants, prevalence of access to emergency caesarean section services, and prevalence of health facility delivery [21]. Socio-demographic indicators are a proxy of barriers to accessing high-quality healthcare services and include wealth quintiles, literacy and educational attainment by mothers and their caregivers, and residence of the mothers (rural or urban) [22]. These indicators influence the ability to seek medical assistance during pregnancy complications; facilitate delivery at a health facility; and seek skilled assistance during delivery [15, 23]. The education status of male partners in communities where the mothers do not have complete autonomy on health expenditure also limits healthcare access [24]. Cultural indicators help to target interventions towards ethnic groups with detrimental cultural practices that impede maternal health [24]. These practices include the utilization of unskilled traditional birth attendants for delivery as dictated by birth rituals [25, 26]; female genital mutilation (FGM) that leaves the mothers vulnerable to obstructed labor, and hemorrhage, and raises the risk of maternal mortality [27]. Gender-based violence especially during pregnancy; early child marriages, which place a large number of underage mothers at risk of sexually transmitted diseases; illicit abortions that may lead to infertility; and compromised autonomy of these mothers on their healthcare decisions, which dictates that they seek the consent of their male partners who may be oblivious to women-specific healthcare needs [28]. Here, we highlight how these four categories of indicators can be used to prioritize interventions aimed at reducing MMR at the sub-national level, in Kenya. Our study leverages uniformly sampled, retrospective data from Kenya's demographic and health survey (DHS), which was collated in 2014 and 2022, and national surveys carried out in the same period [11, 29–31]. DHS surveys are conducted on a quinquennial basis. However, the release of the most recent national DHS report delayed by two years and was released on June 2023. Notably, this release lacked critical data on the MMR, highlighting a significant gap in the data essential for informing and guiding targeted maternal health interventions. In this study, we supplemented the national and subnational MMR values with the 2019 national housing and census survey estimates since they fall within the time-frame for the 2022 DHS survey. These datasets are necessary to guide healthcare interventions in developing nations with a high MMR that currently rely on infrequent survey findings. We suggest entry points for generating robust predictive machine learning models that can circumvent this paucity of publicly accessible DHS datasets. We highlight and quantify disparities in the indicators of MMR across different geographic populations in Kenya during the survey period that can inform more targeted interventions to significantly reduce MMR, and fast-track SDG-3.1 attainment.

Materials and Methods

Study design

A descriptive research design was used to identify maternal mortality indicators in Kenya. The findings of this study provide entry points for the development of predictive tools to monitor maternal mortality rates at the sub-national level in poorly resourced developing countries with high

Mwaura HM, et al., J Women's Health Dev 2024
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maternal mortality.

Study population, data sources and data retrieval

Data used was collected from Kenyan women of reproductive age who are between the age of 15–49 years. Kenya is a low-middle income country (LMIC) African country divided into 47 administrative regions (counties) but was prior to 2010 administered as eight provinces/regions (Figure 1A). Data for the indicators of maternal health was extracted from the standard DHS survey report as it contains standardised data expressed as percentages. However, the DHS surveys exhibited paucity in MMR reporting, for example, the 2022 DHS survey failed to report on MMR estimates thereby prompting us to use the National Housing and Census Survey estimates for the subnational MMR estimates as well as the current national estimate. Prevalence of infectious diseases: TB, and point prevalence of malaria were obtained from other national indicator surveys [30,32]. Datasets were collated at national, provincial (n=8), and county levels (n=47). Four categories of indicators were prioritised for analysis (Table 1) [22].

Subnational MMR from the 2019 census was also used to complement the data from the DHS 2022 [10], The national estimate of MMR was extracted from the 2014 standard DHS publication [11]. The subnational MMR for county and provincial levels for 2013/14 was extracted from the Kenyan policy brief-38 of differential maternal mortality in Kenya [33].

Table 1: The classification of the indicators of maternal mortality.

Classification	Indicator
1. Direct indicators (Woman's health conditions)	• Infectious diseases (HIV, Malaria and TB)
	• Blood pressure
	• Induced abortions
2. Indirect indicators (Hospital-related services)	• Total fertility
	• Delivery by skilled professional
	• Health facility delivery
	• Attendance to antenatal clinic (ANC)
	• Attendance to postnatal clinic (PNC)
	• Birth intervals
3. Social demographic indicators	• Education
	• Religion
	• Place of residence
4. Traditional/cultural indicator	• FGM
	• Autonomy of women
	• Gender-based violence
	• Teenage mothers

Data analysis and visualization

Data of the maternal health indicators from the DHS 2022 together with MMR estimates from the 2019 national census were analysed by geospatial visualisation using GeoDa application version 1.18 [34]. The Kenyan counties' shape file was retrieved from the Kenyan DHS data. The retrieved datasets were used to calculate Pearson's correlation values, which were then visualised as a correlation matrix using the 'corrplot' package in R-programming [35]. The association between regional and county-level MMR and its covariates from the DHS and other national surveys was visualized as bar graphs and line graphs using the 'ggplot2' of the Tidy-verse packages in R-programming [35]. We categorised the data at county and regional level differently to enable consistent comparisons across different datasets from the 2014 and 2022 DHS findings. A forest plot was also used to compare key indicators at national and sub-national levels. The cumulative contribution by multiple indicators for each county was determined using the Wilcoxon Rank Sum Test. This was achieved by arranging the indicators in a descending order, and assigning rank position with highest ranked 47 and lowest 1. Indicators with positive correlation to MMR, for example: total fertility, teenage mothers, and distance to the health facility, were ranked in a descending order. A cumulative rank-sum value was achieved by getting the sum of rank-sum values for all indicators. The percentile rank-sum position for each county was then determined by expressing the cumulative ranksum value of each county as a percentage of the highest possible cumulative rank-sum value. We then compared the performance of the regions to the national average by calculating the rate-ratios.

Ethical approval and consent to use datasets

This study was conducted using data from the Kenya National Bureau of Statistics. This data was anonymised and does not have any identifying information; and researchers did not have access to codes that can be used to identify individuals from whom it was collected. The ethical approval for the study was obtained from the University of Nairobi Ethics and Research Committee. The office of the Director General of the Kenya National Bureau of Statistics granted permission to access, collate, analyse, and disseminate data.

Results

National and subnational variations in MMR key indicators in Kenya

There has been a slow reduction in national MMR in Kenya over the last decade from 495 deaths per 100,000 live births in 2009 to 355 deaths per 100,000 live births in 2019. The 2022 DHS report did not include data on MMR but reported the subnational estimates of the other maternal health indicators at the county level. however, the 2014 DHS survey reported a national MMR of 362 deaths per 100,000

Mwaura HM, et al., J Women's Health Dev 2024
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live births; but specific indicators were predominantly presented at the regional (provincial) level, with county-level data often omitted. Moreover, critical data on indicators of maternal mortality ratio (MMR), including induced abortion and high blood pressure prevalence, were notably absent. Notably, in 2020, Kenya exhibited an increased country-level average MMR of 530 deaths per 100,000 live births, representing an increase from the previous reports. The subnational MMR estimates displayed irregular trends. For example, the 2009 national census estimates revealed a wide range of MMR levels, from extremely high (2,780 deaths per 100,000 live births) in Mandera County to very low (47 deaths per 100,000 live births) in Kirinyaga County, highlighting substantial regional variations. The 2019 national census estimates indicated improvements compared to 2009, with MMR ranging from 614 (very high) in Garissa County to 67 (very low) in Nyeri County. These disparities underscore the diverse landscape of maternal mortality outcomes within Kenya as some communities are on track towards the SDG 3.1 goal while others continue to face higher risks. We explored the 2014 and 2022 DHS datasets to quantify and compare the prevalence and indicator risk factors of MMR. There was a notable increase in the number of health facility deliveries in the North Eastern region (Marsabit, Garissa, Wajir, Isiolo, Samburu counties and Turkana counties) in 2022. Varied deployment of interventions at sub-national level led to an increase or decrease of MMR risk factors, for example an increase in the number of teenage mothers in Marsabit county compared to a decrease in Wajir county within the same period.

Individual and the Wilcoxon Rank Sum values of the all indicators at county level were plotted on the map of Kenya using the 2022 DHS dataset (Figure 1A-P). In eleven counties, the percentile ranks for maternal health indicators were below 20%. Notably, West-Pokot (8.2%), Wajir (9.7%), Turkana (12.5%), and Samburu (13.0%) trailing on the list. This outcome aligns with the elevated MMR in the same counties. Seventeen counties had percentile rank values higher than 60% with Kiambu (89.4%), Kirinyaga (88.4%), Embu (88.1%), and Nyeri (88.1%) leading on the list; as is also associated with their better maternal healthcare outcomes. Pearson's correlation matrix (Figure 1 R) revealed a negative correlation between decreased MMR and longer birth intervals, use of modern contraception, ANC clinic attendance, delivery at an institution, skilled birth attendants at clinics, higher literacy among women, increase in caesarean section acceptability, and increased women's autonomy in health decisions. Conversely, a positive correlation was observed with increased total fertility, higher numbers

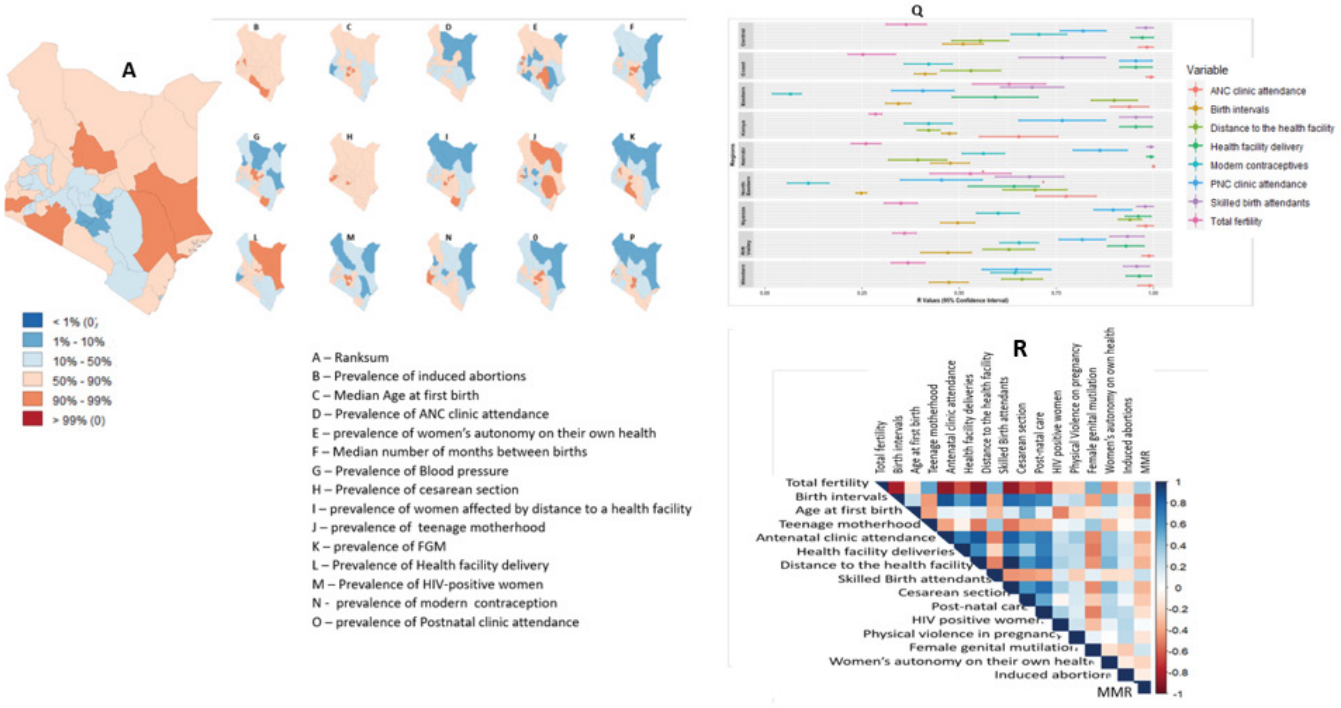

Figure 1: Prevalence of direct and indirect indicators in the counties as compared to the national average

(A) Ranksum values representing the national average. (B) Prevalence of induced abortions (Percentage per county). (C) Median Age at first birth (Number of years). (D) ANC clinic attendance (Percentage per county), (E) Women's autonomy on their own health (Percentage per county), (F) Median number of months between births (Months), (G) Prevalence of Blood pressure (Percentage per county), (H) prevalence of caesarean section uptake (Percentage per county), (I) Prevalence women affected by distance to a health facility (Percentage per county), (J) Prevalence of teenage motherhood (Percentage per county), (K) Prevalence of FGM (Percentage per county), (L) Prevalence of Health facility delivery (Percentage per county), (M) Prevalence of HIV-positive women (Percentage per county), (N) Modern contraception uptake (Percentage per county), (O) Postnatal clinic attendance (Percentage per county). (Q) Forrest plot displaying the national and sub-national variation of MMR the indicators in 2022, (R) Pearson's correlation matrix of the MMR and the indicators.

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Mwaura HM, et al., J Women's Health Dev 2024
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of women living with HIV, increased distance to health facilities, increase in number of teenage mothers, and high prevalence of female genital mutilation (FGM)

Variations in prevalence of direct and indirect indicators of MMR

We analysed the trends of TB, malaria, and HIV, which are infectious diseases that disproportionately contribute to maternal mortality across Kenya. We observed an overlap in the geographical distribution of high malaria and HIV endemicity in coastal counties (Mombasa (8.2%), and Taita Taveta (8.9%)), those adjacent to Lake Victoria (Kisumu (21.0%), Homa Bay (25.0%), and Migori (19.2%), and Turkana (7.9%). However, some counties exhibited high prevalence of malaria and low prevalence of HIV (Nyandarua, Kakamega, Vihiga, and Nyamira counties) (Supplementary Figure 1A). Moreover, an elevated prevalence of TB was evident along the coast (Mombasa), Nyanza (Siaya, Kisumu, Homa Bay, and Migori), and Nairobi regions. There was a positive correlation between the prevalence of malaria and the prevalence of HIV (Pearson's correlation coefficient r= 0.6).

The prevalence of blood pressure was highest in the Kirinyaga County (20%), Taita-taveta County (18.1%), and Laikipia County (15.0%); and lowest in Samburu County (1.7%), Garrisa County (2.3%) and West-Pokot county (2.6%) (Figure 1A and Figure 2A). Prevalence of induced abortions was highest in Busia County and (5.0%); notably, a total of 25 counties reported 0% prevalence of induced abortions. Under indirect indicators; Substantial variation in ANC attendance is evident across Kenya, with the most pronounced disparities observed between the Central province (99.9±1.2%) (Figure 1Q and figure 2b) and the North Eastern province (66.5±5.6%)

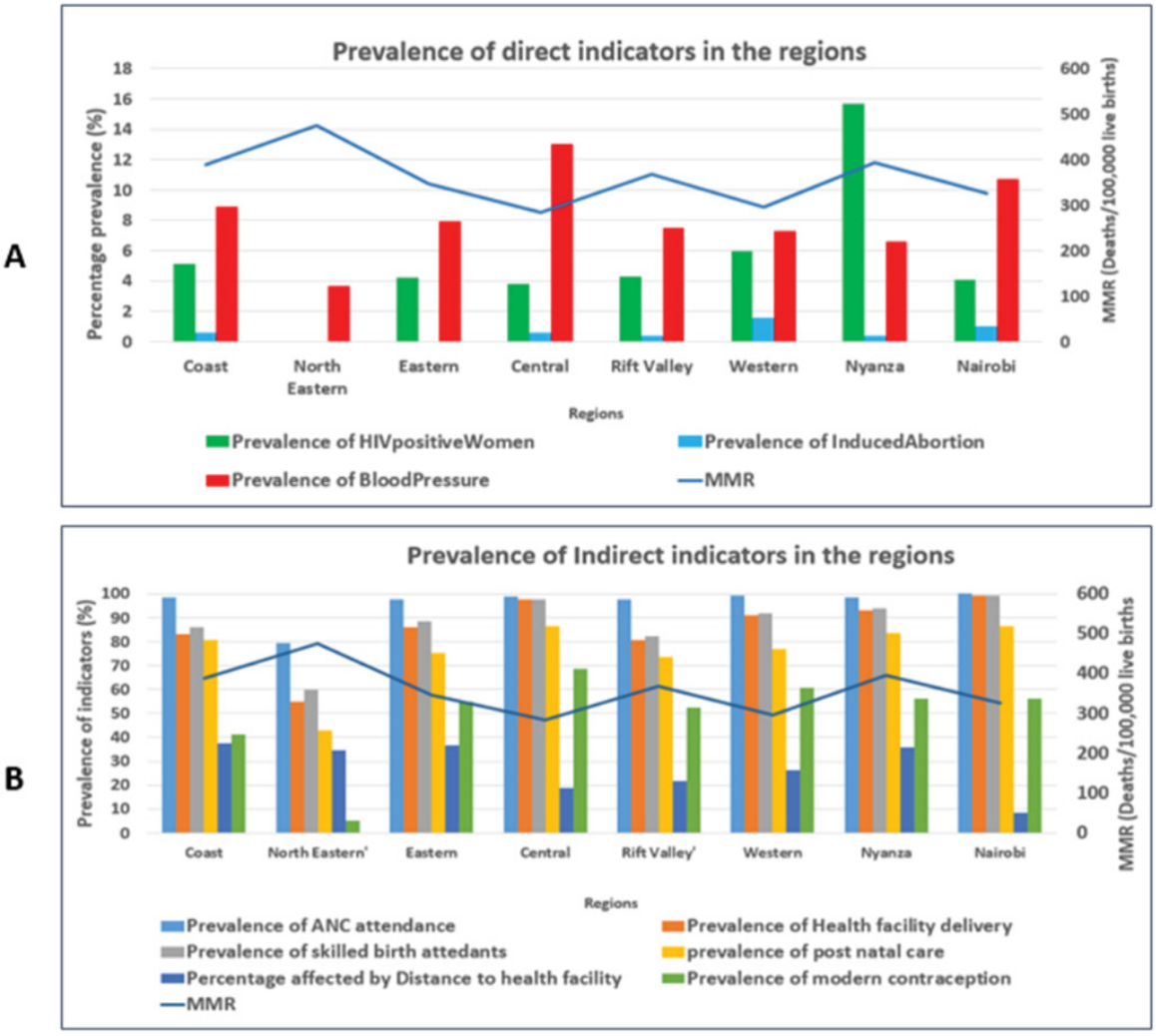

Figure 2: Distribution of the MMR and direct and indirect indicators across Kenyan regions.

(A) Distribution of MMR (deaths per 100,000 live births), prevalence of HIV-positive women, prevalence of induced abortion, prevalence of high blood pressure. (B) Distribution of MMR (deaths per 100,000 live births), ANC clinic attendance, skilled-attendant births, health institution deliveries, post-natal clinic attendance within 48 hours after delivery, modern contraception uptake, mothers who are affected by distance to the health facility.

Mwaura HM, et al., J Women's Health Dev 2024
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Comparison of indirect indicators at the sub-national level to the national average suggests that ANC attendance has the best performance related to reduction of MMR (Figure 1Q). On the contrary, uptake of modern contraceptives had the poorest performance (Central r^2 = 0.71 (0.63 - 0.77) %, and North Eastern r^2 = 0.11 (0.06 - 0.16) % respectively (Figure 1Q). Rift Valley, Western, Coast, and North Eastern regions were lower than the national average across all indirect indicators; while Central, Nairobi, and Eastern were above the national average (Figure 2B). This suggests heterogeneity in the indicators of maternal mortality between counties in Kenya.

Variations in prevalence of detrimental cultural practices

We analysed cultural indicators and observed that gender-based violence during pregnancy was highest in Nairobi, an urban setting, and lowest in North Eastern, a marginalised rural area (18.1% and 2.7% respectively) (Figure 3A). We also compared FGM rates and ethnicity, religion, educational attainment, place of residence, and wealth status. North Eastern and Nyanza regions had the highest rates of practicing FGM (97.5% and 36% respectively) (Figure 3B).

The ethnic communities exhibiting the highest rate of practicing FGM are Somali (93.6%), Samburu (86%), and Kisii (84.4%); a trend which coincides with their residence in the North Eastern and Nyanza regions respectively. We conducted a comparison of FGM prevalence with various social demographics and found higher rates in communities that practice Islamic religion (51.1%), live in rural settings (25.9%), have no education (13.0%), and are in the lowest wealth quintile (6.2%) (Figure 2B). The highest prevalence of teenage motherhood was in Nyanza (22.2%), Rift-Valley

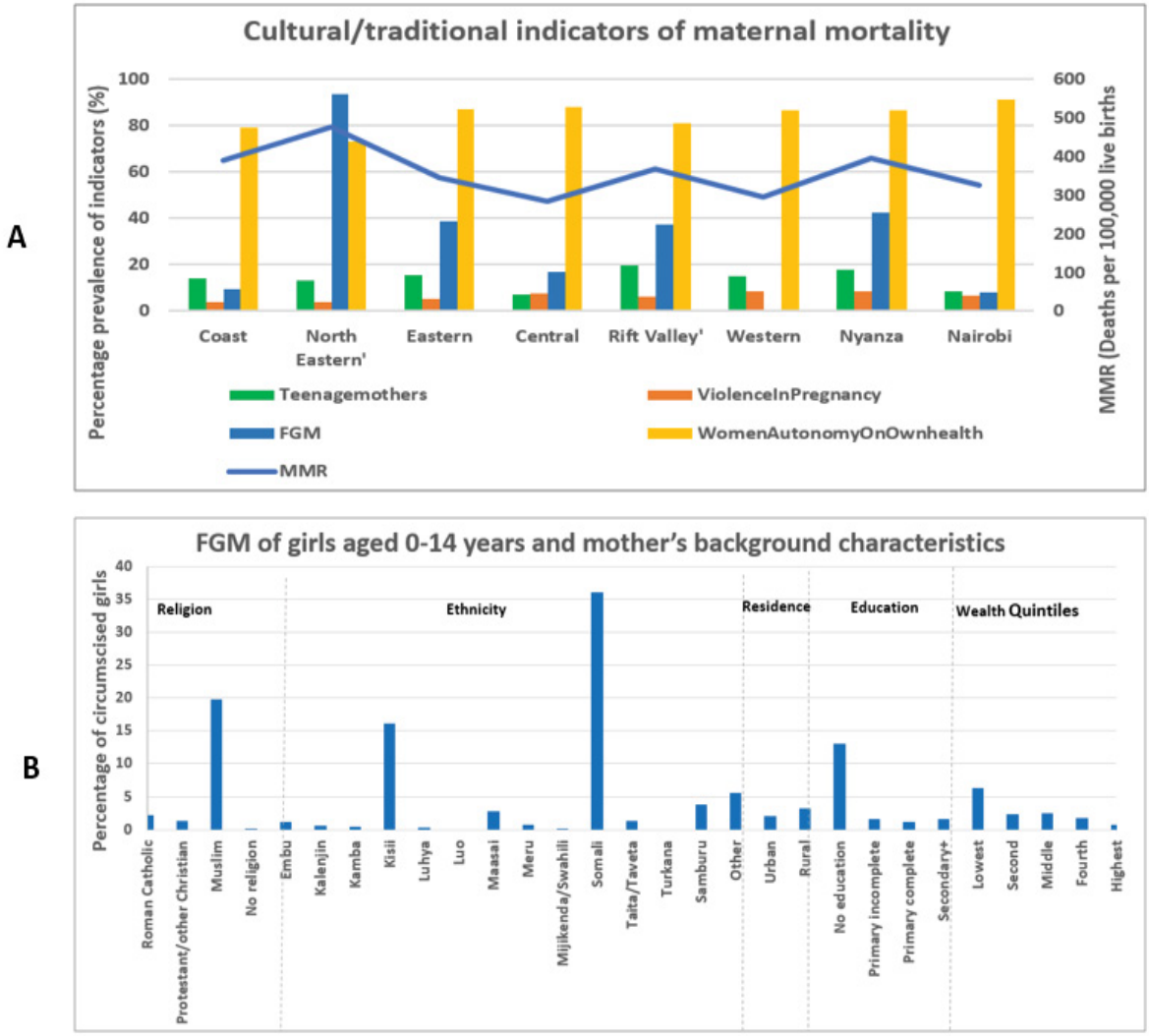

Figure 3: The cultural indicators of MMR Kenya.

(A) Prevalence of FGM, prevalence of teenage motherhood, percentage of women making independent decisions on their own health, and percentage of mothers experiencing physical violence during pregnancy, (B) Prevalence of FGM in girls against different maternal background characteristics.

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Mwaura HM, et al., J Women's Health Dev 2024
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(21.2%), and Coast (20.8%) provinces. The lowest number of married women with autonomy on their healthcare was in the North-Eastern province (63.3%) (Figure 3A).

Analysis of social-demographic indicators

We examined two socio-demographic indicators: educational attainment and wealth quintile of the mothers (Supplementary figure 2). North Eastern province had the highest number of mothers who lack formal education (74.9%), and in the lowest wealth quintile (40%) (Supplementary figure 2A). The uptake of modern contraceptives, seeking services at health facilities for ANC and PNC clinics and during childbirth were highest in women with high educational attainment and in high wealth quintiles (Supplementary figure 2A) (Supplementary Figure 1B). The same group of women also had longer birth intervals ((Supplementary figure 2C), and were least affected by the distance to health facilities as a determinant of seeking health services (Figure 3B).

Discussion

The findings from the 2014 and 2022 DHS surveys offer crucial insights on maternal health indicators that can guide MMR intervention strategies. These survey findings are not uniform and have varying levels of county-level details making it challenging to easily infer interventions that would significantly reduce MMR. The reduction in national MMR between 2014 and 2019 (362 and 355 deaths per 100,000 live births, respectively) shows an overall positive trend, despite variations at the sub-national level. There are pronounced variations at the county level, ranging from 2780 (Mandera County) to 47 (Kirinyaga County) in 2014, and 67 (Nyeri County) to 641 (Garissa County) in 2019. This illustrates the persistence of localised disparities that warrant targeted interventions. Comparisons of the findings from the DHS 2014 and 2022 surveys show notable improvements in health facility deliveries in select counties (Marsabit, Garissa, Wajir, Isiolo, Samburu, and Turkana). However, the prevalence of teenage motherhood exhibited a heterogeneous pattern, with an increase in Marsabit County contrasting a decrease in Wajir county. This disparity suggests diverse interventions deployed during the period under consideration. There is need for a reliable data management tool that would compensate for the paucity of information from these surveys to ensure continuous monitoring that guides intervention strategies to ensure SDG attainment. Pearson's correlation matrix depicts intricate relationships between MMR and several indicators. Negative correlations with birth intervals, modern contraception prevalence, ANC clinic attendance, health institution delivery, skilled birth attendants, higher educational attainment, increased number of caesarean sections, and women's autonomy in health decisions; underscoring the role of improved maternal care access and empowerment in reducing MMR. Conversely, there are positive correlations with increased total fertility, increase in women living with HIV, increased distance to health facilities, higher numbers of teenage mothers, and high prevalence of female genital mutilation (FGM); highlighting the complex interplay between socio-cultural factors and maternal health outcomes. Robust data collection methodology, comprehensive understanding of multifaceted factors influencing maternal health, and targeted interventions are necessary to identify and formulate policies that address disparities in MMR across diverse communities.

Malaria, TB, and HIV are the major infectious diseases that disproportionately contribute to maternal mortality [36,37]. We observed an overlap of a high burden of malaria, HIV and TB in areas near large water bodies (lakes and the Indian Ocean), which provide breeding grounds for malaria vectors [39]. High malaria transmission rates in these regions are also favoured by high temperatures and high precipitation [40–42]. Interventions to control malaria will reduce maternal morbidity by up to 25% [43]. Kenya has a high malaria endemicity and is one of the 15 countries in Africa contributing to 80% of total malaria deaths globally [42]. Effective interventions for the control of malaria include awareness programs on behavior change and preventive measures through mass media and targeting the lower socioeconomic population in these regions [44]. High HIV prevalence in communities is associated with an increased risk of maternal mortality [38]. Maternal mortality rates exhibited a tenfold increase in HIV-positive women as compared to their uninfected counterparts [45, 46]. Susceptibility to TB and malaria in HIV patients increases due to compromised immunity and increased rate of disease progression in HIV patients associated with waning immune responses [47]. Although it is well established that HIV prevalence is high in urban and marginalised rural settings in sub-Saharan Africa [20, 23], fishing communities have also been identified as the highest-risk groups for HIV infection [48, 49]; an observation that is echoed by the 2022 KDHS data where the highest proportion of HIV positive women is found in Homa-bay county (25%), Kisumu County (21%), Siaya county (19%) and Migori county (17%). In Kenya, a disproportionate number of pregnant women (95.5%) attended ANC clinics, which is consistent with the global trends (86%) among expectant mothers [50]. Engagement with ANC clinics is associated with heightened utilisation of additional health facility services, including health facility deliveries and postnatal care (PNC) clinic visits. This pattern is closely linked to the educational and informative sessions provided within ANC clinics, which encourage subsequent positive healthcare actions [51]. ANC clinic attendance is significantly influenced by wealth quintiles and education attainment [52], with MMR remaining highest in marginalised regions [53]. The uptake of modern contraceptives remains limited, primarily due to concerns regarding potential side effects, religious convictions, misconceptions, and constrained access to these contraceptives, particularly in resource-poor

Mwaura HM, et al., J Women's Health Dev 2024
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settings [54] Contraception plays a pivotal role in reduction in maternal deaths by mitigating the probability of unplanned and high-risk pregnancies, and especially incidental high-parity births [55]. High parity has also been associated with an increased risk of mortality due to vascular complications [56]. Therefore, focused interventions towards family planning education and appropriate resourcing is required in regions with high fertility rates, especially in the marginalised regions where uptake of health services is threatened by poverty and long distances to the health facilities [51]. The diverse cultural landscape in Kenya encompasses multiple ethnic communities, some of whom continue to exercise detrimental traditional practices, like female genital mutilation (FGM), which regarded as an essential rite of passage in to adulthood. Regrettably, this practice catalyses early and coerced marriages, premature sexual debut, and consequently contributes to a heightened prevalence of teenage motherhood. FGM is hazardous contributes to maternal mortality [27]. Sequelae of FGM include hemorrhage and obstructed labor culminate in increased fatality rates during childbirth, especially in marginalized regions with limited health facility infrastructure and skilled birth attendants during delivery. Interventions targeting FGM should be guided by the geographical distribution of ethnic groups and communities still conducting this practice [11, 57]. Cultural practices also influence the decision-making dynamics within the family structure, often undermining the autonomy of married women concerning their health. Women frequently depend on the consent and choices of male partners, who may lack comprehensive knowledge about their healthcare necessities. However, this situation can be mitigated through male partner engagement in attending ANC clinics, accompanied by education encompassing pregnancy-related danger signs and other maternal health essentials. Cultural practices also impact decision-making framework in the family set-up and compromise the autonomy of married women on their health. Women rely on permission and decisions from male partners who may not be well informed about their healthcare requirements. This practice is attenuated by the male partner's involvement in ANC clinic attendance coupled with training on danger-signs of pregnancy among other maternal health needs [58]. An increase in the number of teenage mothers in remote and marginalised regions is associated with cultural practices, early and forced marriages [54]; as well as dissoluteness [59], which may be improved by focused group training of these at-risk and vulnerable populations. Teenage mothers are exposed to the risk of complications due to obstructed labour and haemorrhage associated with their underdeveloped reproductive structures; however, they are less likely to seek health facility services compared to their older counterparts, due to social stigma and lack of economic resources [60]. Education attainment and wealth quintiles emerge as the primary demographic factors influencing maternal mortality. Marginalized regions had poor educational enrolment compounded by underserved educational systems depicted inability to complete basic primary school education due to poverty, early teenage pregnancies, and child labour [61]. Lack of education is invariably coupled with the lowest wealth quintiles and is predominant in the resource-poor regions, which are also characterised by high MMR. This also impedes the willingness and ability to uptake modern contraceptives, and access health facility services during pregnancy, delivery and postpartum. Interventions in the marginalised regions should aim to improve access to health facility services. Other Additional interventions that boost both formal and informal education of the mothers and their partners should incorporate maternal health needs, trainings on FGM and HIV transmission, rectitude, gender-based violence, and woman involvement in decision making. The government's intervention efforts to mitigate the impact of wealth on maternal health includes a uniform waiver on service fee in all public hospitals; which has led to significant increase in utilisation of maternal health services in Kenya [62].

Conclusions

Our findings suggest a wide spectrum of direct, indirect, cultural and socio-economic factors collectively contribute to elevated MMR. Some counties are performing better than the national average, while others are lagging behind, implying heterogeneity in the sub-national maternal healthcare status. This suggests that customised interventions coupled with targeted resourcing in different sub-national populations are required to address maternal mortality and accelerate the attainment of SDG-3 targets. Implementation of these tailored mix of interventions alongside appropriate resource allocation will undoubtedly reduce MMR in Kenya. While the present study focused on the analysis of indicators of MMR to highlight intervention entry points, mathematical models that use these datasets to predict future trends given certain interventions would be useful guides for intervention strategies and earmarking required resources.

Declarations

Ethical approval

The ethical approval for the study was obtained from the University of Nairobi Ethics and Research Committee at the University of Nairobi. The office of the Director General of the Kenya National Bureau of Statistics granted permission to access, collate, analyse, and disseminate data.

Consent for Publication

Not Applicable

Availability of Data and Materials

The datasets analysed during the current study are publicly

Mwaura HM, et al., J Women's Health Dev 2024
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available in the Demographic and Health Survey repository (https://dhsprogram.com/pubs/pdf/fr308/fr308.pdf) [18].

Competing Interest

The authors declared that they have no competing interest.

Funding

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Author's Contributions

BK conceived the study. HM performed the analyses. HM, TK, and BK interpreted the results. HM, TK and BK wrote the manuscript. All authors read and approved the final manuscript.

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Mwaura HM, et al., J Women's Health Dev 2024
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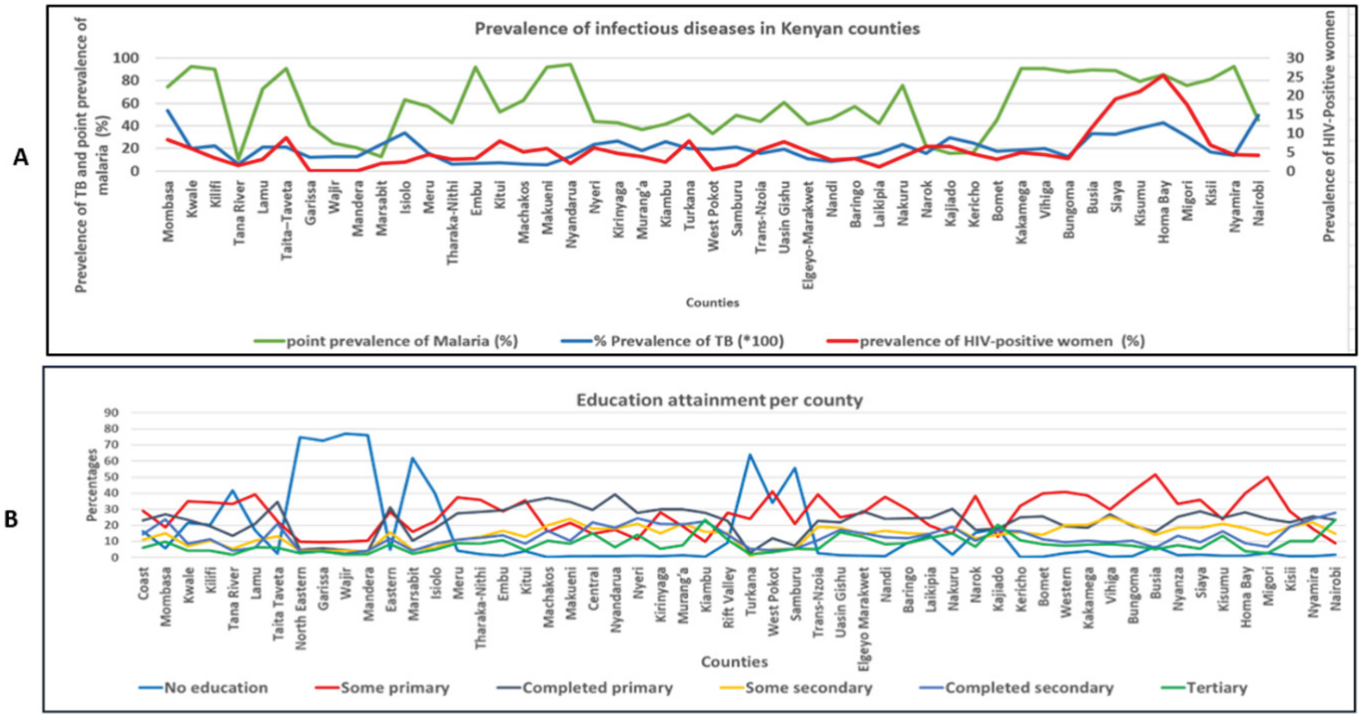
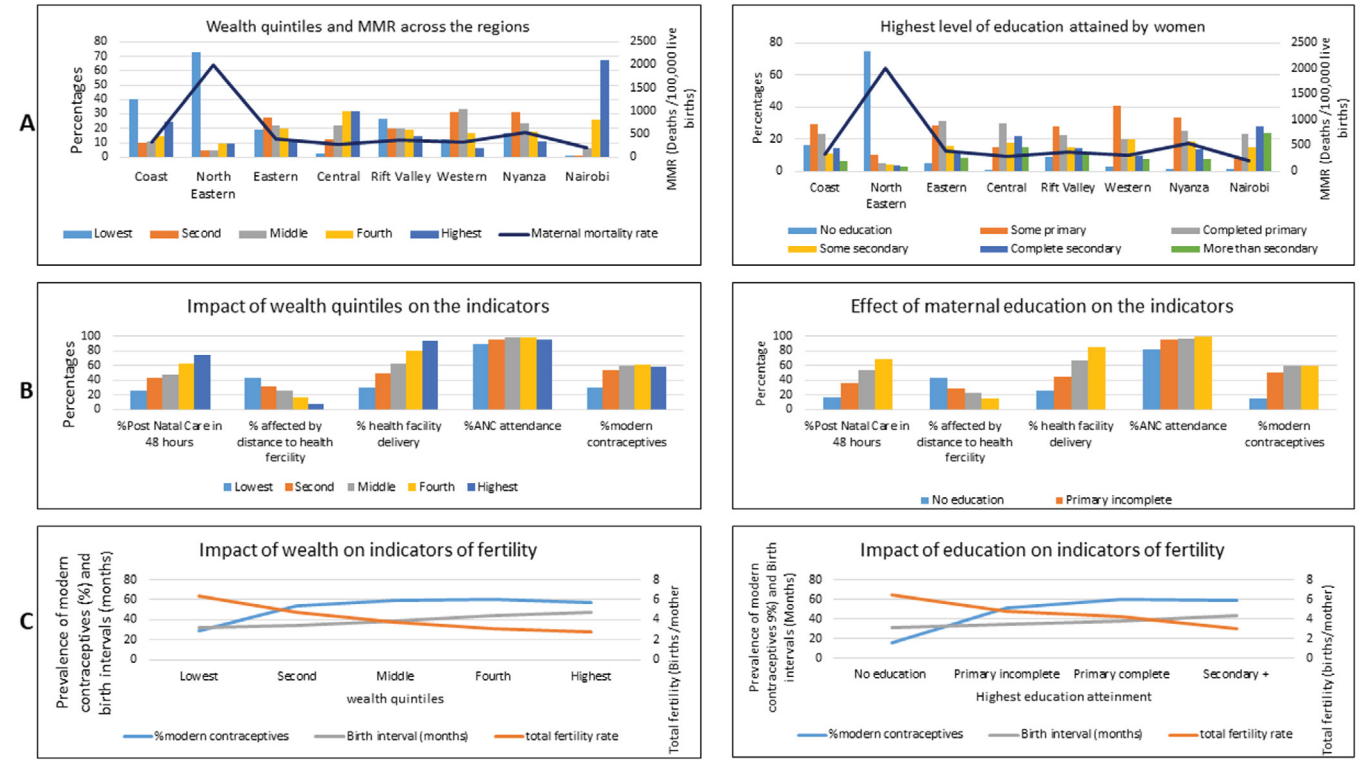


Supplementary Figure 1: Trends of HIV, malaria and TB; and education attainment in the Kenyan counties.

(A) Prevalence of HIV, TB and malaria in the counties, (B) Patterns of education attainment by women across the counties in Kenya.



Supplementary Figure 2: Impact of social demographic indicators on maternal mortality, uptake of health facility services and fertility in Kenya. *(A) patterns of education attainment and wealth quintiles against MMR in the regions, (B) Impact of Education and wealth on uptake of maternal health facility services, (C) Impact of education attainment and wealth quintiles on indicators of fertility.*

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