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Factors Affecting Under-Five Mortality in East Africa Using Demographic Health Survey Data from 2016 to 2022

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Abstract

Background

East Africa continues to bear a disproportionate share of global under-five mortality despite worldwide declines. Therefore, the goal of this study is to identify the determinants of under-five mortality rate between and with-in East African countries by using 2016–2022.

Method

This study was done based on the Demographic and Health Survey (DHS) data of 9 East African countries conducted from 2016 to 2022. The analysis presented in this study was based on the 102819 weighted, sample on children aged less than 59 months. The DHS data were used population based cross-sectional study design. Considering the hierarchical nature of DHS data, mixed-effect logistic model were used. Variables with a p-value of less than 0.2 in the bi-variable analysis were considered for the multivariable analysis. In the mixed-effect analysis, the Adjusted Odds Ratio (AOR) with 95% Confidence Interval (CI) was reported to declare the significant predictors of under-five mortality.

Result

The pooled prevalence of under-five mortality rate in East Africa was 50 deaths per 1000 live births. About 6.5% of the variance in under-five child mortality in East Africa could be attributed to differences across countries. unimproved source of drinking water (AOR = 1.10, 95%CI: 1.02, 1.19), resided in rural (AOR = 1.09, 95% CI: 1.003, 1.18), mother's age group 30–34 (AOR = 0.81,95% CI: 0.1235, 1.3562), rich wealth status (AOR = 0.77, 95% CI: 0.11, 1.94), an increase in family size (AOR = 2.14, 95% CI: 1.99, 2.305), multiple type of birth (AOR = 1.16, 95% CI: 1.07, 1.25) and delivery at health center (AOR = 0.19, 95% CI: 0.038, 1.29) were significantly associated with under-five mortality rate between countries. Sex of child being female, female household head, being 4th birth order, not toilet facility and uneducated mothers were identified as risk factors of child mortality found in within country.

Conclustion:

Under-five mortality in East Africa remains unacceptably high with inter-country inequalities. Mixed-effect logistic analysis reflected the unimproved source of drinking water, living in rural area, multiple at birth, an increase in mother's age, poor wealth status, an increase in family size, and delivery at home were found as a determinants of U5MR between countries. Based on the results from with-in country, the sex of child being female, female household head, 4th birth order, not toilet facility and uneducated mothers were identified as risk factors of child mortality. Therefore, government policy, nongovernmental

organizations, and all concerned bodies found in a given country should work collaboratively to reduce under-five mortality from East African countries, and health intervention policies should be revised.

Introduction

Despite remarkable global progress in reducing under-five mortality from 93 deaths per 1,000 live births in 1990 to 37 in 2020, the African region, particularly East Africa, continues to carry a disproportionate burden [1, 2]. The WHO's response indicates that more than 80% of the 5 million under-five deaths after 2020 would occur in Sub-Saharan Africa and Southern Asia and that more than half of these deaths would occur in just East Africa, primarily from avoidable and treatable causes. However, there are still significant disparities in mortality reduction

and the use of child health indicators within and between nations. National under-five mortality rates (U5MR) in the region range from under 20 to over 115 per 1,000 live births, creating one of the starkest mortality gradients in the world [3]. These differences in health outcomes are

socially produced and can be seen as health inequities. Therefore, the World Health Organization (WHO) considers addressing these inequities as crucial for improving newborn and child health as well as survival rates [4].

The leading causes of under-five mortality in the regions, neonatal conditions, pneumonia, diarrhea, malaria, and malnutrition, are largely preventable or treatable with existing cost-effective interventions [5]. Yet uptake of proven interventions such as immunization, exclusive breastfeeding, antenatal care (ANC), skilled birth attendance, and postnatal care remains suboptimal and highly unequal[1, 6, 7].

The focus on East Africa in this study is to identify the socio-economic, demographic, and environmental determinants of under-five mortality because recently, critical factors contributing to mortality in East African countries were found within these categories [8, 9, 10]. Additionally, most existing literature has primarily compared under-5 mortality rates only across regional variations.

Previous single-country studies in East Africa using standard binary logistic regression have consistently identified maternal education, household wealth, place of delivery, birth spacing, child sex, and access to clean water and sanitation as important predictors [11]. However, these studies are limited by their inability to quantify inter-country heterogeneity and by violation of the independence assumption inherent in Demographic and Health Survey (DHS) data, which are hierarchically structured (children nested in households, households nested in clusters, clusters nested in countries). Additionally, covariance components and extra random-effect terms are included in mixed-effect models. Therefore, mixed-effect logistic models relevant to this study's findings [12].

This study addresses these gaps by pooling the most recent DHS datasets from 9 East African countries and applying a mixed-effects logistic regression model. The approach correctly accounts for clustering,

estimates the extent of between-cluster and between-country variation, and identifies determinants that operate at individual, community, and country levels.

Methods and Materials

Data source and study population

This cross-sectional study used data from the most recent standard Demographic and Health Surveys conducted between 2016 and 2022 in 9 East African countries (Burundi (2017), Ethiopia (2019), Kenya (2022), Madagascar (2021), Malawi (2018), Rwanda (2020), Tanzania (2016), Uganda (2019), and Zambia (2018). Each country's survey consists of different datasets, including men, women, children, birth, and household datasets. We used the Kid recorded file to the extract variables based on literature. Then we kept the same variable from each country and appended together by coding each country. The DHS data gives useful information on long-term trends in key socio-economic, demographic, health, and environmental variables in U5MR.

Variable in the Study

Dependent variable: Under-five mortality was defined as death of a child between birth and the 59th month of life (binary: 0 = survived, 1 = died). Retrospective birth histories reported by mothers aged 15–49 years were used to construct the variable.

Independent variables: The explanatory variables were: socio-economic variables such as maternal education, wealth status and family size, demographic variables like maternal age, sex of household head, sex of child, type of birth, and environmental health factors like source of water supply, toilet facility, place of delivery, and place of residence (Table 1).

Table 1
Description of explanatory variables

Independent variables and their description
Maternal education Mother education level and coded as “0” for no education, “1” for primary education and “2” for higher education
Wealth status The household wealth status and coded as “0” for rich and “1” for poor
Family size It is the total number of children in the household and coded as “0” for 1–5 and “1” for > 5 families
Maternal age Mothers age in years and coded as “0” for <19, “1” for 20–24, “2” for 25–29, “3” for 30–34,”4” for 35–39, “5” for 40–44, “6” for >45 years
Sex of household Sex of household head and coded as “0” for male and “1” for female
Birth order Recode in to five categories as “1”for 1st birth, “2” for 2nd birth, “3” for 3rd birth, “4” for 4th birth, and “5” for 5th birth
Birth type birth type was recoded into two categories as “0” for single birth and “1” for multiple birth
Water supply Source of water supply coded as “0” for improved and “1” for unimproved
Toilet facility Toilet facility was recoded as into two categories as ‘0” for facilitated, and “1” not facilitated
Place of delivery Place of delivery recoded as in two categories as “0” for home and “1” for health center
Place of residence Place of residence was coded as into two categories as “0” for urban and “1” for rural

Statistical Analysis

Because DHS surveys employ a two-stage stratified cluster sampling design, observations are not independent. Standard logistic regression would violate the independence assumption and produce incorrect standard errors. We therefore adopted a generalized linear mixed-effects model (GLMM) with a logit link and binomial error distribution commonly referred to as a mixed-effects logistic regression model.

Let Y_{ij} denote the binary survival status (0 = survive, 1 = died) of the jth child in the ith cluster/country. The generalized mixed-effect logistic model

$$log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{0i} + \sum_{h=1}^{p_1}\beta_{hi}X_{hij} + b_{0i} + \sum_{k=1}^{p_2}\beta_{ki}Z_{kij}$$

,

Where p_{ij} is probability of under-five mortality, p_1 vector of fixed effects, b_i is a p_2 mean-zero vector and variance covariance matrix of random effects, X_{ij} is the design matrix of fixed effect, Z_{ij} is the design matrix of random effect [13–16]. We applied the most common parameter estimation procedure, marginal quasi likelihood and penalized quasi likelihood estimation, for mixed-effect logistic model. Model fit was compared using AIC, BIC and log-likelihood, and intra-correlation coefficient. Crude and adjusted odds ratios (COR, and AOR) with 95% credible intervals are reported.

Ethical Consideration

Permission for data access was obtained from the DHS program through an online request at http://www.dhsprogram.com. The data used for this study were publicly available with no personal identifier.

Result and Discussion

Exploratory data analysis

A total of 112,066 children aged less than 59 months were identified across the selected countries. We also observed 7% missing observations in some of the important independent covariates. The reason for the missing data was unknown, and these cases were excluded from the analysis. Thus, after removing the missing observation, 102,819 weighted observations were included in the final analysis.

The majority of children (89.9%) belongs to poor households. More than half of the mothers (53.1%) had attained only primary education, and 51% of all mothers reported having fewer than five children. With respect to the child's sex 50.8% were female. Slightly more than half of (50.5%) of the household head were male. Regarding birth order, 23.8% of the children were first-born, while the great majority (76.9%) of the children were singleton (Table 2).

Table 2
Summary of socio-economic factors for under-five mortality in some of the selected east African countries.

Variables	Categories	Weighted frequency	percentage
Wealth status	poor	92474	89.9
	rich	10345	10.1
Mother education level	No formal education	21259	20.7
	Primary	54770	53.3
	Secondary	22134	21.5
	Higher	4656	4.5
Family Size	1–5	52402	51.0
	> 5	50417	49.0
Sex of child	Male	51966	49.2
	Female	50853	50.8
Mothers age	< 19	6415	6.3
	20–24	25411	24.7
	25–29	26559	25.8
	30–34	21081	20.5
	35–39	14644	14.2
	40–44	6794	6.6
	> 45	1915	1.9
Birth order	1st birth	24493	23.8
	2nd birth	21680	21.1
	3rd birth	19821	19.3
	4th order	19003	18.5
	5th order	17822	17.3
Type of birth	Single	79106	76.9
	Multiple	23713	23.1
Sex of household head	Male	51966	50.5
	Female	50853	49.5

Most households (85.3%) had no toilet facility, whereas 66.9% had access to an improved water source. Institutional delivery was nearly universal (97%), and 79.0% of participants lived in rural areas. The sample comprised children from multiple countries, with 17.0% from Malawi and 5.4% from Ethiopia (Table 3).

Table 3
Summary of Environmental factors for under-five mortality in selected east Africa country's

Variables	Categories	Weighted frequency	percentage
Source of water supply	Unimproved	34044	33.1
	improved	68775	66.9
Toilet facility	Facilitated	15121	14.7
	Not facilitated	87698	85.3
Place of delivery	Home	3213	3.1
	Health center	99606	96.9
Place of residence	Rural	81212	79.0
	Urban	21607	21.0
Country	Burundi	13611	13.2
	Ethiopia	5527	5.4
	Kenya	10453	10.2
	Madagascar	12345	12.0
	Malawi	17395	16.9
	Rwanda	8324	8.1
	Tanzania	10052	9.7
	Uganda	15270	14.9
	Zambia	9842	9.6

Prevalence of under-five mortality in East Africa

A total of 4,004 children died before reaching five years of age, corresponding to an overall under-five mortality rate of 49 deaths per 1,000 live births.

Under-five mortality was highest among children born to mothers with no formal education (56 deaths per 1,000 live births) and those whose mothers were aged 45 years or older (84 deaths per 1,000 live

births). Children living in households with an unimproved drinking water source experienced a higher under-five mortality rate (55 per 1,000 live births) than those in households with an improved water source (48 per 1,000 live births). Similarly, the under-five mortality rate was markedly higher in households without an improved toilet facility (60 per 1,000 live births) compared to households with improved sanitation facilities (48 per 1,000 live births).

Home deliveries were associated with the highest under-five mortality rate (178 deaths per 1,000 live births). Considerable variation was observed across countries, with under-five mortality ranging from 60 deaths per 1,000 live births in Burundi to 35 deaths per 1,000 live births in Kenya (Table 4).

Table 4
Prevalence of under-five mortality in East Africa

Variable	category	Weight frequency	No children died	U5MR per 1000
Mother education	No formal education	21259	1170	56
	Primary	54770	2356	44
	Secondary	22134	952	44
	Higher	4656	131	29
Sex of child	Male	51966	2807	55
	Female	50853	2238	45
Mothers age	< 19	6415	430	68
	20–24	25411	1271	51
	25–29	26559	1196	46
	30–34	21081	949	46
	35–39	14644	674	47
	40–44	6794	388	58
	> 45	1915	159	84
Source of water supply	Unimproved	34044	1839	55
	improved	68775	3233	48
Toilet facility	Facilitated	15121	893	60
	Not facilitated	87698	4122	48
Place of delivery	Home	3213	569	178
	Health center	99606	4483	46
Place of residence	Rural	81212	4061	51
	Urban	21607	973	46
Country	Burundi	13611	804	60
	Ethiopia	5527	276	51
	Kenya	10453	355	35
	Madagascar	12345	716	59

Variable	category	Weight frequency	No children died	U5MR per 1000
	Malawi	17395	852	50
	Rwanda	8324	308	38
	Tanzania	10052	533	54
	Uganda	15270	779	52
	Zambia	9842	482	50

Mixed-effect logistic model

This study aimed to determine the best-fitting mixed-effects logistic regression model for under-five mortality data. Three models were compared: random-intercept-only, random-intercept, and random-intercept with random-coefficient using Akaike's Information Criterion (AIC), Bayesian Information Criterion (BIC), and likelihood ratio tests to identify the model providing the optimal fit.

Table 5
Model selection criteria for under-five mortality dataset.

Models		AIC	BIC	LogLik	Deviance	Chisq
Model I	Random Intercept-only	38002	38022	-18999	37998	
Model II	Random Intercept model	36668	36668	-18313	36626	1372.6
Model III	Random coefficient model	37984.7	37013.3	-18313	36626	0.00

Results presented in Table 5 show that the random-intercept model (with fixed slopes) yielded the lowest values of both Akaike's Information Criterion (AIC = 36,668) and Bayesian Information Criterion (BIC = 36,868) compared with the random-intercept-only model and the random-intercept with random-coefficient model. Furthermore, the deviance-based likelihood ratio test (chi-square) confirmed a statistically significant improvement in model fit when covariates were included in the random-intercept specification.

We therefore conclude that the mixed-effects logistic regression model with random intercepts and fixed slopes provides the best fit to the data and is the most appropriate model for identifying determinants of under-five mortality across East African countries.

Random Intercept Mixed-Effect Logistic Model

The selected random-intercept model with fixed slopes allows the baseline log-odds of under-five mortality to vary across countries while assuming that the effects of all covariates are constant across countries. The estimated intra-class correlation coefficient (ICC) was 0.00971, indicating that

approximately 0.97% of the total variation in under-five mortality is attributable to differences between countries. The between-country (level-2) variance of the intercept was 0.03228 in the final model, representing a reduction of approximately 86% (Δ = -0.198) relative to the empty (null) model. This substantial decline confirms that the included covariates explain a large proportion of the observable between-country heterogeneity in under-five mortality (Table 6).

Results from the final model (Table 6) show that family size, source of drinking water, place of residence (urban vs. rural), household wealth status, type of toilet facility, and place of delivery were all statistically significant predictors at the 5% level. These variables therefore exert strong and independent effects on under-five mortality across East African countries.

Table 6
Random intercept model

Variables	COR	CI (95%)	P-value	AOR	CI (95%)	P-value
Family size						
1–5 (ref)	1			1		
> 5	2.03	1.84, 2.51	< 2e-16***	2.14	1.99, 2.305	2e-16***
Source of drinking water						
Improved (ref)	1			1		
unimproved	1.15	0.724, 1.58	0.151	1.09	1.023, 1.196	0.016*
Place of residence						
Urban (ref)	1			1		
Rural	1.12	0.234, 1.36	0.057	1.09	1.003, 1.187	0.040291
Wealth index						
Poor (ref)	1			1		
Rich	1.32	0.59, 1.66	0.0051**	0.77	0.110, 1.94	1.78e-08**
Mothers age						
< 19 (ref)	1			1		
20–24	1.46	1.17, 1.92	0.221	1.49	1.103, 2.034	0.11701
25–29	1.06	0.641, 1.44	0.061	1.61	0.592, 1.820	0.15534
30–34	0.8	0.302, 1.47	4.55e-05***	0.81	0.123, 1.356	1.14e-05***
35–39	1.33	1.015, 1.86	0.045*	1.36	1.273, 1.421	0.06631.
40–44	1.12	0.721, 1.61	0.162	1.15	0.692, 1.263	0.07684.
> 45	1.41	1.22, 1.63	0.015	0.83	0.116, 1.524	0.08380.
(Ref = reference category)						
(*= significant level)						

Variables	COR	CI (95%)	P-value	AOR	CI (95%)	P-value
Family size						
type of birth						
single birth (ref)	1			1		
multiple birth	1.16	0.722, 1.59	0.06	1.16	1.076,1.255	0.00126**
place of delivery						
Home (ref)	1			1		
Health center	0.25	0.043, 0.875	< 2e-16***	0.19	0.038, 1.291	2e-16***
Random effect	$\sigma_b{}^2$ = 0.03228					
AIC = 36668	ICC = 0.00971					
BIC = 36868						
(Ref = reference category)						
(*= significant level)						

Results from the final random-intercept mixed-effects logistic regression model (Table 6) revealed several factors that were independently and significantly associated with under-five mortality in East Africa. Children living in households with larger family size had more than twice the odds of dying before age five (AOR = 2.14, 95% CI: 1.997, 2.305) compared with those in smaller households, holding all other covariates constant. Use of an unimproved drinking water source was associated with modestly elevated mortality risk (AOR = 1.10, 95% CI: 1.023, 1.196), implying approximately 10% higher odds relative to improved sources. Rural residence also increased the odds of under-five mortality by 9% (AOR = 1.09, 95% CI: 1.003, 1.187) compared with urban residence.

Higher household wealth exerted a protective effect: children born to mothers in the richest wealth quintile had substantially lower odds of death (AOR = 0.77, 95% CI: 0.110, 1.940) than those born to mothers in the poorest quintile. Maternal age was likewise protective; children of mothers aged 30–34 years faced approximately 19% lower odds of mortality (AOR = 0.81, 95% CI: 0.123, 1.356) than children of adolescent mothers aged 15–19 years. Children from multiple births carried a 16% higher risk of death (AOR = 1.16, 95% CI: 1.076, 1.255) compared with singletons.

Finally, place of delivery emerged as one of the strongest predictors. Children delivered in a health facility had approximately 81% lower odds of dying before age five (AOR = 0.19, 95% CI: 0.038, 1.291) compared with those delivered at home.

These results underscore the importance of socioeconomic conditions, environmental sanitation, maternal characteristics, and access to institutional delivery in determining under-five survival across East African countries.

Random Coefficient Mixed-Effect Logistic Model

The random-coefficient model was fitted to allow covariate effects to vary across countries. Each key covariate (source of drinking water, place of delivery, family size, place of residence, type of birth, and mother's age) was tested separately with a random slope. All random-slope variances were near zero and non-significant ($p > 0.05$), indicating no substantial between-country heterogeneity in covariate effects. The simpler random-intercept model with fixed slopes was therefore retained.

Table 7
Random-coefficient model

Groups	Name	variance	Std.Dev	AIC	BIC
Random effects:					
source of drinking water	(Intercept)	0.000e + 00	0.000000	37984.7	37013.3
place of delivery	(Intercept)	3.936e-07	0.0006273	37298.6	37327.3
wealth status	(Intercept)	8.240e-06	0.0028706	37965.2	37993.9
family size	(Intercept)	1.487e-07	0.0003857	37741.5	37770.1
place of residence	(Intercept)	0.0000	0.0000	38004.4	38033.1
type of birth	(Intercept)	0.00023	0.01516	37085.0	37013.7
mothers age	(Intercept)	2.51e-05	0.000106	37934.9	37963.6

Random-slope variances for all covariates were near zero and non-significant, confirming no between-country variation in effects. Additionally, the random-coefficient model showed higher AIC and BIC values (Table 7) than the random-intercept model. Thus, random slopes added no value, and the random-intercept model with fixed slopes was retained.

The factors influencing under five mortality rates with-in a specific country

East African countries exhibit considerable contextual heterogeneity, including differences in political systems, economic inequality, and cultural norms. Consequently, certain risk factors for under-five mortality may be country-specific rather than uniformly shared across the region. These unique determinants can encompass socioeconomic disparities, demographic patterns, healthcare access, and environmental conditions that operate distinctly within each national context.

Table 8
Risk factor within each country using mixed-effect logistic model

Factors in each country	estimate	AOR	p-value	CI (95%)
Ethiopia				
(intercept)	2.2756	9.73	4.42e-08***	8.110, 10.331
sex of household head (female)	0.81386	2.25	0.01606 *	1.921, 2.463
family size (> 5)	0.9406	2.56	4.68e-07***	2.147, 3.382
mother age (30–34)	-0.5638	0.56	0.01379*	0.169, 1.241
place of residence (rural)	0.8995	2.45	0.00386**	1.343, 2.791
birth outcome (multiple birth)	0.7787	2.17	0.00526**	1.347, 3.115
Burundi				
(Intercept)	1.6615	5.26	3.25e-05***	4.013, 6.411
toilet facility (facilitated)	-0.2094	0.81	0.02489*	0.014, 1.672
place of delivery (Health center)	-0.3351	0.71	0.005555**	0.664, 1.724
type of birth (multiple birth)	-1.932	0.14	< 2e-16***	0.085, 1.013
wealth status (rich)	-1.0987	0.33	0.004347 **	0.232, 1.905
source of drinking wate r(unimproved)	0.1667	1.18	0.000683***	0.371, 2.577
Rwanda				
(Intercept)	1.7521	5.76	0.00137**	4.392, 6.054
sex of child (female)	0.8077	2.24	2.14e-05 ***	2.457, 2.691
type of birth (multiple birth)	0.8193	2.26	< 2e-16 ***	2.392, 2.866
wealth status (rich)	-1.8098	0.16	2.32e-05***	0.041, 1.225
family size (> 5)	0.9424	2.56	8.14e-09***	1.462, 3.237
source of drinking water (unimproved)	0.0851	1.08	0.0052**	0.192, 1.257
Tanzania				
(Intercept)	2.2883	9.85	< 2e-16 ***	8.526, 10.244
birth order (4th birth)	-1.2448	0.28	6.09e-05***	0.080, 1.037
type of birth (multiple birth)	1.5961	4.93	< 2e-16***	3.724, 5.306
place of delivery (Health center)	-0.3973	0.67	0.000126***	0.511, 1.038
place of residence (Rural)	0.5561	1.74	0.000229***	1.105, 2.461

Factors in each country	estimate	AOR	p-value	CI (95%)
wealth status(rich)	-0.2771	0.75	0.00484**	0.573, 1.662
Uganda				
(Intercept)	2.0826	8.02	< 2e-16***	7.481, 9.015
mother educational level (No education)	0.4695	1.59	0.001333**	1.119, 2.417
toilet facility (facilitated)	0.3509	0.70	0.004381**	0.402, 1.964
type of birth (multiple birth)	1.3230	3.75	< 2e-16 ***	2.448, 4.237
place of residence (Rural)	0.2655	1.30	0.005069**	0.461, 2.241
place of delivery (Health center)	-1.1745	0.31	0.018946 *	0.011, 0.716
Kenya				
(Intercept)	3.0893	21.9	1.02e-11***	19.017, 2.518
sex of child(female)	7.196e-01	2.05	0.004814**	1.266, 3.119
sex of household head (female)	0.3736	1.45	1.07e-08***	0.631, 1.725
mother age (45–49)	0.5810	1.78	0.040628*	1.477, 2.468
wealth status (rich)	-3.710e-01	0.69	0.023376 *	0.399, 1.545
source of drinking water (unimproved)	2.7569	15.75	3.42e-09***	14.028, 16.479
Madagascar				
(Intercept)	2.3438	10.42	< 2e-16 ***	9.641, 11.558
toilet facility (non-facilitated)	0.3156	1.37	0.001530**	1.019, 2.009
family size (> 5)	0.6578	1.93	4.57e-11***	1.531, 2.582
sex of child (Female)	0.2448	1.27	0.002362**	0.664, 1.846
type of birth(multiple birth)	1.1733	3.23	1.84e-09***	2.073, 4.557
birth order (4th birth)	-1.1156	0.33	0.000293***	0.102, 0.613
Malawi				
(Intercept)	2.242e + 00	1.27	< 2e-16 ***	0.065, 1.731
place of delivery (Health center)	-3.562e-01	0.96	0.00411 **	0.563, 1.852
mother educational level (No education)	3.112e-01	1.36	1.71e-05***	0.565, 1.861
sex of household head (Female)	6.532e-01	1.92	5.69e-05 ***	1.331, 2.058
place of residence (Rural)	4.254e-01	1.53	0.02132*	0.431, 1.779

Factors in each country	estimate	AOR	p-value	CI (95%)
Zambia				
(Intercept)	2.5839	13.24	1.64e-15 ***	12.044, 14.821
wealth status (Poorest)	-0.5858	0.55	0.021395 *	0.299, 1.066
source of drinking water (unimproved)	-0.5192	0.59	0.000114 ***	0.371, 1.501
mothers age (30–34)	0.4397	1.55	0.035789 *	0.397, 1.994
family size (> 5)	1.0029	2.72	< 2e-16 ***	1.653, 3.558
sex of household head(Female)	0.5791	1.78	0.006192**	1.521, 2.117

The analysis of under-five mortality across East African countries revealed a combination of unique and shared risk factors Table 8.

Female household headship emerged as a distinctive predictor in several countries (Ethiopia, Kenya, Malawi, and Zambia), suggesting that households headed by women may face particular socioeconomic constraints or resource limitations that elevate child mortality risk. In Ethiopia, this was the only factor that clearly distinguished it from the rest of the region.

Poor access to improved toilet facilities was a specific contributor in Burundi, Uganda, and Madagascar. In Burundi, where the highest under-five mortality rates were recorded, the availability and quality of sanitation facilities stood out as a critical determinant. In Uganda and Madagascar, the absence of adequate sanitation similarly increased exposure to hygiene-related diseases.

Gender of the child was significantly associated with mortality in Rwanda, Kenya, and Madagascar, with female children consistently showing higher risk than males. This pattern points to potential gender-based disparities in healthcare access, nutrition, or cultural preferences favoring male children.

Maternal age at birth influenced mortality in multiple settings, most notably in Kenya, where children born to women aged 45–49 experienced approximately three times the mortality risk (6.1%) of those born to women aged 15–19 (4.6%). Mother's age was also a significant factor in Ethiopia and appeared among common regional predictors.

Birth order exhibited notable variation. In Tanzania, it had a stronger association than elsewhere and showed a protective effect with increasing order. In Madagascar, children of fourth or higher birth order similarly faced lower mortality risk.

Maternal education emerged as a key determinant particularly in Uganda and Malawi, where lack of formal education (or low educational attainment) was linked to higher mortality, likely through reduced knowledge of nutrition, hygiene, and health-seeking behavior. In Tanzania, primary-level maternal education was also associated with elevated risk.

Several socioeconomic and environmental factors were consistently associated with under-five mortality across the region: place of residence (typically higher risk in rural areas), type of birth (multiple births carrying greater risk), source of drinking water, household wealth status (poorer quintiles consistently showing higher mortality), and family size (larger households generally linked to increased risk).

In summary, although unique vulnerabilities exist, notably female household headship, poor sanitation, gender discrimination against female children, and specific birth-order effects, many determinants are shared across East Africa. The most pervasive risk factors include rural residence, low household wealth, unimproved drinking water, large family size, multiple births, and older maternal age. These findings underscore the importance of both country-specific interventions targeting distinctive risks and broader regional strategies addressing common socioeconomic and environmental challenges.

Discussion

The Sustainable Development Goal 3.2 seeks to end preventable deaths of children under five years of age [17]. In the pooled sample of the nine East African countries studied, 4.9% of children died before their fifth birthday, corresponding to an under-five mortality rate of 49 per 1,000 live births.

The analysis identified several determinants that were consistently associated with elevated under-five mortality across the region at the 5% significance level: larger family size (> 5 members), use of unimproved drinking water sources, rural residence, multiple births, lower household wealth index, extreme maternal ages (particularly older mothers), and home delivery. These findings align with extensive prior research in low- and middle-income settings and reflect resource dilution, environmental exposure, and limited access to quality healthcare services [18].

Large family size increases competition for limited household resources, including food, supervision, and healthcare, thereby raising mortality risk. This resource-dilution hypothesis is supported by earlier studies across sub-Saharan Africa [19]. Access to improved drinking water sources was protective, consistent with evidence from Ghana and broader sub-Saharan African analyses showing that safe water reduces diarrheal disease, a leading cause of under-five death [20, 21]. Rural residence was associated with higher mortality, reflecting poorer infrastructure, longer distances to health facilities, and lower socioeconomic conditions compared with urban areas.

Multiple births (twins or higher) carried substantially higher odds of mortality, attributable to prematurity, low birth weight, growth retardation, and feeding difficulties, as previously reported in Ethiopia and elsewhere [22, 23, 24]. Children from poorer households faced significantly greater risk than those from wealthier households, confirming that economic resources determine access to nutrition, clean water, and timely medical care. The unequal distribution of resources has long been identified as a fundamental driver of child survival disparities [25–27].

Beyond these common regional determinants, country-specific factors also emerged. Female household headship significantly increased under-five mortality in Ethiopia, Kenya, Malawi, and Zambia [10]. This

association likely reflects greater economic vulnerability, limited decision-making power, and reduced access to resources in female-headed households, often resulting from widowhood, divorce, or male out-migration, as documented in earlier Ethiopian and regional studies [28, 29].

Poor access to improved toilet facilities was a notable risk factor in Burundi, Uganda, and Madagascar. Inadequate sanitation facilitates fecal-oral transmission of pathogens, contributing to diarrheal diseases and environmental enteropathy, major causes of child death. This finding reinforces public health evidence linking sanitation deficits to elevated under-five mortality [30–32].

Female child sex was associated with higher mortality in Rwanda, Kenya, and Madagascar, suggesting persistent gender discrimination in intra-household resource allocation, healthcare-seeking behavior, or cultural preferences favoring male children. Such disparities, though diminishing in many settings, remain evident in parts of East Africa [33–35].

Higher birth order (fourth or later) was protective in Tanzania and Madagascar, consistent with the maternal experience hypothesis: with each successive birth, mothers gain knowledge and confidence in childcare, pregnancy management, and health-seeking practices. Maternal education emerged as a critical protective factor in Uganda and Malawi; children of uneducated mothers faced substantially higher risk, mediated through poorer knowledge of nutrition, hygiene, immunization, and timely care-seeking [36].

In conclusion, under-five mortality in East Africa is driven by a combination of pervasive regional determinants, rooted in poverty, rural disadvantage, and limited service access, and context-specific vulnerabilities such as female household headship, sanitation deficits, and gender bias. These findings underscore the need for both broad-based interventions targeting shared socioeconomic and environmental risks and tailored country-level strategies addressing unique determinants to accelerate progress toward Sustainable Development Goal targets.

Strength and Limitation of the Study

This study benefits from large, nationally representative DHS datasets across nine East African countries, enabling robust regional and national inferences. The use of two-level mixed-effects logistic regression appropriately accounts for clustering and hierarchical variability. These features enhance the relevance of findings for evidence-based policy and intervention planning.

However, reliance on mothers' recall of events in the five years preceding the survey may introduce recall bias. Additionally, despite including a wide range of covariates, the analysis is limited to variables available in DHS data, potentially resulting in residual confounding from unmeasured factors.

Conclusion

In this study across nine East African countries, under-five mortality prevalence was 4.9%, highest in Burundi, Madagascar, Tanzania, and Uganda, and lowest in Ethiopia, Rwanda, Malawi, Zambia, and Kenya; 6.5% of variation was attributable to between-country differences. Regionally, multiple births, unimproved drinking water, large family size, and rural residence increased mortality risk, while maternal age 30–34 years, higher wealth, and institutional delivery were protective. Country-specific factors included female household headship (risk in Ethiopia, Kenya, Malawi, Zambia), lack of improved toilet facilities (Burundi, Uganda, Madagascar), female child sex (Rwanda, Kenya, Madagascar), higher birth order being protective (Tanzania, Madagascar), and low maternal education elevating risk (Uganda, Malawi). These findings call for integrated regional interventions on common risks and targeted national strategies for country-specific determinants to reduce preventable under-five deaths.

Declarations

Ethics approval and consent to participate

This study utilized data from the Demographic and Health Survey (DHS), which follows strict procedures to ensure the privacy and confidentiality of all respondents and households. Standard DHS survey protocols and questionnaires are reviewed and approved by the Institutional Review Board (IRB) of the International Coaching Federation (ICF). In addition, country-specific DHS protocols undergo review by both the ICF IRB and, typically, the host country's national IRB. Detailed information on ethical considerations for DHS surveys is available at https://www.dhsprogram.com/methodology/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm. *The dataset was not shared or passed on to other bodies and was anonymized to maintain its confidentiality. All methods were carried out in accordance with relevant guidelines and regulations.*

Consent for publication

The manuscript has not been published or submitted elsewhere, and all authors have approved its submission to this journal.

Declaration of Competing Interest

All authors declared that there is no conflict of interest.

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Author Contribution

Y.B: Conceptualizations, Data curation, Methodology, Visualization, Data Analysis, writing original draftS.F: Conceptualization, Methodology, Investigation, Reviewing and Editing, SupervisionS.B: Conceptualizations, Data curation, Methodology development, Visualization, Data Analysis, Reviewing and Editing, Supervision

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Data Availability

The data analysed in this study are available from the Demographic Health Survey (DHS) program website at http://www.dhsprogram.com. Access to the datasets requires registrations and approval from the DHS program by explaining the objective of the study.

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