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Original Article

The Impact of Socio-Economic, Demographic, and Geographic Factors on the Mortality of Children Under the Age of Five in Kenya, 2022

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Abstract

Background: Reducing the under-five child mortality is vital to a nation's development; global progress has been made in the past two decades. Nevertheless, substantial efforts in the Sub-Saharan Africa region are required to address critical risk factors to attain the Sustainable Development Goals (SDGs) by 2030. We aimed to identify the impact of socio-economic, demographic, and geographic factors on under-five child mortality in Kenya.

Methods: This study utilized data from the 2022 Kenyan Demographic and Health Survey (KDHS). We extracted mortality data for children under the age of five and demographic, socio-economic, and household/geographic factors.

Results: Overall, 19,530 children under the age of five yr were included, with 9,950 (50.95%) males and 9,580 (49.05%) females. Amongst children, 18,836 (96.45%) were alive and 694 (3.55%) were dead. Study findings revealed a significant association between the mother's age and the child's death. Mothers aged between 15 and 19 yr of age indicate higher odds of child death. The odds of death of children not breastfed is 1.69 times that of other children. Mothers who had no child above five years old previously had higher odds of child mortality than those with at least three children above five years old.

Conclusion: Under-five child mortality is significantly associated with breastfeeding, the mother's age, and mothers who had a child previously in Kenya. The identified significant determinants align well with the SDG 2030 targets of improving socio-economic status, healthcare systems and reducing inequality. Therefore, the study suggests that preventing underaged women's pregnancy, proper maternal nutrition among pregnant women, and breastfeeding should be practiced as they are more likely to reduce under-five child mortality.

Keywords: Survey logistic regression; Adjusted odds ratios; Under-five mortality; Kenya

Introduction

African children face higher mortality risks than those in developed countries. The 2015 WHO report revealed that the under-five child mortality rate (U5MR) was recorded at 5.5% in Sub-Saharan Africa and 1.0% in European countries (1). Between the period preceding the 2022 KDHS, the neonatal mortality rate stood at 21 deaths per 1,000 live births, the infant mortality rate was 32 deaths per 1,000 live births, and the under-five mortality rate was 41 deaths per 1,000 live births (2, 3). Kenya has experienced a decrease in childhood mortality rates over time. Following its peak in 2003, the under-five mortality rate dropped from 115 deaths per 1,000 live births to the current rate of 41 deaths per 1,000 live births (2).

The 2022 KDHS indicates overall enhancements in health indicators compared to previous surveys (2). The fertility rate dropped to 3.4 children per woman from 3.9 reported in the 2014 KDHS (2). Modern family planning methods among married women in Kenya have seen an upward trend, increasing from 18% in 1989 to 57% in 2022. Maternal health indicators have notably improved, with 66% of women attending four or more antenatal visits for their latest live births in 2022, compared to 58% in 2014. Moreover, 80% of live births occurred in health facilities in 2022, up from 60% in 2014 (2).

Infant and under-five mortality rates in Kenya have significantly improved over the years. From 1989 to 2022, the infant mortality rate dropped from 61 deaths per 1,000 live births to 32 deaths per 1,000 live births. Similarly, the under-five mortality rate decreased from 90 deaths per 1,000 live births in 1989 to 41 deaths per 1,000 live births in 2022 (2, 3). In 2022, the prevalence of stunting in children under five was 18%, marking a considerable drop from 35% recorded in 2008-9 (2, 3). This reduction signals a decrease in long-term undernourishment among young children, contributing to lower child mortality rates. Additionally, 80% of children aged two or younger received the complete essential vaccinations in 2022 (2, 3). Between 1998 and 2022, the proportion of women aged 15 to 49 reporting circumcision decreased from 38% to 15%. This shift reflects changing cultural attitudes towards female genital mutilation (FGM) in Kenya (2). FGM is linked to childbirth complications, highlighting the complexity of cultural practices impacting maternal health. A changing cultural stance on FGM could indirectly lower childbirth-related deaths by enhancing women's general well-being, though the effect might not be immediate. To reduce maternal mortality, it is important to ensure access to skilled birth attendants, proper healthcare facilities, and education on safe birthing practices (4).

In 2015, the under-five child mortality rates had decreased globally between 1990 and 2015. Over 25 years, the global child mortality rate dropped from 9% to 4.3% (5-8). The under-five mortality rate in Kenya remained consistent between rural and urban areas at 41 deaths per 1,000 live births over the five years before the 2022 survey (2). Over the ten years preceding the 2022 KDHS, there was a general decrease in child mortality with higher levels of maternal education (2). Keeping a gap of at least three years between children helps lower the risk of infant death, with Kenya's median birth interval standing at 42.1 months (2). Infants born within two years of a previous birth face significantly higher under-five mortality rates, accounting for 17% of non-first births in Kenya. For these ten years, children with birth intervals of two years or less experienced the highest under-five mortality rate, reaching 67 deaths per 1,000 births (2).

Despite Kenya's progress in reducing under-five mortality, achieving the SDG of fewer than 25 deaths per 1,000 live births by 2030 remained challenging. In 2015, Kenya adopted world SDG 3, aiming to eliminate preventable deaths among children under five. The target: fewer than 25 deaths per 1,000 live births by 2030 (9-12). Kenya has made progress in child health and reducing mortality, but ongoing efforts are crucial to

achieve the targeted goals, involving initiatives like widened healthcare access and improved maternal and child services. However, achieving the SDG target depends on ongoing investment in healthcare infrastructure, continued research, addressing gaps, enhancing access to quality healthcare in remote regions, and tackling factors and preventable illnesses linked to child mortality. Consequently, we aimed to identify the factors influencing under-five child mortality in Kenya using suitable statistical methods.

Methods and Materials

The research utilized the 2022 KDHS data collected by the Kenyan National Bureau of Statistics and the Ministry of Health (MoH), alongside other collaborators. The 2022 KDHS aims to offer comprehensive insights into Kenya's population and health landscape. It marks the seventh Demographic and Health Survey conducted in Kenya since 1989. Furthermore, the 2022 KDHS is crucial for tracking SDGs progress in Kenya. Additionally, it supplies essential indicators for monitoring both national and sub-national development plans, including Kenya's Vision 2030, Medium Terms Plans (MTPs), County Integrated Development Plans (CIDPs), and Africa Agenda 2063 aspirations (2, 13).

The 2022 KDHS employed a sample design that aimed to generate estimates on a national scale, encompassing urban and rural areas and specific indicators for each of Kenya's 47 counties. The survey utilized a two-stage cluster random sampling method stratified by households, using the 2014 Kenyan population census as the sampling framework. In total, 32,156 women aged 15 to 49 from selected households consented to participate in the survey. Among these participants, 19,530 were eligible for this study, meeting the criteria of age 15 to 49 and having children under five in their household. None of the eligible participants were excluded due to missing data, as there were no instances of missing values. For further details on the sampling methodology, the 2022 KDHS report provides additional comprehensive information (2, 3).

Study Variables

This study focused on under-five child mortality as the response variable, which denotes whether a child is alive or deceased. It examines 11 independent variables categorized into three groups: demographic factors (such as the child's sex, mother's age, breastfeeding, and marital status), socio-economic aspects (including educational level, employment status, and wealth index), and household characteristics (such as the number of children aged five or older, the total number of children ever born, residential area, and primary water source).

Statistical Methods

Logistic regression analyzes the relationship between the explanatory variables and the binary under-five child mortality data. Logistic regression may not be suitable for complex survey designs, but survey logistic regression is employed to ensure valid statistical inferences by accounting for factors like stratification, sampling weight, clustering, and design effects in parameter estimation and standard error adjustments (14, 15).

Neglecting the complex nature of the survey design during the modeling process can cause errors in standard error estimation, potentially leading to biased estimates (15, 16). Survey logistic regression uses pseudo-maximum likelihood estimation to mitigate this issue (16). This approach incorporates weighting the estimating equation. As a result, we define the response variable as y_{hij} , which equals one if the event occurred in h^{th} individual within i^{th} household within j^{th} primary sample unit; otherwise, it is 0. The total number of observations, denoted as n, can be calculated as the sum of n_{hji} for each combination of $h, j,$ and i , $n = \sum_{h=1}^{H} \sum_{j=1}^{n'_h} \sum_{i=1}^{n'_{hj}} n_{hji}$, where $h = 1, \dots, H$, representing the strata, within each stratum, $j = 1, \dots, n_h$, representing primary sampling units (PSUs), each PSU is further divided into $i = 1, \dots, n_{hj}$, representing second-

ary sampling units (SSUs), comprehending n_{hji} elements (16). The sampling weight for the hji^{th} unit in the dataset is indicated as w_{hji} (16). These weights are determined based on the sampling probability at each stage. Specifically, the design weights are obtained by multiplying the household design weights by the inverse of the household response rate within each stratum (17, 18).

Let π_{hji} represent the probability that the event occurred in h^{th} individual within the i^{th} household within the j^{th} primary sample unit, such that $\pi_{hji} = P(y_{hij} = 1)$. Similarly, let $1 - \pi_{hji}$ represent the probability that the event did not occur in the h^{th} individual within i^{th} within the j^{th} primary sample unit, such that $1 - \pi_{hji} = P(y_{hij} = 0)$. Based on these probabilities, the survey logistic regression model can be expressed as follows:

$$logit\left(\pi_{hji}\right) = log\left\{\frac{\pi_{hji}}{1-\pi_{hji}}\right\} = X'_{hji}\beta \quad (1.1)$$

where π_{hji} represents a vector that captures the characteristics of the h^{th} individual within the i^{th} household within the j^{th} primary sample unit, while β represents a vector of unknown model coefficients (16). Considering the complex survey design, estimating the parameters β in the logistic regression model is accomplished through a weighted maximum likelihood approach known as the pseudo maximum likelihood function (15, 16). This approach incorporates the use of sampling weights in the estimation of β. The pseudo maximum likelihood function calculates the contribution of a single observation to the overall estimation and is expressed as follows:

$$\pi_{hji}^{w_{hji}y_{hji}}(1-\pi_{hji})^{(1-w_{hji}y_{hji})} \quad (1.2)$$

Thus, the pseudo-likelihood function with weight w_{hji} for n observations is given by

$$L(\beta|w_{hji}Y_{hji}) = \prod_{h=1}^{H}\prod_{j=1}^{n'_h}\prod_{i=1}^{n'_{hj}}\pi_{hji}^{w_{hji}y_{hji}}(1-\pi_{hji})^{(1-w_{hji}y_{hji})} \quad (1.3)$$

The design effect (DEFF) is defined as the ratio of the variance of an estimate under a complex sample design to the variance of the estimate that would result from a simple random sample of the same size (16, 19). Mathematically, the design effect is given by:

$$DEFF = \frac{Variance\ under\ the\ complex\ design}{Variance\ under\ the\ simple\ random\ sample} \quad (1.4)$$

Design effects provide a measure of the relative efficiency of the sample design in comparison to simple random sampling. The square root of the DEFF referred to as the design effect factor (DEFT), acts as an inflation factor for standard errors computed using the complex survey sample. A DEFT value less than 1 indicates that the sample design improves efficiency, reducing the standard error of the estimate. A DEFT value equal to 1 means that the sample design has no impact on standard error. Conversely, a DEFT value greater than 1 indicates a sample design that inflates the standard error of the estimate (16).

Ethical Approval and Institutional Review Board Statement

Since the study relied on existing secondary data, ethical approval was not necessary as per the DHS guidelines. Additional details regarding the ethical clearance specified related to DHS datasets can be found in the source: https://dhsprogram.com/Data/terms-of-use.cfm. All methods adhered to the guidelines in the Declaration of Helsinki.

Results

Table 1 illustrates the demographic, socio-economic, and household characteristics of chil-

dren under five. *P*-values demonstrated in Table 1 are obtained from the Chi-square test. At a 5% significance level, the univariate cross-tabulation analysis uncovers that mother's age, breastfeeding, marital status, education level, employment status, number of children above or aged five, and total children ever born are significantly associated with under-five child mortality. There were 9,950 boys (50.95%) and 9,580 girls (49.05%). Notably, the mortality rate was higher among boys, with 368 (1.88%) deceased, compared to 326 (1.67%) among girls. Out of the 19,530 eligible women, a significant portion fell within the 20 to 29 age group (50.87%), with the majority, 65.77%, residing in rural areas. Around 13.46% had completed higher education, while a more significant percentage, 55.51%, were unemployed. Nearly half of the participants, 49.98%, belonged to low-income households. Additionally, 9,219 children (47.20%) did not receive breastfeeding, and among them, 483 (2.47%) passed away. A notable observation is that mothers with primary education, numbering 6,896 (35.31%), experienced a higher under-five child mortality rate of 290 (1.48%) compared to those with higher education, where only 68 (0.35%) had children who passed away in this age group.

A significant portion of deceased children, totaling 360 (1.84%), belonged to households with elevated unemployment rates, while 343 (1.76%) came from households categorized with a poor wealth index. Moreover, children born to mothers residing in rural areas exhibited a slightly higher mortality rate, with 444 (2.27%) deaths compared to 250 (1.28%) deaths among those in urban settings. The majority of the children, around 8,080 (41.37%), were born to mothers who had at least one child above or aged five previously. Access to safe water sources was available to 12,501 (64.01%) of the children. Notably, a significant proportion of participants, numbering 5,286 (27.07%), had given birth to at least five children.

Table 1: Descriptive statistics of the study data, 2022 Kenyan DHS

Covariates	*Total N (%)*	*Response Variable N (%)* *Child dead*	*Child alive*	*P-value*
	19,530	694 (3.55)	18,836 (96.45)	
Demographic Characteristics				
Sex of child				0.2647
Male	9,950 (50.95)	368 (1.88)	9,582 (49.06)	
Female	9,580 (49.05)	326 (1.67)	9,254 (47.38)	
Mother's Age				0.0043
15 - 19 years	948 (4.85)	43 (0.22)	905 (4.63)	
20 - 29 years	9,935 (50.87)	331 (1.69)	9,604 (49.18)	
30 - 39 years	7,231 (37.03)	249 (1.27)	6,982 (35.75)	
40 – 49 years	1,416 (7.25)	71 (0.36)	1,345 (6.89)	
Breastfeeding:				<0.0001
No	9,219 (47.20)	483 (2.47)	8,736 (44.73)	
Yes	10,311 (52.80)	211 (1.08)	10,100 (51.72)	
Marital status:				0.0033
Not married	4,898 (25.08)	207 (1.06)	4,691 (24.02)	
Married	14,632 (74.92)	487 (2.49)	14,145 (72.43)	
Educational level:				0.0005
No education	4,464 (22.86)	141 (0.72)	4,323 (22.14)	
Primary education	6,896 (35.31)	290 (1.48)	6,606 (33.82)	
Secondary education	5,542 (28.38)	195 (1.00)	5,347 (27.38)	
Higher education	2,628 (13.46)	68 (0.35)	2,560 (13.11)	
Socio-economic characteristics				
Employment:				0.0497
No	10,841 (55.51)	360 (1.84)	10,481 (53.67)	
Yes	8,689 (44.49)	334 (1.71)	8,355 (42.78)	
Wealth index:				0.7873
Poor	9,762 (49.98)	343 (1.76)	9,419 (48.23)	
Middle	3,379 (17.30)	116 (0.59)	3263 (16.71)	
Rich	6,389 (32.71)	235 (1.20)	6,154 (31.51)	
Household characteristics				

Table 1: Continued….

Number of children >= 5 years old				<0.0001
0	1,010 (5.17)	220 (1.13)	790 (4.05)	
1	8,080 (41.37)	293 (1.50)	7,787 (39.87)	
2	7,179 (36.76)	151 (0.77)	7,028 (35.99)	
>= 3	3,261 (16.70)	30 (0.15)	3,231 (16.54)	
Total children ever born				<0.0001
1	3,753 (19.22)	83 (0.42)	3,670 (18.79)	
2	4,478 (22.93)	157 (0.80)	4,321 (22.12)	
3	3,559 (18.22)	139 (0.71)	3,420 (17.51)	
4	2,454 (12.57)	97 (0.50)	2,357 (12.07)	
>= 5	5,286 (27.07)	218 (1.12)	5,068 (25.95)	
Residential area:				0.3120
Urban	6,686 (34.23)	250 (1.28)	6,436 (32.95)	
Rural	12,844 (65.77)	444 (2.27)	12,400 (63.49)	
Water source:				0.1654
Safe water	12,501 (64.01)	427 (2.19)	12,074 (61.82)	
Not safe water	7,029 (35.99)	267 (1.37)	6,762 (34.62)	

The AIC, SC, and -2 log L of the full model (Intercept and Covariates) is smaller compared to the corresponding criterion of the reduced model (Intercept only); this indicates that the fitted full model better explains the data (Table 2). The *P*-values corresponding to the likelihood ratio, Score test, and Wald tests are less than 0.05. The overall fitted survey logistic model is significant. There is a significant contribution of independent variables in predicting of the response variable (in our case, the child is not alive). In other words, at least one parameter is significantly different from zero. A moderate (78.6%) association exists between the predicted probabilities and the observed responses. In addition, Table 2 shows that the concordant rate was 77.7%.

Table 2: Survey logistic regression model fit statistics

Criterion	***Intercept only***	***Intercept and Covariates***		
AIC	5176.163	4485.028		
SC	5183.932	4655.936		
-2 Log L	5174.163	4441.028		
Model evaluation parameters				
Test	F Value	Num DF	Den DF	P-value
Likelihood Ratio	35.66	19.8259	31702	< 0.0001
Score	21.97	21	1579	< 0.0001
Wald	25.74	21	1579	< 0.0001
Association of predicted properties and observed response				
Percent Concordant	77.7	Somers'D	0.572	
Percent Discordant	20.4	Gamma	0.583	
Percent Tied	1.9	Tau-a	0.039	
Pairs	13072184	c	0.786	

The result of the Receiver Operating Characteristic (ROC) curve obtained from the ordinary logistic regression model is presented in Fig. 1. The figure shows that the Area under the Curve is equal to 0.7918, indicating the model's predictive power is moderate.

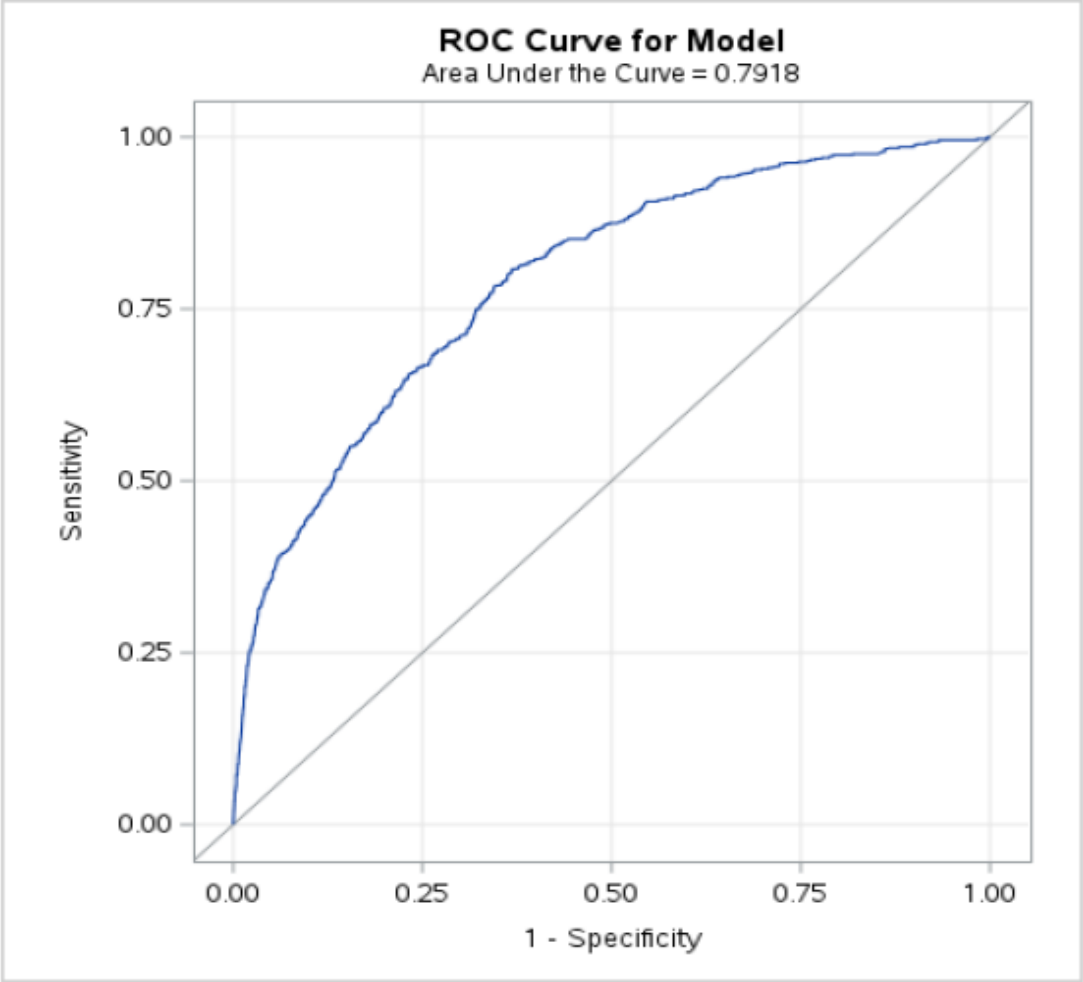

Fig. 1: ROC Curve obtained from ordinary logistic regression

Table 3 exhibits the findings from the survey logistic regression analysis. Adjusted odds ratios were used to determine the relationship between under-five child mortality and exposure variables. Based on the results, the odds of death of under-five children born to younger mothers, specifically those aged 15 to 19 yr old, significantly higher (with a $P<0.0002$), estimated to be 2.93 times greater than those born to mothers aged 20 to 29 yr old. Additionally, the absence of breastfeeding significantly increased the odds of under-five child mortality ($P=0.0002$), estimated to be 1.69 times higher compared to children breastfed. The odds of death of children born to unemployed mothers is approximately 1.09 times higher than that of children born to employed mothers. Additionally, mothers who previously had at most four children experienced significantly lower odds of child mortality compared to those who had at least five children previously. Moreover, children born to mothers who had no children above or aged five previously had substantially higher odds of under-five child mortality (with a $P<0.0001$), estimated to be approximately 48.73 times greater than those born to mothers who had at least three children aged above five previously.

Table 3: Survey Logistic Regression output and study results of design effects

	Adjusted odds ratios	***Standard Error***	***P-value***	***Design effects***	
Parameter	AOR (95% CI)			DEFF	DEFT
Demographic characteristics					
Sex (ref: Female)					
Male	1.13 (0.93; 1.38)	0.1	0.2211	1.56	1.25
Mother's Age (ref: 20 - 29)					
15 – 19 yr	2.93 (1.66; 5.18)	0.29	0.0002	2.33	1.53
30 – 39 yr	0.56 (0.42; 0.75)	0.15	<0.0001	1.86	1.36
40 – 49 yr	0.43 (0.72; 0.67)	0.23	0.0002	2.06	1.43
Breastfeeding (ref: Yes)					
No	1.69 (1.29; 2.23)	0.14	0.0002	2.42	1.55
Marital Status (ref: Not married)					
Married	1.15 (0.89; 1.48)	0.13	0.2639	2.09	1.45
Educational Level (ref: Higher)					
No education	0.89 (0.56; 1.44)	0.24	0.6549	1.59	1.26
Primary education	0.83 (0.54; 1.26)	0.22	0.38	1.89	1.37
Secondary education	1.02 (0.68; 1.55)	0.21	0.9112	1.96	1.4
Socio-economic characteristics					
Employment (ref: Yes)					
No	1.09 (0.87; 1.38)	0.12	0.4181	1.78	1.33
Wealth index (ref: Rich)					
Middle	0.99 (0.71; 1.39)	0.17	0.9763	1.71	1.31
Poor	1.07 (0.77; 1.48)	0.16	0.6766	1.51	1.23
Household characteristics					
Number of children >= 5 yr old (ref: >= 3)					
0	48.73 (26.77; 88.71)	0.31	<0.0001	1.98	1.41
1	6.33 (3.55; 11.28)	0.29	<0.0001	2.1	1.45
2	2.42 (1.38; 4.24)	0.28	0.0019	1.96	1.4
Total children ever born (ref: >= 5)					
1	0.07 (0.04; 0.13)	0.28	<0.0001	1.96	1.4
2	0.29 (0.20; 0.43)	0.19	<0.0001	1.6	1.26
3	0.47 (0.32; 0.69)	0.19	0.0001	1.84	1.36
4	0.57 (0.39; 0.81)	0.18	0.0019	1.65	1.28
Residential area (ref: Urban)					
Rural	1.12 (0.84; 1.49)	0.15	0.4273	1.86	1.36
Water source (ref: Safe water)					
Not safe water	0.88 (0.69; 1.12)	0.12	0.3129	1.78	1.33

Furthermore, Table 3 displays the DEFT values derived from the square root of DEFF for each estimated variance component. Most design effect values surpass one, signifying the significance of incorporating survey logistic regression. Its tendency for larger standard errors in contrast to logistic regression highlights the necessity to consider survey design features. This approach aids in averting the underestimation of variance.

Discussion

The study's objective centered on identifying factors impacting under-five child mortality in Kenya, utilizing the 2022 KDHS dataset. The analysis calculated adjusted odds ratios using survey logistic regression, accounting for binary outcomes and sampling design (15). The findings highlighted significant determinants of under-five child mortality, including maternal age, breastfeeding, mothers with children aged five and above, and the overall number of children ever born (20). Notably, the study unveiled compelling evidence within the data that underscores the association between mother's age and under-five child mortality in Kenya, aligning with earlier research (8, 9). Echoing the discoveries of others (6, 21), this study underscores the pivotal role of demographic, socio-economic, and environmental factors in determining under-five child mortality. Despite progress made by the Kenyan government, challenges persist in combating under-five mortality rates.

Similar to previous studies (12, 20-23), this research observed a higher rate of child mortality among mothers who did not breastfeed in comparison to those who did. However, unlike findings from other studies (24-26), this study did not establish a significant impact of education on child mortality. Additionally, child born to mothers with a poor wealth index faced higher mortality rates compared to those from wealthier households, emphasizing the critical role of household income in under-five child mortality. Notably, the total number of children ever born and the presence of children above or aged five in the household significantly affected under-five child mortality in Kenya (27). Consequently, these results recommend prompt interventions to enhance maternal well-being, household income, and family planning services to diminish under-five mortality rates further.

Conclusion

The study findings will add to the government's fight to change the socio-economic status of the Kenyan people. Implementing educational programs specifically aimed at pregnant women is crucial, equipping them with knowledge about the benefits of breastfeeding during the early postpartum months. Policy interventions should be strengthened or implemented to address preventable deaths of under-five children, with an emphasis on improving maternal and child health services, such as family planning services to improve child health and pregnancy outcomes, skilled birth attendance, antenatal care, and postnatal care for both mother and child. Policymakers must focus on gender equality and women's empowerment through education and economic opportunities, as empowered women tend to make informed health decisions for themselves and their children. The government should enhance healthcare access, especially in rural and underserved areas, conduct widespread immunization campaigns to ensure all children receive essential vaccinations against preventable diseases. These findings will guide policymakers, assisting them with accelerating quality of life in accordance with the government's Vision 2030.

Availability of data and material

The data used in this study can be obtained by requesting the ORC macro and DHS: https://dhsprogram.com/.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interests.

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