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Trends and Associated Factors of Under-five Mortality Based on 2008–2016 Data in Kersa Health and Demographic Surveillance Site, Eastern Ethiopia

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Abstract

Background: Of the 6.2 million estimated deaths of children under 15 years of age globally, the death toll of children under 5 years of age accounted for 5.3 million. In Ethiopia, even though significant progress has been made, facility-based research shows that the mortality rate of children under 5 is still high. In the country, particularly in the eastern part, evidence on trends in under-five mortality and associated factors from population-based longitudinal data is limited. **Objective**: The objective of the study was to assess under-five mortality focusing on the trends and associated factors based on 2008–2016 data in Kersa Health and Demographic Surveillance Site, Eastern Ethiopia. **The method**: The study was based on 9 years of surveillance data. The surveillance site was founded in 2007 with the aim of producing community-based health and demographic data in the eastern Ethiopia. Data were collected from the surveillance site and analyzed with STATA version 15 (for factor analysis) and/or Statistical Package for Social Sciences (SPSS) version 26 (for trend analysis) and Microsoft (MS) Excel software. The autoregessive integrated moving average (ARIMA) model and Mann–Kendall were used to analyze mortality trends. Multi-level logistic regression was used to assess the associated factors. **Result**: There were a total of 18 759 newborns in the surveillance sites, of which 1602 died of children under 5 years of age, and the total mortality rate for children under 5 years of age was 85 per 1000 live births. Trend analysis shows that the mortality rate of children under 5 has been steadily declining during the study period. Multi-level logistic regression shows that the variance of the random component model related to the intercept term is statistically significant, which means that there is a change in the mortality rate of children under 5 between the survey years, which is explained by the random intercept term. Antenatal care visits by mothers (AOR = .61, 95% CI = .49, .74), primary education (AOR = .58, 95% CI = .49, .68), normal birth weight (AOR = .78, 95% CI = .64, .95), and having 2 or fewer total births (AOR = .37, 95% CI = .22, .37) were all associated with child death. **Conclusion**: Despite the downward trend, the mortality rate of children under 5 years old at the surveillance sites is high. Effective intervention measures should be implemented.

Keywords

under-five mortality trend, associated factors, Kersa health and demographic surveillance site

“What is already known on this subject?” and “What does this study add?”

Previous studies that examined children under age 5 mortality in Ethiopia found that socio-demographic characteristics (educational status of mother, marital status, occupation of mother/caregiver), age at first marriage, Antenatal Care Visit (ANC) visit, skilled birth attendant, pregnancy

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termination, types of fuel used, and housing conditions were linked with under 5 child mortalities.[1,3,7,9,10,14,15] However, these studies were institutional-based cross-sectional and used small and limited data. Due to this, the inference associated with the estimated parameters may be different from the actual value, resulting in wrong generalization.

In addition, some articles emphasized specific diseases related to child mortality and used simple statistical analysis to show the trend and factors associated with mortality. Additionally, studies' aggregate analysis of the first 59 months of life is very limited in Ethiopia, especially since most studies focus on Neonatal. Furthermore, much work remains to be done in order to obtain an accurate figure of childhood deaths in the country. This study aimed to show the trend of under-five child mortality and common factors associated with mortality using community-based longitudinal data.

Background

Child mortality is an important demographic, health, and development issue for a number of reasons. Mortality is one of the 3 measures (along with fertility and migration) that determine population size and growth rate, the age-sex distribution, and the spatial spread of the population.[1,2] It is an essential indicator of development and crucial evidence of a country's value and priorities.[2,3] According to the World Health Organization (WHO) report of 2018, under-five deaths accounted for 5.3 million of the estimated deaths of 6.2 million children and adolescents under the age of 15 years. The risk of a child dying before completing 5 years of age is still highest in the WHO African regions (76 per 1000 live births), around 8 times higher than that in the European region (9 per 1000 live births).[3] However, there was a decline in the trend, which was 39 deaths per 1000 live births in 2018 compared to 93 deaths in 1990 and 76 per 1000 live births in 2000, a 59% and 49% decline, respectively. The total number of under-five deaths dropped to 5.3 million in 2018 from 12.5 million in 1990. On average, 15 000 children died before age 5 every day in 2018, compared to 34 000 in 1990 and 27 000 in 2000. Sub-Saharan African countries remain the region with the highest under-five mortality in the world. In 2018, the region had an average under-five mortality rate of 78 deaths per 1000 live births. These indicate that 1 in 13 children died before they celebrated their fifth birthday.[4]

In Ethiopia, there has been a tremendous effort to reduce child mortality that has brought remarkable progress in the past 2 decades. However, under-five mortality is still high, with 67 deaths per 1000 live births, meaning that 1 in 15 children in Ethiopia die before reaching age 5.[4-11] According to various studies under 5, mortality is influenced and/or determined by various social, economic, demographic, environmental, cultural, or behavioral factors. Some of these factors influence under-five mortality directly, while others affect it indirectly.[9-11]

A cross-sectional study found that mothers' education, wealth status, place of residence, religion, immunization, type of birth, breastfeeding, housing, sanitation, and source of drinking water were all linked to under-five child mortality.[10-12] In particular to Ethiopia, few of the studies conducted examine factors associated with under-five mortality in the country's base health facilities which are not representative of the under-five population of children aged under 5 years in the country. In addition, there is a limited study, particularly in the Eastern part of the country, that assesses the trends and risk factors associated with under-five mortality based on the data of longitudinal. There are previous studies that were conducted on the same surveillance site with various years of data analysis.[13,31,32,41] But they focused on neonatal mortality and the cause of death. In addition, they did not indicate the trend of under-five mortalities in the area. Few of them presented a trend of neonate death with data that appeared to indicate an upward or downward trend over time, which was frequently presented without a statistical analysis, making it difficult for decision-makers to determine whether these apparent trends were due to chance variation.[13,31,41] Therefore, population-based longitudinal study is the method of choice to discover factors associated with death in Ethiopia. Therefore, this study aimed to assess the trends in under-five childhood mortality and identify factors associated with under-five mortality (U5M).

Materials and Methods

Study Area and Period

Kersa Health and Demographic Surveillance Site (KHDSS) is one of the districts in the eastern Hararghe zone that was established in 2007. It is 44 km west of Harar and 531 km from the capital, Addis Ababa. Kersa Health and Demographic Surveillance Site (KHDSS) is located in Kersa district, East Hararghe Zone, Oromia region. It is located between 41 0 40′ 0′ and 41 0 57′ 30' (longitude) and 09 0 15′ 15′ and 09 0 29′ 15' (latitude). In 2007, the Central Bureau of Statistics estimated that the total population of the region was 170 816. Of which 86 134 were males (50.4%) and 84 682 were females (49.4%); 11 384 (6.67%) of its population were rural residents. The district has 7 health centers, 7 health stations, and 8 private pharmacies in different locations in the district (CSA, 2012). The study was conducted from February 20th to February 30th, 2020.

Study Design

Kersa HDSS uses an open cohort population-based longitudinal surveillance design. It follows individuals in selected sites longitudinally every 3 months up to 2012 and every 6 months since 2013. Death registration and verbal autopsy for cause of death are taken for newborns ≤28 days, children's 4 weeks to 15 years, and adults ≥15 years, adopted from the

2007 standardized World Health Organization (WHO) questionnaires. It covers all socio-economic, demographic, and environmental conditions of subjects longitudinally followed (individuals and household units).

Source and Study Population

The source population is all children under the age of 5 recorded in the KHDSS database from 2008 to 2016. The study population was children under 5 years of age, selected from the Kersa Health and Demographic Surveillance System database.

Inclusion and Exclusion Criteria

All children under the age of 5 years recorded in the KHDSS database were included in the study. Children under 5 years of age with incomplete socio-demographic data were excluded from the study sample size determination.

Data Extraction Method and Tools

First of all, the available data on the Kersa health and demographic surveillance system database was observed, and appropriate data was extracted from the KHDSS database and Open Data Kit (ODK) by trained data collectors who have enough knowledge and experience in operating computers using the prepared data collection format from the already existing record.

Data Collection Procedure in the Surveillance Site

KHDSS covers 24 kebeles in Kersa District (the smallest administrative unit in the country) and 12 kebeles in Harar Town. The baseline information was assessed in 2007. There are permanently employed data collectors in each kebele who update the list of individuals living in the house during the 6-monthly field visits. The data collected includes births, deaths, and moving in or out every 6 months. Immunization, human waste disposal, solid waste disposal, water supply, housing conditions, reproductive health, nutrition, HIV/AIDS, and health care seeking and use are assessed and updated every year, and economic status is updated every 2 years. The death registration for the deceased, which includes verbal autopsies for the cause of death, was taken from close relatives, typically after the mourning period of 45 days. The verbal autopsy questionnaire is based on the World Health Organization (WHO) verbal autopsy form for neonates (less than 28 days of age), children (4 weeks to 15 years of age), and adults (15+ years of age). The verbal autopsies are done by data collectors separately from the regular surveillance data collection.[6] At the end of each data extraction day, the principal researcher checks the completeness, clarity, and consistency of the data extracted from each record.

Variables

Outcome Variables: Under-Five Child Mortality

Independent variables. Socio-economic characteristics such as gender, mother's education, religion, marital status, occupation, antenatal care (ANC), vaccination, birth outcome, breast-feeding, birth interval, parity, birth attendant, place of delivery, environmental factors, such as the source of drinking water and the distance between the water source and the house, whether the household has a separate kitchen and window, the type of toilet, and whether it is shared, and the materials the house is made of.

Operational definition. *Under-five mortality*—The death of children before reaching the age of 5 years in the study area.

Under 5 mortality rate(U5MR)—is the rate calculated as equal to the number of deaths of children under 5 in calendar years between 2008 and 2016 divided by the number of under-five children in the same years and multiplied by 1000.

Water source—water utilized for drinking and for domestic purposes such as preparing food, whether it is from a protected or unprotected source.

Sanitation facilities—presence and utilization of facilities such as latrines and types of latrines.

Normal birth weight—birth weight of equal to 2,500g

Big birth weight—birth weight of greater than 2,500g.

Low birth weight—birth weight of less than 2,500g

Data quality control. Data quality was ensured during data extraction, recoding, and analysis. During the data extraction period, adequate training and follow-up were provided for all data extraction personnel. The principal investigator worked closely with the data manager during data extraction. At the end of each day, the extracted data was reviewed and checked for completeness, accuracy, and consistency by the investigator, and corrective discussions were undertaken with all research team members. During the data extraction, the principal researcher worked closely with the data manager. At the end of each day, the investigator reviewed and checked the completeness, accuracy, and consistency of the data extraction form and had a corrective discussion with members of the research team. Prior to further analysis, data were checked for incompleteness and cleaned using statistical software (SPSS version 26 and/or STATA version 15). The data was further cleaned by visualizing and calculating frequencies and sorting in STATA and/or SPSS. A correction was made according to the original data.

Data Processing and Analysis

STATA version 15 (for analysis of associated factors) and/or SPSS version 26 (for trend analysis) software were used to edit, clean, and analyze the data. To look for outliers, consistency, and missing values, a frequency distribution was performed. The descriptive analyses used were proportion, mean, and median. The mortality rate was calculated for the entire study period. The Box–Jenkins method was used to analyze the trend of under 5 deaths, which is a time series. The method follows iterative application of the model; (i) identification (using plots of the data, autocorrelations, and partial autocorrelations) to select a simple model; (ii) estimation (using maximum likelihood estimation (MLE) to maximize the probability of obtaining the data that we have observed); (iii) model diagnostic checking (the fitted model is checked for inadequacies by scatter plot of residuals on the *y* axis and fitted values on the *x* axis to detect non-linearity, unequal error variances, and outliers). Based on the Box–Jenkins method, the ARIMA model is used to predict the mortality trend of children under 5 years of age. Autoregressive Integrated Moving Average (ARIMA) is a time series method that fits specific statistical equations to past data. The model is expressed as ARIMA (p, d, q) s, where p means the order of auto-regression, d means the degree of trend difference, and q means the order of moving average. It requires a stable time series data set, which means that the time series has no fluctuations or periodicity over time. This means the ARIMA model is applied to stationary data only (a dataset is stationary if it has a constant mean, variance, and covariance over time). If the data is not stationary, then it is made so by the process of differencing (the process of subtracting an observation from the previous time step observation until the data is stationary by the Augmented Dickey–Fuller test). Parameters of the ARIMA model (p, d, q) were estimated by the ACF (autocorrelation function) graph and the PACF (partial autocorrelation) graph. A simple line graph was used to show the trend in under-five mortality. A Mann–Kendall trend test was also employed to check the trend significance as well as at what rate the trend changed over the period. The factors associated with under-five mortality were analyzed using multi-level modeling by considering the nesting of the outcome variables (child mortality) with the survey years. Individual-level covariates and survey years were modeled to examine variations and predict under-five child mortality.

For multi-level modeling in stata, 2 steps were followed. First, an empty model was built by fitting without factors to test the random variability in the intercept by survey year. This is to check whether multi-level logistic regression is an appropriate statistical model for the data. Then, a full model was built to evaluate the impact of the survey and the variables of interest simultaneously. In the full model, the variables included were antenatal care utilization, radio, television, type of drinking water source (improved or unimproved), toilet type (improved or unimproved), maternal age, maternal education, family size, place of delivery, birth attendant, mother's occupation, sex of a child, pregnancy duration, and the presence of a window in the house and residence. By extracting variables with a *P*-value of <.25 from the binary logistic regression model, the variables are included in the multivariate regression. Variables with a *P*-value of .05 or lower in the multivariable logistic regression model were considered significantly and independently associated with under-five mortality.

Result's

Socio-Demographic and Economic Characteristics of Children and Households

The total number of live births at the surveillance sites from 2008 to 2016 was 18 759, of which males accounted for 9574. Of the total number of births, 1602 children under the age of 5 died during this period.

The majority of children (94%) are rural residents. Of the children's caregivers or mother socio-demography, most of them were Oromo in the ethnic group (98.4%), illiterate in education status (78%), and Muslim in religion (98.24%). About nine-tenths of mothers were married (88%). There were 17 920 working mothers (95.73%), and 3064 (16.33%) mothers receiving antenatal care during pregnancy. More than three-quarters of mothers give birth at home with an unskilled attendant. Half of the mothers gave birth during the term period, followed by post-term 8673 (46.23%). Regarding house conditions and sanitation facilities, the house floor was made up of earth or mud (17 836 [95%]), followed by cement (921 [5%]), and most of them (10 749 [57%]) did not have a latrine and practiced open field (Table 1).

Regarding the causes of death shown in Table 2, most of the deaths of children under 5 at the surveillance site were due to infectious diseases, with the highest proportion of diarrhea (42.9%), followed by malnutrition.

According to the data, infant mortality accounted for more than 62% of the 9 consecutive years of surveillance, with neonatal mortality accounting for 38%.

Under-Five Child Mortality Trends in a Surveillance Site.

The mortality rate was slightly declined in neonates and infants at the 5% significance level of the Mann–Kendall trend test (Sen's slopeNMR = -1.034, PNMR = .179, Sen's slopeIMR = -1.46, PIMR = .348) and a steady decrement in under-five children (Sen's slopeU5DR = -3.55, PU5MR = .006) during the 9 consecutive surveillance years in the study area. Under-five deaths indicated a significant decreasing trend during the study period. In general, the magnitude of decline varies among the component rates that combine to form the under-five mortality rate (Table 3).

In the surveillance site, the overall rate of under-five child deaths is 85 per 1000 live births. Regarding the age distribution of deaths in the surveillance sites during 9 consecutive years, infant mortality was 55 deaths per 1000 live births and neonatal mortality was 29 deaths per 1000 live births (Supplementary, Figure 1).

Table 1. Background characteristics of children and mothers/caregivers in Kersa health and demographic surveillance, 2008–2016, Ethiopia, 2020.

Factors	Category	Frequency(n)	Percent (%)
Sex of child	Female	9185	48.97
	Male	9574	51.03
	Total	18 759	100
Residence	Urban	1126	6.00
	Rural	17 633	94.00
	Total	18 759	100
Religion	Muslim	18 429	98.24
	Orthodox	312	1.70
	Other believers	18	.06
	Total	18 759	100
Ethnicity	Oromo	18 459	98.40
	Amhara	300	1.60
	Total	18 759	100
Mother marital status	Not married	2143	11.50
	Married	16 317	87.80
	Divorced	122	.70
	Total	18 759	100
Birth weight	Low birth weight	15 540	83
	Normal birth weight	3190	17.01
	Big birth weight	29	.15
	Total	18 759	100
Mother relation to head	Head	323	1.72
	First spouse of head	15 773	84.08
	Other	2663	14.2
	Total	18 759	100
Age of mother at first birth	≤17	4815	25.67
	18 – 24	13 211	70.4
	≥25	733	3.9
	Total	18 759	100
Total born	≥5	13 471	71.81
	3 to 4	2323	12.4
	≤2	2965	15.8
	Total	18 759	100
Types of fuel used	Electricity/Kerosene	51	.27
	Charcoal/Firewood	14 235	75.9
	Dung/straw	4473	23.8
	Total	18 759	100
Type of material the roof made of	Thatched/Leaf	801	4.3
	Plastic sheet	123	0.7
	Corrugated iron	17 795	94.9
	Others	40	0.2
	Total	18 759	100
Type of material the floor made of	Earth/Mud	17 836	95.1
	Cemented/Carpeted	921	4.9
	Total	18 757	99.99
Type of material the wall made of	Bamboo/Wood	961	5.1
	Cement/Bricks/stone w	39	0.2
	Truck with mud	17 759	94.7
	Total	18 759	100
Does the house have window	Yes	2857	15.23
	No	15 902	84.8
	Total	18 759	100

(continued)

Table 1. (continued)

Factors	Category	Frequency(n)	Percent (%)
Does the house have separate sleeping room	Yes	1960	10.45
	No	16 799	89.6
	Total	18 759	100
Household share latrine facilities	Yes	2111	11.25
	No	16 648	88.75
	Total	18 759	100
Location of water source	In compound	946	5
	Outside of compound	17 813	95
	Total	18 759	100
Type of water source the HHS use	Protected	15 500	82.6
	Unprotected	3259	17.4
	Total	18 759	100

Table 2. Causes of death in children under the age of 5 in Kersa health and demographic surveillance data analysis from 2008 to 2016, Ethiopia, 2020.

Causes	Number (%)	Percent (%)
Diarrhea	421	42.9
Malnourishment	188	19.1
Sudden death	126	12.8
Prematurity	63	6.4
Measles	54	5.5
Pneumonia	26	2.6
Pregnancy complication	23	2.3
TB	9	0.9
Accident	9	0.9
Malaria	5	0.5
Jaundice	5	0.5
Meningitis	4	0.4
Cancer	2	0.2
HIV AIDS	1	0.1
Others	11	1.1

Regarding sex-specific under-five mortality rates over a 9-year period, a decreasing pattern was observed in both sexes. A wide gap of mortality was observed in 2008 with a higher male under-five mortality rate (Figure 1).

Model for Predicting Under-five Child Mortality in a Surveillance Site

The under-five mortality rate from 2008 to 2016 was used to fit the prediction model through Box–Jenkin's methodology of model identification, parameter estimation, and model diagnosis. The Under 5 Mortality Rate (U5MR) in the surveillance site showed stationary based on an augmented-Dickey–Fuller test with a stationary *P*-value of <.001 within a 95% confidence interval, indicating that there was no significant change in trend (Supplementary, Figure 2). Consequently, differencing was not considered, and a differencing order (d) of 0 was employed. Six tentative models were selected based on the autocorrelation function (ACF) and

Table 3. Mortality rates in neonates, infants, and under-five age children in Kersa health and demographic surveillance 2008–2016, Ethiopia, 2020.

		Neonates		Infants		Under-five children's	
Year	Live Birth	Deaths	Mortality Rate	Deaths	Mortality Rate	Deaths	Mortality Rate
2008	1471	36	24.47	68	46.23	68	46.23
2009	1618	60	37.08	102	63.04	110	36.41
2010	1881	68	36.15	126	66.99	166	34.64
2011	1487	41	27.57	116	78.00	210	34.35
2012	1700	50	29.41	100	58.82	193	25.38
2013	2210	60	27.15	107	48.42	178	18.50
2014	2077	60	28.89	114	54.89	209	20.44
2015	2963	76	25.65	131	44.21	263	22.71
2016	3043	91	29.90	159	52.25	205	16.13
Sen's slope		−1.034		−1.46		−3.55	
P-value		.179		.348		.006	

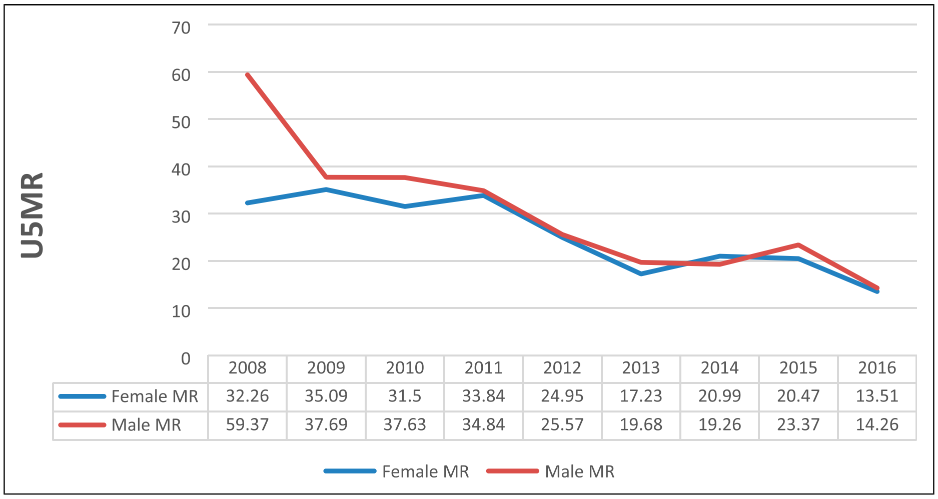

Figure 1. Distribution of sex-specific under-five mortality rates in Kersa HDSS, 2008-2016, Ethiopia, 2020.

Table 4. Estimated parameters of selected tentative models fit to the ARIMA model to predict under-five mortality rate in Kersa health and demographic surveillance site 2008–2016, Ethiopia, 2020.

Proportion of death	ARIMA (1,0,1)	ARIMA (1,0,2)	ARIMA (1,0,3)	ARIMA (1,0,4)	ARIMA (1,0,5)	ARIMA (1,0,6)
Significant coefficient	2	1	4	5	5	1
Sigma^2 (volatility)	3.01	1.47	1.19	2.12	−1.74	−1.37
Log-likelihood	−270.46	−268.38	−265.79	−256.86	−256.72	−261.19
AIC	548.93	546.76	543.59	527.73	529.44	540.37
SBIC	559.62	560.12	559.63	546.43	550.83	564.43

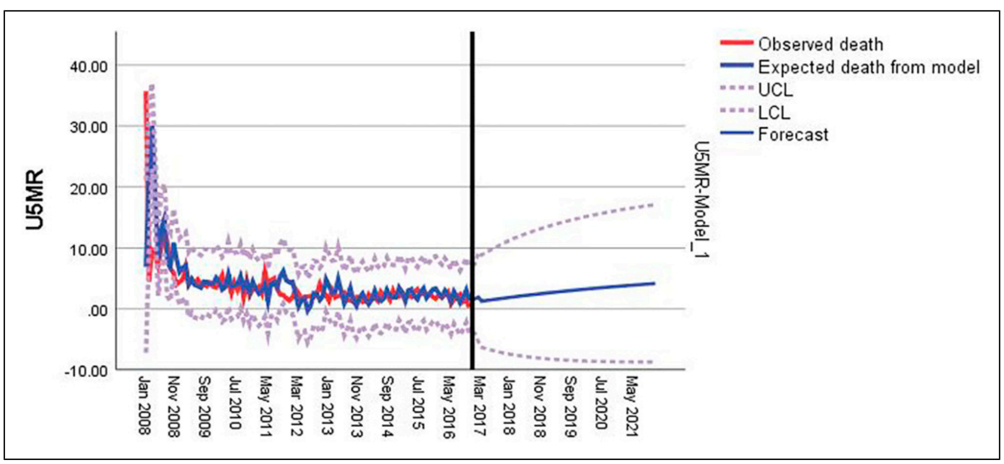

Figure 2. The observed, expected, and predicted values of the ARIMA (1, 0, 4) model of under-five mortality with 95% confidence limits in Kersa health and demographic surveillance, Ethiopia, 2020.

partial autocorrelation function (PACF) values of significant lags, of which ARIMA (1, 0, 4) was fitted to the model for prediction based on the parsimony criteria of model selection having the smallest number of parameters to be estimated with Akaike Information Criteria (AIC) 527.73 and Bayesian Information Criteria (SBIC) 546.43. For the Box–Jenkin method, for estimating trends, models with the most significant coefficient, the lowest volatility, the highest log-likelihood statistic, and the lowest AIC and SBIC are the preferred models. (Table 4).

Based on the fitted model, the mortality rate is expected to decline ahead of the surveillance year of 2016 with fewer fluctuations in the trend. The prediction interval for the times is wider, with a 95% confidence interval. This wide range of

Table 5. Multi-level logistic regression on under-five mortality and associated factors in Kersa health and demographic surveillance site; 2008–2016, Ethiopia, 2020.

			Full Model		
			Child Status		
Variables	Category	Empty Model (95% CI)	Alive	Died	AOR (95% CI)
Water sources	Unimproved		2902	300	
	Improved		13 946	1302	.95 (.83, 1.09)
Presence of radio	No		12 556	1252	
	Yes		4292	350	.86 (.75, .99)
Have toilet	No toilet		9635	975	
	Has toilet		7213	627	.99 (.89, 1.11)
Fuel type	Solid biomass		16 799	1601	
	Non-solid biomass fuel		49	1	
Window presence in the house	No		14 220	1413	
	Yes		2628	189	.80 (.67, .95)
Presence of television	No		15 893	1553	
	Yes		955	49	.91 (.63, 1.30)
Attending antenatal care	No		14 060	1467	
	Yes		2788	135	.61 (.49, .74)
Place of delivery	Home		13 135	1375	
	Health facility		3713	227	.90 (.59, 1.36)
Birth attendant	Unskilled		13 197	1386	
	Skilled		3651	216	.73 (.48, 1.12)
Pregnancy duration	Preterm		232	124	
	Term		8820	637	.13 (.10, .16)
	Post-term		7796	841	.15 (.12, .20)
Family size	Two and/or less		2799	166	.37 (.22, .37)
	Three-four		1936	80	.28 (.31, .45)
	More than 5		12 113	1356	
Birth weight	Low		13 810	1421	
	Normal		3015	175	.78 (.64, .95)
	Big		23	6	5.16 (1.98, 13.47)
Education of mother	No-education		13 050	1360	
	Elementary		3249	209	.58 (.49, .68)
	Higher		549	33	.80 (.54, 1.18)
Age of mother	≤17		4254	452	
	18-24		11 929	1094	.84 (.75, .95)
	>24		665	56	.82 (.60, 1.10)
Occupation of mother	Housewife		730	44	
	Has employed		16 081	1557	.66 (.48, .91)
Residency	Rural		15 789	1545	
	Urban		1059	57	.89 (.64, 1.24)
Sex of child	Female		8134	742	.93 (.84, 1.03)
	Male		8714	860	
Random intercept for survey		.13 (.04, .40)			.68 (.22, 2.07)
Intra-survey year correlation in %		3.72 (1.23, 10.75)			17.16 (6.39, 38.6)

predictions indicates the high uncertainty of the prediction (Figure 2).

Factors Associated With Under-five Mortalities in Surveillance Site

Our model adequacy test showed that multi-level logistic regression was found to be the best fit for the data. The result shows that the variance of the random component model related to the intercept is statistically significant, implying the presence of under-five child death variations among survey years that are accounted for by a random intercept term. The empty model shows that there is a change in the mortality rate of children under 5 in the survey year, with a random intercept of .13 and an intra-year coefficient of 3.7%. In a full model, where the variables of interest were included, the random intercepts for the survey indicated significant differences among survey years in the mortality of under-five children with a .68 intercept and a 17.2% intra-survey year correlation coefficient. Mothers who received antenatal care had a 39% (AOR = .61, 95%CI = .49, .74) lower chance of under-five death compared to mothers who did not receive antenatal care. Those mothers who had a term delivery had an 87% (AOR = .13, 95% CI = .10, .16) lower chance of their child's death compared to mothers with preterm birth. Similarly, the under-five mortality in the surveillance site among households with windows in the house was 20% (AOR=1.19, 95% CI = .988, 1.421) lower chance compared to a house that did not have a window (Table 5).

Discussion

From 2008 to 2016, the under-five mortality rate at the Kersa Health and Demographic Surveillance Site dropped significantly, despite a slight decrease in neonatal and infant mortality. The current finding is consistent with prior studies conducted in similar areas (Kersa HDSS)[13,31,32] and other previous studies conducted at national and community-based levels that reported a similar trend of under-five children's deaths.[13] However, these findings revealed lower infant and neonate death rates than the study conducted in Uganda.[14] The decreasing trend in the mortality rate of U5C (under 5 children) during the study period agrees with the national and international decrement of under-five children dying. The decreasing trend of under-five deaths during the study period may be a consequence of an essential improvement in health services, such as education on health problems and how to prevent and control them, maternal and child health care, including family planning, immunization against major infectious diseases and current government policy priority areas of child health (improvement in resource mobilization, scale-up of high-impact interventions coordination and partnership).

The forecast for the next 5 years from 2016 shows that there is a certain downward trend in the mortality rate of children under 5, but there is a certain degree of uncertainty. Uncertainty in the prediction could be due to the inaccuracy of data. Therefore, using recent and accurate data, such predictions can be used for forecasting progress toward sustainable development goals.

The finding shows the socio-demographic characteristics of the mother's association with under-five mortality in the surveillance site. After controlling for other variables, the mother's educational status emerges as a strong predictor of under-five mortality, which is consistent with other studies conducted in southwest Ethiopia[15] and the latest Ethiopian demographic and health survey of 2016 analysis[30] and elsewhere.[33,34,36] The reason may be that educated mothers are more capable of gaining health care access and receiving antenatal care services because of their better income, higher health literacy, and power to make healthier decisions on the health for themselves and their children. Furthermore, education can contribute to child survival by suspending early marriage and motherhood as a result of the decreased total number of children a woman has.[16]

A strong association was shown between maternal working and under-five deaths. Children of mothers working were found to be significantly increasing odds of under-five mortality. This is higher than the 2011 analysis of Ethiopian demographic and health survey.[17] This could be because of increased family income, which enables parents to provide their children with higher quality health care services and improve mothers' and thus child wellbeing.[18]

In addition, this study revealed a significant relationship between the mother's gestational age and the under-five mortality rate. Mothers who had a preterm pregnancy experienced much higher child deaths than those mothers who had given birth at term. This finding is consistent with the EDHS analyses of 2000, 2005, and 2011.[19] It is also consistent with previous research that has found a high risk of mortality among children under the age of 5 whose mothers gave birth prematurely.[38-40] This could be due to babies born prematurely having more health problems at birth and later in life than babies born later.[20] This may also be due to the following reasons: increased mortality from sudden infant death syndrome, prolonged impairment of pulmonary function, infections and respiratory conditions, early birth itself, and increased susceptibility to various health conditions, including behavioral disorders, neurological conditions, impaired vision and hearing, and chronic illness.[38-40]

The findings of the study confirmed that mothers who had more than 5 total births experienced significantly higher child mortality than those who had less than 2 total births. This variable is, in 1 way or another, related to family planning that affects family size. Family size is positively associated with child mortality. This is comparable with the study conducted in Nigeria.[21] Different reasons are given for the rise in mortality for mothers who have had many children. This may be because of insufficient support and care for the child.[29] However, the findings of this study are not in line with the study conducted in the Afar region, which has shown family sizes have a significant reduction in child mortality.[35]

The risk of under-five deaths was higher among children who lived in houses built with inadequate materials than in those with standard and moderate housing materials (a house built in the absence of windows and inadequate materials from which the roof was built). The house built with moderate housing materials (windows installed) reduced the risk of dying more than a child in a house built with inadequate materials. These finding gave credential to other studies conducted in northern Ethiopia[22,23] Nigeria,[36] and Pakistan[37] that established an association between ill health and poor housing conditions because of inadequate building materials. The standard quality of the materials with which the house is built is entirely related to the durability of the materials the house is built with and the health of the family living in it.[22]

Poor housing conditions could lead to the formation of damp in the house, which can result in the formation of molds and different kinds of fungal pathogens that can cause different types of respiratory health problems such as asthma.[24] In addition, there are cracked buildings (walls); this provides a favorable environment for the reproduction of various insects such as cockroaches, mites, and arthropods, all of which promote the pathogenesis of respiratory health problems.[25,26]

The current study also revealed that house those who did not have windows and shared latrine facilities had experienced higher under-five deaths than those who had windows and not shared latrine facilities, respectively. This may be due to poor ventilation and poor sanitation which led to the death of children from respiratory diseases and diarrheal diseases respectively.[27] However, the finding is slightly different from the studies conducted in some else.[27,28]

Strength and Limitations of the Study

This study had several strengths. First, it is representative surveillance that uses a standardized method that yields a high response rate. Second, the pooled method (large sample size) maximized the study power and permitted valid generalization of the results to a population of similar characteristics. Third, advanced statistical analysis was used to estimate the outcome and factors associated with it. However, it faces a number of limitations: First, some important predictors of under-five deaths were not included in the analysis because of imprecise measurement due to incomplete or mislabeled variables, restricted variable data, inconsistent values, and missing records of the predictors. Second, the analysis considers under-five children who had vital information, which might lead to an underestimation of mortality rates. The effects of some associated factors may also be underestimated.

Conclusion

During the study period, the mortality rate of children under 5 at the surveillance site dropped significantly. Mother's education, pregnancy duration, safe sanitation, birth weight, total number of children born, and house material were all significantly associated with under-five deaths in the surveillance site. As a result, an intensified effort is required to address the issue. In realization of this fact, we recommend that efforts toward access to prenatal care and quality care service throughout the pregnancy, childbirth, and postnatal period should be ensured to reduce the incidence of low birth weight and other pregnancy related complications. Improving the literacy status of women is essential so that they can care for their children for better health. Broad-scale public health and educational efforts in various areas, especially on sanitation and family planning, will have a strong impact on child health and survival. Strategies aimed at socio-economic development may also impact child survival.

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Authors' Contributions

GD and AG conceived and designed the study, analyzed the data, interpreted them and drafted the manuscript. DA, YM, and KB have contributed to data analysis and interpretation. All authors have read and approved the final manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data Availability

The data set used and/or analyzed in the current study belongs to Kersa

HDSS. The data set is accessible upon filling out an agreement form based on the data sharing policy online with the link http://www.haramaya.edu.et/research/projects/kds-hrc/kdshrc-project-data/kds-hrc-data-sharingpolicydocument/. The author confirmed that they did not collect or do not own the data and that other researchers can access the same data in the same manner as the authors through a formal request. According to the application, the Kersa HDSS team conducts an evaluation, and the applicant can analyze the raw data. If the application is granted open access, sensitive information like names, identification numbers, and house numbers is removed before providing the data set to the applicant through generating new identification numbers to enable them to link it back to the original data. The derived data supporting the results of this study will be available from the corresponding author upon reasonable request.

Ethical Approval and Consent to Participate

The Kersa HDSS site was established after ethical approval from various agencies. The site has received ethical approval from the Centers for Disease Control and Prevention (CDC), the Ethiopian Public Health Association (EPHA), the Ethiopian Science and Technology Agency, and the Haramaya University Health Research Ethical Review Committee (HRERC). Similarly, for these studies, secondary data for analysis was obtained after getting an approval letter from the Institutional Health Research Ethics Review Committee of Haramaya University College of Health and Medical Sciences. The letter was written from Haramaya University to the College of Health and Medical Sciences, Kersa HDSS office. Full permission was obtained from these offices, and identifying information for the study was obtained upon request. The data was fully anonymized in order to protect the privacy of those prior to accessing it. The name or any other identifying information was not used, and the information taken from the database was kept strictly confidential. The information retrieved was used for the study's purposes only.

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Supplemental Material

Supplemental material for this article is available online.

References

1. Negera A, Abelti G, Bogale T, Gebreselassie T, Pearson R. *An Analysis of the Trends, Differentials and Key Proximate Determinants of Infant and Under-five Mortality in Ethiopia*. : ICF International: Calverton; 2013. https://dhsprogram.com/pubs/pdf/FA79/FA79.pdf
2. NPC N. *National Planning Commission*; 2016:236. Addis Ababa https://www.greengrowthknowledge.org/national-documents/ethiopia-growth-and-transformation-plan-ii-gtp-ii. Growth and transformation plan ii gtp ii
3. Gebretsadik S, Gabreyohannes E. Determinants of under-five mortality in high mortality regions of Ethiopia: an analysis of the 2011 Ethiopia Demographic and Health Survey data. *International Journal of Population Research*. 2016;2016.
4. UNICEF. 2018. *Annual Reports*. [online] Available at:. https://www.unicef.org/about/annualreport/> Accessed February 25, 2020.
5. WHO. 2018. *Annual Reports*. [online] Available at:. https://www.unicef.org/about/annualreport/> Accessed December 25, 2020.
6. CSA. *Statstical Report of 2007 Population and Housing Census*; 2020. Retrieved from http://www.csa.gov.et/census-report/complete-report/census-2007?start=5. Accessed December 25, 2020.
7. Deribew A, Tessema GA, Deribe K, et al. Trends, causes, and risk factors of mortality among children under 5 in Ethiopia, 1990-2013: findings from the Global Burden of Disease Study 2013. *Popul Health Metrics*. 2016;14(1):42.
8. CSA. *The Ethiopian Demographic and Health Survey*; 2016. retrieved from https://dhsprogram.com/pubs/pdf/FR328/FR328.pdf. Accessed December 29, 2020.
9. Woldeamanuel BT. *Socioeconomic, Demographic, and Environmental Determinants of Under-5 Mortality in Ethiopia: Evidence from Ethiopian Demographic and Health Survey*. Child Development Research; 2016:2019.
10. Dejene T, Girma E. *Social Determinants of Under-five Mortality in Ethiopia: Event History Analysis Using Evidence from Ethiopian Demographic and Health Survey (EDHS)*; 2013.
11. Irwin LG, Siddiqi A, Hertzman G. *Early Child Development: A Powerful Equalizer. Vancouver, BC: Human Early Learning Partnership*. HELP; 2007.
12. Samuel GW. *Proximate Determinants: The Pathways of Influence of Underlying Factors on Under-five Mortality in Nigeria*. Doctoral dissertation, Covenant University; 2017.
13. Assefa N, Oljira L, Baraki N, et al. HDSS profile: the kersa health and demographic surveillance system. *Int J Epidemiol*. 2016;45(1):94-101.
14. Doherty T, Rohde S, Besada D, et al. Reduction in child mortality in Ethiopia: analysis of data from demographic and health surveys. *Journal of global health*. 2016;6(2):020401.
15. Deribew A, Tessema F, Girma B. Determinants of under-five mortality in Gilgel gibe field research center, Southwest Ethiopia. *Ethiop J Health Dev*. 2007;21(2):117-124.
16. LeVine RA, Rowe ML. Maternal literacy and child health in less-developed countries: evidence, processes, and limitations. *J Dev Behav Pediatr*. 2009;30(4):340-349.
17. Ayele DG, Zewotir TT, Mwambi H. Survival analysis of under-five mortality using Cox and frailty models in Ethiopia. *J Health Popul Nutr*. 2017;36(1):25.
18. Sidorenko A. *Positive Effects of Maternal Employment on Child Development*; 2015. retrieved from. 301201517 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4796381/. Accessed March 29, 2020.
19. Mersha A, Bante A, Shibiru S. Neonatal mortality and its determinates in public hospitals of Gamo and Gofa zones, southern Ethiopia: prospective follow up study. *BMC Pediatrics*. 2019;19(1):499.
20. Trønnes H, Wilcox AJ, Lie RT, Markestad T, Moster D. Risk of cerebral palsy in relation to pregnancy disorders and preterm birth: a national cohort study. *Dev Med Child Neurol*. 2014;56(8):779-785.
21. Asiki G, Newton R, Marions L, Seeley J, Kamali A, Smedman L. The impact of maternal factors on mortality rates among children under the age of five years in a rural Ugandan population between 2002 and 2012. *Acta Paediatr*. 2016;105(2):191-199.
22. Biks GA, Berhane Y, Worku A, Gete YK. Exclusive breast feeding is the strongest predictor of infant survival in Northwest Ethiopia: a longitudinal study. *J Health Popul Nutr*. 2015;34(1):9.
23. CDC. *Basic Facts about Moulds and Dampness*; 2020. Retrieved from https://www.cdc.gov/mold/faqs.htm. Accessed April 29, 2020.
24. Portnoy J, Miller JD, Williams PB, et al. Environmental assessment and exposure control of dust mites: a practice parameter. *Ann Allergy Asthma Immunol*. 2013;111(6):465-507.
25. Yong T-S, Jeong KY. Household arthropod allergens in Korea. *Kor J Parasitol*. 2009;47(suppl l):S143.
26. Cheng JJ, Schuster-Wallace CJ, Watt S, Newbold BK, Mente A. An ecological quantification of the relationships between water,

sanitation and infant, child, and maternal mortality. *Environ Health*. 2012;11(1):4.
27. Negera A, Abelti G, Bogale T, Gebreselassie T, Pearson R. *An Analysis of the Trends, Differentials and Key Proximate Determinants of Infant and Under-five Mortality in Ethiopia*. : ICF International: Calverton; 2013.
28. Shifa GT, Ahmed AA, Yalew AW. Socioeconomic and environmental determinants of under-five mortality in Gamo Gofa Zone, Southern Ethiopia: a matched case control study. *BMC International Health and Human Rights*. 2018;18(1):14.
29. Who.int.. 2020. [online] Available at: https://www.who.int/pmnch/topics/child/countdownreportpages11-21.pdf> Accessed December 25, 2020.
30. Fenta HM, Tesfaw LM, Derebe MA. Trends and Determinants of Underweight among Under-Five Children in Ethiopia: Data from EDHS. *Int J Pediatr*. 2020;2020(1):1-9.
31. Assefa N, Lakew Y, Belay B, et al. Neonatal mortality and causes of death in Kersa Health and Demographic Surveillance System (Kersa HDSS), Ethiopia, 2008-2013. *Maternal Health, Neonatology and Perinatology*. 2016;2(1):7-10.
32. Dheresa M, Daraje G. A 12 Years Neonatal Mortality Rate and Its Predictors in Eastern Ethiopia. *Global Pediatric Health*. 2021;8:2333794X211025407.
33. Khan JR, Awan N. A comprehensive analysis on child mortality and its determinants in Bangladesh using frailty models. *Archives of public health = Archives belges de sante publique*. 2017;75(1):58-60.
34. Adebowale SA, Morakinyo OM, Ana GR. Housing materials as predictors of under-five mortality in Nigeria: evidence from 2013 demographic and health survey. *BMC Pediatrics*. 2017;17(1):30-33.
35. Gebremichael SG, Fenta SM. Factors Associated with U5M in the Afar Region of Ethiopia. *Advances in Public Health*. 2020;2020.
36. Ezeh OK, Agho KE, Dibley MJ, Hall JJ, Page AN. Risk factors for postneonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis. *BMJ Open*. 2015;5(3):e006779-e006779.
37. Quamrul HC, Islam R, Hossain K. Effects of demographic characteristics on neonatal, post neonatal, infant and child mortality. *J Biol Sci*. 2010;2:132-138.
38. Bruce B, Kirkland S, Waschbusch D. The relationship between childhood behaviour disorders and unintentional injury events. *Paediatr Child Health*. 2007;12(9):749-754.
39. Stephens AS, Lain SJ, Roberts CL, Bowen JR, Nassar N. Association of gestational age and severe neonatal morbidity with mortality in early childhood. *Paediatr Perinat Epidemiol*. 2016;30(6):583-593.
40. Thunqvist P, Gustafsson PM, Schultz ES, et al. Lung function at 8 and 16 years after moderate-to-late preterm birth: a prospective cohort study. *Pediatrics*. 2016;137(4).
41. Desta BN, Assefa N, Damte TD, Hordofa LO. Neonatal mortality and its risk factors in eastern Ethiopia: a prospective cohort study in Kersa health and demographic surveillance system (Kersa HDSS). *Mortality*. 2016;13(18):19.