Mortality Trends Assessment of a Community-Based Primary Health Care Program Implementation in Rural Kisii County, Kenya (2017–2024)

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Acronyms and Abbreviation

CBIO	Census-Based, Impact-Oriented
CBPHC	community-based primary health care
CHV	community health volunteer
CHW	community health worker
CI	confidence interval
DHS	Demographic and Health Survey
ENMR	early neonatal mortality rate
IGHA	Impact Global Health Alliance
IRR	incidence rate ratio
KIKOP	Kisii Konya Oroiboro Project
LNMR	late neonatal mortality rate
MMR	maternal mortality ratio
MNCH	maternal, neonatal, and child health
NMR	neonatal mortality rate
PHC	primary health care
PNMR	perinatal mortality rate
RHV	Routine Home Visit
RMNCAH	reproductive, maternal, neonatal, child, and adolescent health
U5MR	under-five mortality rate
VE	vital events
WHO	World Health Organization

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Introduction

Despite substantial reductions of maternal mortality ratio (MMR) and progress in child survival, maternal mortality, under-five and neonatal deaths remain a central global health concern, and progress toward 2030 targets is uneven across settings. Globally, more than 260,000 women die annually due to pregnancy or child-birth related complications, and more than 5 million children die before reaching the age of five. Sub-Saharan Africa continues to bear a disproportionate share of this burden, accounting for approximately 70% of maternal deaths and 57% of global under-five deaths, despite representing only 30% of live births worldwide.

Within this broader context, Kenya has made important progress in reducing maternal and child mortalities through sustained investments in primary health care (PHC) and reproductive, maternal, neonatal, child, and adolescent health (RMNCAH) policies. Since the establishment of the Kenya Expanded Programme on Immunization in 1980, the country has implemented successive efforts to improve maternal and child health, including expansion of immunization and nutrition-related services, malaria and HIV control, reduction of user fees for key services, and broader initiatives to extend essential care to underserved populations (Awe et al., 2023; Macharia et al., 2019; Macharia et al., 2021). However, substantial inequalities in service availability, intervention coverage, and health outcomes persist across counties and subnational populations (Keats et al., 2018; Macharia et al., 2021). Important predictors of health outcomes include socioeconomic conditions, rural-urban differences, geography, and climate (Awe et al., 2023; Macharia et al., 2019; Samuel et al., 2021; Keats et al., 2018).

Community-based primary health care (CBPHC) has long been regarded as an important strategy for improving maternal neonatal child health (MNCH) in low-resource settings, particularly where barriers to facility access remain substantial. As an extension to facility care, CBPHC extends health services into households and communities and may therefore contribute

to improved access to care and equity. A major review led by Perry et al. (2017) concluded that community-based delivery platforms can extend preventive and selected curative services beyond facilities and into households and communities, with benefits across maternal, neonatal, and child health domains. Effective approaches commonly include community health workers, household outreach, participatory women's groups, and structured community education models such as Care Groups (Perry et al., 2015; Prost et al., 2013). CBPHC bridges gaps between communities with formal health systems by emphasizing accessibility, affordability and cultural relevance (Black et al., 2017).

One implementation model within CBPHC is the Census-based impact-oriented (CBIO+) approach, which combines census-based community identification, community-oriented outreach, and local health promotion strategies (Perry et al., 1999). Previous evaluations of CBIO models in resource-constrained settings have reported substantial reductions in maternal and child mortality over several years of implementation. For example, CBIO programs in Bolivia were associated with an 52% reduction in under-five mortality. When implemented with Care Group and the construction of local birthing centers, the CBIO adaptation (CBIO+) achieved a 63% maternal mortality decline and 22% under-five mortality decline in Guatemala and 63% under-five mortality decline in Liberia (Perry et al., 2026). Taken together, these findings suggest that large mortality declines under CBPHC models are plausible. However, despite growing evidence of CBPHC's impact on maternal and child mortality outcome, longitudinal evidence on mortality trends remains limited and the outcomes of mortality trends are still context specific. District-level analyses based on community surveillance data are also relatively scarce outside Demographic and Health Surveys (DHS), modeled estimates, and routine facility data.

Planning and accountability of community-based interventions require timely and credible local mortality data, which are often limited in settings with incomplete civil registration and

vital statistics systems. In such contexts, community-based vital events reporting and household-based surveillance approaches offer a pragmatic way of documenting births and deaths in defined populations and can improve local visibility of mortality patterns (Amouzou et al., 2014; Nichols et al., 2019; Silva et al., 2016). At the same time, these systems have important limitations that may affect completeness and accuracy of data. Prior studies have shown that data completeness can vary by setting, supervision intensity and workload. Very early neonatal deaths are especially likely to be missed, annual or retrospective household reporting like census may introduce recall bias, leading to underestimation of child mortality. In addition, the classification of stillbirth and neonatal mortality is commonly reported. These considerations are important when interpreting mortality trends derived from community-based surveillance data (Amouzou et al., 2014; Nichols et al., 2019; Silva et al., 2016; Perry et al., 2023).

The Kisii Konya Oroiboro Project (KIKOP) in rural Kisii County, Kenya, provides an opportunity to examine maternal and child mortality trends using community-based vital events data collected repeatedly in three defined catchment areas during implementation of a CBIO+ approach project. The project's vital events registration system documents pregnancies, stillbirths, births, and deaths over time within the catchment population. In settings where routine registration remains limited, such data can support population-based descriptions of mortality patterns at a smaller scale than is typically available from national surveys alone, providing valuable insights to identify local epidemiological priorities, which help refine and re-align the interventions accordingly.

The objective of this study is to synthesize all the existing KIKOP vital events data into a uniform database for future analysis and describe trends in maternal, perinatal, neonatal, post-neonatal, and under-five mortality across three rural catchment areas in Kisii County from baseline through 2024 using community-based vital events data collected during the period of

KIKOP implementation. A secondary objective of the study is to assess the usefulness of these data for local mortality surveillance in resource constrained settings where routine registration system remains incomplete.

Methods

Study design

This study is a population-based observational analysis of mortality trends using community-based vital events data collected in three rural catchment areas of Kisii County, Kenya, from baseline (2017-2019) through 2024. The analysis was designed to describe temporal patterns in maternal and child mortality during the period of KIKOP implementation. The unit of analysis was the catchment area by program year.

Research questions and objectives

The primary analytic question of this study was how maternal and child mortality changed from baseline to the period of KIKOP program implementation across the three catchment areas. The primary objective was to describe trends in maternal, perinatal, neonatal, post-neonatal, and under-five mortality from baseline through program years 1-7 using community-based vital events data.

Secondary questions examined whether mortality levels differed between the earlier implementation period (program years 1-3) and the later implementation period (program years 4-7), and whether mortality patterns varied among the three catchment areas during the study period.

For neonatal and under-five mortality outcomes, an additional question was whether observed changes were driven primarily by deaths in the early neonatal period (0-6 days) or by deaths occurring later in infancy and childhood.

A further objective was to assess the usefulness of community-based vital events registration data for local mortality surveillance in settings where routine civil registration

systems remain incomplete.

Study setting

The project was implemented in three catchment areas of Matongo, Iranda and Nyagoto, which are in the Kisii county of Kenya. Baseline data collection and program implementation began sequentially across the three areas. Baseline periods were defined as the 12 months preceding program implementation in each area: July 2017 to June 2018 in Matongo, February 2018 to January 2019 in Iranda, and January 2019 to October 2019 in Nyagoto. Program implementation began in July 2018 in Matongo, February 2019 in Iranda, and November 2019 in Nyagoto. Because of data quality concerns (underreporting of live births and mortality events) identified in Nyagoto at baseline during verification, two months of baseline data in Nyagoto (November-December 2018) were excluded, resulting in a 10-month baseline period for that catchment area; mortality rates for Nyagoto baseline were calculated using births recorded during the included months only. The three areas are geographically and socio-culturally similar.

Program context

KIKOP was a CBPHC program implemented through a CBIO+ approach. The project was rooted in the Care Group model, which leverages structured mother-to-mother health education delivered by trained community volunteers. Through regular group meetings, household-level counseling, and systematic dissemination of key health messages, Care Group Leaders acted as critical agents of change, supporting women across pregnancy, postpartum, and early childhood and facilitating the diffusion of lifesaving knowledge within and between households. Complementary interventions, including Routine Home Visits (RHVs) and community mobilization activities led by Community Health Volunteers (CHVs) further reinforced the project's goal of expanding awareness of maternal and child danger signs, enhancing nutrition and newborn care practices, and strengthening linkages to health facilities

capable of providing 24/7 MNCH services.

To monitor progress and track the effects of its interventions, KIKOP employed a vital events (VE) registration system that routinely documents pregnancies, live births, stillbirths, migrations, and deaths. These data are collected annually across the three catchment areas and provide a unique opportunity to examine trends in perinatal, neonatal, under-five, and maternal mortality over time. The VE system served as a critical tool for assessing change within communities without a reliable civil registration system.

Data sources and data collection

The main data source for this analysis was the project's annual vital events registration census conducted by program staff and recruited enumerators. For the project and this analysis, vital events were defined as newly identified pregnancies, births (both live births and stillbirths), and deaths. The project maintained a vital events register for the study period (2017-2024) in both paper and digital forms. A project vital events register with routine household visit records and census data combined was incorporated to enhance the completeness of the registration.

Baseline demographic and vital events censuses were used to establish quantitative baseline measures for population indicators and key mortality indicators. A baseline census was conducted in each area prior to the start of the program to capture vital events that happened in the previous 12 months before program implementation.

The baseline household census collected demographic and health-related information for all residents within the KIKOP project catchment areas. The vital events portion of the census was repeated annually in each catchment using a standardized household census form, collecting information on pregnancy outcomes (miscarriages, stillbirths and live births) and deaths as well as gathering information for project implementation (such as presence of a pregnant woman in the household). Until 2023, the census was completed in each catchment at the start of the new program year. In 2023, KIKOP moved their vital events data collection

to occur at the same time at the start of the calendar year, leaving a gap between the end program year and the start of the 2024 calendar year in 2023. Although census visits were not conducted during these months, births and deaths that occurred during the gap were subsequently reported by households during later census rounds. The events in the gap were retained in the analytic dataset and assigned to corresponding program year based on the recorded event date.

During the census, enumerators visited each household accompanied by the corresponding community health volunteer for that village. The pregnancy/pregnancy outcome register included the mother's name, date of birth, age, estimated date of delivery, actual delivery date, delivery outcome, including if the outcome was a stillbirth, miscarriage or live birth, and child's name. The mortality register included the deceased's name, role in the family, date of birth, date of death, age in years at the time of death, age in months at the time of death, age in days at death, primary and secondary causes of death, and mortality category. The mortality categories were (1) women of reproductive age, (2) maternal mortality, (3) under-five mortality, (4) stillbirth, (5) early neonatal mortality (first 7 days of life), (6) neonatal mortality (first 28 days of life), and (7) 1-<60- month mortality (between 28 days and 5 years of life).

The structured census form was written in English. Enumerators who were speakers of the local Kisii language (called Gusi, a Bantu language distinct from Swahili) used either English or translated into Gusi at the time of the interview. Recruited enumerators received 2-3 days of training. The training included an explanation of the project's goals and indicators, interview procedures and protocols, consent form, data management process and confidentiality policy, and practice in conducting the census in the local language. The training was observed and managed by KIKOP/IGHA staff and supervisors.

Data from each vital events census were analyzed and reported each year (usually 3 months after the conclusion of data collection).

Data Analysis

Data analysis for this study was conducted using Stata and Microsoft Excel. Stata was used for data cleaning, recoding, organizing the vital events dataset, and regression analysis. Excel was used for tabulation and calculation of mortality rates and confidence intervals for each catchment area and time period.

All entries in the dataset were cross-checked against paper registers. When inconsistencies were identified (e.g., discrepancies in dates, survival status, or classification of pregnancy outcomes), queries were returned to the responsible community health worker (CHW) on a weekly basis. CHWs revisited the household to verify the correct information and update the register when necessary. Verification was conducted by graduate students and KIKOP staff to ensure accuracy and completeness of the mortality records. In addition, a pooled project dataset derived from the RHV records was used as a supplementary verification source to identify potentially missing events and improve the completeness of vital events dataset. However, no capture-recapture analysis was conducted.

No statistical analysis was conducted to detect systematic differences by demographic variables. During data verification, strong differences across catchment areas were note noted, the only noted challenges in KIKOP's vital events reporting were occasional incomplete registration of twin births and missing report of corresponding live birth when early neonatal deaths were reported.

Mortality categories were derived from age-at-death variables. The definitions of the mortalities aligned with WHO's global health observatory for comparability and are listed below in Table 1.

Table 1. Definitions of mortality indicators used in this study

Mortality	Definition
Maternal mortality	Death of a woman while pregnant or within 42 days of termination of pregnancy, from any cause related to or aggravated by the pregnancy or its management, excluding accidental or incidental causes.
Under-five mortality	Deaths between birth and exactly 5 years of age.

Stillbirth	Deaths after 28 weeks of pregnancy, but before or during birth.
Perinatal mortality	Stillbirths and deaths that occurred in the perinatal period (last trimester of pregnancy and first week of life).†
Neonatal mortality	Deaths during the first 28 completed days of life.
Early neonatal mortality	Deaths during the first 7 days of life.
Late neonatal mortality	Deaths occurring after the 7th day but before the 28th completed day of life.
Post-neonatal mortality	Deaths occurring between 28 days and 364 days of life.
1-<60- month mortality	Deaths occurring between 28 days of life and exactly 5 years of age.

† Perinatal period is defined as the period commencing at 28 completed weeks of gestation and ending at 7 completed days after birth.

A series of descriptive and inferential analyses were conducted to assess trends in maternal, perinatal, stillbirths, neonatal, post-neonatal, and under-five mortality across the three project catchment areas. Because program implementation began at slightly different calendar times across the three catchment areas, data were reorganized relative to each area's program start date. This approach allowed mortality patterns to be compared over time and among catchment areas based on length of program implementation from the baseline period to the early implementation period (PY1-3), and the later implementation period (PY4-7).

95% confidence intervals (CIs) were calculated for each mortality estimate to account for the statistical uncertainty associated with small numbers of reported deaths. Although these mortality estimates were calculated from population-based vital events registration rather than sample survey data, confidence intervals were included because rare events in small populations may yield unstable rate estimates. This analysis followed the approach described by Perry et al. (2023), who applied a method originally proposed by Selvin for mortality measures based on small numbers in the absence of sampling (Perry et al., 2023; Selvin, 1991). The formula for the 95% CI used in this study is:

D = number of deaths; n = population at risk (number of live births/total births)

$$95\%\ CI = \left(\frac{D-2\sqrt{D}}{n}, \frac{D+2\sqrt{D}}{n}\right)$$

To evaluate changes over time, regression models were fitted with the number of deaths specified as the outcome and the number of live births (or total births for stillbirth and perinatal outcomes) as the exposure term. By including births as an exposure term, the models estimate mortality rates rather than raw counts to account for differences in the population at risk across time periods.

For each mortality category, three complementary models were applied. First, catchment area-year models were fitted to assess linear temporal trends across the implementation period, with mortality counts modeled as a function of program year and catchment area. These models were used to examine whether mortality changed consistently over time and whether mortality levels differed across catchment areas after adjustment for implementation year. Catchment area was included as a categorical covariate to adjust for differences in mortality levels.

Second, mortality counts were aggregated across all three catchment areas to compare baseline with the combined implementation period (PY1-7). The purpose of this model was to improve estimate stability given the relatively small population size and small number of events. Finally, mortality counts were aggregated to compare the earlier implementation period (PY1-3) with the later implementation period (PY4-7) for all three catchment areas.

Model fit and overdispersion were assessed for the catchment area-year models using deviance and Pearson goodness-of-fit tests. For outcomes without substantial overdispersion, Poisson regression was retained. For under-five, post-neonatal and 1-<60-month mortality, tests outcomes suggested lack of fit and negative binomial regression was used for the catchment area-year models. These tests were not applied to the two pooled comparison models because those models were based on only two aggregated observations.

Incidence rate ratios (IRRs) derived from the models were used to quantify relative changes in mortality. IRRs represent the ratio of mortality rates between comparison periods, with

values below 1 indicating a reduction in mortality and values above 1 indicating an increase. All comparisons are reported with 95% confidence intervals and p-values.

Results

Results are presented for maternal mortality, under-five mortality, stillbirth mortality, perinatal mortality, neonatal mortality, early neonatal mortality, late neonatal mortality and post-neonatal (1-59 month) mortality. Tables 2-10 contain the data used for the analyses.

Maternal mortality

Level

At baseline, the pooled maternal mortality ratio across the three catchment areas was 1,140 per 100,000 live births (95% CI: 334-1,945), based on 8 maternal deaths among 702 live births. During the full program period (PY 1-7), 3,088 live births and 9 maternal deaths were registered across all three catchment areas. This corresponds to an overall maternal mortality ratio (MMR) of 291 per 100,000 live births (95% CI: 97-486).

Changes over time

Annual MMR values fluctuated considerably, reflecting the rare nature of maternal deaths in small populations. Using aggregated years to stabilize estimates, maternal mortality declined significantly from baseline to the full program period (PY1-7), with IRR of 0.26 ($p = 0.005$), indicating a 74% reduction in MMR. No significant change was observed when comparing PY1-3 with PY4-7, indicating that most of the decline occurred early, between the baseline and the initial years of the program.

Comparisons between catchment areas

No statistically significant differences in MMR were detected between the three catchment areas when combining data across all years, which is expected given the very small total number of maternal deaths (n = 9 across eight years).

Under-five mortality (0-59 month)

Level

At baseline, a total of 65 deaths of under-five children were reported across the three catchment areas, yielding an U5MR of 93 per 1,000 live births (95% CI: 70-116). During the program implementation, 56 under-five deaths were reported from program years 1 to 7, yielding a U5MR of 18 deaths per 1,000 live births (95% CI: 13-23).

Changes over time

The downward trend in under-five mortality across baseline to implementation years was statistically significant (IRR = 0.71, p<0.001). When data from all three catchment areas were aggregated, under-five mortality showed a large and statistically significant decline from baseline to PY1-7. U5 mortality declined by 80% over the course of implementation (IRR 0.20, 95% CI: 0.14-0.28, p < 0.001). A 16% decline was observed comparing PY4-7 to PY1-3 but this was not statistically significant (IRR = 0.84, 95% CI: 0.48-1.48, p = 0.55).

Comparisons between areas

The differences in under-five mortality rate among the three catchment areas were not statistically significant.

Stillbirth

Level

A total of 31 stillbirths were recorded in the baseline period across three areas, and 48 stillbirths were recorded between program years 1 to 7. This corresponds to a baseline stillbirth rate of 42 per 1,000 total births (95% CI: 27-57) and 15 per 1,000 total births during the period of program implementation (95% CI: 11-20).

Changes over time

The stillbirth rate showed a statistically significant downward trend over time (IRR = 0.67, p < 0.001). Compared to baseline level, stillbirth rates were significantly lower during program implementation (IRR = 0.36, p < 0.001), corresponding to an approximate 64% reduction.

When comparing later implementation years (PY4–7) to earlier years (PY1–3), stillbirth rates were further reduced by approximately 69% (IRR = 0.31, p = 0.004).

Comparisons between areas

After adjustment for implementation period, the differences were not statistically significant across three areas in terms of stillbirth mortality.

Perinatal mortality

Level

A total of 61 perinatal deaths were registered at baseline and 75 perinatal deaths during the implementation period, yielding a baseline perinatal mortality rate of 83 per 1,000 total births (95% CI: 62-105). The perinatal mortality rate during program implementation year was 24 per 1,000 total births (95% CI: 18-29).

Changes over time

Perinatal mortality showed a large and statistically significant decline from baseline to the full program period (PY1-7) when aggregating data from all areas. The IRR comparing PY1-7 with baseline was 0.28 (95% CI: 0.20-0.39, $p < 0.001$), corresponding to a 72% reduction. A further significant decline was also observed within the implementation period. Comparing the early years of the program (PY1-3) with later years (PY4-7), the perinatal mortality rate decreased by 60% (IRR = 0.40, 95% CI: 0.23-0.72, p = 0.002). This suggests a continued improvement in perinatal outcomes across the duration of implementation, beyond the initial baseline-to-program reduction.

Comparisons across program areas

Perinatal mortality rates did not differ significantly across the three catchment areas.

Neonatal mortality (0-27 day)

Level

The baseline neonatal mortality rate was 50 deaths per 1,000 live births (35 neonatal deaths;

95% CI: 33-67). Within program years, a total of 34 neonatal deaths were registered across all three areas, corresponding to a mortality rate of 11 deaths per 1,000 live births (95% CI: 7-15).

Changes over time

Neonatal mortality rate continued to decrease over time; each additional program year was associated with an estimated 39% reduction in neonatal mortality (IRR = 0.61, $p < 0.001$). When data from all three catchment areas were aggregated, neonatal mortality declined substantially from baseline to the program period. The IRR comparing PY1-7 to baseline was 0.22 (95% CI: 0.14–0.35, $p < 0.001$), corresponding to a 79% reduction in neonatal mortality.

The NMR did not differ statistically significantly between PY 1-3 and PY 4-7 (IRR = 0.55, 95% CI: 0.25–1.21, $p = 0.14$). This pattern suggests that much of the mortality reduction occurred early in the project period, followed by a continued but more gradual decline.

Comparisons between areas

Controlling for time, neonatal mortality was lowest in Nyagoto. Nyagoto exhibited significantly lower neonatal mortality compared to both Matongo (IRR = 0.38, $p = 0.008$) and Iranda (IRR = 0.49, $p = 0.049$). There was no statistically significant difference between Matongo and Iranda ($p = 0.39$).

Early neonatal mortality (0-6 day)

Level

In this analysis, early neonatal mortality is defined as deaths during the first 7 days of life. Aggregating all three areas, the baseline early neonatal mortality rate (ENMR) was 43 deaths per 1,000 live births (30 deaths; 95% CI: 27-58). During program years, the overall ENMR declined to 9 deaths per 1,000 live births (95% CI: 5-12).

Changes over time

Early neonatal mortality showed a statistically significant downward trend from baseline across implementation years (IRR = 0.63, $p < 0.001$). Comparing program implementation

years to baseline, early neonatal mortality declined markedly (IRR = 0.20, 95% CI: 0.12–0.34, $p < 0.001$), corresponding to an approximately 80% reduction in mortality. No statistically significant difference was observed between the early and late periods in program implementation (IRR = 0.75, 95% CI: 0.33–1.71, p = 0.50).

Comparisons between areas

Adjusting for implementation year, the difference between Iranda and Matongo was not statistically significant (IRR = 0.82, p = 0.505). However, Nyagoto had a significantly lower early neonatal mortality rate than Matongo (IRR = 0.43, p = 0.033) but did not differ significantly compared with Iranda.

Late neonatal mortality (7-27 day)

Level

In this analysis, late neonatal mortality is defined as deaths after the 7th day but before the 28th completed day of life. Baseline late neonatal mortality was 7.1 per 1,000 live births (5 deaths), compared to 2.3 per 1,000 live births during PY1-7 (7 deaths).

Changes over time

The late neonatal mortality rate continued to decrease from baseline across program implementation years. When modeling continuously for time and adjusting for catchment area, each additional program year was associated with an estimated 49% reduction in late neonatal mortality (IRR = 0.51, p = 0.009). Late neonatal deaths were rare across all three catchment areas, and no deaths were reported after the third year of program implementation.

Comparison across areas

The differences across the three catchment areas were not statistically significant.

Post-neonatal mortality (28-364 day)

Level

Post-neonatal mortality is defined as deaths between 28 days and 364 days of life. During

baseline, 23 deaths were recorded among 702 live births (32.8 per 1,000), compared to 14 deaths among 3,088 live births during PY1-7 (5 per 1,000).

Changes over time

Post-neonatal mortality showed a clear downward trend over time. Each additional program year was associated with an estimated 29% reduction in post-neonatal mortality (IRR = 0.71, p = 0.018). When comparing program implementation years to baseline, post-neonatal mortality was substantially lower during the program period (IRR = 0.14, 95% CI: 0.07–0.27, p < 0.001), corresponding to an approximate 85% reduction. No statistically significant difference was observed between early and later implementation years (IRR = 1.33, p = 0.59).

Comparisons between areas

After adjusting for implementation year, post-neonatal mortality did not differ significantly across the three catchment areas.

1-<60- month mortality (1-59 month)

Level

1-<60- month mortality was defined as death between 28 days of life and exactly 5 years of age. At baseline, a total of 30 1-<60- month deaths were reported, the corresponding baseline 1-<60- month mortality rate was 43 deaths per 1,000 live births (95% CI: 27-58). There was a total of 22 1-<60- month deaths in the years of implementation. The 1-<60- month mortality rate was 7 deaths per 1,000 live births (95% CI: 4 to 10).

Changes over time

1-<60- month mortality rate declined over time (IRR = 0.79, p = 0.035). Across all three areas, the 1-<60- month mortality rate declined sharply by 83% (p < 0.001) from baseline. Within the program implementation period, the mortality in PY4-7 did not differ significantly from PY1-3 (IRR = 1.48, p = 0.36). The overall decline in 1-<60- month mortality occurred mostly early in the project rather than progressively over time.

Comparisons across program areas

1-<60- month mortality did not differ significantly across the three catchment areas.

Table 2. Number of live births, maternal deaths, and maternal mortality ratios (MMRs) in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of live births registered	No. of maternal deaths registered	MMR (95% CI)	No. of live births registered	No. of maternal deaths registered	MMR (95% CI)	No. of live births registered	No. of maternal deaths registered	MMR (95% CI)	No. of live births registered	No. of maternal deaths registered	MMR (95% CI)
a. By program years												
Baseline	219	3	1370 (0, 2952)	303	2	660 (0, 1594)	180	3	1667 (0, 3591)	702	8	1140 (334, 1945)
PY 1	208	1	481 (0, 1442)	309	1	324 (0, 971)	241	2	830 (0, 2003)	758	4	528 (0, 1055)
PY 2	217	1	461 (0, 1382)	290	0	0	218	0	0	725	1	138 (0, 414)
PY 3	158	0	0	209	0	0	128	0	0	495	0	0
PY 4	111	0	0	121	0	0	138	0	0	370	0	0
PY 5	110	0	0	174	0	0	146	2	1370 (0, 3307)	430	2	465 (0, 1123)
PY 6†	126	1	794 (0, 2381)	126	1	794 (0, 2381)	14	0	0	266	2	752 (0, 1815)
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1193	6	503 (92, 914)	1532	4	261 (0, 522)	1065	7	657 (160, 1154)	3790	17	449 (231, 666)
b. Consolidated data and total by program years												
Baseline	219	3	1370 (0, 2952)	303	2	660 (0, 1594)	180	3	1667 (0, 3591)	702	8	1140 (334, 1945)
PY 1-3	583	2	343 (0, 828)	808	1	124 (0, 371)	587	2	341 (0, 823)	1978	5	253 (27, 479)
PY 4-7	391	1	255 (0, 767)	421	1	238 (0, 713)	298	2	671 (0, 1620)	1110	4	360 (0, 721)
PY 1-7	974	3	308 (0, 664)	1229	2	163 (0, 393)	885	4	452 (0, 904)	3088	9	291 (97, 486)
Total	1193	6	503 (92, 914)	1532	4	261 (0, 522)	1065	7	657 (160, 1154)	3790	17	449 (231, 666)

† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Table 3. Number of live births, under-five deaths, and under-five mortality rates (U5MRs) in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of live births registered	No. of 0-<60m deaths registered	U5MR (95% CI)	No. of live births registered	No. of 0-<60m deaths registered	U5MR (95% CI)	No. of live births registered	No. of 0-<60m deaths registered	U5MR (95% CI)	No. of live births registered	No. of 0-<60m deaths registered	U5MR (95% CI)
a. By program years												
Baseline	219	24	110 (65, 154)	303	28	92 (57, 127)	180	13	72 (32, 112)	702	65	93 (70, 116)
PY 1	208	8	38 (11, 66)	309	13	42 (19, 65)	241	3	12 (0, 27)	758	24	32 (19, 45)
PY 2	217	3	14 (0, 30)	290	4	14 (0, 28)	218	2	9 (0, 22)	725	9	12 (4, 21)
PY 3	158	3	19 (0,41)	209	2	10 (0, 23)	128	0	0	495	5	10 (1, 19)
PY 4	111	2	18 (0, 43)	121	3	25 (0, 53)	138	2	14 (0, 35)	370	7	19 (5, 33)
PY 5	110	1	9 (0, 27)	174	1	6 (0, 17)	146	4	27 (0, 55)	430	6	14 (3, 25)
PY 6†	126	2	16 (0, 2381)	126	3	24 (0, 51)	14	0	0	266	5	19 (2, 36)
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1193	43	36 (25, 47)	1532	54	35 (26, 45)	1065	24	23 (13, 32)	3790	121	32 (26, 38)
b. Consolidated data and total by program years												
Baseline	219	24	110 (65, 154)	303	28	92 (57, 127)	180	13	72 (32, 112)	702	65	93 (70, 116)
PY 1-3	583	14	24 (11, 37)	808	19	24 (13, 34)	587	5	9 (1, 16)	1978	38	19 (13, 25)
PY 4-7	391	5	13 (1, 24)	421	7	17 (4, 29)	298	6	20 (4, 37)	1110	18	16 (9, 24)
PY 1-7	974	19	20 (11, 28)	1229	26	21 (13, 29)	885	11	12 (5, 20)	3088	56	18 (13, 23)
Total	1193	43	36 (25, 47)	1532	54	35 (26, 45)	1065	24	23 (13, 32)	3790	121	32 (26, 38)

† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Table 4. Number of total births, stillbirths, and stillbirth rates in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of total births registered	No. of stillbirths registered	Stillbirth Rate (95% CI)	No. of total births registered	No. of stillbirths registered	Stillbirth Rate (95% CI)	No. of total births registered	No. of stillbirths registered	Stillbirth Rate (95% CI)	No. of total births registered	No. of stillbirths registered	Stillbirth Rate (95% CI)
a. By program years												
Baseline	228	9	39 (13, 66)	321	18	56 (30, 83)	184	4	22 (0, 43)	733	31	42 (27, 57)
PY 1	211	3	14 (0, 31)	322	13	40 (18, 63)	246	5	20 (2, 39)	779	21	27 (15, 39)
PY 2	221	4	18 (0, 36)	295	5	17 (2, 32)	224	6	27 (5, 49)	740	15	20 (10, 31)
PY 3	159	1	6 (0,19)	211	2	9 (0, 23)	130	2	15 (0, 37)	500	5	10 (1, 19)
PY 4	111	0	0	122	1	8 (0, 25)	141	3	21 (0, 46)	374	4	11 (0, 21)
PY 5	111	1	9 (0, 27)	174	0	0	146	0	0	431	1	2 (0, 7)
PY 6†	127	1	8 (0, 24)	127	1	8 (0, 24)	14	0	0	268	2	7 (0, 18)
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1212	19	16 (8, 23)	1572	40	25 (17, 33)	1085	20	18 (10, 27)	3869	79	20 (16, 25)
b. Consolidated data and total by program years												
Baseline	228	9	39 (13, 66)	321	18	56 (30, 83)	184	4	22 (0, 43)	733	31	42 (27, 57)
PY 1-3	591	8	14 (4, 23)	828	20	24 (13, 35)	600	13	22 (10, 34)	2019	41	20 (14, 27)
PY 4-7	393	2	5 (0, 12)	423	2	5 (0, 11)	301	3	10 (0, 21)	1117	7	6 (2, 1)
PY 1-7	984	10	10 (4, 17)	1251	22	18 (10, 25)	901	16	18 (9, 27)	3136	48	15 (11, 20)
Total	1212	19	16 (8, 23)	1572	40	25 (17, 33)	1085	20	18 (10, 27)	3869	79	20 (16, 25)

† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Table 5. Number of total births, perinatal deaths, and perinatal mortality rates (PNMRs) in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of total births registered	No. of perinatal deaths registered	PNMR (95% CI)	No. of total births registered	No. of perinatal deaths registered	PNMR (95% CI)	No. of total births registered	No. of perinatal deaths registered	PNMR (95% CI)	No. of total births registered	No. of perinatal deaths registered	PNMR (95% CI)
a. By program years												
Baseline	228	21	92 (52, 132)	321	31	97 (62, 131)	184	9	49 (16, 82)	733	61	83 (62, 105)
PY 1	211	7	33 (8, 58)	322	18	56 (30, 82)	246	6	24 (4, 44)	779	31	40 (25, 54)
PY 2	221	5	23 (2, 43)	295	9	31 (10, 51)	224	8	36 (10, 61)	740	22	30 (17, 42)
PY 3	159	3	19 (0, 41)	211	2	9 (0, 23)	130	2	15 (0, 37)	500	7	14 (3, 25)
PY 4	111	2	18 (0, 43)	122	4	33 (0, 66)	141	3	21 (0, 46)	374	9	24 (8, 40)
PY 5	111	2	18 (0, 43)	174	0	0	146	1	7 (0, 21)	431	3	7 (0, 15)
PY 6†	127	1	8 (0, 24)	127	2	16 (0, 38)	14	0	0	268	3	11 (0, 24)
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1212	41	34 (23, 44)	1572	66	42 (32, 52)	1085	29	27 (17, 37)	3869	136	35 (29, 41)
b. Consolidated data and total by program years												
Baseline	228	21	92 (52, 132)	321	31	97 (62, 131)	184	9	49 (16, 82)	733	61	83 (62, 105)
PY 1-3	591	15	25 (12, 38)	828	29	35 (22, 48)	600	16	27 (13, 40)	2019	60	30 (22, 37)
PY 4-7	393	5	13 (1, 24)	423	6	14 (3, 26)	301	4	13 (0, 27)	1117	15	13 (6, 20)
PY 1-7	984	20	20 (11, 29)	1251	35	28 (19, 37)	901	20	22 (12, 32)	3136	75	24 (18, 29)
Total	1212	41	34 (23, 44)	1572	66	42 (32, 52)	1085	29	27 (17, 37)	3869	136	35 (29, 41)

† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Table 6. Number of live births, neonatal deaths, and neonatal mortality rates (NMRs) in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of live births registered	No. of neonatal deaths registered	NMR (95% CI)	No. of live births registered	No. of neonatal deaths registered	NMR (95% CI)	No. of live births registered	No. of neonatal deaths registered	NMR (95% CI)	No. of live births registered	No. of neonatal deaths registered	NMR (95% CI)
a. By program years												
Baseline	219	14	64 (30, 98)	303	15	50 (24, 75)	180	6	33 (6, 61)	702	35	50 (33, 67)
PY 1	208	7	34 (8, 59)	309	7	23 (6, 40)	241	1	4 (0, 12)	758	15	20 (10, 30)
PY 2	217	2	9 (0, 22)	290	4	14 (0, 28)	218	2	9 (0, 22)	725	8	11 (3, 19)
PY 3	158	2	13 (0, 31)	209	1	5 (0, 14)	128	0	0	495	3	6 (0, 13)
PY 4	111	2	18 (0, 43)	121	3	25 (0, 53)	138	0	0	370	5	14 (1, 26)
PY 5	110	1	9 (0, 27)	174	0	0	146	1	7 (0, 21)	430	2	5 (0, 11)
PY 6†	126	0	0	126	1	8 (0, 24)	14	0	0	266	1	4 (0, 11)
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1193	28	23 (15, 32)	1532	31	20 (13, 28)	1065	10	9 (3, 15)	3790	69	18 (14, 23)
b. Consolidated data and total by program years												
Baseline	219	14	64 (30, 98)	303	15	50 (24, 75)	180	6	33 (6, 61)	702	35	50 (33, 67)
PY 1-3	583	11	19 (7, 39)	808	12	15 (6, 23)	587	3	5 (0, 11)	1978	26	13 (8, 18)
PY 4-7	391	3	8 (0, 17)	421	4	10 (0, 19)	298	1	3 (0, 10)	1110	8	7 (2, 12)
PY 1-7	974	14	14 (7, 22)	1229	16	13 (7, 20)	885	4	5 (0, 9)	3088	34	11 (7, 15)
Total	1193	28	23 (15, 32)	1532	31	20 (13, 28)	1065	10	9 (3, 15)	3790	69	18 (14, 23)

† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Table 7. Number of live births, early neonatal deaths, and early neonatal mortality rates (ENMRs) in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of live births registered	No. of early neonatal deaths registered	ENMR (95% CI)	No. of live births registered	No. of early neonatal deaths registered	ENMR (95% CI)	No. of live births registered	No. of early neonatal deaths registered	ENMR (95% CI)	No. of live births registered	No. of early neonatal deaths registered	ENMR (95% CI)
a. By program years												
Baseline	219	12	55 (23, 86)	303	13	43 (19, 67)	180	5	28 (3, 53)	702	30	43 (27, 58)
PY 1	208	4	19 (0, 38)	309	5	16 (2, 31)	241	1	4 (0, 12)	758	10	13 (5, 22)
PY 2	217	1	5 (0, 14)	290	4	14 (0, 28)	218	2	9 (0, 22)	725	7	10 (2, 17)
PY 3	158	2	13 (0, 31)	209	0	0	128	0	0	495	2	4 (0, 10)
PY 4	111	2	18 (0, 43)	121	3	25 (0, 53)	138	0	0	370	5	14 (1, 26)
PY 5	110	1	9 (0, 27)	174	0	0	146	1	7 (0, 21)	430	2	5 (0, 11)
PY 6†	126	0	0	126	1	8 (0, 24)	14	0	0	266	1	4 (0, 11)
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1193	22	18 (11, 26)	1532	26	17 (10, 24)	1065	9	8 (3, 14)	3790	57	15 (11, 19)
b. Consolidated data and total by program years												
Baseline	219	12	55 (23, 86)	303	13	43 (19, 67)	180	5	28 (3, 53)	702	30	43 (27, 58)
PY 1-3	583	7	12 (3, 21)	808	9	11 (4, 19)	587	3	5 (0, 11)	1978	19	10 (5, 14)
PY 4-7	391	3	8 (0, 17)	421	4	10 (0, 19)	298	1	3 (0, 10)	1110	8	7 (2, 12)
PY 1-7	974	10	10 (4, 17)	1229	13	11 (5, 16)	885	4	5 (0, 9)	3088	27	9 (5, 12)
Total	1193	22	18 (11, 26)	1532	26	17 (10, 24)	1065	9	8 (3, 14)	3790	57	15 (11, 19)

† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Table 8. Number of live births, late neonatal deaths, and late neonatal mortality rates (LNMRs) in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of live births registered	No. of late neonatal deaths registered	LNMR (95% CI)	No. of live births registered	No. of late neonatal deaths registered	LNMR (95% CI)	No. of live births registered	No. of late neonatal deaths registered	LNMR (95% CI)	No. of live births registered	No. of late neonatal deaths registered	LNMR (95% CI)
a. By program years												
Baseline	219	2	9 (0, 22)	303	2	7 (0, 16)	180	1	6 (0, 17)	702	5	7 (1, 13)
PY 1	208	3	14 (0, 31)	309	2	6 (0, 16)	241	0	0	758	5	7 (1, 12)
PY 2	217	1	5 (0, 14)	290	0	0	218	0	0	725	1	1 (0, 4)
PY 3	158	0	0	209	1	5 (0, 14)	128	0	0	495	1	2 (0, 6)
PY 4	111	0	0	121	0	0	138	0	0	370	0	0
PY 5	110	0	0	174	0	0	146	0	0	430	0	0
PY 6†	126	0	0	126	0	0	14	0	0	266	0	0
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1193	6	5 (1, 9)	1532	5	3 (0, 6)	1065	1	1 (0, 3)	3790	12	3 (1, 5)
b. Consolidated data and total by program years												
Baseline	219	2	9 (0, 22)	303	2	7 (0, 16)	180	1	6 (0, 17)	702	5	7 (1, 13)
PY 1-3	583	4	7 (0, 14)	808	3	4 (0, 8)	587	0	0	1978	7	4 (1, 6)
PY 4-7	391	0	0	421	0	0	298	0	0	1110	0	0
PY 1-7	974	4	4 (0, 8)	1229	3	0	885	0	0	3088	7	2 (1, 4)
Total	1193	6	5 (1, 9)	1532	5	3 (0, 6)	1065	1	1 (0, 3)	3790	12	3 (1, 5)

† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Table 9. Number of live births, post-neonatal deaths, and post-neonatal mortality rates in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of live births registered	No. of post-neonatal deaths registered	Post-neonatal mortality rate (95% CI)	No. of live births registered	No. of post-neonatal deaths registered	Post-neonatal mortality rate (95% CI)	No. of live births registered	No. of post-neonatal deaths registered	Post-neonatal mortality rate (95% CI)	No. of live births registered	No. of post-neonatal deaths registered	Post-neonatal mortality rate (95% CI)
a. By program year												
Baseline	219	5	23 (2, 43)	303	13	43 (19, 67)	180	5	28 (3, 53)	702	23	33 (19, 46)
PY 1	208	1	5 (0, 14)	309	4	13 (0, 26)	241	1	4 (0, 12)	758	6	8 (1, 14)
PY 2	217	1	5 (0, 14)	290	0	0	218	0	0	725	1	1 (0, 4)
PY 3	158	0	0	209	1	5 (0, 14)	128	0	0	495	1	2 (0, 6)
PY 4	111	0	0	121	0	0	138	1	7 (0, 22)	370	1	3 (0, 8)
PY 5	110	0	0	174	1	6 (0, 17)	146	1	7 (0, 22)	430	2	5 (0, 11)
PY 6†	126	1	8 (0, 24)	126	2	16 (0, 38)	14	0	0	266	3	11 (0, 24)
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1193	8	7 (2, 11)	1532	21	14 (8, 20)	1065	8	8 (2, 13)	3790	37	10 (7, 13)
b. Consolidated data and total by program years												
Baseline	219	5	23 (2, 43)	303	13	43 (19, 67)	180	5	28 (3, 53)	702	23	33 (19, 46)
PY 1-3	583	2	3 (0, 8)	808	5	6 (1, 12)	587	1	2 (0, 5)	1978	8	4 (1, 7)
PY 4-7	391	1	3 (0, 8)	421	3	7 (0, 15)	298	2	7 (0, 16)	1110	6	5 (1, 10)
PY 1-7	974	3	3 (0, 7)	1229	8	7 (2, 11)	885	3	3 (0, 7)	3088	14	5 (2, 7)
Total	1193	8	7 (2, 11)	1532	21	14 (8, 20)	1065	8	8 (2, 13)	3790	37	10 (7, 13)

† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Table 10. Number of live births and deaths among children 1-<60- months of age and corresponding mortality rates in catchment areas, 2017-2024

Years	Catchment Area											
	Matongo			Iranda			Nyagoto			All Areas		
	No. of live births registered	No. of 1- < 60 m deaths registered	1- < 60- m mortality rate (95% CI)	No. of live births registered	No. of 1- < 60 m deaths registered	1- < 60 m mortality rate (95% CI)	No. of live births registered	No. of 1- < 60 m deaths registered	1- < 60 m mortality rate (95% CI)	No. of live births registered	No. of 1- < 60 m deaths registered	1- < 60 m mortality rate (95% CI)
a. By program years												
Baseline	219	10	46 (17, 75)	303	13	43 (19, 67)	180	7	39 (9, 68)	702	30	43 (27, 58)
PY 1	208	1	5 (0, 14)	309	6	19 (4, 35)	241	2	8 (0, 20)	758	9	12 (4, 20)
PY 2	217	1	5 (0, 14)	290	0	0	218	0	0	725	1	1 (0, 4)
PY 3	158	1	6 (0, 19)	209	1	5 (0, 14)	128	0	0	495	2	4 (0, 10)
PY 4	111	0	0	121	0	0	138	2	14 (0, 35)	370	2	5 (0, 13)
PY 5	110	0	0	174	1	6 (0, 17)	146	3	21 (0, 44)	430	4	9 (0, 19)
PY 6†	126	2	16 (0, 38)	126	2	16 (0, 38)	14	0	0	266	4	15 (0, 30)
PY 7‡	44	0	0	X	X	X	X	X	X	44	0	0
Total	1193	15	13 (6, 19)	1532	23	15 (9, 21)	1065	14	13 (6, 20)	3790	52	14 (10, 18)
b. Consolidated data and total by program years												
Baseline	219	10	46 (17, 75)	303	13	43 (19, 67)	180	7	39 (9, 68)	702	30	43 (27, 58)
PY 1-3	583	3	5 (0, 11)	808	7	9 (2, 15)	587	2	3 (0, 8)	1978	12	6 (3, 10)
PY 4-7	391	2	5 (0, 12)	421	3	7 (0, 15)	298	5	17 (2, 32)	1110	10	9 (3, 15)
PY 1-7	974	5	5 (1, 10)	1229	10	8 (3, 13)	885	7	8 (2, 14)	3088	22	7 (4, 10)
Total	1193	15	13 (6, 19)	1532	23	15 (9, 21)	1065	14	13 (6, 20)	3790	52	14 (10, 18)

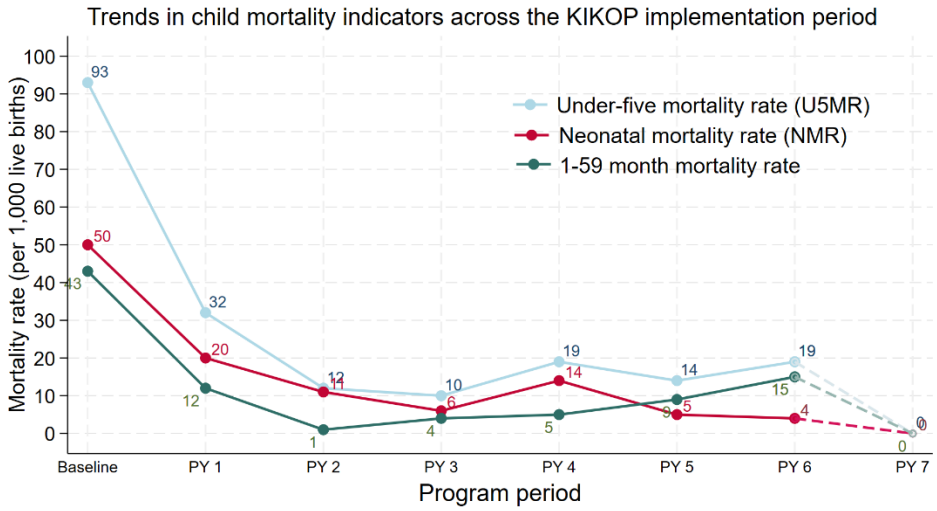
† Program implementation began sequentially in catchment areas, PY6 is complete for Matongo. Iranda and Nyagoto include data through December 31, 2024.
‡ Program implementation began sequentially in catchment areas, PY7 only includes data for Matongo through December 31, 2024.

Discussion

Principal findings

Substantial and sustained improvements were observed across most mortality indicators during the period of KIKOP implementation, including maternal, stillbirth, perinatal, neonatal, post-neonatal, and under-five mortality. The largest reductions generally occurred between baseline and the early years of implementation, after which mortality levels remained comparatively low. The decline in child mortality appeared to be driven primarily by improvements in the perinatal and neonatal period and differences across catchment areas were limited for most indicators.

Figure 1. Trends in child mortality indicators over the KIKOP implementation period



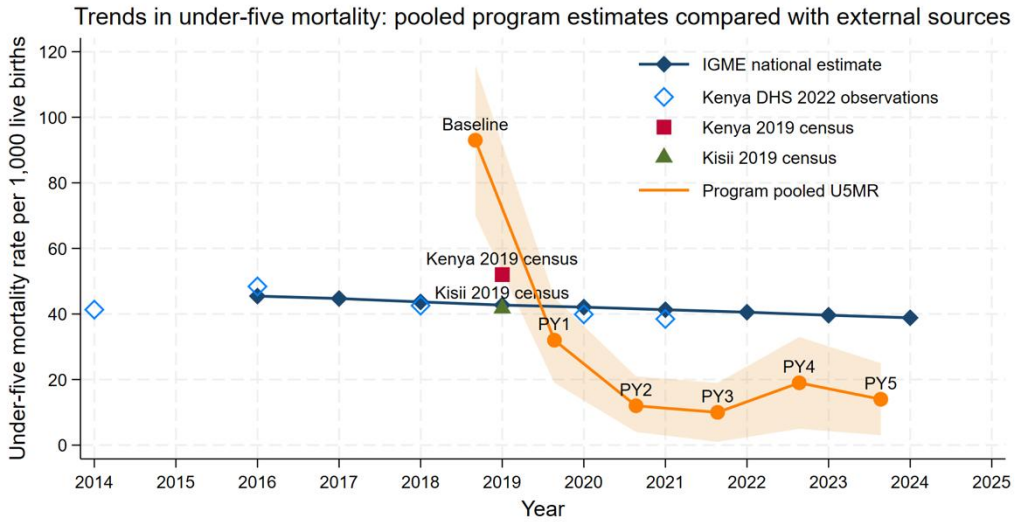
The trends and magnitude of mortality reduction observed in this study are broadly consistent with the wider literature on the CBIO, CBIO+, and Care Group approaches, which have documented meaningful improvements in maternal and child survival across a range of resource-constrained settings. Reviews of the CBIO approach and its adaptations in Bolivia, Guatemala, and Liberia have reported substantial mortality reductions, although the scale of change has varied across program contexts. In Bolivia, the Montero CBIO project reported approximately a 50% reduction in under-five mortality within five years of implementation

(Perry et al., 2003). In Guatemala, implementation of the CBIO+ approach was associated with an estimated 59.1% reduction in maternal mortality and a 24% decline in under-five mortality (Perry et al., 2023). In Liberia, LiST-based modeling suggested that under-five mortality declined by approximately 63% over four years of program implementation (Zomonway et al., 2026).

Comparing with national/county levels

Prior to the program's implementation, child mortality in the catchment areas was substantially higher than both the national and county averages reported in the Kenya 2022 DHS and other external estimates. Following the implementation of the program, substantial reductions in child mortality indicators were observed in the catchment areas. While national under-five mortality declined gradually between 2017 and 2024, the sharper reductions observed in the program areas suggest that national trends alone are unlikely to fully explain the improvements. These findings are consistent with the potential contribution of the program's integrated community-based interventions and strengthened service delivery within the catchment population.

Figure 2. U5MR trends in pooled program estimates compared with external sources

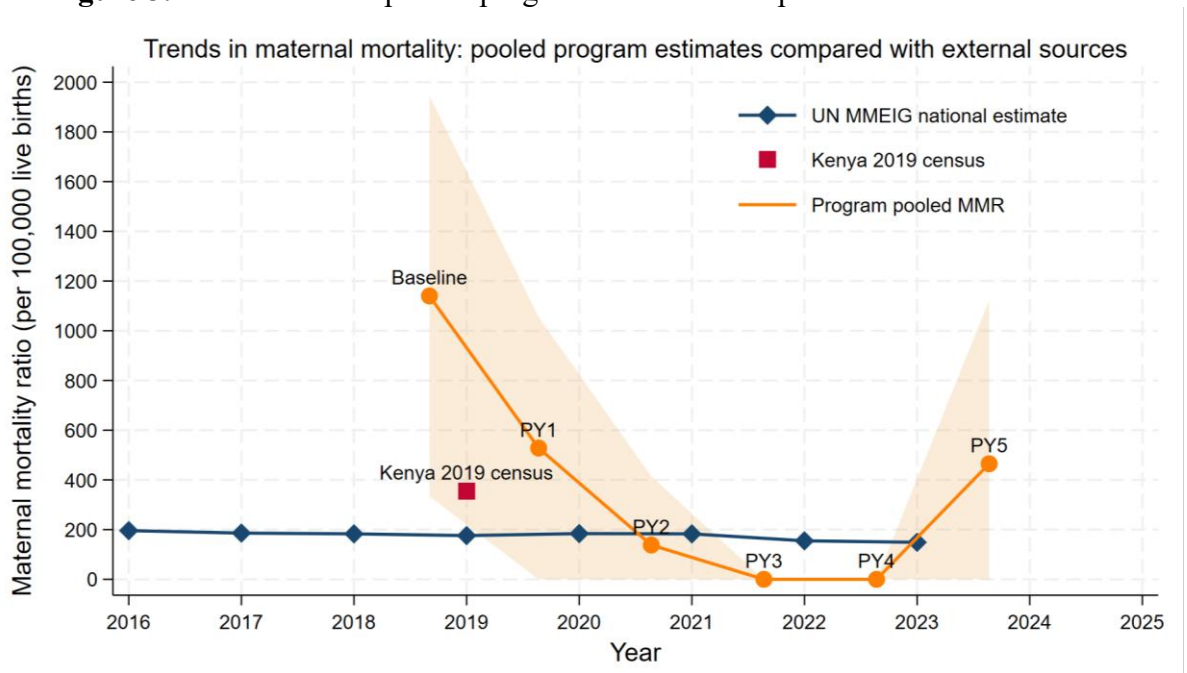


*Program estimates were pooled across the three catchment areas. Shaded bands indicate 95% confidence intervals.

In comparison, maternal mortality trends were more difficult to interpret. Maternal deaths

are relatively rare events, and only a small number of events (0 to 8) were captured in the population each year given size of the population. Consequently, maternal mortality ratio estimates were highly sensitive to small changes in the number of death and showed wide confidence intervals. Although the program's community-based surveillance system has confidence in capturing births and deaths comprehensively, the small number of maternal deaths limits the ability to draw firm conclusions regarding temporal trends or potential program impact.

Figure 3. MMR trends in pooled program estimates compared with external sources



*Program estimates were pooled across the three catchment areas. Shaded bands indicate 95% confidence intervals.

Main driver of child mortality reduction: perinatal and neonatal period

Although reductions were observed in multiple child mortality indicators, the most pronounced improvements occurred in stillbirth, perinatal, and neonatal mortality. Within neonatal mortality, early neonatal mortality contributed to most of the decline. The decline in neonatal mortality also played a major role in the decline in U5MR. Similarly, the Guatemala CBIO+ mortality assessment, early neonatal mortality also represented the largest share of neonatal deaths; nearly two-thirds of neonatal deaths occurred on the first day of life and more

than four-fifths occurred within the first week (Perry et al., 2023).

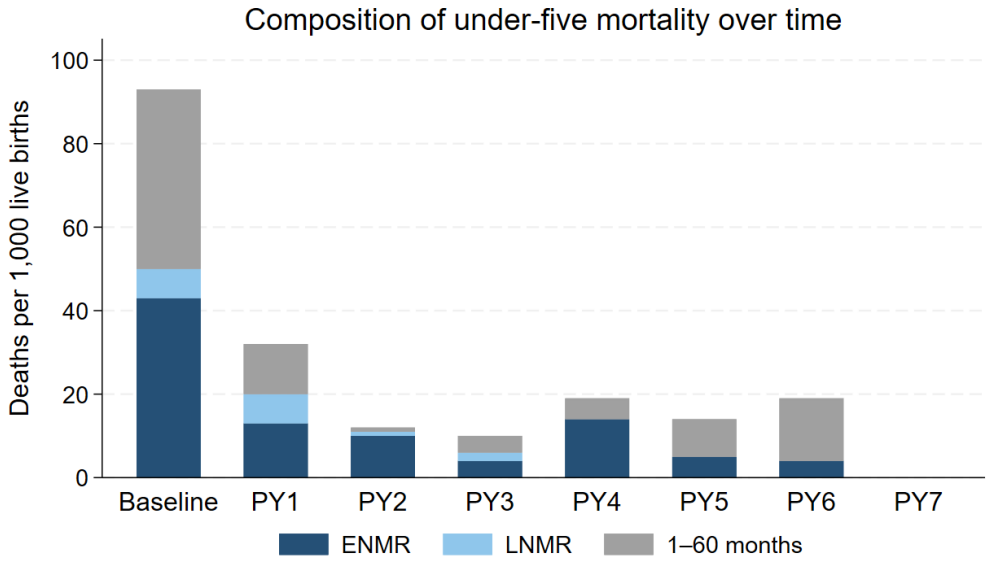
Although this study was not designed to attribute mortality decline to specific program components, prior literature provides insight into possible pathways. The same study from Guatemala found that home birth was associated with a markedly higher risk of neonatal death, highlighting the importance of timely access to skilled delivery and immediate newborn care. Care Group projects have shown to bring strong improvements in behaviors and services related to child survival, including appropriate diarrhea treatment, pneumonia care seeking, immunization uptake, feeding practices, and preventive child health practices (Perry et al., 2015). Together, those findings suggest that mortality in the earliest phase of life is highly sensitive to intrapartum conditions, birth attendance, referral delays, and early postnatal management.

KIKOP emphasized identification of pregnant women, routine household visits, Care Group meetings, promotion of maternal and newborn danger sign recognition, and stronger community-facility linkages. Together, these activities may have had their greatest influence on timely care seeking, safer delivery, and immediate newborn management, which are especially relevant to stillbirth, perinatal, and early neonatal survival.

Changing priorities for child mortality improvement

Because early neonatal deaths accounted for most neonatal deaths at baseline in KIKOP, reductions in this group had a particularly large effect on the overall neonatal mortality rate and by extension on under-five mortality. However, as neonatal mortality declined, the relative contribution of deaths occurring after the neonatal period became more prominent. The proportion of deaths occurring between 1 to 59 months increased from 46% at baseline to 79% at the end of sixth program year.

Figure 4. Composition of under-five mortality over the KIKOP implementation period



This shift suggests the importance of shifting program intervention to post-neonatal deaths, focusing on common causes of post-neonatal child mortality, including diarrhea, pneumonia, malaria, and malnutrition. Continued progress in under-five survival therefore depends not only on improvements in the perinatal period but also on attention to nutrition, infection prevention, timely care seeking, and treatment continuity during infancy and early childhood.

In that sense, KIKOP may now be entering a stage in which the next marginal gains in child survival will come less from further steep reductions in neonatal mortality and more from sustained attention to post-neonatal mortality.

Early versus sustained effects

Another pattern observed was that the largest improvements occurred between baseline and the early years of implementation, while comparisons between earlier and later implementation stages (PY 1-3 vs PY 4-7) were generally smaller and less often statistically significant. The continuous-time models still supported an overall downward trend across several indicators.

This pattern suggests that the three areas showed rapid early gains, and then quickly maintained at lower mortality levels. Similar patterns have also been documented in other CBIO and Care Group experience. In Liberia, rapid gains in service coverage and large estimated declines in under-five mortality were achieved in four years of program

implementation. In contrast, Montero program in Bolivia shows how mortality reductions can accumulate over a long period of time once mortality levels are low. In that program, it took approximately 12 years for the under-five mortality rate to decline from around 7 to 3.2 per 1,000 live births (Chavez et al., 2020). These examples suggest that CBPHC programs may often produce their most visible declines early, when unmet need is greatest and key maternal and child health practices can improve quickly, followed by a later phase of slower improvement and maintenance. KIKOP appears to fit that general pattern.

Geographic variation

Across the three catchment areas, mortality patterns were similar for most outcomes once implementation year was taken into account. Area differences were generally limited, which may suggest that the program model was implemented in a sufficiently similar way across the catchments to generate shared improvements. The main exception was neonatal mortality, where Nyagoto showed lower rates than Matongo and Iranda, with a similar pattern for early neonatal mortality relative to Matongo.

Nonetheless, prior CBIO experience suggests that local differences in implementation strength, duration of exposure, community trust, or facility linkage can produce meaningful sub-area variation even within the same program. For KIKOP, the broader pattern is that most gains were shared across areas, while neonatal survival may have improved more strongly in Nyagoto for reasons that warrant further investigation.

Limitations

The CBIO approach relies on multiple complementary data sources including routine home visitation (RHV) records, annual vital events (VE) registrations, and Care Group documentation to support community health surveillance. However, the KIKOP program was unable to maintain the Care Group tracking system, and resource constraints limited the team's ability to process RHV records from their raw form. As a result, this analysis is primarily based

on the annual VE registers, with RHV information incorporated only in a derived pre-processed dataset after VE data had already been cleaned. Because the team did not have insight into all steps of RHV data cleaning, it is possible that some individual events were missed during that consolidation. Nevertheless, the use of VE records as the primary data source provides a strong and coherent foundation for the mortality estimates presented.

Another limitation is related to the realignment of vital events (VE) data collection time points in 2022. Because the three program areas began implementation at different points in the calendar year, their annual censuses were also conducted at different times, complicating direct comparisons across areas. In 2022, no VE data were collected between July and December in Matongo, between February and December in Iranda, and during December in Nyagoto. The next round of data collection took place simultaneously across all three areas in November-December 2023 and relied on respondents' recall of events that occurred from January to December 2023. This gap in data collection introduces the potential for underreporting. However, when events were disaggregated by month, no substantial drop in reported number of births was observed for the months affected by the gap, suggesting that households may have retrospectively reported events during the subsequent annual census. For this reason, the gap months were retained in the analysis. Nonetheless, the irregular timing of VE collection and reliance on extended recall periods could have reduced the completeness of the data relative to continuous surveillance.

Finally, this study has limited ability to attribute the observed mortality declines to KIKOP interventions. Although comparisons with external sources and mortality levels suggest that external factors alone are unlikely to fully explain the magnitude of change observed in the catchment areas, the absence of a control area, incomplete process documentation, and lack of repeated measurement of knowledge, practices, and coverage mean that the study cannot directly test whether change occurred through the pathways proposed in the program's theory

of change.

Health systems and public health implications

These findings have implications beyond KIKOP project and the three catchment areas. First, they highlight the practical value of community-based vital events surveillance within routine PHC information systems. Although Kenya has made progress in civil registration and health information systems, mortality reporting remains uneven across places and reporting platforms, and routine facility-based systems do not fully capture deaths occurring outside facilities. The 2023 Kenya Vital Statistics Report shows that more than 16% of neonatal deaths are registered as occurring in the community rather than in health facilities, while death registration remains concentrated in a relatively small number of counties, highlighting persistent geographic inequities in mortality visibility (KNBS, 2025). At the same time, evidence from Kenya's PHC reform literature suggests that health information and digital integration remain incomplete, including at the level of Primary Care Networks (PCNs) and community systems (Amboko et al., 2025). Findings from KIKOP's community-based vital events system suggest that local mortality levels and patterns may differ significantly from national estimates alone. Insights from community based surveillance can help better identify key contributing factors to mortality decline and the directions for future program adaptation. From a policy perspective, this suggests that electronic community health information system (eCHIS) should be more fully operationalized and better integrated into PHC monitoring and planning processes so that community-generated data can inform decision-making at community, facility, and sub-county levels.

The findings and the KIKOP experience also suggest that implementation actors beyond government health departments, particularly NGOs and other external partners, should be better aligned with county community health systems rather than operating in parallel. Existing evidence on PHC and PCN implementation in Kenya shows that a lack of policy awareness,

relevance, and prioritization is common at the local level of the health administration team. Without dedicated financing and budget arrangements, community outreach activities often remain highly dependent on partner support (Amboko et al., 2025; Karimi et al., 2025). NGO activities like KIKOP's can help fill important operational gaps by sustaining household outreach, community mobilization, and mortality surveillance in underserved settings. However, the limited coordination between NGO-led activities and county health department teams may reduce the impact of these efforts. In the case of KIKOP, this challenge is reflected in the difficulty in aligning project activities with the county agenda and in the limited exchange between project-generated data and government information systems. As a result, activities and evidence remain separate and siloed rather than mutually reinforcing. Beyond increasing NGO participation, alignment between partner activities and the county's PHC workplan is critically important. NGO activities should be linked to and incorporated into government accountability, reporting, and planning structures. This would include clearer roles for the government's primary health networks in oversight and accountability, stronger ownership and integration of data, and efficient use of external partners and resources to support the public system's PHC functions (Karuga et al., 2023; Amboko et al., 2025; Karimi et al., 2025).

Conclusion

This study provides a comprehensive assessment of mortality patterns across three catchment areas over seven years of KIKOP implementation in rural Kisii County, Kenya. Substantial declines were observed in most maternal and child mortality indicators, with the largest improvements seen in stillbirth, perinatal, neonatal, and under-five mortality. The findings suggest that CBPHC approaches, supported by local vital events surveillance, can generate useful insight into mortality patterns in settings where routine registration systems remain incomplete. Comparisons between mortality levels in the program areas and external sources further suggest that the observed reductions are unlikely to be explained by secular

trends alone. However, in the absence of a comparison group and sufficient process indicators, conclusions regarding program attribution should remain cautious. Overall, these analyses contribute to KIKOP's ongoing population health surveillance, provide a foundation for future analyses, and offer useful guidance for program adaptation.

Practicum experiences

Project #1: Mortality Trends Assessment of a Community-Based Primary Health Care Program Implementation in Rural Kisii County, Kenya

Organization: Impact Global Health Alliance; Kisii Konya Oroiboro Project

Student's Role: Data analyst consultant

Activities and key deliverables

1. Managed and cleaned a longitudinal mortality dataset (2017-2024) from a CBPHC program, developing a structured data cleaning protocol and coding rules in Stata.
2. Verified birth and mortality records by cross-checking digital data with paper surveillance forms and archival records, working with field officers to resolve discrepancies and deduplicate observations.
3. Calculated mortality rates for multiple indicators including maternal mortality, stillbirth, perinatal, neonatal, post-neonatal, and under-five mortality, supporting population-level mortality surveillance.
4. Constructed Poisson regression models in Stata to assess temporal trends in mortality rates and evaluate changes over program implementation years.
5. Organized findings into MSPH capstone thesis examining mortality trends in a CBPHC program in rural Kenya.
6. Facilitated the organization of a 7-day field visit and workshop in program site in Kenya.

Project #2: Global Primary Health Care - Global Health Established Field Placement

Organization: International Institute for Primary Health Care - Ethiopia

Student's Role: Global PHC Intern

Activities and key deliverables

1. Contributed to the implementation and improvement of the Global Primary Health Care (PHC) training program, which equips health system managers and implementers with

skills to design and lead PHC service delivery.

2. Conducted course evaluation analysis using participation tracker data, descriptive statistics from survey responses, and qualitative feedback coding; synthesized findings and recommendations into a written evaluation presented with the program team to inform course updates.
3. Developed 7 instructional storyboards covering two course modules to convert in-person sessions into structured online learning modules, integrating learning objectives, redesigned slide content, discussion prompts and exercises.
4. Reviewed and proofread 8 course modules and compiled the final participant guide to support course delivery and ensure consistency across learning materials.
5. Contributed to the development of the GPHC Fellowship mentorship component by refining a mentorship guide and designing a mentor-mentee matching survey.
6. Revised three modules of the Healthcare Quality course to improve content clarity and alignment with course learning objectives.
7. Supported preparation of a course evaluation study by revising the research protocol for program assessment.
8. Assisted in screening participant profiles for the Health Harmonization and Alignment course to support candidate selection.

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