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Effect of health extension service on under-five child mortality and determinants of under-five child mortality in Derra district, Oromia regional state, Ethiopia: A cross-sectional study

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Abstract

Objectives: Under-five child mortality is the highest in Ethiopia even though it decreased steadily in the last two decades. Hence, this study aimed to identify the risk factors and effects of Health Extension Service on under-five child mortality per mother in Derra district, Ethiopia.

Methods: The study used a three-stage sampling technique and a random sample of 446 mothers. Cross-sectional data were collected using a structured interview and analyzed using descriptive and inferential (propensity score and Poisson regression) analysis.

Results: One-fourth (23.5%) of mothers experienced at least one under-five child mortality in the last 13 years and the propensity score analysis also indicated that utilizing and model in the Health Extension program reduced under-five child mortality per mother by 29.84% and 15.71%, respectively. The Poisson regression model identified that kebeles, not utilized health extension program (incidence rate ratio 2.25, 95% confidence interval (1.33, 3.85)), not model in health extension program (incidence rate ratio 1.79, 95% confidence interval (1.07, 3.18)), primary educational level (incidence rate ratio 0.14, 95% confidence interval (0.18, 0.91)), mother aged at first birth less than 20 years (incidence rate ratio 1.82, 95% confidence interval (1.90, 3.05)), source of drinking water not pipped (incidence rate ratio 2.36, 95% confidence interval (1.20, 3.18)), and child delivered at home (incidence rate ratio 2.48, 95% confidence interval (1.26, 4.8)) significantly influence under-five child mortality per mother at 5% level of significance.

Conclusion: Health extension service utilization reduced under-five child mortality per mother, and education level, source of drinking water, place of child delivery, and place of residence (kebele) were significant risk factors for under-five child mortality per mother. The health sectors and district health offices should work on health extension program to increase the community awareness of basic preventive and promotive health services and minimize risk factors of under-five child mortality.

Keywords

Health extension, propensity score analysis, Poisson regression, under-five child mortality

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Introduction

Mortality in childhood around the world shows remarkable progress in child survival, and millions of children have better survival chances than in 1990. Specifically, under-five mortality rate fell to 41 deaths per 1000 live births in 2016 from 93 in 1990, a 56% reduction. In all countries, the under-five mortality rate reduced by more than two-thirds. Among those countries, 28 low- and lower-middle-income countries achieved a two-thirds or more reduction in the under-five mortality rate since 1990. The total number of under-five

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deaths dropped to 5.6 (5.3, 5.8) million in 2016 from 12.6 (12.4, 12.8) million in 1990. On average, 15,000 children died every day in 2016, compared to 34,000 in 1990.[1] Despite the progress, millions of children die due to preventable or treatable disease and lack of limited access to basic health interventions such as vaccination, nutrition, clean water, sanitation, and medical treatment of infectious disease.[1,2]

Globally, under-five deaths are unevenly distributed and about 80% of under-five deaths occur in two regions, sub-Saharan Africa and Southern Asia, and about half the worldwide under-five child death occurred in six countries namely, India, Nigeria, Pakistan, the Democratic Republic of the Congo, Ethiopia, and China. Sub-Saharan Africa remains the region with the highest under-five mortality rate in the world and had an average of 79 deaths per 1000 live births with a global share of under-five child mortality of 49.2% in 2016.[1]

The current death toll of Ethiopia (58 deaths/1000) is relatively higher as compared to neighboring countries such as Kenya (49 deaths/1000), Eritrea (45 deaths/1000), and Rwanda (39 deaths/1000 live births) in 2016. However, Ethiopia has registered a sound reduction of under-five death rate between 1990 and 2016 from 203 deaths per 1000 live births to 58 deaths per 1000 live births.[1] Even though the death toll of Ethiopia is relatively higher than that in neighboring countries, it achieved the millennium development goal (59 deaths per 1000 live birth) of child mortality before 2015.

Diseases that are readily preventable or treatable with proven, cost-effective interventions cause most under-five deaths. Infectious diseases and neonatal complications are responsible for the vast majority of under-five deaths globally.[1] Ethiopia has launched an innovative community-based health extension services program in 2003 at the national level to improve access and utilization of preventive, promotive, and basic curative services, especially for children and mothers.[3] The effect of health extension service on child and maternal mortality revealed a significant influence on child health indicators, which could be attributable such as DPT3, BCG, OPV3, measles, and full immunization to the presence of the health extension program (HEP) in the districts in Tigray regional state of Ethiopia.[4,5]

The latest Ethiopia demographic and health survey (EDHS) indicate under-five child mortality has significantly declined from 166 deaths per 1000 live births in 2011 EDHS to 67 death per 1000 live birth (one in every 15 children does not survive to their fifth birthday) in 2016 EDHS. Based on the regional state of Ethiopia, under five-child mortality runs between 39 per 1000 in Addis Ababa and 125 per 1000 in Afar, while it is 79 per 1000 live birth (1 in every 13 children does not survive to their fifth birthday) in Oromia regional state of Ethiopia.[6] Currently, all childhood mortality of Ethiopia decreased over time and the under-five child mortality was 55 per 1000 live birth.[7] Even if Ethiopian under-five child mortality declined progressively, the death rate is the highest.

The government of Ethiopia has made a progressive decline in under-five child mortality and intensified the HEP, but there is no evidence showing the effects of HEP on under-five child mortality in the study area. Hence, the study aimed to identify the major risk factors and effects of HEP on under-five child survival in Derra district, Oromia regional state of Ethiopia.

Methods

Descriptions of study area and population

The study was conducted in the Derra district of North Shewa Zone of Oromia regional state, which is 213 km far from Addis Ababa, the capital city of Ethiopia. The district is located between 12° 92′ and 13° 12′ N latitude and 34° 40′ and 35° 80′ E longitude and elevation from 1798 to 2118 m above sea level and its administrative center is Gundo Meskel.[8] The district has 34 kebeles clustered under seven health centers and a total population of 223,218, among these 115,442 are male and 117,778 are female.[9]

The study design

The study was conducted using a cross-sectional study on randomly selected households/mothers from 10 December 2017 to 20 January 2018.

Inclusion and exclusion criteria

The study included mothers, who aged 15–49 years, lived in the study area for more than 1 year and have at least one under-five child.

Sampling techniques and procedures

The study used a three-stage sampling technique to select the samples. In the first stage, four health (Gundo Meskel, Harbu Meskel, Tuti, and Cheka) centers were selected out of seven based on their geographical location. In the second stage, 10 kebeles were selected from these health centers proportionally using simple random sampling. The 10 sampled kebeles were Dembi Birjie, Kabi Gololcha, Ada'a Melke, and Beyo Nono from the Gundo Meskel health center, Cheka and Weglo Mikael from the Cheka health center, Keraba and Gebro from the Tuti health center, and Becho Wajitu and Makefta Jiru from the Harbu Meskele health center. In the third stage, households/mothers who fulfilled the inclusion criteria were selected systematically. The eligible participants in the selected who were not available during the data collection were re-examined three times. While more than one deserving mother was there in the chosen household, a lottery method was employed.

Data collection procedure and quality controls

The study used a structured, interviewer-administered questionnaire through a face-to-face interview. Sixteen diploma

and BSc holder data collectors and two MSc and BSc holder supervisors participated in data collection. The data collectors and supervisors took training for 2 days on data collection tools and how to approach the study participants.

Before the actual data collection, a pretest was done on 5% of the sample at Yaya kebele. Then, the adequacy of the checklist was evaluated and ambiguous questions were modified before the actual data collection. The principal investigator with supervisors supervised the data collection closely and monitored daily data for completeness and consistency.

Sample size determination

Using the pilot survey, the standard deviation of under-five mortality is 0.384, the total number of households in selected kebeles is N = 9584, significance level $\alpha = 0.05$, margin of error d = 0.05, and design effect = 2.0.[10] Then, the sample size computed using[11] formula as:

$$n = \tilde{n} \times \text{deff}$$

where n is the total sample size for clustered and $\tilde{n}$ is the sample size for simple random samples and defined as

$$\tilde{n} = \frac{\text{no}}{1 + \frac{\text{no}}{\text{N}}}$$

$$\text{where—} \; n_0 = \frac{(\text{Z}\alpha/2)^2 S^2}{\text{d}^2} = \frac{(1.96)^2 0.384^2}{0.05^2} = 226.49 = 227$$

$$n = \frac{227}{1 + \frac{227}{9584}} = 222.7 = 223 \times 2.0 = 446$$

Then, the overall sample size is 446 allocated to each kebele proportionally.

Variable of interest in the study

Response variable. Under-five child mortality is a discrete variable that takes counted value of under-five-year child deaths each mother has experienced in the last 13 years (2004/2005 to 2017/2018) and Y_i takes the number of under-five child death each mother experienced, $y_i = 0, 1, 2 \ldots$

Explanatory variables. Are these variables expected to affect under-five child mortality per mother? The variables were ages of mothers, mother educational level, mother age at first birth, source of drinking water, place of last childbirth, kebeles, utilization of HEP, and model in HEP.

Operational definitions

HEP utilization. HEP delivers 26-health service, which was categorized into four major health services category. These major health services are: hygiene and environmental sanitation (11) services, prevention and disease control (4) services, family health (8) services, and health education and communication (3) services. HEP utilization was measured using respondent's utilization of selected health extension services (services given by health extension workers at the health post and outreach in the previous 5 years). Respondent's score above or equal to the median was considered as utilized, and respondent's score below the median was classified as not utilized.

Model in HEP. It was households who attended at least 75% of the training given by health extension workers and implemented at least 75% of the HEP packages.

Statistical analysis

The study used descriptive statistics (percentage, mean, standard deviations, and bar chart) and inferential statistics (propensity score analysis and Poisson regression) using Stata-14 software.

Propensity score analysis

Propensity score is an appropriate measure of the conditional probability of receiving treatment, the scores used to estimate the causal effects of the treatment. The goal of propensity score analysis is to generate an estimate of the causal effect of the program or policy on its intended outcomes by matching covariate patterns as[12] stated.

Let Y be the outcome variable (under-five child death per mother), T be the treatment variables (model in HEP and utilizing HEP) (T = 1 treated, T = 0 untreated), and X be observable covariate; the probability of receiving the treatment conditional on the covariate is: $P(x_i) = P_r(T_i = 1 / X_i = x_i)$, and its average treatment effect for treated is: $\text{ATT} = E(Y_i^1 - Y_i^0 / T = 1)$.

Poisson regression model

The Poisson regression model is a regression model for count data where the dependent variable is the count of nonnegative values and the independent variable may be dichotomous, polychromous, or continuous; categorical factors were represented by dummy variables.[13]

Let $Y_1, Y_2, \ldots, Y_n$ be dependent random response variables with Y_i denoting the number of under-five child mortality for ith mother within a given time or exposure (number of children) with mean parameter λ_i and X_i denote a vector of explanatory variables for the ith mother. The Poisson regression model has a Poisson distribution with the conditional mean μ_i $\left(\text{Y}_\text{i} \sim \text{Poisson}\left(\lambda_\text{i}\right), \text{i} = 1, 2, , \ldots, \text{n}\right)$ on a given vector X_i for case i. Then, the Poisson equation of the model with rate parameter λ_i[13,14] is given by

$$p(Yi = yi) = \frac{e^{-\mu_i} \lambda_i^{y_i}}{yi!}, \lambda_\text{i} > 0 \text{ and } y_i = 0, 1, 2, \ldots$$

where mean and variance are equal, $E(Y_i) = \mathrm{Var}(Y_i) = \lambda_i$. Equality of the mean with the variance is the equi-dispersion property of the Poisson model.

The mean of the response variable λ_i related with the linear predictor through the link function. Let X be $n \times (k+1)$ matrix of explanatory variables. The relationship between Y_i and *i*th row vector of X, linked by $g(\lambda_i)$, is the canonical link function given by[13]

$$E(Y_i) = \lambda_i = Ni \exp(X_i\,'\beta)$$

where $X_i = (x_{i0}, x_{i1}, ..., x_{ik})'$ is the *i*th row of covariate matrix $(x_{i0} = 1)$, $\beta = (\beta_0, \beta_1, \ldots, \beta_k)'$ is an unknown $(k+1)$-dimensional vector of regression parameters, and *Ni* is an exposure variable (number of children a mother had), whereas its ln(*Ni*) is the offset variable. The log of the mean λ_i assumed a linear function of the independent variables, that is

$$\ln(\lambda_i) = \ln(Ni) + \beta o + \sum_{i=1}^{k} \beta_i X_i$$

Dispersion and model adequacy test

To check overdispersion and compare the adequacy of the Poisson model over the negative binomial model, the deviance test, Pearson test, and dispersion index were used. The overall test of regression model fit and individual test was done using deviance statistics, log-likelihood ratio statistic, and t-test as stated by McCullagh and Nelder.[14]

Ethics approval and consent to participate

The study was conducted in accordance with the Helsinki Declaration. Ethical clearance was also obtained from an Institutional Review Board of Madda Walabu University with reference number *Mwu/RCS/021/2017*. Verbal informed consent was obtained from the entire study participant before the interview. The verbal informed consent was appropriate because of the participant's education level (ability to read and write) and approved by an Institutional Review Board. The verbal informed consent was obtained from a legally representative of the household.

A formal letter of cooperation written by Statistics department on behalf of Madda Waalabu University was submitted to the Derra district health and administrative office and permission was obtained from these offices. All participants were informed verbally about the study and their consent to participate. After getting respondent's willingness to participate in the study, the data were collected.

Results

Demographic characteristics of respondent

As shown in Table 1, among the total sampled 446 mothers, 51 (11.4%), 245 (54.9%), and 150 (33.6%) were aged 15–24, 25–34, and 35–49, respectively. More than one-half of the participant were not educated 301 (67.5%), while 96 (21.5%) primary education completed and 49 (11.0%) secondary and above completed.

Based on employment, 285 (63.9%) were farmers, 109 (24.4%) were housewives, and 52 (11.7%) were others. While 335 (75.1%) delivered at home, 111 (24.9%) delivered their last child at the health center. Concerning mother's age at first birth, 293(65.7%) gave their first birth less than or equal to 20 years old and 153 (34.3%) gave birth greater than 20 years old.

Distribution of under-five child mortality

The percentage and the pattern of under-five child mortality per mother of the sampled mothers experienced during the past 13 years (2004/2005 to 2017/2018) are shown in Figure 1. About 341 (76.5%) of the mother had not encountered under-five child mortality, whereas 105 (23.5%) of mothers experienced at least one under-five child death (19.1%, 3.5%, and 0.9% of these mothers experienced one, two, and three under-five child deaths, respectively). The patterns of under-five child death showed highly skewed to the right with excess zeros and mean 0.29.

Under-five child mortality versus HEP service

Based on the HEP utilization of the households, 92.4% of those who utilized HEP did not face under-five child mortality and 7.5% (4.9%, 2.2%, and 0.5% of them faced one, two, and three under-five child mortality, respectively) of them encountered under-five child mortality. Among those who did not utilize HEP, 65.3% of them did not face under-five child mortality and 34.7% (29.0%, 4.6%, and 1.1% of them faced one, two, and three under-five child mortality, respectively) of them encountered at least one under-five child mortality. Accordingly, those who did not utilize HEP were more likely to face under-five child mortality than those who utilized it, as shown in Figure 2.

Figure 3 shows that 89.7% of those who were models in HEP did not face under-five child mortality and 10.2% (8.4%, 1.9%, and 0.0% of them faced one, two, and three under-five child mortality, respectively) of them encountered under-five child mortality. While 65.3% of those who did not model in HEP did not face under-five child mortality and 30.7% (24.8%, 4.5%, and 1.4% of them faced one, two, and three under-five child mortality, respectively) of them encountered at least one under-five child mortality. Consequently, mothers who were from the model in HEP household were less likely to face under-five child mortality than those who were not model.

Under-five child death per mother versus demographic and socioeconomic character

Table 2 shows the frequency distribution of under-five child mortality per mother and percentage across the different

Table 1. Demographic characteristics of respondent.

Variables	Categories	Frequency	Percent (%)
Mother age, years	15–24	51	11.4
	25–34	245	54.9
	35–49	150	33.6
Mother education	Not educated	301	67.5
	Primary	96	21.5
	Secondary and above	49	11.0
Mother employment	Farmer	285	63.9
	Housewife	109	24.4
	Other	52	11.7
Source of drinking water	Piped water	124	27.8
	Not Piped water	322	72.2
Place of residence (kebele)	Kabi Gololcha	70	15.7
	Ada'a Melkie	48	10.8
	Dembi Birje	42	9.4
	Makefta Jiru	64	14.3
	Becho Wajitu	30	6.7
	Beyo Nono	35	7.8
	Weglo Mikael	38	8.5
	Keraba	37	8.3
	Gebro	55	12.3
	Cheka	27	6.1
Place of last child delivery	At Home	335	75.1
	At health center	111	24.9
Mother age at first birth	⩽20 years old	293	65.7
	>20 years old	153	34.3

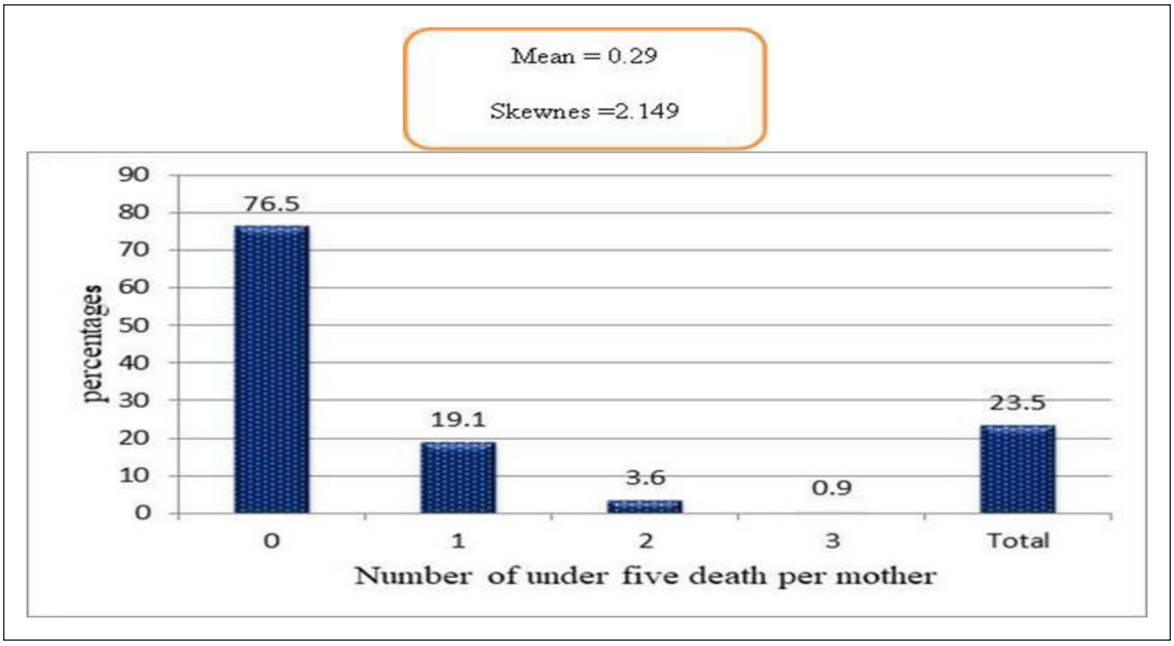

Figure 1. Under-five child death number per mother.

demographic and socioeconomic characteristics. The percentage of under-five child mortality runs between 7.28 in Gebro and 42.86 in Becho Wajitu kebeles. Moreover, based on age distribution of mothers, under-five child mortality was the highest (27.33%) for those mothers aged 35–49 and the lowest (7.85%) for those aged 25–34.

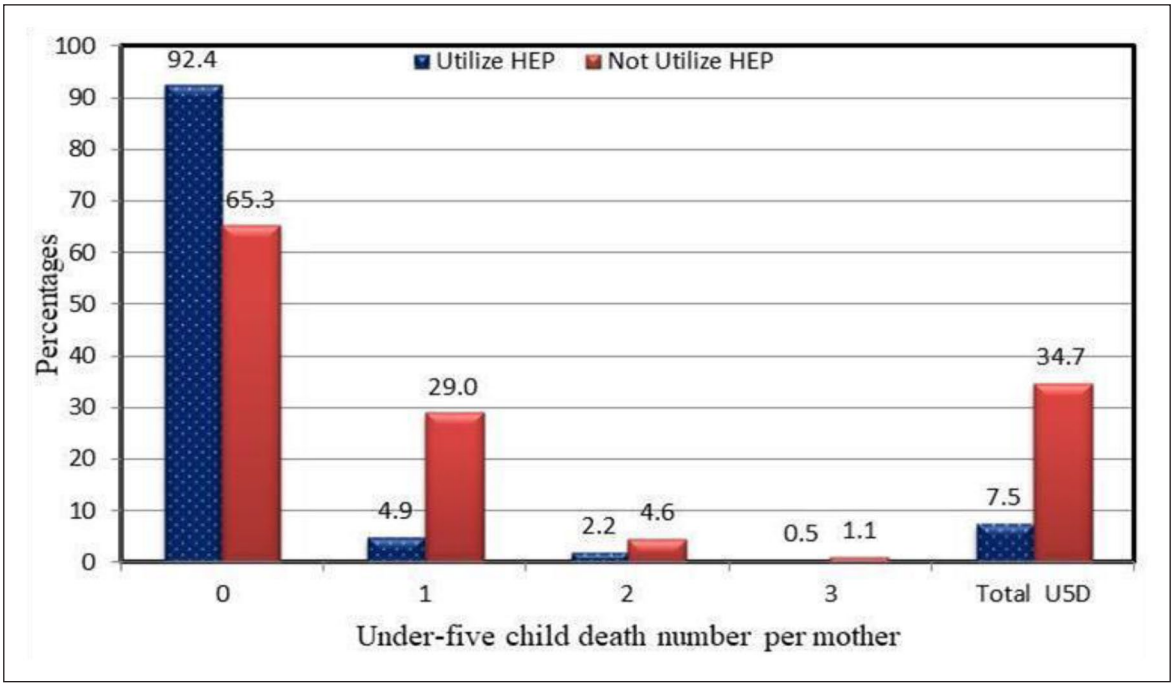

Figure 2. Under-five child mortality per mother over HEP utilization.

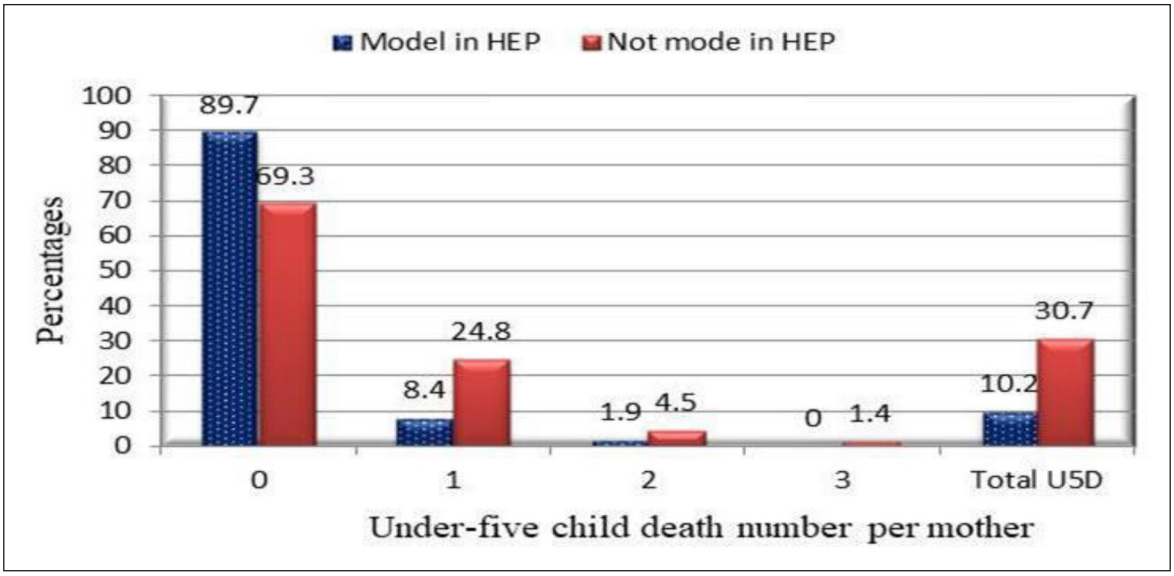

Figure 3. Under-five child mortality per mother over being model.

Based on the education level, mothers who had no education experienced the highest percentage (31.56%), and those who had secondary and above education experienced the lowest (6.12%) under-five child mortality. Similarly, mothers who gave their first birth before age 20 were more likely to experience under-five child mortality (29.39%) than those who gave their first birth after age 20 (12.43%).

Similarly, based on the source of drinking water, those households who use nonpiped sources of drinking water had experienced higher percentages of under-five child mortality (29.19%) than those who had used piped sources of drinking water (8.87%). Likewise, those who delivered their recent child at home faced a higher percentage of under-five child mortality (27.49%) than those who delivered at health centers (8.11%).

Finally, mothers whose occupation was farming faced higher percentages of under-five child mortality (28.32%), while housewives and others faced 13.76% and 17.33% under-five child mortality, respectively.

Table 2. Descriptive results of the number of under-five child mortality.

Variables	Categories	Frequency of U5 mortality				% of U5D per mother
		0	1	2	3	
Kebeles	Kabi Gololcha	61	8	1	0	12.86
	Ada'a Melke	39	6	2	1	18.75
	Dembi Birjie	28	14	0	0	33.33
	Makefta Jiru	48	9	7	0	25.00
	Becho Wajitu	19	7	3	1	36.67
	Beyo Nono	20	14	0	1	42.86
	Weglo Mikael	27	10	1	0	27.03
	Keraba	24	11	2	0	35.14
	Gebro	51	3	0	1	7.28
	Cheka	24	3	0	0	11.11
Mother age, years	15–24	47	3	1	0	7.85
	25–34	185	54	4	2	24.49
	35–49	109	28	11	2	27.33
Mother education	No education	206	75	16	4	31.56
	Primary	89	7	0	0	7.29
	Secondary and above	46	3	0	0	6.12
Mother age at first birth	<20 years	207	66	16	4	29.35
	>20 years	134	19	0	0	12.43
Drinking water	Piped water	113	11	0	0	8.87
	Non piped water	228	74	16	4	29.19
Mother occupation	Farmer	205	68	10	3	28.32
	Housewife	94	12	3	0	13.76
	Others	43	5	3	1	17.31
Place of delivery	At Home	239	77	15	4	27.46
	At health center	102	8	1	0	8.11

Effects of HEP on under-five child mortality: a propensity score analysis

Effects of HEP on under-five child mortality per mother estimated using neighbor (5) matching algorithm and presented in Table 3. On average, models in HEP reduced under-five child mortality per mother by 0.1571 relative to those who are not models and HEP utilization also reduced under-five child mortality per mother by 0.2984.

Determinants of under-five child mortality: a Poisson regression analysis

Goodness of fit and test for overdispersion. Table 4 shows Poisson and negative binomial models of the test statistic. The AIC and BIC values for the Poisson regression model are smaller than those for the negative binomial model, which indicates that the Poisson regression model is better than the negative binomial model for this data set. Moreover, using the formal statistical test of dispersion parameter, Ho: $\alpha = 0$ versus H_1: $\alpha > 0$ indicates that the null hypothesis is not rejected because p value $0.12 > 0.05$ and concludes that the Poisson regression model better fits this data.

Determinants of under-five child mortality: a Poisson regression. The Poisson regression result revealed that Kebeles, mother's education level, mother age at first birth, model in HEP, HEP utilization, source of drinking water, and place of child delivery were significantly affected under-five child mortality per mother at 5% level of significance as shown in Table 5 and interpreted in terms of its incidence rate ratios.

Place of residence (kebeles) such as living in Ada'a Melke, Dembi Birjie, Makefta Jiru, Becho Wajitu, Beyo Nono, Weglo Mikael, and Keraba significantly affected under-five child mortality per mother at 5% level of significance. The expected rate ratio of under-five child mortality per mother for mothers who were living in Ada'a Melke, Dembi Birjie, Makefta Jiru, Becho Wajitu, Beyo Nono, Weglo Mikael, and Keraba were 3.99, 2.63, 2.97, 4.68, 3.95, 2.72, and 5.72 time higher than those who were living in Gebro kebele, respectively, holding other variables constant.

The expected rate ratios of under-five child mortality per mother for those mothers who aged less than 20 years old at their first childbirth were 1.87 times higher as compared to those who aged greater than 20 years at their first childbirth, holding all other factors constant.

The expected rate ratios of under-five child mortality per mother for those mothers who had primary education compared to those who had no education 0.586 (1.414) times less as compared to those who had no education, holding all other factors constant.

Table 3. Effects of HEP on under-five child mortality per mother.

Outcome (Under-five child death per mom)	ATT				
	Treated	Control	Difference	SE	T test
Being model in HEP	0.12338	0.28052	−0.15714	0.06464	−2.43*
Utilization of HEP	0.38709	0.6854	−0.2984	0.15108	−1.97*

ATT: average treatment effect for treated; HEP: health extension program; SE: standard error.
*Significant at 5% level of significance.

Table 4. Goodness of fit between Poisson and negative binomial models.

Criteria	Poisson model	Negative binomial model
AIC	515.82	517.69
BIC	581.39	587.399

AIC: Akaike information criteria; BIC: Bayesian information criterion.
Likelihood ratio test for dispersion $\alpha = 0$ versus not, chibar2 = 1.38, p-value = 0.12.

Table 5. Poisson regression model of under-five child mortality per mother.

Variables/categories	IRR	SE	Z	p values	95% CI of IRR	
					Lower	Upper
Kebeles (Ref: Gebro)						
Kabi Gololcha	1.483	0.769	0.76	0.447	0.536	4.102
Ada'a Melke	3.998	2.001	2.77	0.006*	1.498	10.66
Dembi Birjie	2.638	1.291	1.98	0.047*	1.011	6.888
Makefta Jiru	2.971	1.369	2.36	0.018*	1.204	7.330
Becho Wajitu	4.689	2.251	3.21	0.001**	1.822	12.01
Beyo Nono	3.956	1.888	2.88	0.004**	1.555	10.07
Weglo Mika'el	2.714	1.362	1.99	0.047*	1.014	7.258
Keraba	5.729	2.837	3.53	0.000**	2.170	15.11
Cheka	2.275	1.64	1.14	0.254	0.553	9.349
Mage (Ref: > 20 years)						
Less than 20 years	1.817	0.470	2.31	0.021*	1.094	3.018
Mother education (Ref: not educated)						
Primary	0.414	0.166	−2.20	0.028*	0.188	0.909
Secondary and above	0.484	0.288	−1.22	0.223	0.150	1.557
Model in HEP (Ref: yes)						
Not model	1.799	0.472	2.24	0.025*	1.076	3.008
Utilize HEP (Ref: yes)						
No	2.251	0.617	2.96	0.003**	1.315	3.853
Source of water (Ref: piped)						
Not piped	2.362	0.807	2.51	0.012**	1.208	3.018
Place of delivery (Ref: at health)						
At home	2.487	0.855	2.65	0.008*	1.267	4.88
Intercept	0.0016	0.0010	−9.63	0.000**	0.0004	0.0061
Ln (number of children)	1	Offset				

CI: confidence interval; HEP: health extension program; IRR: incidence rate ratio; SE: standard error.
*and **significant at 5% and 1%, and Ref is reference category.

The expected rate ratios of under-five child mortality per mother for those mothers who were not a model were 1.79 times higher as compared to those who were models in HEP, holding all other factors constant. As compared with those mothers who did not utilize HEP, the expected rate ratios of under-five child mortality per mother were 2.25 times higher, holding all other factors constant.

The expected rate ratio of under-five child mortality per mother for those mothers who used nonpiped water for drinking was 2.36 times higher than those who used piped water for drinking, holding other factors constant.

The expected rate ratio of under-five child mortality per mother for those mothers who delivered their recent child at home was 2.48 times higher than those who delivered at health centers, holding other factors constant.

Discussion

In this study, propensity score analysis and Poisson regression were used to investigate and identify the effect of HEP and risk factors of under-five child mortality in the district. The result confirms that HEP significantly reduced under-five child mortality, and the risk factors identified and discussed as below:

HEP service reduced under-five child mortality effectively in the district which is in line with study,[4,5] which assesses the impact of health extension service on the child, maternal mortality, and child health indicators in the Tigray region and improving health through community involvement. HEP reduced the under-five child mortality by enhancing community's child health indicators service use and effective community participation in the basic and preventive approach of community involvement.

Studies have shown that place of residence is another determinant of under-five child mortality per mother, those who live in urban and suburban are less likely to experience under-five child mortality than those who in rural area. In this study, those who lived in different kebeles of the district had different rates/risks of under five-child mortalities, which is in line with previous studies of Geremew et al.,[15] Gebremichael and Fenta,[16] Berelie et al.,[17] Lamichhane et al.,[18] Bedada,[19] and Bedane et al.[20] that place of residence influenced under-five child mortality.

The education level of mothers is an important predictor of under-five child mortality, in which under-five child mortality per mother decreases as the education level increases. Studies showed that the lower the maternal education level, the higher in experiencing under-five child mortality per mother. Educated mothers are expected to have a higher awareness of nourishing and treating with capable healthcare services to their children than those who had no education. The result of this finding showed that as the education level of mothers increases, the rate of experiencing under-five child mortality per mother decreases, and similar findings were obtained[15,16,19,21–26] that educated mothers experienced less under-five child mortality than those not educated mothers.

Different studies revealed that mothers' age at their first birth was a determinant factor for under-five child mortality. The result of this finding showed that children born to young mothers were more likely to die before age 5 than those born to older mothers. Similar findings by Bedada,[19] Bedane et al.,[20] Fenta and Fenta,[21] Woldeamanuel,[22] Ayele and Zewotir,[26] and Berhie and Yirtaw[27] obtained that younger mothers experienced more under-five child mortality than older mothers did because the younger mothers were less capable of nourishing and treating their child.

A model family in HEP is a family who implements about 75% of primary healthcare services. Since, HEP is a preventive and curative health service, especially for mothers and children, model in a HEP decrease the rate of under-five child mortality per mother, as it increases awareness about the basic preventive and curative health services. In this study, those mothers who were models in HEP were less likely in experiencing under-five child mortality than those who were not models in HEP, which is in line with[4,5] the finding that model families in HEP improved the survival of children.

Place of delivery also significantly affected under-five child mortality per mother. Children born at health centers have less risk of death than those born at home due to the accessibility of child delivery service at health centers. In this study, children delivered at home were more likely to the risk of death than those delivered at health centers, and it is in line with previous studies.[15–18]

Utilizing HEP is another predictor of under-five child mortality per mother. HEP is implemented to enhance the awareness of healthcare service for the community, especially for mothers and children. Hence, those who utilized HEP were expected to be aware of the risk factors of under five-child death and take safety measures. In this finding, those mothers who did not utilize HEP were more likely to experience under-five child mortality than those who utilized HEP, which is consistent with[4] findings that HEP implementation significantly improved the health status of children in the Tigray region.

Source of drinking water was also a predictor of under-five child mortality; those who used nonpiped drinking water were more likely to experience under-five child mortality than those who used piped water. This is due to nonpiped drinking water being more likely exposed to water-borne diseases such as diarrhea and others. In this study, the rate of under-five child mortality per mother was higher for those mothers who used nonpiped drinking water, which is in line with the previous studies of Berelie et al.,[17] Gebretsadik and Gabreyohannes,[24] Bereka et al.,[28] and Bitew et al.[29]

Limitation and strength

The data were adjusted for the three stage-sampling design used in the survey to make the finding of this study

reproducible. Nevertheless, the finding should be handled with cautions: first, the study did not consider sociocultural, economic, and environmental factors that might have an impact on under-five child mortality.

Second, due to the cross-sectional survey, subjects were randomly selected and treatments were not randomly allocated to subjects, which was challenging to determine the cause–effect relationship between predictors and under-five child mortality. However, propensity score matching mimics randomization by creating a sample of participants who received the treatment (use HEP and model in HEP) is comparable on all observed covariates to the participant who did not receive (not use HEP and not model in HEP).

Conclusion

In the last 13 years (2004/2005–2017/2018), one-fourth of mothers faced at least one under-five child mortality. Health extension service use and model in HEP significantly reduced under-five child mortality per mother.

Mothers' education level, age at their first birth, model in HEP, utilizing HEP, place of child delivery, and source of drinking water were significantly associated with under-five child mortality per mother. Hence, the government, the regional state, and district health offices have to work on a HEP to enhance the community awareness of basic preventive and promotive health services and to minimize risk factors of under-five child mortality.

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Availability of data and materials

The data set used and/or analyzed during the current study is available from the corresponding author on reasonable request.

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.

Ethical approval

The study was conducted in accordance with the Helsinki Declaration. Ethical approval for this study was obtained from an Institutional Review Board of Madda Walabu University with reference number *Mwu/RCS/021/2017*.

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Informed consent

Verbal informed consent was obtained from the entire study participant before the interview. The verbal informed consent was appropriate because of the participant's education level (ability to read and write) and which also approved by an Institutional Review Board. The verbal informed consent was obtained from a legal representative of the household. A formal letter of cooperation written by Statistics department on behalf of Madda Waalabu University was submitted to Derra district health and administrative office and permission were obtained from these offices. All participants were informed verbally about the study and their consent to participate. After getting the respondent's willingness to participate in the study, the data were collected.

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