BMJ Open

Childhood mortality and associated factors in Migori County, Kenya: evidence from a cross-sectional survey

Joseph R Starnes ,[1,2] Ash Rogers,[2] Jane Wamae,[2] Vincent Okoth,[2] Sandra A Mudhune,[2] Alyn Omondi,[3] Vincent Were,[4] Doreen Baraza Awino,[2] Christina Hope Lefebvre,[5] Samantha Yap,[5] Tom Otieno Odhong,[6] Beffy Vill,[6] Lawrence Were,[7] Richard Wamai[5]

To cite: Starnes JR, Rogers A, Wamae J, *et al*. Childhood mortality and associated factors in Migori County, Kenya: evidence from a cross-sectional survey. *BMJ Open* 2023;**13**:e074056. doi:10.1136/bmjopen-2023-074056

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2023-074056).

Received 29 March 2023
Accepted 08 August 2023

Check for updates

© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

Correspondence to
Dr Joseph R Starnes; joseph.starnes@vumc.org

ABSTRACT

Objectives The under-five mortality (U5M) rate in Kenya (41 per 1000 live births) remains significantly above international goals (25 per 1000 live births). This is further exacerbated by regional inequalities in mortality. We aimed to describe U5M in Migori County, Kenya, and identify associated factors that can serve as programming targets.
Design Cross-sectional observational survey.
Setting Areas served by the Lwala Community Alliance and control areas in Migori County, Kenya.
Participants This study included 15 199 children born to respondents during the 18 years preceding the survey.
Primary and secondary outcome measures The primary outcome was mortality in the first 5 years of life. The survey was powered to detect a 10% change in various health metrics over time with 80% power.
Results A total of 15 199 children were included in the primary analyses, and 230 (1.5%) were deceased before the fifth birthday. The U5M rate from 2016 to 2021 was 32.2 per 1000 live births. Factors associated with U5M included year of birth (HR 0.926, p<0.001), female sex (HR 0.702, p=0.01), parental marriage (HR 0.642, p=0.036), multiple gestation pregnancy (HR 2.776, p<0.001), birth spacing less than 18 months (HR 1.894, p=0.005), indoor smoke exposure (HR 1.916, p=0.027) and previous familial contribution to the National Hospital Insurance Fund (HR 0.553, p=0.009). The most common cause of death was malaria.
Conclusions We describe factors associated with childhood mortality in a Kenyan community using survival analyses of complete birth histories. Mortality rates will serve as the baseline for future programme evaluation as a part of a 10-year study design. This provides both the hyperlocal information needed to improve programming and generalisable conclusions for other organisations working in similar environments.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The study includes a large cohort of children (N=15 199) born in Migori County, representing the largest reported cohort from the area.
- ⇒ The underlying survey was derived from tools validated in a wide variety of settings including Kenya.
- ⇒ The cross-sectional nature of the survey allows comment only on association and not causation.
- ⇒ Unknown date of death for a subset of children limited analyses, although multiple sensitivity analyses helped offset this limitation.

INTRODUCTION

The Millennium Development Goals set the target of reducing under-five mortality (U5M) by two-thirds, or from 93 to 31 per 1000 live births, between 1990 and 2015.[1] This goal was not met, but the overall global U5M rate did fall by 52% over this period.[2] Building on this momentum, the Sustainable Development Goals (SDGs) transitioned to a goal of ending preventable U5M by 2030.[3] Specifically, the target was set at 25 per 1000 live births, and there is optimism that this SDG is attainable.[4]

Kenya experienced a slower rate of decline in U5M from 1990 to 2015 but still saw a decrease of 2.4% per year.[2] This slower decline is consistent with overall inequality in mortality metrics over this time period.[5] The 2014 Kenya Demographic and Health Survey (KDHS) estimated U5M at 52 per 1000 live births.[6] Preliminary data from the 2022 KDHS show continued improvement at 41 per 1000 live births,[7] but this is still far above the goal set in the SDGs. Further, national-level statistics mask regional inequality in mortality. Regional U5M rates in Kenya in 2014 ranged from 42 to 82 per 1000 live births.[6] This underlines the need for local data to inform ongoing programmatic efforts, especially in decentralised health systems like Kenya where allocative health decisions are made at the county level.[8]

Migori County is situated in western Kenya in the former Nyanza province and has a population of approximately 1.1 million.[9] The economy primarily relies on subsistence farming with fishing prevalent in areas that border Lake Victoria. The region has historically underperformed on health metrics, having the highest rate of U5M in Kenya at 82 per 1000 live births in 2014.[6] The most common causes of childhood

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.

mortality in the region are malaria, anaemia, acute respiratory infection, gastroenteritis and malnutrition.[10–12] Our previous work in a smaller portion of Migori County found similar results, with malaria, anaemia and respiratory infection as the most common causes.[13] This research also found that short birth spacing, season of birth and multiple-gestation pregnancies were associated with mortality.[13]

In an effort to palliate these negative outcomes, the Lwala Community Alliance (Lwala) was founded in 2007 to promote the health and well-being of communities in Migori County, 1 of 47 counties in Kenya. Lwala operates a hospital with inpatient, outpatient, maternal, child, reproductive and HIV care in North Kamagambo in northeast Migori County. Programming includes an innovative community-led health programme that activates community governance structures, professionalises the community health worker (CHW) role, incorporates traditional birth attendants into the healthcare system and supports public health facilities to improve the quality of care. To monitor impact and allow for improvement, a repeated cross-sectional household survey was designed to assess a wide variety of health metrics in both programming and control areas.[14–18] This study aims to use the most recent iteration of this survey to expand our prior mortality work.

METHODS

Study setting

Lwala began working in North Kamagambo, one of four administrative wards within the Rongo subcounty (figure 1). Since then, programming has expanded to all of Rongo subcounty, one of eight subcounties within Migori County. Notably, at the time of this survey, Central Kamagambo was not yet part of the implementation area. The 2021 survey also included two planned expansion wards in Awendo subcounty (North Sakwa and Central Sakwa), where programming had not yet been implemented, as well as two control wards in Uriri subcounty (Central Kanyamkago and West Kanyamkago).

Sampling and survey

The survey and sampling methodology have been described in detail elsewhere.[14] Briefly, the survey was powered to detect a 10% change in health metrics over time with 80% power. Households were sampled using a modified procedure based on the WHO Expanded Programme of Immunisation (EPI).[19 20] Each area was split into grid squares, and survey teams would begin the day at the centre of a grid square using global positioning system technology. The spin-the-bottle technique was then used to select households randomly.[19] This approach minimises the traditional biases of the spin-the-bottle technique[21] by using an arbitrary starting point in place of the centre of a town as was done in the original EPI methodology.

The survey was based on validated tools to capture a wide variety of health metrics[6 22 23] and was administered using a customised Research Electronic Data Capture (REDCap) tool.[24 25] Specifically, it included a complete birth history of all children born to the respondent or their spouse. Sex, birthdate, death date and cause of death were recorded for all children. Demographic, health and

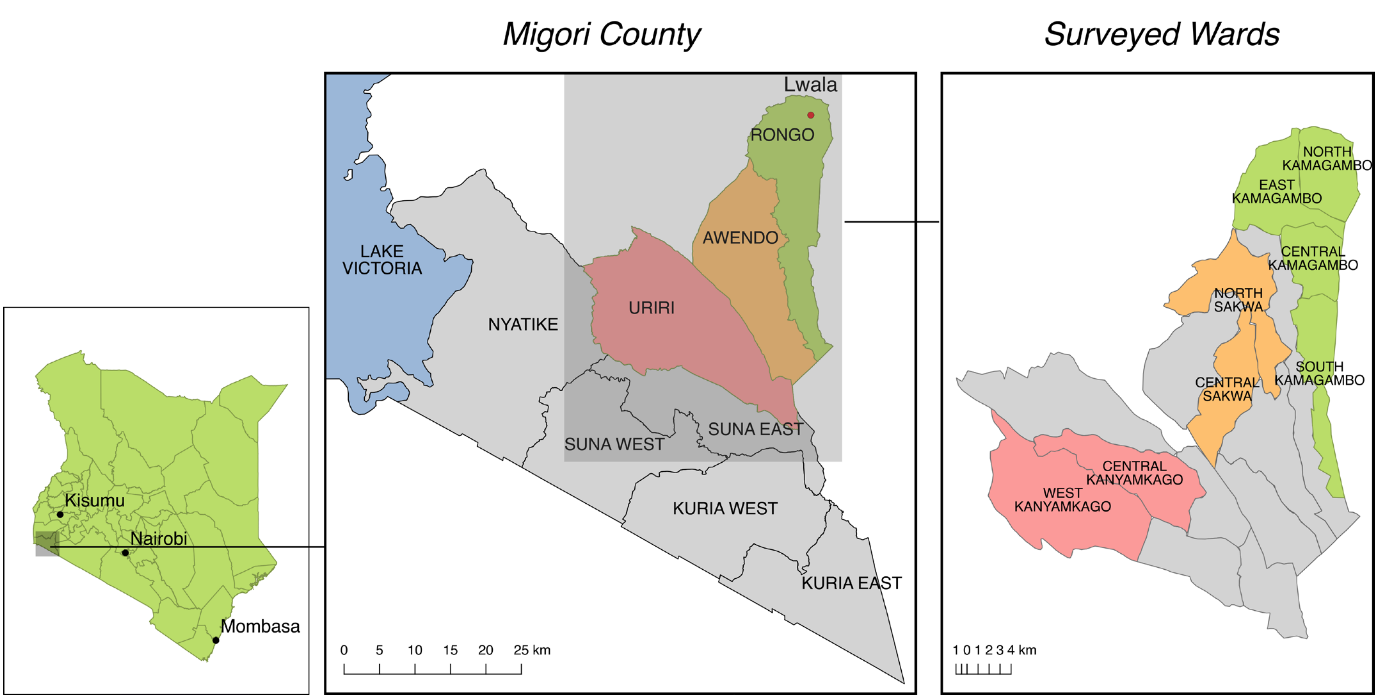

Figure 1 Migori County, Kenya. Lwala programming began in North Kamagambo in Rongo subcounty (green). At the time of the survey, all of Rongo except Central Kamagambo was receiving Lwala services. The next expansion is planned for Awendo (orange). Two areas in Uriri, Central Kanyamkago and West Kanyamkago, serve as comparison wards (red). Lwala, Lwala Community Alliance.

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.

socioeconomic data were captured about the respondent and household.

Definitions

Childhood mortality was defined as reported death prior to the fifth birthday. Birth during the long rainy season was defined as birth from April to June. Wealth quartiles were calculated and defined using the multiple correspondence analysis methodology.[26] Indoor smoke exposure was defined as the presence of an indoor cooking stove without ventilation at the time of the survey.

Statistical analysis

A preliminary list of variables available in the survey was created a priori based on previous studies of associations with childhood mortality and organisational experience based on an analytical framework modified from Mosley and Chen (online supplemental figure 1).[27,28] Multivariable Cox regression with clustering at the household level was used to estimate the effects of independent variables on survival with effects given as HRs. Observation time for all models began on the birthdate and ended on whichever came first among the death date, the birthday marking the end of the risk period (fifth birthday) and the interview date. Deceased children with a missing date of death (n=119) were excluded from Cox analyses because their risk time could not be determined. Sensitivity analysis with the interview date used as the death date, which is the most conservative possible value, was also performed. An additional sensitivity analysis was performed using only singleton births to ensure findings were not driven by multiple gestation births. Logistic regression models were used in sensitivity analyses. To model changes in cause of death over time, we used subdistribution HRs to account for competing risks.[29] Mortality rates were calculated using the Kaplan-Meier cumulative failure function. In order to not underestimate mortality rates, children with missing dates of death were counted in these estimates. All analyses were performed using Stata V.14.2 (StataCorp, College Station, Texas, USA).

Patient and public involvement

The public was involved in the design and conduct of this research. Lwala organises community committees to launch their own holistic health initiatives and participate in the governance of community and primary levels of healthcare. These committees inform programming priorities, which in turn influence the priorities of this research. Public research forums are held following each iteration of the survey.

RESULTS

Demographics

A total of 15 318 children were born in the 18 years preceding the survey, and 375 (2.5%) were deceased. Among the deceased, 119 had an unknown date of death. These individuals were excluded from the primary analysis. This left 15 199 children in the primary cohort, with 230 (1.5%) deceased before the fifth birthday (table 1). Deceased children were generally born in earlier years, were predominately male, had less educated mothers, were more often twins, had shorter birth spacing and were part of families that less frequently contributed to the National Hospital Insurance Fund (NHIF). There was also substantial variation across regions with very few deaths reported in Central and North Sakwa.

Cause of death

Malaria was both the most common cause of death for under-five deaths (22.6%) and all child deaths (16.3%) (table 2). Measles and respiratory infections were the next most common causes in both categories, but no other cause contributed to 10% of deaths. A large number of causes were unknown, including 37.4% of under-five deaths and 56.0% of all deaths.

Survival analysis

Table 3 shows the results of multivariable Cox regression for U5M. There was a significant decrease in mortality with each 1-year increase in the year of birth (HR 0.926, p<0.001). Female sex (HR 0.702, p=0.01) and parental marriage (HR 0.642, p=0.036) were both protective against U5M. Multiple gestation pregnancy, meaning twin births, was associated with increased mortality (HR 2.776, p<0.001). Although twins were relatively rare in the dataset, representing just 316 children (2.1%), a disproportionate number (19, 6.0%) were deceased prior to the fifth birthday. Birth spacing less than 18 months (HR 1.894, p=0.005) and indoor smoke exposure (HR 1.916, p=0.027) were associated with increased U5M. Finally, previous familial contribution to the NHIF was protective against U5M (HR 0.553, p=0.009).

Sensitivity analysis using the interview date as the date of death for children with missing death dates did not substantially change the results with the exception of the coefficient for the year of birth. This was no longer significantly associated with mortality. Logistic regressions using both scenarios were also performed and demonstrated similar results to the Cox regressions (online supplemental tables 1 and 2). An additional sensitivity analysis was performed using a Cox regression and only singleton births (online supplemental table 3). These results were similar with the exception of the fact that parental marriage was no longer significantly associated with mortality.

Competing-risks analyses

Competing-risks regressions were performed individually for each cause of death to determine which causes were decreasing over time (table 4). The biggest reduction over time was for measles (subdistribution HR 0.830, p<0.001). Malaria and labour complications also decreased over time. Cause-specific mortality rates followed the same

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.

Table 1 Descriptive statistics by vital status

	Child living at 5 years (n=14 969)	Child deceased at 5 years (n=230)	Total (N=15 199)
Birth year	2015 (2010, 2018)	2011 (2007, 2016)	2015 (2010, 2018)
Maternal age (years) (N=14 953)	22.7 (19.2, 27.0)	22.0 (18.6, 26.2)	22.6 (19.2, 27.0)
Birth order	2 (1, 3)	2 (1, 3)	2 (1, 3)
Age if alive (years)	6.1 (3.0, 10.4)	–	–
Age at death (months)	–	7.6 (2.0, 23.9)	–
Child sex (N=14 337)			
Female	7491 (53.1)	97 (44.5)	7588 (52.9)
Male	6628 (46.9)	121 (55.5)	6749 (47.1)
Marital status			
Single	268 (1.8)	0 (0)	268 (1.8)
Married monogamous/cohabitating	12 000 (80.2)	153 (66.5)	12 153 (80.0)
Married polygamous	1395 (9.3)	37 (16.1)	1432 (9.4)
Widowed/separated/divorced	1305 (8.7)	40 (17.4)	1345 (8.9)
Maternal education (N=14 903)			
Primary or less	9085 (61.9)	171 (76.0)	9256 (62.11)
Secondary or more	5593 (38.1)	54 (24.0)	5647 (37.9)
Region			
North Kamagambo	2018 (13.5)	37 (16.1)	2055 (13.5)
East Kamagambo	2012 (13.4)	34 (14.8)	2046 (13.5)
Central Kamagambo	1855 (12.4)	31 (13.5)	1886 (12.4)
South Kamagambo	1786 (11.9)	28 (12.2)	1814 (11.9)
Central Kanyamkago	1869 (12.5)	33 (14.4)	1902 (12.5)
West Kanyamkago	1985 (13.3)	40 (17.4)	2025 (13.3)
North Sakwa	1869 (12.5)	22 (9.6)	1891 (12.4)
Central Sakwa	1575 (10.5)	5 (2.2)	1580 (10.4)
Wealth quartile			
Severely poor	3855 (25.8)	73 (31.7)	3928 (25.8)
Poor	4066 (27.2)	59 (25.7)	4125 (27.1)
Vulnerable	3843 (25.7)	58 (25.2)	3901 (25.7)
Non-poor	3205 (21.4)	40 (17.4)	3245 (21.4)
Multiple gestation	297 (2.0)	19 (8.3)	316 (2.1)
Born long rain	5505 (36.8)	88 (38.3)	5593 (36.8)
Time since last birth			
Less than or equal to 18 months	811 (5.4)	25 (10.9)	836 (5.5)
Greater than 18 months or first birth	14 158 (94.6)	205 (89.1)	14 363 (94.5)
Visited by CHW last 3 months	5791 (38.7)	107 (46.5)	5898 (38.8)
Ever contributed to NHIF	3883 (25.9)	39 (17.0)	3922 (25.8)
Indoor smoke exposure	661 (4.4)	17 (7.4)	678 (4.5)

CHW, community health worker; NHIF, National Hospital Insurance Fund.

pattern as raw number of deaths and ranged from 1 to just above 4 per 1000 live births.

Mortality rates

Mortality rates were calculated for children born in the 5 years preceding the survey (birth year 2016 or later). The interview date was used as the date of death for children with missing death dates. The overall U5M rate in the cohort was 32.2 per 1000 live births (table 5).

DISCUSSION

We report the U5M rate and associated factors in a large cohort of children living in Migori County, Kenya. Our

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.

Table 2 Cause of death

	Under-five deaths (N=230)	All deaths (N=375)*
Anaemia	12 (5.2)	13 (3.5)
Congenital anomalies	3 (1.3)	4 (1.1)
Diarrhoea	5 (2.2)	5 (1.3)
Injury	2 (0.9)	4 (1.1)
Malaria	52 (22.6)	61 (16.3)
Measles	20 (8.7)	22 (5.9)
Labour complication	13 (5.7)	13 (3.5)
Respiratory infection	18 (7.8)	21 (5.6)
Sickle cell disease	4 (1.7)	5 (1.3)
Other†	15 (6.5)	17 (4.5)
Unknown	86 (37.4)	210 (56.0)

*Includes children with unknown death date and deaths after 5 years.
†Convulsions, non-specific infection, tumour, drowning, malnutrition.

Table 3 Multivariable Cox regression for under-five mortality

	HR	95% CI	P value
Year of birth	0.926	(0.895 to 0.957)	**<0.001**
Female	0.702	(0.535 to 0.92)	**0.01**
Maternal age (years)	0.987	(0.96 to 1.015)	0.356
Parents currently married/in relationship	0.642	(0.424 to 0.971)	**0.036**
Mother with secondary or more education	0.737	(0.5 to 1.087)	0.124
Birth order	1.011	(0.867 to 1.178)	0.891
Wealth quartiles			
Not poor	Ref	–	–
Vulnerable	0.948	(0.572 to 1.574)	0.838
Poor	0.798	(0.479 to 1.328)	0.385
Severely poor	0.965	(0.576 to 1.616)	0.892
Multiple gestation	2.776	(1.669 to 4.617)	**<0.001**
Born during long rain season	0.991	(0.744 to 1.319)	0.95
Birth spacing ≤18 months	1.894	(1.216 to 2.948)	**0.005**
Household region			
North Kamagambo	Ref	–	–
East Kamagambo	0.879	(0.516 to 1.497)	0.635
Central Kamagambo	1.018	(0.545 to 1.901)	0.956
South Kamagambo	0.962	(0.539 to 1.717)	0.895
Central Kanyamkago	1.252	(0.717 to 2.187)	0.429
West Kanyamkago	1.322	(0.755 to 2.317)	0.329
North Sakwa	0.809	(0.443 to 1.478)	0.491
Central Sakwa	0.195	(0.068 to 0.562)	**0.002**
Visited by CHW last 3 months	1.353	(0.955 to 1.917)	0.089
Ever contributed to NHIF	0.553	(0.356 to 0.86)	**0.009**
Indoor smoke exposure	1.916	(1.075 to 3.415)	**0.027**

The bolded values are statistically significant (p<0.05).
CHW, community health worker; NHIF, National Hospital Insurance Fund.

overall U5M rate of 32.2 per 1000 live births is lower than recently available estimates for Kenya (41 per 1000 live births).[7 30] This may reflect a lower regional mortality rate, although historically Migori County, located in the former Nyanza province, has had mortality rates higher than the national average.[6] Regional estimates for mortality from the 2022 KDHS have not yet been published making direct comparison difficult. Of note, the mortality rate in North Kamagambo, 21.5 per 1000 live births, represents a continued improvement from 29.5 per 1000 live births calculated using the same survey and methodology over the period 2012–2016 in our previous work.[13] This is a faster decline in both absolute mortality and proportion compared with rates for Kenya as a whole over similar time periods. These were recently reported in the KDHS as 46 per 1000 live births from 2013 to 2017 and 41 per 1000 live births from 2018 to 2022.

Several variables used primarily for adjustment in our model did show a significant association with mortality. There was a significant decrease in mortality with each increase in the year of birth. The magnitude of this reduction (HR 0.926) is essentially identical to our previous work, which found an HR of 0.931.[13] This finding is consistent with known decreases in U5M in Kenya over the period covered by our birth cohort.[2 6 30] Similarly, female child sex was protective against U5M (HR 0.702, p=0.01). This has also been observed in systematic reviews and studies from various countries[31–37] and was reported in the 2022 KDHS.[7] Children of parents that were married or currently in a relationship were also less likely to be deceased, although not when only singleton births were analysed. This relationship has been observed in a variety of studies and may be related to differences in socioeconomic status and social support in families with single parents.[36 38 39]

Several modifiable risk factors were associated with mortality and may serve as potential programming targets in the region and elsewhere. Specifically, short birth spacing of less than 18 months was associated with increased mortality (HR 1.894, p=0.005). We observed a similar finding in our previous study,[13] and this association has been consistently demonstrated in various contexts.[40–44] Multiple mechanisms for this association have been proposed, including maternal nutritional deficiencies, cervical insufficiency, vertical infection transmission, sibling competition, lactation difficulties, transmission of infection between siblings and insufficient time for uterine healing from previous deliveries.[45] There

Table 4 SHRs per year for most common causes of death

	Under-five deaths, n (%)*	Mortality rate†	SHR‡	95% CI	P value
Anaemia	12 (5.2)	1.0	0.895	(0.785 to 1.020)	0.097
Malaria	52 (22.6)	4.1	0.906	(0.852 to 0.962)	0.001
Measles	20 (8.7)	1.6	0.830	(0.750 to 0.918)	<0.001
Labour complications	13 (5.7)	0.9	0.861	(0.775 to 0.956)	0.005
Respiratory infection	18 (7.8)	1.4	0.918	(0.824 to 1.022)	0.824

*Percentages do not sum to 100% as only most common causes of death analysed.
†Cause specific mortality rates are reported as under-five mortality rates per 1000 live births.
‡Subdistribution HR (SHR) is reported per year increase in year of birth.

may also be competition for limited familial resources in economically disadvantaged households. These results suggest that increasing family planning access and therefore birth spacing consistent with the WHO recommendation for interpregnancy interval of 24 months[46] may be a mechanism for decreasing U5M. Family planning is a key component of Lwala's programming and will be the focus of subsequent research involving this same dataset.

Indoor smoke exposure, defined as an indoor cooking stove without ventilation, was also associated with mortality (HR 1.916, p=0.027). Meta-analyses have found a significant association between indoor cooking and all-cause mortality.[47] This relationship may be mediated through increased rates of respiratory infection, low birth weight, preterm birth and stunting. However, randomised controlled trials using either improvement in ventilation or cleaner cooking fuels have had mixed results.[48 49] This inconsistency may be attributed to insufficient exposure reduction in the setting of ongoing home exposure and community exposure. Our study adds to the evidence of the effect of exposure on mortality, but further work is needed to determine ideal mitigation strategies.

Interestingly, previous contribution to the NHIF was also associated with decreased U5M in our population (HR 0.553, p=0.009). The NHIF was established in 1966 and is one of Africa's oldest social health insurance programmes. However, relatively few studies have analysed its efficacy. Limited studies of NHIF have shown that covered children are more likely to receive cancer treatment and survive cancer.[50] Adults with NHIF were more likely to survive to hospital discharge at a single centre,[51] and pregnant women with HIV are more likely to access obstetric services if they have NHIF.[52] Pregnant women with NHIF were also more likely to deliver at a facility and to have a skilled birth attendant.[53] To our knowledge, this is the first study to demonstrate a broad association between NHIF and all-cause U5M in Kenya. This adds significantly to the literature and the policy discussion around NHIF. However, it is important to note that the only data available in the survey were regarding ever having contributed to NHIF and not contribution at the time of the birth of a child or enrolment.

Table 5 Under-five mortality rates (2016–2021)

Region	Rate (per 1000 births)
North Kamagambo	21.5
East Kamagambo	28.0
Central Kamagambo	39.9
South Kamagambo	48.2
Central Kanyamkago	16.7
West Kanyamkago	47.9
North Sakwa	33.0
Central Sakwa	17.7
Overall	32.2

Although it is not a modifiable risk factor, multiple gestation pregnancy was associated with U5M in this cohort (HR 2.776, p<0.001). This is consistent both with our previous work[13] and with substantial literature from varying locations and in Kenya specifically.[40 54 55] As children of multiple gestation pregnancies make up only about 2% of children in this cohort, this represents a relatively small population that can be targeted for more intensive monitoring and intervention.

Interpretation of causes of death is limited given the large number of children for which this is unknown. Generally, malaria and respiratory infections were among the most common, consistent with our prior research[13] and other studies from the region.[10–12] Competing-risk analyses suggest that three of the five most common causes of death—malaria, measles and labour complications—are decreasing in prevalence. In contrast, there was no significant decrease over time in deaths from anaemia and respiratory infection. It is not unexpected that measles deaths have decreased over time given high and increasing vaccination rates in Kenya.[56] Although malaria deaths were decreasing, the mortality rate from malaria remains much higher than any other single cause. Overall, these data would suggest that programmes and policies in the area should remain focused on malaria and that new programmes are needed for improved care of anaemia and respiratory infections. The high level of unknown cause of death is likely attributed to our approach; cause of death was ascertained using a

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.

single question instead of more detailed methodologies, such as verbal autopsy. Verbal autopsy studies in the region have found an indeterminate cause in just 2.1% of cases.[12]

We did not find a visitation by a CHW in the 3 months preceding the survey to have a significant effect on childhood mortality. This is not surprising given that 3 months preceding the survey is temporally removed from the birth and death of most children in the dataset. Data regarding visitation around the birth of each individual child are not available in the survey and would be difficult to capture in this cross-sectional study. Visitation by a CHW in the preceding 3 months was much higher in intervention sites (North, East and South Kamagambo) at 66.0% than at non-intervention sites (21.4%). The effect of this visitation will be the focus of ongoing research using this dataset.

Limitations

The primary limitation of this study is the cross-sectional nature of the survey, which allows comment only on association and not causation. Additionally, this means that variables collected at the household level, such as parental marriage and wealth quartiles, are current household characteristics, while a child may have been born under different circumstances. Cross-sectional surveys also rely on the memory of respondents regarding births and deaths of children. However, this seems unlikely to tangibly affect the results as these are major life events that are unlikely to be forgotten, although we were missing dates of death for a substantial number of deceased children. It is unclear from the data available whether this was secondary to data collection concerns or lack of recall. To offset this limitation, we performed several sensitivity analyses both with and without these children to verify the primary conclusions of the paper. Finally, our analysis of cause of death was limited both by the large number of deaths for which the cause was unknown and the relatively small number of deaths for each cause. This necessitated only univariable competing-risks regressions and did not allow for quantification of the varying effect of other variables included in the larger model on different causes of death. We hope to perform these analyses as additional data are accrued over successive timepoints in our larger study.

CONCLUSIONS

We describe factors associated with childhood mortality, including multiple gestation pregnancies, short birth intervals and indoor smoke exposure in a Kenyan community using survival analyses of complete birth histories. We also identify several protective factors, including female sex, parental marriage and contribution to the national insurance fund. Mortality rates will serve as the baseline for future programme evaluation as a part of a 10-year study design. This provides both the hyperlocal information needed to improve programming and generalisable conclusions for other organisations working in similar environments.

Author affiliations
[1]Department of Pediatrics, Vanderbilt University Medical Center, Nashville, Tennessee, USA
[2]Lwala Community Alliance, Rongo, Kenya
[3]Adaptive Model for Research and Empowerment of Communities in Africa, Kisumu, Kenya
[4]Kenya Medical Research Institute, Nairobi, Kenya
[5]Department of Cultures, Societies, and Global Studies, Northeastern University, Boston, Massachusetts, USA
[6]Department of Health Services, Migori County Government, Migori, Kenya
[7]Department of Global Health, Boston University, Boston, Massachusetts, USA

Acknowledgements We would like to thank the enumerators who conducted the data collection required for this project and continue to support the Lwala Community Alliance in collecting high-quality data to inform programming and research.

Contributors JRS, AR, JW, VO, SAM, AO, VW, DBA, CHL, SY, TOO, BV, LW and RW contributed to the conception and design of the study; contributed to the interpretation and contextualisation of the analyses; critically revised the manuscript; read and approved the final manuscript and agree to be accountable for all aspects of the work. JRS, JW and VO created the REDCap application for data collection. JW, VO, SAM and RW oversaw data collection. JRS, AO and VW performed statistical analyses. JRS drafted the manuscript.

Funding This research was supported by normal operational funds of the Lwala Community Alliance (Award Number N/A).

Map disclaimer The inclusion of any map (including the depiction of any boundaries therein), or of any geographic or locational reference, does not imply the expression of any opinion whatsoever on the part of BMJ concerning the legal status of any country, territory, jurisdiction or area or of its authorities. Any such expression remains solely that of the relevant source and is not endorsed by BMJ. Maps are provided without any warranty of any kind, either express or implied.

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval The protocol and study design were approved by the Ethics and Scientific Review Committee at AMREF Health Africa (AMREF-ESRC P452/2018) and the Institutional Review Board at Northeastern University (IRB #: 20-09-18). Participants gave informed consent to participate in the study before taking part. A research licence was obtained from the Kenya National Commission for Science and Technology (NACOSTI/P/21/8776).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data are available on reasonable request from the corresponding author.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.

ORCID iD
Joseph R Starnes http://orcid.org/0000-0001-7954-5385

REFERENCES

1. UN General Assembly. United Nations millennium declaration. 2000. Available: https://undocs.org/en/A/RES/55/2
2. GBD 2015 Child Mortality Collaborators. Global, regional, national, and selected Subnational levels of stillbirths, neonatal, infant, and Under-5 mortality, 1980-2015: a systematic analysis for the global burden of disease study 2015. *Lancet* 2016;388:S0140-6736(16)31575-6:1725–74.:.
3. UN General Assembly. Transforming our world: the 2030 agenda for sustainable development. 2015. Available: https://undocs.org/en/A/RES/70/1
4. Independent Group of Scientists appointed by the Secretary-General. *Global Sustainable Development Report 2019: The Future is Now – Science for Achieving Sustainable Development*. New York: United Nations, 2019.
5. World Health Organization. *State of inequality: reproductive, maternal, newborn and child health*. Geneva: World Health Organization, 2015. Available: https://apps.who.int/iris/handle/10665/164590
6. Kenya National Bureau of Statistics. Kenya demographic and health survey. 2014. Available: https://dhsprogram.com/pubs/pdf/fr308/fr308.pdf
7. KNBS and ICF. *Kenya Demographic and Health Survey 2022. Key Indicators Report. Nairobi, Kenya*. 2023.
8. Barasa E, Nyawira L, Musiega A, *et al*. The autonomy of public health facilities in Decentralised contexts: insights from applying a complexity lens in Kenya. *BMJ Glob Health* 2022;7:e010260.
9. Kenya National Bureau of Statistics. *2019 Kenya population and housing census*. Nairobi: Kenya National Bureau of Statistics, 2019.
10. Onyango DO, Akelo V, van der Sande MAB, *et al*. Causes of death in HIV-infected and HIV-uninfected children aged under-five years in Western Kenya. *AIDS* 2022;36:59–68.
11. Odhiambo F, Adazu K, Amornkul P, *et al*. Health and demographic surveillance in rural Western Kenya: a platform for evaluating interventions to reduce morbidity and mortality from infectious diseases. *Am J Trop Med Hyg* 2005;73:1151–8.
12. Amek NO, Odhiambo FO, Khagayi S, *et al*. Childhood cause-specific mortality in rural Western Kenya: application of the InterVA-4 model. *Glob Health Action* 2014;7:25581.
13. Starnes JR, Chamberlain L, Sutermaster S, *et al*. Under-five mortality in the Rongo sub-county of Migori County, Kenya: experience of the Lwala community alliance 2007-2017 with evidence from a cross-sectional survey. *PLoS One* 2018;13:e0203690.
14. Starnes JR, Wamae J, Okoth V, *et al*. Population-based socio-demographic household assessment of livelihoods and health among communities in Migori County, Kenya over multiple Timepoints. *PLoS One* 2021;16:e0256555.
15. Moon TD, Okoth V, Starnes JR, *et al*. Determinants of modern contraceptive prevalence and unplanned pregnancies in Migori County, Kenya: results of a cross-sectional household survey. *Afr J Reprod Health* 2021;25:29–40.
16. Rogers AL, Lee AXT, Joseph JG, *et al*. Predictors of under-five Healthcare utilization in Rongo sub-county of Migori County, Kenya: results of a population-based cross-sectional survey. *Pan Afr Med J* 2022;41:108.
17. Morris M, Okoth V, Prigmore HL, *et al*. The prevalence of interpersonal violence (IPV) against women and its associated variables: >an exploratory study in the Rongo sub-county of Migori County, Kenya. *J Interpers Violence* 2022;37:2083–101.
18. Starnes JR, Di Gravio C, Irlmeier R, *et al*. Characterizing multidimensional poverty in Migori County, Kenya and its association with depression. *PLoS ONE* 2021;16:e0259848.
19. Harris DR, Lemeshow S. Evaluation of the EPI survey methodology for estimating relative risk. *World Health Stat Q Rapp Trimest Stat Sanit Mond* 1991;44:107–14.
20. Bostoen K, Chalabi Z. Optimization of household survey sampling without sample frames. *Int J Epidemiol* 2006;35:751–5.
21. Grais RF, Rose AMC, Guthmann J-P. Don’t spin the pen: two alternative methods for second-stage sampling in urban cluster surveys. *Emerg Themes Epidemiol* 2007;4:8.
22. World Health Organization. *Indicators for assessing infant and young child feeding practices*. Geneva: World Health Organization, 2010.
23. Ballard T, Coates J, Swindale A, *et al*. Household hunger scale: indicator definition and measurement guide. Washington, DC: Food and Nutrition Technical Assistance II Project, 2011.
24. Harris PA, Taylor R, Thielke R, *et al*. Research electronic data capture (Redcap) - A Metadata-driven methodology and Workflow process for providing Translational research Informatics support. *J Biomed Inform* 2009;42:377–81.
25. Harris PA, Taylor R, Minor BL, *et al*. The Redcap consortium: building an international community of software platform partners. *J Biomed Inform* 2019;95:S1532-0464(19)30126-1.
26. Ezzrari A, Verme P. A multiple correspondence analysis approach to the measurement of multidimensional poverty in Morocco 2001–2007. In: Berenger V, Bresson F, eds. *Poverty and Social Exclusion around the Mediterranean Sea*. Boston, MA: Springer US, 2013: 181–209.
27. Mosley WH, Chen LC. An Analytical framework for the study of child survival in developing countries. 1984. *Bull World Health Organ* 2003;81:140–5.
28. Lamichhane R, Zhao Y, Paudel S, *et al*. Factors associated with infant mortality in Nepal: a comparative analysis of Nepal demographic and health surveys (NDHS) 2006 and 2011. *BMC Public Health* 2017;17:53.
29. Fine JP, Gray RJ. A proportional hazards model for the Subdistribution of a competing risk. *Journal of the American Statistical Association* 1999;94:496–509.
30. United Nations Inter-agency Group for Child Mortality Estimation. *Levels & Trends in Child Mortality: Report 2021*. New York: United Nations Children’s Fund, 2021.
31. Bhusal MK, Khanal SP. A systematic review of factors associated with under-five child mortality. *Biomed Res Int* 2022;2022:1181409.
32. Andegiorgish AK, Woldu HG, Elhoumed M, *et al*. Trends of under-five mortality and associated risk factors in Zambia: a multi survey analysis between 2007 and 2018. *BMC Pediatr* 2022;22:341.
33. Ayele DG, Zewotir TT, Mwambi HG. Structured additive regression models with spatial correlation to estimate under-five mortality risk factors in Ethiopia. *BMC Public Health* 2015;15:268.
34. Becher H, Kauermann G, Khomski P, *et al*. Using penalized Splines to model Age- and season-of-birth-dependent effects of childhood mortality risk factors in rural Burkina Faso. *Biom J* 2009;51:110–22. 10.1002/bimj.200810496 Available: http://doi.wiley.com/10.1002/bimj.v51%3A1
35. Ezeh OK, Agho KE, Dibley MJ, *et al*. Risk factors for Postneonatal, infant, child and Under-5 mortality in Nigeria: a pooled cross-sectional analysis. *BMJ Open* 2015;5:e006779.
36. Motsima T. The risk factors associated with under-five mortality in Lesotho using the 2009 Lesotho demographic and health survey. 2016.
37. Naz L, Patel KK, Uzoma IE. Crucial predicting factors of under-five mortality in Sierra Leone. *Clinical Epidemiology and Global Health* 2020;8:1121–6.
38. Yaya S, Bishwajit G, Okonofua F, *et al*. Under five mortality patterns and associated maternal risk factors in sub-Saharan Africa: A multi-country analysis. *PLoS One* 2018;13:e0205977.
39. Kandala N-B, Mandungu TP, Mbela K, *et al*. Child mortality in the Democratic Republic of Congo: cross-sectional evidence of the effect of geographic location and prolonged conflict from a national household survey. *BMC Public Health* 2014;14:266.
40. Becher H, Müller O, Jahn A, *et al*. Risk factors of infant and child mortality in rural Burkina Faso. *Bull World Health Organ* 2004;82:265–73.
41. Fotso JC, Cleland J, Mberu B, *et al*. Birth spacing and child mortality: an analysis of prospective data from the Nairobi urban health and demographic surveillance system. *J Biosoc Sci* 2013;45:779–98.
42. Alam N. Birth spacing and infant and early childhood mortality in a high fertility area of Bangladesh: age-dependent and interactive effects. *J Biosoc Sci* 1995;27:393–404.
43. Saha UR, van Soest A. Contraceptive use, birth spacing, and child survival in Matlab, Bangladesh. *Stud Fam Plann* 2013;44:45–66.
44. Perin J, Walker N. Potential confounding in the association between short birth intervals and increased neonatal, infant, and child mortality. *Glob Health Action* 2015;8:29724.
45. Conde-Agudelo A, Rosas-Bermudez A, Castaño F, *et al*. Effects of birth spacing on maternal, perinatal, infant, and child health: A systematic review of causal mechanisms. *Stud Fam Plann* 2012;43:93–114.
46. World Health Organization. *Report of a WHO technical consultation on birth spacing*. Geneva: World Health Organization, 2007.
47. Bruce NG, Dherani MK, Das JK, *et al*. Control of household air pollution for child survival: estimates for intervention impacts. *BMC Public Health* 2013;13:S8.
48. Smith KR, McCracken JP, Weber MW, *et al*. Effect of reduction in household air pollution on childhood pneumonia in Guatemala (RESPIRE): a randomised controlled trial. *The Lancet* 2011;378:1717–26.

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.

49 Jack DW, Ae-Ngibise KA, Gould CF, *et al*. A cluster randomised trial of Cookstove interventions to improve infant health in Ghana. *BMJ Glob Health* 2021;6:e005599.
50 Mostert S, Njuguna F, van de Ven PM, *et al*. Influence of health-insurance access and hospital retention policies on childhood cancer treatment in Kenya: health-insurance and hospital retention. *Pediatr Blood Cancer* 2014;61:913–8.
51 Stone GS, Tarus T, Shikanga M, *et al*. The association between insurance status and in-hospital mortality on the public medical wards of a Kenyan referral hospital. *Glob Health Action* 2014;7:23137.
52 Were LPO, Were E, Wamai R, *et al*. Effects of social health insurance on access and utilization of obstetric health services: results from HIV+ pregnant women in Kenya. *BMC Public Health* 2020;20:87.
53 Were LPO, Were E, Wamai R, *et al*. The Association of health insurance with institutional delivery and access to skilled birth attendants: evidence from the Kenya demographic and health survey 2008-09. *BMC Health Serv Res* 2017;17:454.
54 Marete I, Tenge C, Pasha O, *et al*. Perinatal outcomes of multiple-gestation pregnancies in Kenya, Zambia, Pakistan, India, Guatemala, and Argentina: a global network study. *Am J Perinatol* 2014;31:125–32.
55 Bellizzi S, Sobel H, Betran AP, *et al*. Early neonatal mortality in twin pregnancy: findings from 60 Low- and middle-income countries. *J Glob Health* 2018;8:010404.
56 Subaiya S, Tabu C, N'ganga J, *et al*. Use of the revised world health organization cluster survey methodology to classify measles-rubella vaccination campaign coverage in 47 counties in Kenya, 2016. *PLoS One* 2018;13:e0199786.

BMJ Open: first published as 10.1136/bmjopen-2023-074056 on 22 August 2023. Downloaded from http://bmjopen.bmj.com/ on June 22, 2024 by guest. Protected by copyright.