Inequality of Opportunity in Prevention of Malaria in Pregnancy in Kenya

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Disclaimer: The findings, opinions and recommendations are, however, those of the author and do not necessarily reflect the views of the Consortium, its individual members or the AERC Secretariat.

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Abstract

Background: Kenya is classified as a malaria epidemic zone with more than 70% of the population at high risk of the disease, while the remaining are at low risk. Pregnant women are more vulnerable to malaria infection, and maternal and infant morbidity and mortality in Kenya are associated with malaria in pregnancy. The government of Kenya promotes malaria prevention in pregnancy using insecticide-treated nets (ITNs) and intermittent prevention treatment in pregnancy (IPTp) using sulfadoxine-pyrimethamine (SP). The objective of this study is to estimate the trend of coverage and inequality of opportunity in the prevention of malaria in pregnancy in Kenya and establish the determinants of these inequalities.

Methodology: We used the Human Opportunity Index (HOI) to examine the equality of opportunity in joint use of two malaria prevention interventions: insecticide-treated nets (ITNs) and intermittent preventive treatment in pregnancy (IPTp) using sulfadoxine-pyrimethamine (SP) among pregnant women in Kenya. The Shapley decomposition method is used to capture the contribution of each circumstance to inequality of these opportunities, using pooled KDHS data for 2003, 2008/09, 2014, and 2022.

Results: We find that between 2003 and 2022 the cummulative national coverage, dissimilarity, and HOI of using ITNs and IPTp–SP were 45.4%, 3.8% and 43.7%. The trend of coverage and HOI increased from 12.2% to 65.3% and from 10.7% to 62.4% during the same period. While inequality decreased from12.8% to 1.6% and then increased to 4.4% in 2022. The coverage implies that malaria prevention services were not available for 34.7% of pregnant women in by 2022. The HOI increased by 48.6% from 2003 to 2008/09, 0.7% of the increase was due to change in the distribution of circumstances and 41.1% increase was due to increase in overall coverage and 6.9% increase was due to equalization effect. In the Lake Victoria region and the Coastal malaria stable areas in Kenya, there was an increasing trend in of utilization of both ITNs and IPTp–SP from 11.8% in 2003 to 83.3% in 2014, then a declined to 65.4% in 2022. The HOI increased from 9.2% to 83.14%, then declined to 59.2%. The dissimilsrity index declined from 22.3 % to 0.16% in 2014, then incresed to 9.5% in 2022. There was a significant decline in inequality of opportunity between 2003 and 2014, but an increase there after. These increase could be attributed to distruptiosn in access to health services during and after COVID-19 outbreak. Using Shapley decomposition, we find the top five circumstances contributing to inequality of opportunity for ITNs and IPTp – SP utilization are:

women's level of education, spouse occupation, average number of women per cluster delivering in the health facilities, among others.

Conclusion: While the country made progress in increasing coverage, access and reducing inequality in malaria prevenion among pregnant women between 2003 and 2014, there were set backs post 2014 leaving over 34% unprotected by 2022. The malaria endemic zone is the most affected. To achieve univeral coverage, the government needs to intensify the efforts to close the gap in coverage and access while eliminating dispatities especially in high risk Lake Victoria region and the Coastal regions.

1. Introduction

Kenya is classified as a malaria epidemic zone with approximately 70% of the population at high risk of malaria transmission and the rest at low transmission risk (WHO, 2018). Malaria is preventable and treatable, but still accounts for a high level of morbidity and mortality in the country. Kenya reported an estimated 3.5 million confirmed malaria cases and 13,300 associated deaths in 2017 (WHO, 2018). Malaria accounts for 30% of outpatient consultations, 19% of the inpatient admissions, and 3-5% of inpatient deaths annually in the country (KNBS and MOH, 2015). In addition, malaria contributes 3% of all mortality in the general population. Pregnant women are more vulnerable to malaria infection and experience severe health outcomes when infected (van Eijk et al., 2011). Malaria in pregnancy is a major economic and public health challenge for developing countries in high transmission zones like Kenya. It increases risks of maternal and neonatal morbidity and mortality, premature delivery, intrauterine growth retardation, low birth weight, foetal distress, and, in severe cases, stillbirth.

Malaria Epidemic in Kenya

Malaria is transmitted to a human host through the bites of a female anopheles mosquito infected with protozoan parasites. Pregnant women infected with malaria can transmit it directly to the foetus or the newborn during delivery. Malaria in pregnancy accounts for 5% of congenital malaria. There is geospatial variation of malaria transmission in Kenya, and the country is classified into four epidemiological zones—with differences in risk mainly determined by altitude, rainfall patterns, and temperatures—the endemic, seasonal/arid transmission, highland epidemic-prone, and low-risk malaria areas (KNBS and MOH, 2015). The endemic zone (Lake Victoria in western Kenya and coastal regions) is an area of stable malaria with intense transmission throughout the year. The seasonal/arid transmission area experiences short, intense malaria transmission during the rainy seasons. The highlands epidemic zones experience seasonal malaria transmission, and the entire population in these regions are vulnerable to malaria; the case fatality rates during the epidemic can be as high as ten times greater than those experienced in stable malaria zones (KNBS and MOH, 2015). The low-risk malaria zones cover the central highlands, including Nairobi.

Among the East African Countries, Kenya has a lower burden of malaria, as shown in Table 1:1 (WHO, 2018). Kenya faces a unique twin burden of malaria and HIV infection among pregnant women. The malaria-endemic areas are also the high HIV burden regions in the country. The country's HIV prevalence rate remains at 4.9% while in the malaria-endemic zones, the prevalence ranges between 13% and 21% in four high HIV burden counties (MoH, 2018). The HIV positive pregnant women are at a higher risk of malaria infection and have exacerbated maternal and child health outcomes; for example, maternal HIV increases congenital malaria and exacerbates reductions in birth weights (Worrall et al., 2007; White et al., 2013). There is an urgent need for the country to achieve universal coverage of the prevention of malaria in pregnancy.

Table 1:1: Malaria burden among East African countries in 2017

Country	Malaria incidence[1]	Estimated cases of malaria (millions)	Estimated deaths (thousands) in 2017
Kenya	70.83	3.5	13.3
Uganda	113.03	8.6	14.4
Tanzania	203.83	15.0	49.0

Source: WHO, Global Health Observatory Data Repository/World Health Statistics (http://apps.who.int/ghodata/).

Prevention, diagnosis, and treatment of malaria in pregnancy

To control malaria among pregnant women in middle and high transmission countries in sub–Saharan Africa, the World Health Organization (WHO) recommends a three-pronged basic package of interventions, including receiving intermittent preventive treatment in pregnancy (IPTp) using sulfadoxine-pyrimethamine (SP) i.e. (IPTp-SPs, sleeping under insecticide-treated nets (ITNs) or long-lasting insecticide-treated nets (LLINs), and malaria case management. The INTs/LLINs prevent malaria by repelling and killing the mosquitoes, hence reducing the mosquitoes and preventing the mosquito bites, while taking IPTp-SPs or SP reduces malaria episodes among pregnant women and their unborn children. These interventions are cost-effective and significantly reduce the adverse effects of malaria in pregnancy (van Eijk et al., 2011; Worrall et al., 2007). White et al. (2011), in their systematic review of costs

[1] Incidence of malaria is the number of new cases of malaria in a year per 1,000 population at risk

and cost-effectiveness of malaria control interventions in Africa, found that the median annual cost of protecting one person from malaria using ITNs and that of protecting a pregnant woman using IPTp-SPs was US$2.20 and US$2.06. The median cost of diagnosis, malaria care, and treatment of uncomplicated malaria and severe malaria per case was US$44.32, US$5.84, and US$30.26, respectively. The study also found the median incremental cost-effectiveness ratio per disability adjusted life year averted for use of ITNs and IPTp-SPs to be US$27 and US$24.

The Government of Kenya adopted the WHO three-pronged policy of prevention of malaria in pregnancy two decades ago and integrated directly observed therapy (DOT) of sulfadoxine-pyrimethamine (SP) into public health facilities' antenatal clinics in 2001, free of charge. Initially, all women in the country were expected to receive at least two doses of sulfadoxine-pyrimethamine during their routine antenatal care visits after the first trimester and at least one month apart, free of charge. In 2009, the government revised this policy to target expectant women residing in moderate to high malaria transmission areas of the country. In 2013, the government increased the sulfadoxine-pyrimethamine dosage to at least three doses in line with revised WHO guidelines. The government subsidizes prevention and treatment of malaria among pregnant women and distributes free treated nets to expectant women and children below one year in all malaria zones through the antenatal care, child clinics, and community health workers (CHWs) since 2006 (WHO 2018 Country data - WHO website). All expectant women who present to public hospitals with fever receive free malaria confirmation diagnosis using rapid diagnostic tests (RDT) before being put on treatment. In Kenya, access to formal, reliable malaria diagnosis is limited in some regions, and people who fall sick, including expectant mothers, often do not test for malaria but choose to buy artemisinin-based therapy (ACT) or other malaria medications over the counter in retail drug shops.

The country witnessed an increase in the use of sulfadoxine-pyrimethamine and ITNs/LLINs among pregnant women (Table 1:2) but failed to achieve the Roll Back Malaria Initiative target of ensuring that all pregnant women receive sulfadoxine-pyrimethamine and at least 80% of the population at risk of malaria in high transmission areas use ITNs/LLINs by 2010. The country is yet to achieve its target of universal coverage of IPTp-SPs and ITN use among pregnant women, and malaria cases among these women remain high, resulting in high maternal and neonatal morbidities and mortalities. Despite integrating the two services, the use of antenatal care and services to prevent malaria in pregnancy varies.

Table 1:2: Percentage of pregnant women using sulfadoxine-pyrimethamine and ITNs

Year	Percentage of pregnant women who took SP (2 or more doses)	Percentage of pregnant women who slept under INTs
KDHS 2003	3	4
MIS 2007	13	40
KDHS 2008/09	15	49
MIS 2010	25	41
KDHS 2014[a]	17	51
MIS 2015[b]	54	58

Source: KDHS 2003, 2008/09 and 2014; MIS 2007, 2010 and 2015. [a] KDHS (Kenya Demographic Health Survey) data is nationally representative. [b] MIS (Malaria Indicator Survey) data collected from 14 epidemic counties

The Kenya Malaria Indicator Survey of 2015 shows that 94% of women interviewed reported seeking antenatal care at least once during their last pregnancy, while 54% and 38% of the women interviewed reported receiving at least two doses and at least 3 doses of sulfadoxine-pyrimethamine during their last pregnancy, respectively (MoH, 2015). The KDHS 2014, which is a nation-wide survey reported that 41% of pregnant women slept under an ITN the night before the survey while 17% of expectant mothers took 2 or more doses of sulfadoxine-pyrimethamine to prevent malaria, and at least one of the doses was administered during antenatal clinic visit, while 10% of women received 3 or more doses during the antenatal care visits. Only 39% of expectant women living in endemic and high transmission malaria regions received 2 or more doses of sulfadoxine-pyrimethamine. This is significantly lower than the expected universal coverage of 100%, given free distribution and the level of antenatal care services use. The sub-optimal use of malaria prevention interventions is also observed in Uganda and Tanzania.

In Uganda, 77%, 45% and 17% of women who had live births 2 years before the survey reported taking at least one dose, at least two doses and at least three doses of sulfadoxine-pyrimethamine respectively, while 64% of pregnant women slept under an ITN the night before the survey (UBOS and ICF, 2017). While in Tanzania, 68%, 35% and 8% of women who had live births 2 years before the survey reported taking at least one dose, at least two doses and at least three doses of sulfadoxine-pyrimethamine respectively, while 54% of pregnant women slept under an ITN the night before the survey (MoH CDGEC, MoH, NBS, OCGS and ICF. 2016).

Inequality in Prevention of Malaria in Pregnancy

Kenya is characterized by regional variation in the use of sulfadoxine-pyrimethamine, with higher use in rural areas and variation within malaria-endemic and high transmission areas or counties, ranging from 23% in Siaya and Homa Bay counties to 79% in Kwale County. The malaria-endemic counties with the lowest utilization rate of sulfadoxine-pyrimethamine are also the counties with the highest HIV prevalence in Kenya, hence the highest risk and burden of malaria in pregnancy. There is also socioeconomic inequality in utilization of sulfadoxine-pyrimethamine and ITNs with pregnant women in high-income households, who have access to mass media, and have high levels of education and access to more services than others (Owiti and Usagi, 2018). There are supply-side factors, including frequent stockouts, failure of health workers to distribute SP and ITNs, and distance to health facilities, among others (Mbengue et al., 2017). However, there is an information gap on inequality of opportunity in malaria prevention in pregnancy.

Using Human Opportunity Index (HOI) and pooled Kenya Demographic and Health Survey data for 2003, 2008/09, 2014, and 2022, I estimated the rate of availability (coverage) and use of interventions to prevent malaria in pregnancy in Kenya and the trends of the same across various years. The study also assessed the correlation between women's circumstances and access to these services, i.e., tested if inequality of opportunity exists, measured the extent and trend of inequality of opportunity using the Dissimilarity Index (D-Index), and the Shapley decomposition method to capture the share of inequality attributable to each circumstance. The study looked at individual, household, and community-level circumstances and the role they play in determining inequality of opportunity in the prevention of malaria in pregnancy.

Objectives:

We used pooled KDHS 2003, 2008/09, 2014, and 2022 to estimate the trend of coverage, inequality of opportunity, and drivers of inequality of opportunity in the prevention of malaria in pregnancy in Kenya between 2003 and 2022. We also assessed the fiscal incidence of these interventions. The specific objectives were to:

1) Estimate the change in coverage and utilization rate of both Sulfadoxine-pyrimethamine and insecticide-treated nets to prevent malaria in pregnancy in Kenya between 2003 and 2022
2) Estimate the extent and trend of inequality in the use of both Sulfadoxine-pyrimethamine and insecticide-treated nets to prevent malaria in pregnancy in Kenya between 2003 and 2022
3) Estimate the percentage contribution of each circumstance to unequal opportunity in the prevention of malaria in pregnancy in Kenya

2. Economics of Malaria in Pregnancy

Introduction

This section highlights the cost of malaria among pregnant women and the link between their health and economic development. Firstly, healthy expectant mothers have a direct effect on the health and development of their children through the in-utero effects and through their role in the care industry. This results in short-term and long-term effects on the accumulation of human capital and the intergenerational transmission of human capital. Secondly, healthy expectant mothers have a higher per capita productivity level in the labour market, resulting in high per capita economic output. Thirdly, better health of these mothers increases returns to education investment through reduced morbidity and mortality, with implications for increased short-term and long-term labour market participation and earnings.

The costs of malaria in pregnancy

Malaria in pregnancy remains a major public health and economic burden among high-transmission countries in SSA, like Kenya, with microeconomic and macroeconomic impacts. The microeconomic impacts are felt at the individual and household level; they include direct costs of interventions —to prevent and treat malaria in pregnancy —and indirect costs due to its consequences. Malaria in pregnancy causes diminished neonatal and child health, intra-uterine growth retardation (IUGR), low birth weight (LBW), premature delivery, foetal distress, congenital malaria, and, in severe cases, stillbirth (White et al., 2013). Evidence shows that low birth weight associated with malaria in pregnancy doubles the risk of child deaths and susceptibility to poor child growth and development, all of which affect mental growth and cognitive skills development, limiting the child's future human capital development, adult health, and productivity (Onarheim et al., 2015).

Malaria infection increases maternal morbidity and severe anaemia, which are leading causes of maternal mortality during delivery. This leads to reduced labour market participation and productivity, leading to low per capita economic output for a country. These deaths also affect women's care role: by resulting in maternal orphans, they influence the child's/children's survival, growth, and human capital development, hence negative intergenerational mobility.

The macroeconomic impact is felt at the country and global levels in terms of public budget allocation for prevention and management of malaria in pregnancy and consequences of malaria in pregnancy, including productivity losses and low GDP. According to Bloom et al. (2004), good health has a positive, sizable, and statistically significant effect on aggregate output, and an increase in the population's life expectancy by one year increases the level of output by 4%. An improvement in expectant mothers' life expectancy will also have a positive impact on economic growth. Gallup and Sachs (2001) also found that countries with intensive malaria had a 1.3% lower per capita growth, while those with a 10% reduction in malaria were associated with a 0.3% higher growth.

Benefits of the prevention of malaria in pregnancy

The use of sulfadoxine-pyrimethamine and ITNs/LLINs among pregnant women is cost-effective and significantly reduces the impact of malaria. Interventions towards the prevention of malaria in pregnancy reduced severe maternal anaemia by 38%, reduced low birth weight by 31% and reduced neonate mortality rates by around 61% (Menendez et al., 2010). They have a long-term positive impact on the demographic and economic outcomes at the individual, neonate, household, and the economy's level. Pregnant women derive direct health benefits (protection from malaria) and produce good health (safe delivery and stay healthy without malaria-related morbidity and mortality) by using malaria prevention interventions.

There is a positive association between malaria prevention and socioeconomic outcomes, including health, education, labour force participation, and earnings. Theoretically, a healthy pregnant woman is more likely to carry a healthy neonate and deliver a healthy baby with improved survival. The healthy children are more likely to achieve the expected early child development milestones, have better cognitive skills, and have the ability to learn. When these children become adults, they have a higher chance of having accumulated human capital and being more productive in the labour market, leading to improved intergenerational mobility and socioeconomic transition.

At the household level, prevention of malaria in pregnancy acts as both a private and a public good. By protecting the pregnant mother, she gains good health—private good—leading to reduced household health expenditures, increased market and household labour productivity. Prevention of malaria in pregnancy results in general population gains—reduced generation malaria incidence in the country, public health expenditure and improved economic growth

Determinants of prevention of malaria in pregnancy

Individual women's and communities' knowledge, attitude, and beliefs about dangers of pregnancy disclosure, antenatal care benefits, and dangers of malaria prevention interventions influence use of antenatal care services and malaria control interventions (Pell et al., 2011). Structural factors such as distance to antenatal care facilities, costs of services, drug stockouts, inadequate health care worker (skill set and numbers), availability of clean drinking water, compliance with IPTp-SPs guidelines, and intra-household decision making influence the use of malaria prevention interventions among pregnant women. Pell et al. concluded that the effectiveness of use of IPTp-SPs and ITNs was influenced by their clinical efficacy and by the social and cultural factors

The effectiveness of antenatal clinics to deliver IPTp-SPs and ITNs to control malaria among pregnant women in Kenya was lower than expected; for example, not all expectant women who sought antenatal care at the right time with the right frequency of visits received the SP as IPTp (Hill et al., 2013). Only 59% of expectant mothers who visited the antenatal care clinics at the eligible trimester received the first dose of SP, while only 23% of the expectant women received the recommended 2 doses of SP and used ITNs during pregnancy. The system effectiveness was even lower for IPTp-SPs given through DOT, under which only 14% of the expectant mothers received the appropriate dosage of SP and used ITNs for malaria prevention (Hill et al., 2013).

The problem statement

Maternal mortality ratio (MMR) remains high in Kenya at an average of 362 maternal deaths per 100,000 live births, with regional variation—the worst county reporting MMR of 3,795 per 100,000. The country failed to achieve Millennium Development Goals (MDGs) 5 of improving maternal health and reducing maternal mortality rate by 75% by 2015, and is yet to achieve any MDGs on reduction in maternal and child morbidity and mortality. Large disparities in maternal health and use of maternal health services exist in the country, with the most vulnerable women being disadvantaged. Unjust and avoidable inequality in maternal health care persists. This threatens the country's ability to achieve universal health coverage (UHC) and Sustainable Development Goal (SDGs) 3 of ensuring healthy lives and promoting wellbeing for all at all ages, reducing maternal mortality rate, and ending preventable deaths of newborns and children under five. Malaria in pregnancy is one of the major contributors to maternal mortality in the country.

Inequality in maternal health remains a persistent challenge in Kenya, yet the country has adopted several public health and fiscal policies aimed at increasing access to maternal health and reducing its inequalities. Some of the major national policies include the Constitution of Kenya 2010, the Health Act of 2017 (RoK, 2010; 2017). Universal Health Coverage (UHC) is one of the Big 4 Development Agenda and the Roll Back Malaria Initiative. Unequal access to maternal health, including malaria prevention interventions, may cause poor women to lose confidence in the health facilities and lead to a reduction in utilization of maternal health services. At the same time, in societies with high-level inequality of opportunity, people are less likely to support a market economy and democracy, implying that expectant women facing inequality of opportunities in malaria prevention may choose not to seek care from health facilities.

Sulfadoxine-pyrimethamine and ITNs use are cost-effective measures able to reduce the disease burden and adverse outcomes of malaria in pregnancy, and although they are subsidized by the government, their use remains at sub-optimal. Secondly, these services are integrated within antenatal care clinics, yet their use remains significantly lower than the use of antenatal care in the country. There is a need to understand the determinants of the sub-optimal use of these services. Existing studies mainly focus on socioeconomic determinants and socioeconomic inequalities studies (Fosu and Mwabu, 2007; White et al., 2013; Usagi and Owiti, 2018), there is no study on inequality of opportunity in malaria prevention among pregnant women. This study provides information on coverage, inequality of access, and circumstances that account for inequality in utilization of Sulfadoxine-pyrimethamine and ITNs among pregnant women in Kenya.

There is an information gap on the coverage, distribution, and inequality in malaria prevention in pregnancy in Kenya. No study on inequality of opportunity in the prevention of malaria in pregnancy has been done; studies using human opportunity index methodology in developing countries focus on maternal and child health (Sanoussi, 2017; Ersado and Aran, 2014). This study proposes to fill this gap by expanding the literature on inequality of opportunity in malaria prevention among pregnant women. The findings of this study will guide policymaking on addressing inequality of opportunity among neonates and under five children as well as policies on increased access and utilization of interventions for preventing malaria among pregnant women.

3. Measures of Inequality

Introduction

Economists and development theorists mainly focus on inequality of outcome and measure the variation in people's achievement in monetary or material wealth, without considering society's moral value, individual's responsibility or capability. The need to consider other forms of inequality—including capability and effort—and moral judgment of fairness is increasingly drawing the attention of economists, political players, and policy makers (Sen, 2012). The argument that factors like gender, race, ethnicity, or country of origin should not influence the distribution of economic benefits and burdens among people is generally agreed.

Traditionally, people were born into some socioeconomic status where they lived and died in—with very little transition — with the belief that one's status was defined by a superior being—God. Gradually, people realised that socioeconomic status can be changed by the actions of the government, society and an individual's effort; this realization has pushed the discussion of the need for equal opportunity among economists and political scientists. Globally, governments adopted some form of equality of opportunity approach and put policies and laws in place—government subsidies and investment in public infrastructure including health and education systems—to improve equality of opportunity for vulnerable members their populations.

The modern theories of justice promote the inequality of opportunity as a preferred approach to assess and address injustice and inefficiency—all individuals should be given equal chance to achieve their potential. Inequality of opportunity suggests that inequality of outcomes is due to inequality in the distribution of circumstances beyond individuals and inequality in their willingness to exert effort—circumstances (parent's wealth and education, genetic make-up and country of residence) and efforts (healthy lifestyle, hours invested in education, and work). An individual's income, health, or education depends on factors beyond and within an individual's control. Individuals, therefore, have responsibilities, and these should be considered when assessing inequalities.

Inequality of opportunity

Inequality of opportunity has dominated political debate and economic development for a long period of time. Most countries acknowledge the need to provide equal opportunity to all their citizens, especially at the onset of their lives, irrespective of their circumstances at birth. "In a well-functioning market economy, opportunities to receive education, have good jobs and earn sufficient income should not be limited based on a person's gender, race, birthplace or parental background" (EBRD, 2016; pp 45, paragraph 1). Generally, such inequality of opportunity is considered inefficient and unfair; it prevents individuals from making the best use of their skills or realizing their potential, hence negatively affecting a country's long-term growth. In addition, it also leads to persistent high income and wealth inequality (EBRD, 2016).

The theoretical foundation of inequality of opportunity is that sources of individuals' desirable outcomes, like health and education, can be divided into two: circumstance factors and effort factors (Roemer, 1998; 2002). The circumstance factors are exogenous and beyond an individual's control. These include gender, family background, and place of birth, among others. The effort factors are endogenous and partially influenced by an individual's choices, hence may be a function of one's circumstances. Inequality arising from circumstance factors is considered illegitimate and unfair, hence must be compensated, while those due to an individual's efforts are considered just and morally acceptable; in fact, an individual should be held responsible for his/her choices. Unequal opportunity is generally viewed as intrinsically unfair and economically inefficient (Ferreira and Walton, 2005; EBRD, 2016); however, unequal outcomes are not treated the same way. Equality of opportunity may imply universal absence or presence of the outcome of interest. If equality of opportunity exists, then an individual's outcome should only be a function of the person's choices, efforts, and talents, and independent of their circumstance.

Maternal health is an important determinant of equal opportunity in a society, yet inequality in maternal health remains substantial and persistent in most countries. This is even more evidenced in the case of inequality in the prevention of malaria in pregnancy, which reinforces and reproduces inequalities in other spheres of the mother's and her children's lives. It significantly influences the unborn child's survival, morbidity, human capital development, adulthood productivity, lifetime health, and intergenerational socioeconomic mobility. Prevention and elimination of malaria in pregnancy is one of the policies geared towards the elimination of preventable maternal and under-five mortalities. Furthermore, it protects the unborn children from the adverse effects of malaria in pregnancy (MiP), hence moving towards equal opportunity for neonates.

There are no studies on inequality of opportunity in malaria prevention among pregnant women in developing countries. We only identified one Sub-Saharan Africa (SSA) study, which estimated cross-country coverage and IOp of malaria prevention in pregnancy, giving an extremely limited coverage (Duran et al., 2016). This study used HOI and D-index to analyse 15 opportunities for reproductive-age women (15-49 years) in SSA. One of these outcomes was the prevention of malaria in pregnancy. The findings show a significant variation in coverage from 0% in Burundi to 90% in Gambia and Zambia. Burundi failed to adopt the WHO policy on malaria prevention in pregnancy due to low malaria cases. However, this methodology has been applied in assessing inequalities in adult health (Fajardo-Gonzalez, 2016), child health (Ersado and Aran, 2014) and maternal health (Sanoussi, 2017).

Inequality of opportunity in health

Inequality of opportunity in health is substantial and persistent in both developed and developing countries (Rosa Dias, 2009). There are just and unjust factors that affect an individual's health outcomes; the unfair factors (circumstances) affect health through a network of indirect effects with uncertain causal relationships, which can be modelled through a structural equation (Fleurbaey and Schokkaert, 2009). In the context of inequality of opportunity in malaria prevention, equality of outcome would imply that all expectant women in malaria-endemic region like Kenya and who have same characteristics like age would use the IPTp-SPs and ITNs, which is an unrealistic expectation, however, equality of opportunity implies that all though women have varying rates of access to malaria prevention interventions, these variations are distributed independent of region of birth, family background and community characteristics. Hence for any vector of C_i defining a pregnant woman's circumstances and any health outcomes H_i for equality of opportunity to prevail the distribution of H_i given C_i should be equal to the distribution of H_i unconditional on C_i, that is, $F(H_i|C_i) = F(H_i)\, hence$ according to Ferreira and Gignoux, (2008), inequality of opportunity is the extent to which $F(H_i|C_i)$ varies from $F(H_i)$.

This study is based on Roemer's (1998; 2002) theoretical foundation with a framework embedded in the Fleurbaey and Schokkaert (2009) structural model; moreover, our health model is a normative interpretation of Grossman

Model (Grossman, 1972) model of health capital and health demand. It generates the demand for health and each of the effort factors, which defines the recursive system of equations. We propose to apply two analytical frameworks: first, we'll use full information maximum likelihood to estimate these recursive equations and allow the systems of the error term to be freely correlated to account for unobserved common factors. Secondly, we'll adopt Roemer's assumption that circumstances and efforts must be orthogonal, and in case of any correlation between the two, then the effort is considered as a circumstance. Using this assumption, we estimated coverage, inequality of opportunity, and the circumstances factors that drive the inequality. These enabled us to assess the relationship between circumstance and health; the address the partial circumstance problem in addition to understanding the inequality of opportunity of malaria prevention among pregnant women.

The Roemer Model for measuring inequality of opportunity

To measure inequality of opportunity, we use Roemer's framework and adopt the Grossman Model (Grossman, 1972), assuming that health is a fundamental commodity produced by inputs labelled as either circumstances and/or efforts. The health production function is:

$$\left(H_{ij}\right) = f(\boldsymbol{C}_i, \boldsymbol{E}_i, \mu) \tag{3}$$

where H_{ij} is the j dichotomous health outcomes for the individual $\boldsymbol{i}$, $\boldsymbol{C_i}$ is the vector of individual exogenous circumstance variables. $\boldsymbol{E}_i$, is the vector of effort factors, which are a function of individual choices and may be endogenous to circumstances, for example's the place of birth and the mother's level of education may influence a child's health status. They are mostly unobserved, hence are not normally captured in most data sets. μ is the residual term which captures luck and other random factors unobserved in the health production function. According to Roemer (1998), efforts are orthogonal to circumstances, implying that any determinant of health status that is correlated with circumstance factors are also circumstance. Equation 1, takes a new form when we incorporate the endogenous characteristics of effort factors and the fact that they're partially influenced by circumstance, we have:

$$\left(H_{ij}\right) = f(\boldsymbol{C}_i, \boldsymbol{E}_i(\boldsymbol{C}_i), \mu) \tag{4}$$

According to Roemer, equality of opportunity requires that $F\left(H_{ij}|\boldsymbol{C}_i\right) = F\left(H_{ij}\right)$, which implies the following:

a) $\frac{\partial f(\boldsymbol{C}_i, E(\boldsymbol{C}_i), \mu)}{\partial \boldsymbol{C}_i} = 0,$ for all $\boldsymbol{C}_i$ i.e., no circumstance factors should have a direct causal effect on H_{ij}.

b) $G\left(E_{ij}|\boldsymbol{C}_i\right) = G\left(E_{ij}\right)$, for all $\boldsymbol{C}_i$ and for all $\boldsymbol{E}_{ij}$, implying each effort variable should be distributed independent of circumstances.

c) $H(\mu|\boldsymbol{C}_i) = H(\mu)$ i.e., random variables and luck are also independent from circumstances.

F, G and H denote cumulative distribution. Inequality of opportunity therefore, measures the extent to which $F\left(H_{ij}|\boldsymbol{C}_i\right) \neq F\left(H_{ij}\right)$. The major interest is to assess whether $F\left(H_{ij}|\boldsymbol{C}_i\right)$ varies across elements of $\boldsymbol{C}_i$ to test for the existence of IOp.

Roemer also defines social types to consist of individuals who share the same circumstance factors, and using a set of observed individual circumstances, the social types can be specified in the data. Furthermore, the model proposes that a distribution of effort within a type is itself a characteristic of that type, and since it's beyond an individual's control, it constitutes a circumstance. Equality of opportunity is achieved when average health outcomes are identical across social types at fixed levels of effort; that is, individuals who exert the same level of effort or adopt a specific lifestyle should experience the same health outcomes irrespective of their status. Based on this framework, we propose to use the human opportunity index (HOI), dissimilarity index, and Shapley-value decomposition to measure coverage, inequality of opportunity, and its drivers.

Variables: Outcome, circumstances, and efforts variables

Outcome variables

In the prevention of malaria among pregnant women, the health outcomes of interest or opportunities are the use of IPTp-SPs and ITNs. Table 3:1 presents the outcome and circumstance variables. We generated average community values (cluster average variables) for variables that could have been considered as effort factors but were closely associated with the women's circumstance factors. For example, a woman's level of education is influenced by her past level of effort — when she was learning— and the characteristics of the household and community she grew up in, but the cluster average level of education is endogenous since no woman can influence the level of education of the women in her community. This was done for cluster variables including antenatal care, teenage pregnancy, and facility delivery.

The circumstance variables:

The choice of circumstances is influenced by empirical literature and the availability of data. Some of the factors identified as influencing access to prevention of malaria in pregnancy include distance to health facilities, health knowledge, community perception of malaria and its treatment in pregnancy, antenatal care practices (service delivery and care-seeking behaviour), maternal age, fertility preference, poverty level, among others.

We considered three categories of circumstance variables: individual level, household level, and community (cluster) level that may influence the expectant women's use of SP and ITNs. Our choice of circumstance factors was informed by exogenous factors that are associated with the use of maternal health services. For example, the expectant mothers have no control over the socioeconomic status of the communities in which they reside; however, from diffusion theory, the community characteristics influence maternal health-seeking behaviour (Palloni, 2001). In terms of malaria prevention, diffusion of new prevention technologies, information, and behaviour is associated with knowledge, attitudes, and behaviour. Women residing in communities with high socioeconomic status are likely to access public health information about malaria in pregnancy and apply the information compared to women residing in low-income environments.

Table 3:1:Trend of maternal mortality ratio among East African Countries

Variables	**Description and Code**
Outcome Variables	
IPTp – SP only	If the respondent took at least 2 doses of SP only No (0) Yes (1)
ITNs/LLINs only	If the respondent slept under an insecticide-treated net the night before data collection: No (0) Yes (1)
IPTp-SPs & ITN/LLINs	If the respondent took at least 2 doses of Fansidar and slept under a treated net the night before data collection: No (0) Yes (1)
Circumstance Variables	

Teenage marriage	If the respondent was 19 years and below at 1st marriage: No (0) Yes (1)
Residence	The respondent's place of residence: Rural (0) Urban (1)
Level of education	The respondent's highest level of completed education: No education (1) Primary (2) Secondary (3) Higher (4)
Parity	Number of children born by the respondents
Spouse education	The respondents' partner or spouse's highest level of completed education: No education (1) Primary (2) Secondary (3) Higher (4)
Spouse Occupation	Not working (0) Professional (1) Agricultural (2) Domestic &manual (3)
Cluster antenatal care demand	The proportion of women who sought at least 4 antenatal care visits for the last child delivered alive per cluster: 0 to 3 visits (0) 4 and above visits (1)
Cluster educational level	The proportion of women with secondary and above level of education per cluster: No (0) Yes (1)
Cluster facility delivery	The proportion of women who had their last delivery in a health care facility per cluster: No (0) Yes (1)
Cluster parity	Average number of children born per woman per cluster
Cluster skilled birth attendant	The proportion of women whose last delivery were assisted by skilled birth attendants. No (0) Yes (1)
Cluster age at 1st birth	Average age of women at first birth per cluster

Empirical Methodology

The study tested inequality of opportunity in the prevention of malaria in pregnancy based on Paes de Barros et al. (2009). This involved four major steps: First, estimating the relationship between the use of interventions to prevent malaria in pregnancy and the circumstances of women using the logistic regression model. Second, using the predicted probability generated to calculate the D-Index to measure inequality of opportunity. Third, estimate the Human Opportunity Index (HOI) and fourth, decompose the D-index using the Shapley value to establish the drivers of inequality.

The logistic regression model

We estimated the logit regression of utilization of malaria prevention interventions (H_{ij}) in Equation (5) by each pregnant woman as a function of a vector of her circumstances ($\boldsymbol{C}_i$). This determined whether the expectant mother had access to the malaria prevention intervention or not. We modified equation (1) by including a vector of control variables $\boldsymbol{X}_i$. The findings of the logit analysis are used to estimate the dissimilarity index and human opportunity index (see Appendix 1 for cummulative logit analysis output)[2] . Our health production function is:

$$(H_{ij}) = f(\boldsymbol{C}_i, X_i, \mu) \tag{5}$$

We excluded the effort factors in our empirical analysis for three reasons: the data used does not capture individual choice i.e., if the expectant mother willingly chose to use or not to use the services; and (ii) the effort variables identified were correlated with the circumstance variables e.g., Women's level of education; and (iii) we generated community average variables for effort variables that were closely associated with individual women circumstances. One could argue that a woman's level of education is influenced by the effort she put in when in school or college, and yet, it is also influenced by other factors beyond the woman, like the parents' education level, distance to school, location of residence, i.e., urban vs rural, and even county of birth. So, the level of education is considered a circumstance variable. The same argument was applied to generate cluster demand for antenatal care— some women may have chosen not to seek antenatal care, but this could be due to distance to hospital, lack of maternal and child health knowledge (due to lack of education). These make it difficult to separate effort factors and circumstance factors. To control for this limitation, we created community-level variables, i.e., average cluster variables, since no individual woman could

[2] For other logit amalysis contact the author.

be able to influence the community characteristics. Roemer argues that where effort factors are correlated with circumstance factors, then they are considered as circumstance factors.

Given these estimated coefficients, we estimated for each expectant woman the predicted probability of utilization of each of the malaria prevention interventions $\hat{p}_i$ based on the predicted relationships ($\hat{\beta}_i$)and vector of their circumstances. Then compute the overall coverage rate or probability of coverage ($\bar{p}$).

$$\hat{p}_i = \frac{\exp\{\alpha + Z_{ij}\gamma_{ij} + X_{ij}\widehat{\beta}_{ij}\}}{1+\exp\{\alpha + Z_{ij}\gamma_{ij} + X_{ij}\widehat{\beta}_{ij}\}} \quad (6)$$

$$\bar{p} = \sum_{i=1}^{n} w_i \hat{p}_i \quad (7)$$

where: $w_i = \frac{1}{n}$ or any other sampling weight, and n is the sample size

The dissimilarity index (D-Index)

We estimated the dissimilarity index (D-Index) of the inequality of opportunity using Equation 7. The D-Index measures the variation in access rates for a given service for the groups defined by circumstance characteristics e.g., sex, place of birth, family background, among others, compared to the average access rate for the same services for the population.

$$D = \frac{1}{2\bar{p}} \sum_{i=1}^{n} w_i |\hat{p}_i - \bar{p}| \quad (8)$$

In this study, D-index measures the disparity in access to malaria prevention interventions among groups of pregnant women defined by their circumstances and the average access rate for the population of expectant women. The dissimilarity index also measures the share of opportunities that must be reallocated from the better-off groups to the worse-off groups to ensure equality in access to the opportunity for all, i.e., IPTp-SPs and INTs. It is estimated by comparing the group means of different combinations of circumstances to the population mean to quantify how outcomes vary by circumstances. It ranges from 0 to 1 (0 to 100 in percentage terms) —it takes the value of zero if there is perfect equality of opportunity in access to malaria prevention interventions.

The Human Opportunity Index (HOI)

Finally, we computed the Human Opportunity Index (HOI) by discounting the penalty for improperly allocated opportunities from the overall coverage. The penalty (P) for inequality i.e. $P = \bar{p} \times D$, is the use of malaria prevention services among pregnant women that are allocated unfairly. HOI is a composite indicator that synthesizes both the absolute level and the level of equitable distribution of health opportunities in a society. It measures the average availability of opportunities discounted by how inequitable the opportunities are distributed among the population (Ersado and Aran, 2014). It is similar to Sen's welfare function that combines income per capita and income distribution indicators. Measuring HOI involves estimating the available opportunities and then adjusting them based of the variation in distribution among different circumstance groups. It increases with an increase in coverage rate and decreases with an increase in inequality of opportunity. The coverage of opportunity estimated by HOI can be interpreted as the number of opportunities in a society that have been allocated based on the equal opportunity principle (Sanoussi, 2017).

$$HOI = C * (1 - \mathrm{D}) \tag{9a}$$

We used the geometric analysis of HOI for sub-regions and year, given that the country is divided into different zones or areas based on malaria endemicity level.

$$HOI_g = \left(\prod_{i-1}^{n} \hat{p}_i^{wi}\right)^{\frac{1}{\Sigma_{1=i}^{n} wi}} \tag{9b}$$

This implies that a change in HOI may be due to either a change in the variation in utilization of malaria prevention services or variation in dissimilarity index, i.e., inequality of opportunity. Furthermore, if access to opportunity is independent of circumstances, then the D-index is equal to zero, and the coverage rate becomes equal to the rate of access to opportunity $(\mathrm{HOI} = C)$. We used the HOI module, a Stata user-written package for analysis. Stata 19 was used for estimation.

Estimating Trend in HOI and D-Index

According to Vega et al, (2010), HOI is determined by group-specific coverage rates and their corresponding population shares (the distribution of circumstances), the changes in HOI can be attributed to changes in the distribution of circumstances (composition effect) or changes in at least some group-specific coverage rates (coverage effect). The composition effect is mostly due to structural changes, for example, demographic changes, overall economic development, and increased investments in health or malaria prevention in the country. The coverage effect can be decomposed into changes due to changes in equality of opportunity (equalization effect) and changes due to average coverage rates (scale effect).

The third objective of this study was to assess the trend of coverage and inequality of opportunity in malaria prevention in pregnancy between 2003 and 2022. We estimated the change in HOI from 2003 to 2008/09 to 2014 and to 2022. And tested the extent to which the D-index and average access accounted for the overall change in HOI. This was estimated by decomposing the disparity in coverage ratio (scale effect) and the difference in inequality of opportunity (the distribution effect) from 2003 to 2008/09 and from 2008/09 to 2014 as follows Paes de Barros et al. (2009).

Change in HOI: $HOI^{t_i} - HOI^{t_0} = \Delta C + \Delta D$ (10)

Scale effect: $\Delta C = C^{t_i}(1 - D^{t_0}) - C^{t_0}(1 - D^{t_0})$

Distribution effect: $\Delta D = C^{t_i}(1 - D^{t_i}) - C^{t_i}(1 - D^{t_0})$

where:

C is coverage rate

D is D-index t_0

t_0 = 2003; t_i = 2008/09, 2014 and 2022

Change in HOI between 2003 and 2022

Change in HOI (2003-2022): $HOI^{2022} - HOI^{2003} = \Delta C + \Delta D$ (10a)

Scale effect: $\Delta C = C^{2022}(1 - D^{2003}) - C^{2003}(1 - D^{2003})$

Distribution effect: $\Delta D = C^{2022}(1 - D^{2022}) - C^{2022}(1 - D^{2003})$

Change in HOI (2003-2014): $HOI^{2014} - HOI^{2003} = \Delta C + \Delta D$ (10b)

Scale effect: $\Delta C = C^{2014}(1 - D^{2003}) - C^{2003}(1 - D^{2003})$

Distribution effect: $\Delta D = C^{2014}(1 - D^{2014}) - C^{2014}(1 - D^{2003})$

Change in HOI (2003-2008/09): $HOI^{2008/09} - HOI^{2003} = \Delta C + \Delta D$ (10c)

Scale effect: $\Delta C = C^{2008/09}(1 - D^{2003}) - C^{2003}(1 - D^{2003})$

Distribution effect: $\Delta D = C^{2008/09}\left(1 - D^{2008/09}\right) - C^{2008/09}(1 - D^{2003})$

These equations were used to measure changes in HOI and inequality of opportunity during the four survey years for the three sets out outcomes. We used the HOISHAPLEY module, a Stata user-written package for analysis (Hoyos, 2013).

Decomposition of dissimilarity index

To achieve the third objective, we used Shapley value decomposition to decompose the total inequality (D-index) and estimated the marginal contribution of each circumstance variable to inequality of opportunity in interventions to prevent malaria in pregnancy, Shorrocks (2012). This involved the calculation of the marginal effects of HOI of adding or removing each of the contributing circumstances in a given sequence. Decomposition equation used:

$$D_{c_j} = \sum S_{CN/\{c_j\}} \frac{|s|!(n-|s|-1)!}{n!}[D(S \cup \{c_j\} - D(S)] \quad (11)$$

Where N is the total number of circumstances; n is the number of selected circumstances in N; S is a subset of N with s circumstances but excluding the particular circumstance c_j; $D(S)$ is the dissimilarity index estimated with S circumstances. $D(S \cup \{c_j\})$ is the dissimilarity index estimated with the subset of circumstances S and the circumstance c_j. The contribution of circumstance c_j to dissimilarity index is defined as

$$\theta_{c_j} = \frac{D_{c_j}}{D(N)} \qquad \text{where} \quad \sum_{i=1}^{N} \theta_i = 1$$

This implies that the sum of the contributions of all the circumstances to D-Index totals to 1 or 100%.

The Data

We use pooled cross-sectional data from three rounds of Kenya Demographic Health Surveys (KDHS) for 2003, 2008/09, 2014, and 2022 surveys. The KDHS is a cross-sectional stratified nationally representative household sample survey in which reproductive-age women 15 to 49 years were randomly selected from clusters throughout the country. In 2003 and 2008/09, the country was divided into 400 clusters, and data were collected from 8.195 and 8,444 women, respectively. However, in 2014 and 2022, the number of clusters was increased to 1612, and data were collected from 31,079 women. In total, 77,613 women aged 15-49 were sampled during the four KDHS. All these women were interviewed for the use of ITNs/LLINs, while women who had live births during the last two years before the survey were interviewed on the use of sulfadoxine-pyrimethamine.

The women who had live births in the 2 years before the survey were asked if, during their last pregnancy, they took any medications to prevent them from getting malaria. The respondents who didn't know the name of the medication they took were shown samples of common antimalarial tablets to choose from. If the respondent reported having taken sulfadoxine-pyrimethamine, they were then asked the number of times they took it and whether it was administered during the antenatal clinic visits. However, all women were asked if they slept under ITNs or LLINs the previous night before the survey. The surveys also include data on demographic and socioeconomic backgrounds of the women, maternal health information, including malaria prevention in pregnancy, antenatal care services, knowledge of HIV and AIDS, perception of domestic violence, among others.

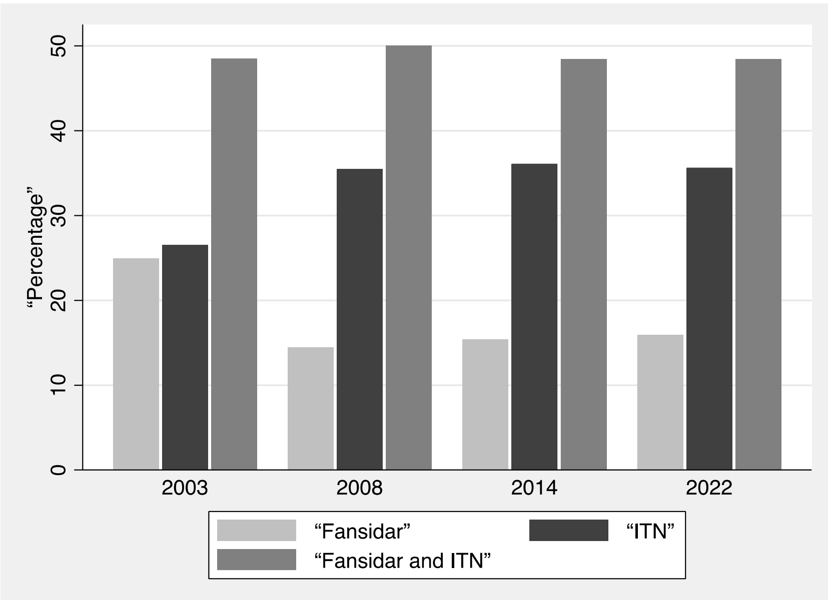
4. Results

This section provides findings for three malaria prevention in pregnancy opportunities. IPTp-SPs use only, use of insecticide-treated nets only (ITNs), and use of both IPTp-SPs and ITNs. The final sample of the study consisted of 77,613 women of reproductive age; however, the sample sizes of various opportunity analyses varied depending on the baseline population and missing values.

Descriptive Statistics

The percentage of expectant women using both IPTp-SPs and ITNs to prevent malaria in pregnancy reduced from 25% in 2003 to 16.4% in 2022 (Figure 4:1). In general, the coverage for different interventions is low and less than 50%.

Figure 4:1: Malaria prevention among pregnant women in Kenya



Given that Kenya is classified into four regions based on malaria-endemicity, the endemic, seasonal/arid transmission, highland epidemic-prone, and low-risk malaria areas, we present the use of various malaria prevention interventions by malaria-endemicity in Figure 4:2. The use of IPTp-SPs (Fansidar) is highest in the Lake Victoria and coastal malaria stable or endemic regions, while the use of both IPTp-SPs and ITNs is lowest among women in malaria-endemic regions. From Figure 4:3, use of IPTp-SPs (Fansidar) only is highest among the poorest, while use of treated nets only is highest among the richest.

Figure 4:2: Malaria prevention among pregnant women by malaria-endemic regions

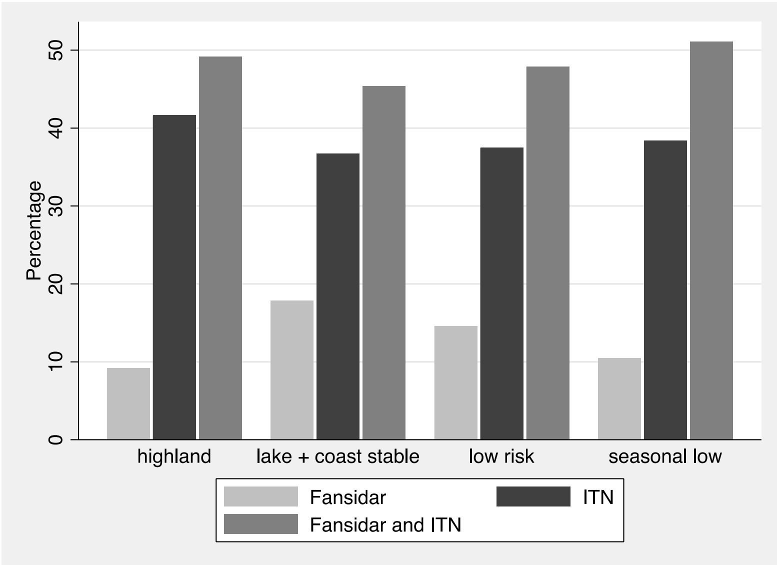
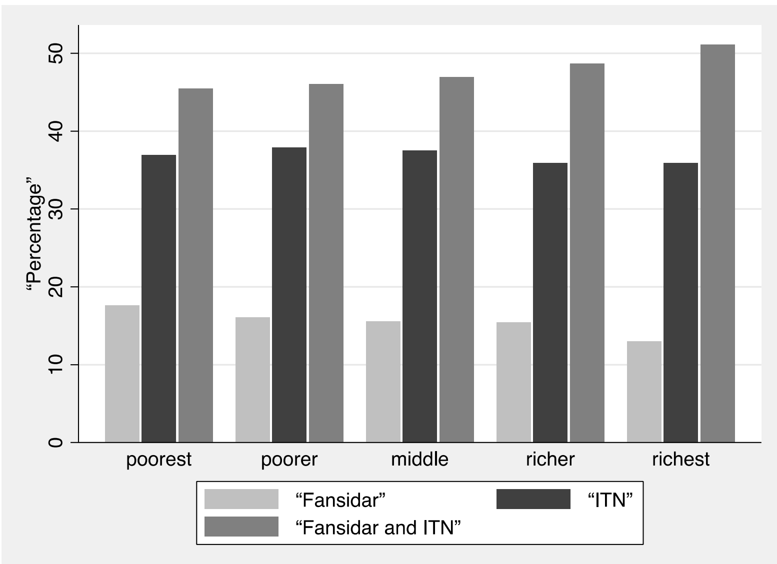


Figure 4:3: Malaria prevention among pregnant women by socioeconomic status



Coverage Rate, Inequality, and access rate of malaria prevention

The average coverage rate, the inequality of opportunity and HOI values for use of various interventions for prevention of malaria in pregnancy are shown in Table 4:1. To interpret these results and those in the tables that follows, it's important to recall that HOI is the inequality adjusted coverage rate of malaria prevention opportunity, and that inequality is measured between groups differentiated by circumstances and individual characteristics. The difference between coverage and HOI for each of the interventions represents the penalty due to inequality between groups, and that penalty is equal to the D-index multiplied by the coverage. In addition, D-index or the inequality of opportunity is the share of total opportunities (e.g. use of IPTp-SPs and ITNs) that would need to be redistributed from the circumstance group with a higher-than-average coverage to those with lower-than-average coverage to achieve equal opportunities. This implies that as the overall coverage rate increases, the dissimilarity index (D-index) decreases.

The National Coverage Rate, Inequality, and Access Rate

Table 4:1 shows the average and trend of coverage, inequality of opportunity, and HOI for use of both IPTp-SPs and ITNs from 2003 to 2022. The average cummulative coverage, dissimilarity, and HOI were 45.4%, 3.8% and 43.7% between 2003 and 2022. The trend of coverage increased from 12.2% in 2003 to 65.3% in 2022. The Human Opportunity Index (HOI) trend increased from 10.7% in 2003 to 62.4% in 2022. The coverage and HOI are very close, implying low levels of inequality of opportunity in the use of both IPTp-SPs and ITNs. However, the coverage of 65.3% in 2022 implies that malaria prevention services were not available for 34.7% of pregnant women who needed them in Kenya. The human opportunity index (HOI) increased by 48.6% from 2003 to 2008/09, 0.7% of the increase was due to change in the distribution of circumstances, —that may be due to demographic changes of increase in government and development partners provision of malaria IPTp-SPs and ITNs to pregnant women—, 41.1% increase was due to increase in overall coverage and 6.9% increase was due to equalization effect. HOI increased by 48.5.1% from 2003 to 2014. Since Kenya is a malaria epidemic zone, the government needs to increase the coverage of these services to enable more women to access them. This will enable the country to move towards meeting Sustainable Development Goal 3 on improving the well-being of women and leaving no one behind.

Table 4:1: National Coverage Rate, Inequality and Access rate of IPTp-SPs and ITNs by Year[3]

	2003	2008/09	2014	2022	Cumulative 2003 - 2022
Original					
Coverage (C)	12.21	60.28	62.19	65.28	45.38
Dissimilarity (D)	12.75	1.64	4.91	4.39	3.77
Human Opportunity Index (HOI)	10.66	59.29	59.14	62.41	43.67
Decomposition (p.p)					
Change (p.p)		48.64	48.48	51.76	
Composition (p.p)		0.69	0.99	3.07	
Scale (p.p)		41.10	41.24	42.25	
Equalization (p.p)		6.85	6.25	6.43	
Decomposition (%)					
Composition (%)		1.34	2.41	7.78	
Scale (%)		85.57	82.54	78.55	
Equalization (%)		13.08	15.05	13.68	

Note: The estimation corresponds to the geometric version of the HOI, which does not report the standard errors.

Table 4:3 shows the coverage, inequality of opportunity, and HOI for use of both IPTp-SPs and ITNs to prevent malaria in pregnancy by malaria endemic zones in 2014 and 2022. The coverage and human opportunity index (HOI) for all malaria zones increased except for the endemic zone (Lake Victoria and Coastal regions). In 2014, the endemic zone had the highest and equal opportunity of malaria prevention.

[3] See Annex 1 for logit analysis used to generate these results.

It's coverage and HOI were very close, implying low levels of inequality of opportunity in the use of both IPTp-SPs and ITNs. Yet, in 2022, the coverage was 65.4% and HOI 59.2%. With very high inequality i.e. D-index of 9.5%. Looking at decomposition by malaria zones in 2014, the human opportunity index (HOI) increased by 20.4% from Highland to Endemic regions, -7.1% of the increase was due to a change in the distribution of circumstances, 23.6% increase was due to an increase in overall coverage, and 3.9% increase was due to the equalization effect. Moving from Highland areas to low-risk and Seasonal malaria areas, HOI decreases by 18.6% and 11.4%. The interpretation of these results requires caution, particularly in the context of Kenya, where malaria treatment and prevention guidelines for expectant women vary by malaria-endemic zones. For example, the Government of Kenya recommends the provision of IPTp-SPs to all expectant women living in high malaria transmission areas and the provision of ITNs/LLINs to all pregnant women living in malaria risk areas. Hence, all expectant women in endemic zones are expected to use both ITNs/LLINs and IPTp-SPs.

Table 4:2: Coverage Rate, Inequality, and Access Rate of IPTp-SPs and ITNs in 2014 and 2022

	2014				2022			
	Highland	Endemic	Low Risk	Seasonal	Highland	Endemic	Low Risk	Seasonal
Original								
Coverage (C)	65.43	83.27	45.59	54.86	70.84	65.39	76.52	53.15
Dissimilarity (D)	4.11	0.16	3.18	6.39	3.73	9.50	1.95	5.05
HOI	62.75	83.14	44.14	51.35	68.20	59.18	75.03	50.46
Decomposition (p.p)								
Change (p.p)		20.39	-18.60	-11.39		-9.02	6.83	-17.74

Composition (p.p)	-7.11	5.21	-10.67	-8.53	-5.16	-4.47
Scale (p.p)	23.59	-23.65	-2.58	-1.26	9.69	-13.16
Equalization (p.p)	3.91	-0.17	1.85	0.77	2.29	-0.10
Decomposition (%)						
Composition (%)	-34.84	-28.03	93.62	94.61	-75.58	25.19
Scale (%)	115.66	127.13	22.61	13.96	141.98	74.22
Equalization (%)	19.18	0.90	-16.23	-8.57	33.60	0.59

Note: The estimation corresponds to the geometric version of the HOI; High land areas is included in analysis. It has data for 2014 and 2022; HOI - Human Opportunity Index

The cummulative average coverage, inequality access and change bewteen malaria zones in 2014 and 2022 is presented in Table 4:3. The other years were excluded in the analysis due to lack of data 2003 and 2008/09 for highland zone. The cumulative results musks the inequality, coverage and access rate of ITNs/LLINs and IPTp-SPs in malaria prevention in pregnancy.

Table 4:3: Coverage Rate, Inequality, and Access Rate for IPTp-SPs and ITNs in Endemic Zone

	Highland	Endemic	Low Risk	Seasonal
Original				
Coverage (C)	67.50	48.09	40.39	46.17
Dissimilarity (D)	2.55	3.76	3.36	4.39
Human Opportunity Index (HOI)	65.78	46.28	39.04	44.15
Decomposition (p.p)				
Change (p.p)		-19.49	-26.74	-21.63
Composition (p.p)		-8.70	-5.03	-9.98
Scale (p.p)		-11.05	-21.75	-12.00
Equalization (p.p)		0.26	0.04	0.36
Decomposition (%)				
Composition (%)		44.64	18.81	46.15
Scale (%)		56.67	81.35	55.50
Equalization (%)		-1.31	-0.15	-1.65

Note: The estimation corresponds to the geometric version of the HOI.

The malaria endemic zone coverage rate, inequality, and access rate

The Lake Victoria region and coastal area are classified as a malaria stable/endemic region in Kenya. They have high maternal and infant mortality associated with malaria. Table 4:4 shows the trends of coverage, inequality of opportunity, and HOI among pregnant women living in these regions from 2003 to 2022. The average coverage trend use of IPTp-SPs and ITNs/LLIN increased from 11.8% in 2003 to 83.3% in 2014 and then decreased to 65.4% in 2022. The dissimilarity index reduced from 22.3% in 2003 to 0.16% in 2014, then increased to 9.5% in 2022, implying that in 2014, there was no inequality in the use of both IPTp-SPs and ITN/LLINs among pregnant women living in the malaria-endemic region. In terms of decomposition by years, the human opportunity index (HOI) increased by 48.3% from 2003 to 2008/09, 0.4% of the increase was due to change in the distribution of circumstances, 35.8% increase was due to increase in overall coverage. This increase was contributed by government and development partners' increased investment and distribution of IPTp-SPs and ITN/LLIN—and 12.1% increase was due to equalization effect. HOI increased by 74% from 2003 to 2014. The coverage and HOI for 2022 are not close, implying the presence of inequality of opportunity in the use of both IPTp-SPs and ITNs/LLINs. The coverage of both IPTp-SPs and ITN/LLINs reduced to 65.4% in 2022, implying that, even in the malaria stable region, the services were not available for 34.6% of pregnant women at risk of malaria.

Table 4:4: Coverage Rate, Inequality, and Access Rate for IPTp-SPs and ITNs in Endemic Zone

	2003	2008/09	2014	2022	Cumulative 2003 - 2022
Original					
Coverage (C)	11.80	58.38	83.27	65.39	48.09
Dissimilarity (D)	22.27	1.63	0.16	9.5	3.76
Human Opportunity Index (HOI)	9.17	57.43	83.14	59.18	46.28
Decomposition (p.p)					
Change (p.p)		48.26	73.96	50.01	
Composition (p.p)		0.37	0.08	1.5	
Scale (p.p)		35.78	52.83	37.87	
Equalization (p.p)		12.11	21.05	10.64	
Decomposition (%)					
Composition (%)		0.76	0.11	3.00	
Scale (%)		74.14	71.42	75.72	
Equalization (%)		25.1	28.46	21.28	

Note: The estimation corresponds to the geometric version of the HOI.

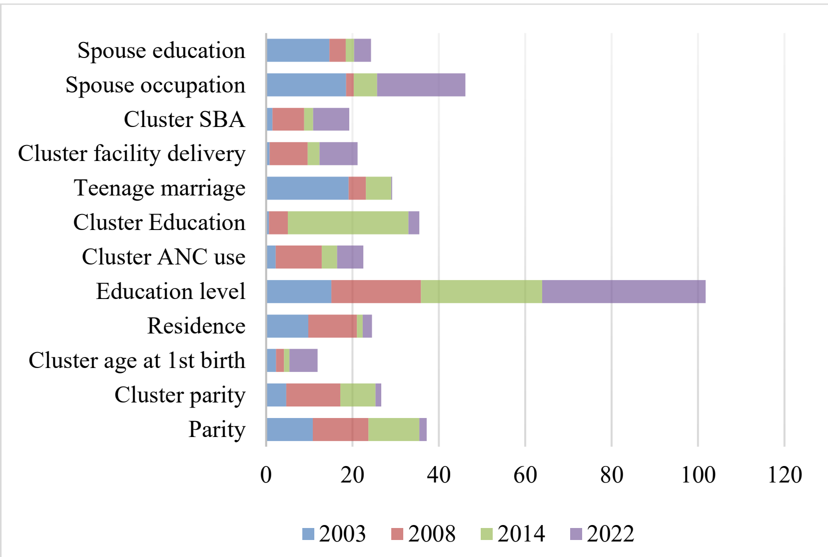
Determinants of Inequality in the prevention of malaria in pregnancy

We present the determinants of inequality of opportunity in the prevention of malaria in pregnancy in Kenya for 2003, 2008/09, 2014, and 2022. The Shapley distribution uses a traditional measure of HOI rather than the geometric measure adopted in the analysis to account for variation in data, e.g., regional variation and years. The section includes national-level determinants, determinants by malaria zones, and trends of variation from 2003 to 2022.

Determinants of Inequality in IPTp-SPs and ITNs use in Kenya

We present the national determinants of inequality IPTp-SPs and ITNs in Kenya for by year in Figure 4:4. Cumulatively, the woman's education level is the most important factor influencing use of both IPTp-SPs and ITNs/LLINs to prevent malaria in pregnancy, followed by the spousal occupation and spousal level of education.

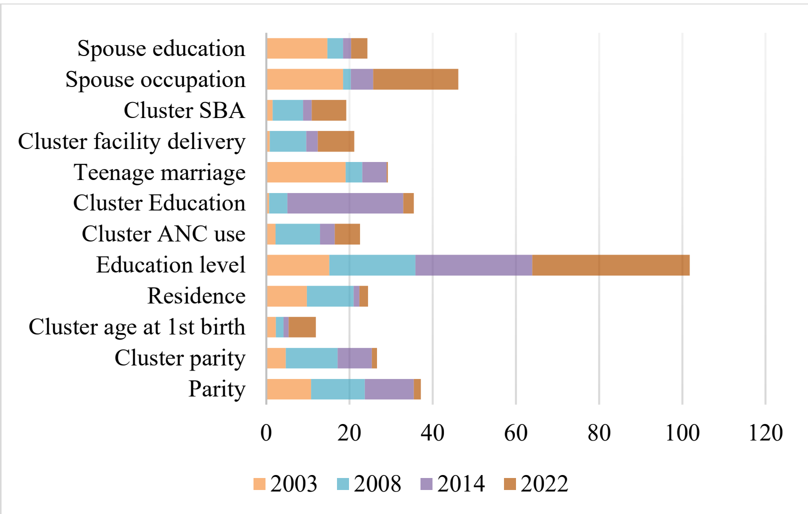
Figure 4:4: Determinants of inequality in IPTp-SPs and ITNs use in Kenya



Determinants of Inequality in IPTp-SPs and ITN/LLINS in malaria zones

The contributions of various circumstances to inequality of opportunity in use of both IPTp-SPs and ITNs per year in malaria endemic zones are presented in Figure 4:5. In 2003, teenage marriage was the main determinant of inequality in prevention of malaria in pregnancy followed by spouse's occupation. In 2008/09, women's level of education was the major determinant followed by the cluster parity. While in 2014, the average number of women per cluster receiving services of skilled birth attendant was the major determinant on inequality in using both IPTp-SPs and INT/LLINs. In general, the women's level of education is the single most important circumstance influencing use of IPTp-SPs and ITNs to prevent malaria in pregnancy.

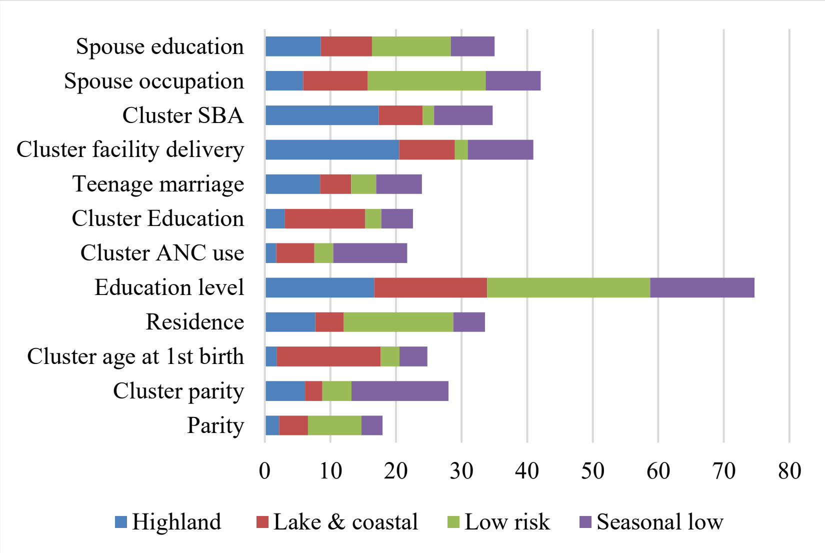
Figure 4:5: Determinants of inequality in IPTp-SPs and ITN/LLINS in Endemic zone



zone

The contributions of various circumstances to inequality of opportunity in the use of both IPTp-SPs and ITNs by malaria endemic areas in 2014 are presented in Figure 4:6. The average cluster facility delivery and cluster skilled birth attendant (SBA) are the major determinants of inequality of opportunity in the use of IPTp-SPs and ITNs in the Highland regions. The average cluster skilled birth attendant and education level are important factors in the Lake Victoria region and coastal malaria stable areas.

Figure 4:6: Determinants of inequality in IPTp-SPs and ITN/LLINS by malaria zone



Discussion

This paper analyzed the evolution of coverage, inequality of opportunity, and access to malaria prevention interventions in pregnancy—namely IPTp-SP and ITNs/LLINs—in Kenya between 2003 and 2022, using the Human Opportunity Index (HOI) framework. The results provide evidence of both progress and persistent disparities in the distribution of these health services.

At the national level, average coverage increased significantly from 12.2% in 2003 to 65.3% in 2022, with the HOI increasing from 10.7% to 62.4% over the same period. These findings reflect improved availability and uptake of malaria prevention services among pregnant women. However, the divergence between coverage and HOI—measured by the D-index—highlights substantial opportunity inequality, particularly in recent years. The D-index decreased steadily until 2014 but rose again to 9.5% in 2022, reversing earlier gains. This re-emergence of inequality is most pronounced in malaria-endemic Lake Victoria and coastal regions of the country, where coverage declined by 18% from 2014 to 2022. These zones experienced the greatest losses in opportunity, despite being the most vulnerable and policy-targeted areas.

Decomposition of the HOI reveals that increases in coverage accounted for the majority of improvements, while equalization effects contributed modestly. For example, from 2003 to 2008/09, 41.1% of the HOI increase were attributable to coverage expansion, compared to only 6.% from reduced inequality. Notably, the observed decline in coverage and HOI in 2022 coincides with the COVID-19 period, suggesting pandemic-induced constraints in both health service delivery and household access, particularly among disadvantaged groups.

From the Shapley decomposition, the major circumstances determining inequality in the prevention of malaria in pregnancy are the individual woman's level of education, the spousal education and occupation, the cluster access to maternal health services—skilled birth attendant, facility delivery, among others. These underscore the intersection of health service delivery with broader structural and socioeconomic variables

From an economic perspective, these findings have implications for the allocative efficiency and targeting of public health resources. The large inequality penalties suggest that improving targeting and delivery in underserved areas could yield substantial welfare gains, particularly in malaria-endemic zones. Moreover, the failure to sustain equitable distribution despite expanded coverage points to potential inefficiencies in program design, implementation, or financing mechanisms.

5. Conclusions

This study demonstrates that while Kenya has achieved significant improvements in the coverage of malaria prevention among pregnant women over the past two decades, these gains have not translated uniformly across population groups or regions. The erosion of equality in access—especially in high-burden areas—suggests that current policy frameworks may not be adequately aligned with spatial and socioeconomic disparities. At the sametime, they may not be able to support the country's recovery from the impact of COVID-19 in access to maternal health services.

The evidence points to the need for more refined and equity-sensitive policy instruments. Increasing investment in the supply of IPTp-SP and ITNs/LLINs must be complemented by better geographic and demographic targeting, improved integration with maternal health services, and efforts to address underlying demand-side constraints, such as education and gender dynamics. There is need for integrated health emergency and pandemic preparedness and response policies that protects supply and demand side of malaria protection services.

Additionally, the application of the HOI and D-index in health service evaluation provides a valuable framework for policymakers seeking to optimize both equity and efficiency. Future health financing strategies must consider not just the expansion of services but also the distributional consequences of public investments in health.

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Appendices

Appendix 1: Logit Model for Cummulative National 2003-2022 Analysis

Prevent_max	Coefficient	Robust std. err.	z	P>z	[95% conf.	interval]
Woman's age	0.009	0.006	1.49	0.136	-0.003	0.020
Urban Residence	0.071	0.062	1.14	0.255	-0.051	0.193
Parity	-0.037	0.018	-2.13	0.033	-0.072	-0.003
Primary Education	0.394	0.072	5.51	0.000	0.254	0.534
Secondary Education	0.750	0.095	7.88	0.000	0.564	0.937
Higher Edication	0.864	0.124	6.95	0.000	0.620	1.107
ANC yes cluster	0.133	0.052	2.54	0.011	0.031	0.235
Cluster parity	-0.096	0.050	-1.9	0.057	-0.195	0.003
Cluster age at 1st birth	-0.212	0.031	-6.86	0.000	-0.272	-0.151
Cluster Educ (Secondary & above)	0.231	0.070	3.3	0.001	0.094	0.368
teen_marri~2 20-49 years	0.028	0.058	0.48	0.628	-0.086	0.142
Cluster facility delivery	0.160	0.134	1.2	0.230	-0.102	0.422
Cluster SBA	0.005	0.138	0.03	0.972	-0.266	0.275
Spouse Professional	-0.224	0.111	-2.01	0.044	-0.442	-0.006
Agricultural	-0.477	0.108	-4.42	0.000	-0.688	-0.266
Domestic and manual	-0.164	0.107	-1.53	0.127	-0.374	0.047
Spouse Educ (Secondary & above)	0.082	0.060	1.38	0.169	-0.035	0.199
Malaria zone 2	-0.574	0.073	-7.89	0.000	-0.717	-0.432
Malaria zone 3	-0.916	0.071	-12.97	0.000	-1.055	-0.778
Malaria zone 4	-0.644	0.083	-7.75	0.000	-0.807	-0.481
_cons	4.394	0.694	6.33	0.000	3.034	5.753

Appendix 2: Logit Model for Year 2003 Analysis [4]

Prevent_max	**Coefficient**	**Robust std. err.**	**z**	**P>z**	**[95% conf.**	**interval]**
Woman's age	0.004	0.015	0.24	0.812	-0.026	0.034
Urban Residence	0.160	0.149	1.08	0.280	-0.131	0.452
Parity	-0.061	0.048	-1.28	0.202	-0.155	0.033
Primary Education	0.095	0.198	0.48	0.633	-0.294	0.483
Secondary Education	0.682	0.241	2.83	0.005	0.210	1.154
Higher Edication	1.133	0.314	3.61	0.000	0.517	1.748
ANC yes cluster	0.020	0.129	0.15	0.879	-0.233	0.272
Cluster parity	0.227	0.138	1.64	0.100	-0.044	0.497
Cluster age at 1st birth	-0.059	0.091	-0.65	0.513	-0.237	0.118
Cluster Educ (Secondary & above)	-0.043	0.216	-0.2	0.843	-0.466	0.381
Teen_Marriage 20-49 years	0.074	0.142	0.52	0.604	-0.205	0.353
Cluster facility delivery	-0.214	0.317	-0.67	0.500	-0.836	0.408
Cluster SBA	0.345	0.326	1.06	0.290	-0.295	0.985
Spouse Professional	0.254	0.144	1.76	0.078	-0.028	0.536
Agricultural	-0.210	0.164	-1.28	0.201	-0.531	0.112
Spouse Educ (Secondary & above)	0.389	0.141	2.76	0.006	0.113	0.666
Malaria zone 2	0.043	0.223	0.19	0.848	-0.395	0.480
Malaria zone 3	0.193	0.223	0.87	0.386	-0.244	0.631
_cons	-2.321	2.023	-1.15	0.251	-6.286	1.643

[4] This model was used for all time decomposition analysis to track trend of change between base year 2003 and the subsequent years.

Appendix 3: Logit Model for Year 2008/09 Analysis

Prevent_max	**Coefficient**	**Robust std. err.**	**z**	**P>z**	**[95% conf.**	**interval]**
Woman's age	-0.014	0.012	-1.10	0.271	-0.038	0.011
Urban Residence	0.643	0.149	4.31	0.000	0.351	0.936
Parity	0.007	0.037	0.17	0.862	-0.067	0.080
Primary Education	0.443	0.146	3.04	0.002	0.158	0.728
Secondary Education	0.880	0.200	4.41	0.000	0.489	1.272
Higher Edication	0.674	0.296	2.27	0.023	0.093	1.255
ANC yes cluster	0.031	0.107	0.29	0.770	-0.179	0.242
Cluster parity	-0.289	0.129	-2.24	0.025	-0.542	-0.037
Cluster age at 1st birth	-0.288	0.084	-3.43	0.001	-0.452	-0.123
Cluster Educ (Secondary & above)	-0.099	0.209	-0.48	0.635	-0.508	0.310
teen_marri~2 20-49 years	0.018	0.128	0.14	0.888	-0.233	0.269
Cluster facility delivery	-0.542	0.262	-2.07	0.038	-1.055	-0.029
Cluster SBA	0.315	0.264	1.20	0.231	-0.201	0.832
Spouse Professional	0.728	0.602	1.21	0.226	-0.451	1.908
Agricultural	0.558	0.602	0.93	0.354	-0.621	1.737
Domestic and manual	0.669	0.601	1.11	0.266	-0.509	1.847
Spouse Educ (Secondary & above)	0.075	0.126	0.59	0.554	-0.173	0.322
Malaria zone 2	0.068	0.200	0.34	0.735	-0.323	0.459
Malaria zone 3	0.189	0.202	0.94	0.349	-0.207	0.585
_cons	6.166	2.038	3.03	0.002	2.171	10.161

Appendix 4: Logit Model for Year 2014 Analysis

Prevent_max	**Coefficient**	**Robust std. err.**	**z**	**P>z**	**[95% conf.**	**interval]**
Woman's age	0.022	0.010	2.28	0.023	0.003	0.042
Urban Residence	0.014	0.092	0.15	0.880	-0.166	0.194
Parity	-0.099	0.030	-3.34	0.001	-0.157	-0.041
Primary Education	0.509	0.110	4.62	0.000	0.293	0.725
Secondary Education	0.784	0.151	5.20	0.000	0.489	1.080
Higher Edication	1.228	0.217	5.65	0.000	0.803	1.654
ANC yes cluster	0.093	0.088	1.06	0.290	-0.079	0.265
Cluster parity	-0.068	0.079	-0.87	0.386	-0.222	0.086
Cluster age at 1st birth	0.062	0.047	1.32	0.187	-0.030	0.155
Cluster Educ (Secondary & above)	0.112	0.102	1.10	0.272	-0.088	0.312
Teen_marriage 20-49 years	-0.040	0.094	-0.43	0.666	-0.224	0.143
Cluster facility delivery	0.125	0.248	0.51	0.613	-0.360	0.611
Cluster SBA	0.079	0.253	0.31	0.756	-0.417	0.574
Spouse Professional	-0.078	0.452	-0.17	0.862	-0.964	0.808
Agricultural	0.002	0.444	0.01	0.996	-0.868	0.873
Domestic and manual	0.075	0.444	0.17	0.866	-0.795	0.945
Spouse Educ (Secondary & above)	0.128	0.098	1.31	0.191	-0.064	0.319
Malaria zone 2	1.157	0.111	10.40	0.000	0.939	1.375
Malaria zone 3	-1.066	0.105	-10.16	0.000	-1.272	-0.861
Malaria zone 4	-0.262	0.104	-2.52	0.012	-0.466	-0.059
_cons	-1.546	1.152	-1.34	0.180	-3.804	0.713

Appendix 5: Logit Model for Year 2022 Analysis

Prevent_max	**Coefficient**	**Robust std. err.**	**z**	**P>z**	**[95% conf.**	**interval]**
Woman's age	-0.032	0.011	-2.77	0.006	-0.054	-0.009
Urban Residence	-0.628	0.113	-5.54	0.000	-0.851	-0.406
Parity	0.132	0.037	3.55	0.000	0.059	0.205
Primary Education	1.258	0.142	8.84	0.000	0.979	1.537
Secondary Education	1.390	0.174	7.98	0.000	1.048	1.731
Higher Edication	1.226	0.211	5.80	0.000	0.812	1.641
ANC yes cluster	0.335	0.104	3.24	0.001	0.132	0.539
Cluster parity	-0.223	0.092	-2.41	0.016	-0.404	-0.042
Cluster age at 1st birth	-0.278	0.057	-4.90	0.000	-0.389	-0.167
Cluster Educ (Secondary & above)	0.031	0.125	0.25	0.804	-0.214	0.276
Teen_marriage 20-49 years	0.219	0.108	2.02	0.043	0.007	0.431
Cluster facility delivery	0.358	0.258	1.39	0.166	-0.148	0.864
Cluster SBA	-0.193	0.264	-0.73	0.466	-0.711	0.326
Spouse Professional	0.366	0.151	2.43	0.015	0.071	0.662
Agricultural	0.427	0.154	2.78	0.005	0.126	0.728
Domestic and manual	0.433	0.140	3.09	0.002	0.158	0.708
Spouse Educ (Secondary & above)	0.010	0.116	0.08	0.934	-0.217	0.236
Malaria zone 2	-0.138	0.132	-1.05	0.293	-0.396	0.119
Malaria zone 3	0.520	0.146	3.58	0.000	0.235	0.806
Malaria zone 4	-0.610	0.137	-4.44	0.000	-0.879	-0.340
_cons	5.718	1.296	4.41	0.000	3.179	8.257

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