Journal of Biosensors & Bioelectronics

Getachew and Bekele, J Biosens Bioelectron 2016, 7:3
DOI: 10.4172/2155-6210.1000213

Research Article Open Access

Survival Analysis of Under-Five Mortality of Children and its Associated Risk Factors in Ethiopia

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Abstract

Child mortality is a factor that is associated with the well-being of a population and it is taken as an indicator of health development and socio economic status. A 2013 report on child mortality states that about three-quarters of all child deaths happened in two regions Africa (46%) and South-East Asia (28%). More than 50% of these deaths were clustered in only six countries: China, Democratic Republic of the Congo, Ethiopia, India, Nigeria and Pakistan. Under-five mortality is higher in rural areas and among poorer and less educated communities (MDG 2013). The Ethiopian Demographic and Health Survey data are used for the study. In this study we have attempted to find out the impact of socioeconomic, demographic, environmental, health related and nutritional factors in under- five mortality of child. In this attempt, we first analyzed our data using Kaplan-Meier non-parametric method of estimation of survival function and compared the survival time of different categories of region and other covariates that influence the child survival. Also we had used Cox proportional hazard model and Staratifed Cox proportional model to compare the hazard of under-five mortality of child for different covariates comparison to the reference categories and the potential covariates which influence under five mortality are found region, mothers' education level, sex, mothers age at first birth, preceding birth interval, contraceptive use, breast feeding, place of delivery, Number of antenatal visits during pregnancy and father occupation are a vital factors for the deaths occurring under the age of five of child. The study recommends that Under-five mortality of child among regions is significant. This is an indication that the risk of U5CD varies from one region to another. Thus, in order to have a bearing on policy recommendations, future studies should focus on identifying risk factors of U5CD for each region of Ethiopia separately in high mortality area.

Keywords: Hazard ratio; Ethiopia; Cox proportional hazard; Under-five; Child mortality

Introduction

Approximately 6.3 million infants and children under five years of age die each year, with large variations in under-five mortality rates and trends across regions and countries (UNICEF, 2013) [1].

A 2013 report on child mortality states that about three quarters of all child deaths happened in two regions Africa (46%) and South-East Asia (28%) [2]. More than 50% of these deaths were clustered in only six countries: China, Democratic Republic of the Congo, Ethiopia, India, Nigeria and Pakistan. On average, 1 out of every 11 children born in sub-Saharan Africa dies before age 5. This is nearly 15 times the average rate (1 in 159) in high-income countries. The highest rates of under-five mortality are concentrated in sub-Saharan Africa and South Asia (UNICEF 2013). About 472,000 Ethiopian children die each year before their fifth birthdays (National strategy for child survival in Ethiopia, 2005) [3]. This tragic fact places Ethiopia sixth among the countries of the world in terms of the absolute number of child deaths. Of every 100 children in Ethiopia, 14 will not live to celebrate their fifth birthday.

From the EDHS report, child mortality rate in Ethiopia was reduced from 166/1000 deaths in 2005 to 88/1000 deaths in 2011 [4]. For the five years preceding the survey, the infant mortality rate was 59 per 1000 live births, the child mortality rate was 31 per 1,000 children surviving to age 1 year, and the under-five mortality rate was 88 per 1,000 live births. This implies that one in 17 Ethiopian children dies before the first birthday and one in 11 Ethiopian children dies before the fifth birth day. During the same five-year period, neonatal mortality was 37 deaths per 1,000 live births, and post neonatal mortality was 22 deaths per 1,000 live births (EDHS, 2011). The study of the reasons why those countries lag behind in terms of reduction in their under-five mortality rate suggests an unequal distribution of health intervention and mortality across various socio-economic groups and region as one of the major reasons.

Under-five child mortality in Ethiopia is one of the highest in the world and it is one of the challenging problems that the country needs to address. Even in an average year, the education, health and economic situation for millions of Ethiopian under-five children can only be described as a crisis. Factors such as, low level of mother's education, unsafe drinking water and sanitation, low family income, birth interval, short to breast feeding time, lack of place of birth delivery and periodic famine continue to put children at risk. The current levels of child mortality in Ethiopia are higher than the target of the minimum Millennium Development Goals (MDGs), which are 88 deaths per 1000 live births. In Sub-Saharan Africa, one in nine children die before age five, more than 16 times the average for developed regions. According to 2011 EDHS one in 17 Ethiopian children dies before the first birthday and one in 11 Ethiopian children dies before the fifth birth day. The objective of this study was to identify the risk factors which are affecting child survival and to investigate the differential of child mortality among region in Ethiopia.

The paper is organized as follows. Section 2 describes the materials and methods. The basic findings of the study are presented and

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Received April 06, 2016; **Accepted** July 15, 2016; **Published** July 25, 2016

Citation: Getachew Y, Bekele S (2016) Survival Analysis of Under-Five Mortality of Children and its Associated Risk Factors in Ethiopia. J Biosens Bioelectron 7: 213. doi: 10.4172/2155-6210.1000213

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discussed in Section 3. Finally, concluding remarks are provided in Section 4.

Data and Methodology

Source of data

The data in this study is based on the 2011 Demographic and Health Survey which is obtained from the Central Statistical Agency (CSA), Ethiopia. The 2011 Ethiopian Demographic and Health Survey (EDHS) is the third compressive survey designed to provide estimates for the health and demographic variables of interest for the following domains: Ethiopia as whole; urban and rural areas of Ethiopia (each as a separate domain); and 11 geographic areas (9 regions and 2 city administrations) [5]. The survey interviewed a nationally representative population in about Information on child mortality was found from the birth history of women who were included in the survey. Since the interest of this study is about children under five ages, a data set consisting of 11,654 children was used, 18,500 households are interviewed and all women of age 15-49 and all men of age 15-59 in these households. The response variable or outcome variables considered in this study are the survival time of a child measured in months from birth until death/censor of children aged less than 60 months. And it is considered with respect to reference period. The children who live start within the reference period are taken into consideration. Children died within the reference period are taken as uncensored cases the children alive in that period are censored cases. Also, 18 potential explanatory variables were considered in this study. The descriptions of these covariates are presented in Table 1 below.

Method of data analysis

Survival analysis: Survival analysis referred to statistical methods for analyzing survival data. Survival time refers to a variable which measure the time from a particular starting time (e.g. Time initiated the treatment) to particular end point of interest (e.g. attaining certain functional abilities) [6]. Survival analysis is concerned with studying the time between entry to a study and a subsequent event and becomes one of the most important fields in statistics. Standard statistical techniques cannot usually be applied because the underlying distribution is rarely normal and the data are often 'censored'. Usually, a first step in the analysis of survival data is the estimation of the distribution of the survival times. Survival times are often called failure times, and event times are uncensored survival times. The survival distribution function (SDF), also known as the survivor function, is used to describe the lifetimes of the population of interest. Let T be a random variable representing survival time of subjects in the population, and t be the realization of T. Then the cumulative distribution function of T is given as $F(t)= P(T < t)$ where T is the survival time of randomly selected individual and a specific point of time.

The survival function: $S(t)$ gives the proportion of children whose survival times are t or longer.

$$S(t) = \Pr(T \geq t) = \exp(-\int_0^t \lambda(u)du) \tag{1}$$

The hazard function can be used to represent the probability that an individual dies at time, conditional on having survived to that time. That is, the function represents the instantaneous death rate for an individual surviving to time t.

$$\lambda(t) = \lim_{\delta \to 0+} \frac{P(t \leq T < t+\delta \mid T \geq t)}{\delta} = \frac{P(t \leq T < t+\delta)}{P(T \geq t) * \delta} \tag{2}$$

Where λ(t): is the hazard function, T is the survival time, $S(t)$: is the survival function, δ: is the instantaneous change.

Non parametric method

Kaplan-Meier estimates: Kaplan Meier estimator is nonparametric, which requires no parametric assumptions. We can compare data from two or more different groups by visual inspection of their respective estimated survival functions or some statistical tests [7]. Thus, we can compare different levels of a certain factor. The Kaplan-Meier estimator at any point in time is obtained by multiplying a sequence of conditional survival probability estimators.

Each conditional probability estimator is obtained from the observed number at risk of dying (n) and the observed number of deaths and is equal $(n-d)/n$. To apply the Kaplan-Meier method suppose that there are n independent individuals in a random sample with observed survival times $t_{(1)}, t_{(2)} \ldots, t_{(n)}$. The distinct ordered failure times observed among the n individuals are $t_{(1)}, t_{(2)} \ldots, t_{(m)}$, $m < n$ as there are more than one individual with the same observed survival time and some of

No	Variable	Description
1	Education level of mother	0=No Education (Ref), 1=Primary, 2=Secondary and above
2.	Education level of Father	0=No Education (Ref), 1=Primary, 2=Secondary and above
3.	Place of residence	0=Urban (Ref), 1=Rural
4.	Region	0=Addis Ababa, 1=Afar, 2=Amahara, 3=Oromiya, 4=Somali, 5=Benishangul Gumuz, 6=SNNP, 7=Gambela, 8=Harari, 9=Tigray 10=Dire Dawa
5	Wealth index	0=Poor (Ref), 1=Medium, 2=Richest
6	Mother Occupation	0=No Occupation, 1=Had Occupation
7.	Father occupation	0=No Working, 1=Had working
8.	Age of Mother at first Birth	0=≤19, 1=20-34, 2=35-49
9.	Birth order	0=First, 1=2-3, 2=4 and above
10	Child sex	0=Male, 1=Female
11.	Marital Status	0=Married, 1=Single, 2 =Widowed, 3=Divorced
12.	Child Twin	0=Single, 1=Multiple
13.	Beast Feeding	0=No, 1=Yes
14	Source of Water	0=Piped Water, 1=Tube water, 2=Dug Water, 3=Surface Water
15	Toilet Facility	0=Flush Toilet (Ref), 1=Pit Toilet, 2=No Toilet Facility
16.	Place of Delivery	0=Public Sector (Ref), 1=Home, 2=Private Sector
17.	Number of antenatal Visits	0=No Visits (Ref) 1=1, 2=2-3, 3=4 and above visited
18	Contraceptive Use	0=Not Using, 1=Using

Table 1: Detailed description of all variables related to child death is presented as follows.

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the observations may be right-censored, i.e., the survival status of the individual might not be known at the time of the analysis.

The probability of survival at time $_{(j)}$, ($t_{(j)}$) is then estimated by

$$P(t_{(j)}) = (n_j - d_j) / n_j \tag{3}$$

Where,

n_j is the number of individuals who are alive just before time t_j and d_j is the number of those who die during this time.

Consequently the estimated probability of surviving beyond t_j, S(t) is

$$\hat{S}(t)\prod_{j/t(j)\le t}\frac{n_j - d_j}{n_j} \tag{4}$$

Cox's proportional hazards regression model: A popular model used in survival analysis that can be used to assess the importance of various covariates in the survival times of individuals or objects through the hazard function [8]. Cox proportional hazards model is a commonly used model in providing hazard ratio to compare survival times of two or more population groups. The exponentiated linear regression part of the model describes the effects of explanatory variables on hazard ratio.

The Cox model is given in the form of

$$h(t,x,\beta) = h_0(t)\exp(\beta' x_i) \tag{5}$$

where $h_0(t)$ is the baseline hazard function at time t, $x_i' = x_{1i}, x_{2i}, \ldots x_{pi}$ for i =1,2…..n is a vector of measured covariates for the i^{th} individual at time t, and β' is a p vector of unknown regression parameters that are assumed to be the same for all individuals in the study.

First, if the vector of covariate is a zero vector, then the hazard function for the i^{th} individual is the baseline hazard function. It is the hazard function in the absence of covariates or when all of the coefficients of the covariates are assumed to be zero. Second, if we divide the above equation both sides by $h_0(t)$, we get the following equation which indicates where the term proportional comes from. Since for each individual, $e^{x_i'}$ is constant across time.

$$\frac{h_i(t,x_i)}{h_0(t,0)} = \frac{h_0(t)\exp(\beta' x_i)}{h_0(t)} = e^{\beta' x_i} \tag{6}$$

Staratifed cox regression model: Since the Cox regression model relies on the hazards being proportional, i.e., on the effect of a given covariate not changing over time, it is very important to verify that the covariates satisfy the assumption of proportionality. If this assumption is violated, the simple Cox regression model is invalid and more complicated analyses such as the Stratified Cox regression model or the extended Cox regression model are required [7,8].

The Staratifed Cox regression model is a modification of the Cox regression model by the stratification of a covariate that does not satisfy the proportional hazards assumption. Covariates that are assumed to satisfy the proportional hazards assumption are included in the model, whereas the predictor being Staratifed is not included. Let k covariates fail to satisfy the proportional hazards assumption and p covariates satisfy proportional hazards assumption. The covariates not satisfying the proportional hazards assumption are denoted by $Z_1, Z_2, \ldots Z_k$ and the covariates satisfying the proportional hazards assumption are denoted by $X_1, X_2, \ldots X_p$. To form the Staratifed Cox regression model, a new variable is defined from z variables and denoted by*. The stratification variable Z^* has k^* categories, where k^* is the total number of combinations (strata) formed after categorizing each of z's. There are interaction and no-interaction models defined in the concept of the Staratifed Cox regression model. In this paper we are considering the No interaction Staratifed cox regression model.

No-Interaction Staratifed cox regression model: The no-interaction model is defined as follows:

$$h_g(t,x) = h_{0g}(t)\exp[\beta_1 x_1 + \beta_2 x_2 \ldots\ldots\ldots \beta_p x_p], g = 1,2,3\ldots\ldots\ldots, k^* \tag{7}$$

Where, the subscript g represent the starata. The strata are the different categorizations of the stratum variable. The variable z^* is not implicitly included in the model, whereas the, which are assumed to satisfy the proportional hazards assumption are included in the model. The baseline hazard function, h_{0g}, is different for each stratum. However, the coefficients are the same for each stratum. Since the coefficients of the x, are the same for each stratum, the hazard ratios are same for each stratum.

Results and Discussion

Descriptive analysis

From a total of 11322 children are included in the study where 5333 are male and 5147 are females, were 1880 are from urban and 9442 children are from rural areas. From the total 2000 children are born in the first birth order, 3366 in 2-3 and 5114 are in 4+ birth order; while, from a total 8260 mothers had using contraceptive and 2220 are not.

While regard to education 7949 mothers and 5840 fathers had no education while 2623 mothers and 4076 fathers had primary education and the remaining 528 mothers and 1406 fathers had secondary and above educational level. While regard to age of mothers at first birth there are 7517, 2954 and 9 live births in the age group of less than 19, 20-34 and 35 years and above.

When we look to region of residence 382 child from Addis Ababa, 1089 from Afar, 1276 are from Amahara 1612 are from Oromiya, 975 are from Somali, 996 are from Benishangul Gumuz 1587 are from SNNP 801 are from the Gambela 801 are from Harari, 1190 are from Tigray and 673 are from Dire Dawa. Also from the above Table 4 we observed that wide regional differences in under-five mortality are observed, as well. Under-five mortality rates range from a low of 14 per 382 live births in Addis Ababa to a high of 95 per 996 live births in Benishangul-Gumuz. Under-five mortality is also relatively high in Afar, Gambela, SNNP and Somali.

Also I had observe that 5611 children are from poor family, 1841 children are from a Family where their Economic status are medium, whereas the rest 3870 children are from rich family. Among the total deaths, about 460 (8.2%) were found for the children with parents poor or low standard of living index and the mortality rate has been observed 134 (7.35%) for the children whose mothers medium socio economic status and 248 (6.4%). From a total 11322 mothers of 62 child are single, 10535 are married, 206 are widowed and 519 mothers are divorced. From a total 2317 children are in less than 24 Preceding birth interval, 4970 are between 25-48 and 4035 are greater than or equal to 49 months. With regard to occupation from a total 7954 mothers and 339 fathers had no any occupation and 3368 mothers and 10983 fathers had occupation.

With regard to child of twin 10235 children are born as single birth and 245 children are born as multiple birth. From place of delivery from a total 8963 child are delivered at home and 1187 are delivered at public sector and 330 are at private sector. The other is from the

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environmental variables 285 house hold had toilet facility, 4686 had pit toilet and 6351 had no toilet facility. While 2885 had 2885 house had piped water, 655 had tube well water, 1832 had had dug well water, 5397 had surface water and the remaining 553 had other types of water.

Summary statistics

In any data analysis it is always a great idea to do some univariate analysis before proceeding to more complicated models. The univariable analysis is applied first to identify the impact of individual variable on time to event before proceeding more complicated model selection. In survival analysis it is highly recommended to look for the categorical variable the non-parametric model Kaplan-Meier curves are generated and the significance of impact is tested by log-rank test individually (Table 2).

According to the above Table 2 the variables were found to be statistically significant difference in experiencing death event are: region, socio economic status, child twin, mothers' education, Age of mother at first birth, source of drinking water, contraceptive use, sex, place of delivery, number of antenatal visits during pregnancy, preceding birth interval, toilet facility, father occupation, source of drinking Water, breast feeding and place of residence are the variables which have statistically significant difference in experiencing death event. And the variables which do not clearly experiencing the death event are marital status, Birth order and mother occupation; these variables are those variables were their p-value is above the 0.2-0.25 (Figure 1).

Covariates	Chi-Sqaure	Df	Pr>chi-square
Region	25.346	10	0.005
Socioeconomic status	10.881	2	0.004
Marital status	0.392	3	0.942
Birth Order	1.359	2	0.507
Contraceptive use	28.911	1	0
Mother Education level	9.644	2	0.008
Age of Mother at first birth	5.431	2	0.066
Child Twin	249.428	1	0
Sex	6.707	1	0.01
Place of delivery	8.422	2	0.15
NAVD Pregnancy	13.605	3	0.003
Preceding Birth interval	83.607	2	0
Toilet Facility	3.976	2	0.137
Mother occupation	0.626	1	0.429
Father occupation	46.725	1	0
Source of Drinking water	13.862	4	0.008
Breast feeding	228.587	1	0
Father Education	7.734	2	0.021
Place of residence	3.585	1	0.058

Table 2: Log rank test for equality of survival time among the different groups of covariates for children under-five mortality.

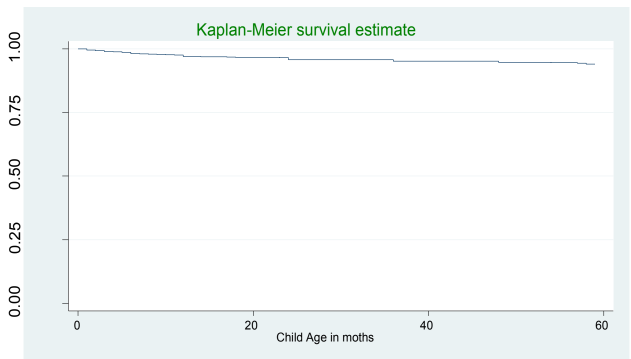

Figure 1: The plot of the overall estimate of kaplan-meier survivor function of under-five mortality of child in Ethiopia.

The result of the over all of Kaplan Meier estimation indicate that most child death occurs at the earlier months and then gradually declined to as the age child advanced to 60 months (Figure 2).

From the above figure we can see that the survival rate of child or the survival probability of under-five of children in Benishangul Gumuz region, Afar, Gambela SNNP less survival where the survival probability of the child in Addis Ababa region is high. This indicates that there is a differential of child mortality among regional state of Ethiopia.

The outcomes for the Cox proportional hazard analysis for the individual variables are summarized as shown below (Table 3).

From the above univariable Cox regression analysis, all covariates had significant impact on child survival except marital status, Birth order, Mother Occupation, which is their p value is over the threshold for our model selection that is greater than 0.25. The other way of including the variables from univariable Cox proportional hazard model to Multivariable Cox proportional hazard model is the log likelihood ration method. The −2 log of the null model is 15,429.621. The selection potential covariate should be based on the reduction of this value of the null model. From the above table breast feeding is the highest reduction of −2 value of the null model which is 15,219.024 and the second highest reduction of the value of the null or empty model is the type of birth or child twin 15,291.33. Then the selection covariate for Multivariable Cox regression is goes on this manner (Table 4).

The variables that are significant in multivariable Cox regression case are Region, Contraceptive use, Mother Education, Child twin, Sex, Place of delivery, Father occupation, Preceding birth interval, Breast feeding. But those variables which are dropped from Table 3 are Father Education, Place of residence, Age mother at first birth, Number of Antenatal visit, Source of drinking Water, Toilet facility and socio economic status should be examined further. This examination is done because some variables could become significant in the presence of others. These variables are therefore added to the model from Table 3, one at a time, and any that reduces -2 significantly are retained in the model. The model after selection of covariates at a significance level of 10% is presented below (Table 5).

The result of the analysis reveals that, some of those variables were found to be significant and therefore they can be retained in the model. Thus, variables that significant dropped at the univariate are birth order, from the multivariable are, Age of mother at first birth and number of antenatal visits during Pregnancy are the covariates that had significant impact on child.

After the final model of significant explanatory variables was created, it was necessary to validate the proportional hazards assumption. The proportional hazards (PH) assumption is just another way of saying that the hazard ratio (HR) does not change over time for some predictor.

If the HR does change over time for, then is said to interact with time, so adding a × time interaction term provides a better fitting model and fixes the problem of non-PH. To test the PH assumption, then, you can add × time interaction term and test it for significance. If

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Covariates (Reference)	β	S.e(β)	Wald	d.f	Sig	HR	95% CI for HR	-2logL
Region (Addis Ababa) (Ref)			24.21	10	0.007			15,403.17
Afar	0.872	0.286	9.298	1	0.002	2.393	(1.366,4.192)	
Amara	0.661	0.287	5.307	1	0.021	1.937	(1.104,3.401)	
Oromiya	0.679	0.282	5.788	1	0.016	1.971	(1.134,3.426)	
Somali	0.765	0.291	6.921	1	0.009	2.149	(1.215,3.8011)	
Benishangul Gumuz	0.967	0.286	11.42	1	0.001	2.631	(1.501,4.611)	
SNNP	0.746	0.282	7.001	1	0.008	2.109	(1.213,3.666)	
Gambela	0.834	0.294	8.052	1	0.005	2.302	(1.294,4.095)	
Harari	0.608	0.308	3.898	1	0.048	1.836	(1.004,3.356)	
Tigray	0.581	0.29	4.014	1	0.045	1.788	(1.013,3.156)	
Dire Dawa	0.334	0.316	1.114	1	0.291	1.396	(0.751,2.595)	
Marital Status(Married)			0.384	3	0.944			5,429.23
Single	-0.116	0.501	0.053	1	0.817	0.891	(0.333,2.379)	
Widowed	0.041	0.024	0.027	1	0.869	1.041	(0.644,1.684)	
Divorced	-0.093	0.17	0.3	1	0.584	0.911	(0.652,1.272)	
Sex (Male)	-0.178	0.069	6.551	1	0.01	0.837	(0.731,0.959)	15,423.03
Socio Economic status (Poor)			10.6	2	0.005			15,418.80
Medium	-0.116	0.098	10.52	1	0.239	0.891	(0.735,1.1.080)	
Richest	-0.256	0.079	1.389	1	0.001	0.774	(0.664,0.904)	
Birth order (first)			10.52	2	0.514			15428.29
2-3	-0.111	0.099	1.262	1	0.261	0.895	(0.737,1.086)	
4 and above	-0.048	0.091	0.285	1	0.594	0.953	(0.797,1.138)	
Contraceptive (Not Using)	-0.523	0.099	27.69	1	0	0.593	(0.488-0.720)	15,398.31
MElevel (No Education)			9.166	2	0.01			15,418.58
Primary	-0.076	0.081	0.866	1	0.352	0.927	(0.791,1.087)	
Secondary+	-0.641	0.217	8.726	1	0.012	0.527	(0.344,0.806)	
AMFbirth (≤19)			5.122	2	0.077			15,424.97
20-34	-0.982	0.708	1.922	1	0.166	0.374	(0.123,0.654)	
35-49	-0.139	0.079	3.059	1	0.08	0.87	(0.745,1.017)	
Child Twin (single)	1.527	0.108	201.6	1	0	4.602	(3.728-5.682)	15,291.33
FEducation (No Education)			7.543	2	0.023			15,421.88
Primary	-0.144	0.075	3.666	1	0.056	0.866	(0.748,1.003)	
Secondary+	-0.28	0.118	5.604	1	0.018	0.756	(0.599,0.953)	
Pdelivery (Public Sector)			8.117	2	0.017			15,422.41
Home	0.514	0.19	7.314	1	0.007	1.62	(1.152,2.428)	
Private sector	0.81	0.115	0.496	1	0.481	1.04	(0.866,1.356)	
NAVDP (No Visit)			13.23	3	0.004			15,416.23
1	0.193	0.079	5.955	1	0.015	1.121	(1.039,1.416)	
2-3	-0.006	0.116	0.003	1	0.958	0.994	(0.791,1.249)	
4+	-0.177	0.115	2.371	1	0.124	0.838	(0.669,1.050)	
PB interval (≤ 24 month)			79.09	2	0			15,356.41
25-48 months	-0.691	0.83	69.02	1	0	0.501	(0.425,0.590)	
≥ 49 months	-0.589	0.086	47.32	1	0	0.555	(0.469,0.656)	
Tfacility (Flush toilet)			3.887	2	0.143			15,425.69
Pit toilet latrine	0.9	0.242	0.137	1	0.711	1.094	(0.681,1.758)	
No toilet facility	0.221	0.24	0.847	1	0.357	1.247	(0.779,1.996)	
Mother occupation (No)	0.058	0.074	0.613	1	0.434	1.06	(0.916,1.226)	15,429.01
Father occupation (No Working)	-0.897	0.137	42.78	1	0	0.408	(0.312,0.533)	15,396.25
SD water (Piped water)			13.47	4	0.009		(0.991,1.844)	15,415.45
Tube water	0.302	0.158	3.629	1	0.057	1.352	(1.161,1.793)	
Dug water	0.366	0.111	10.91	1	0.001	1.443	(1.116,1.793)	
Surface water	0.287	0.091	10.03	1	0.002	1.333	(1.116,1.592)	
Other	0.26	0.174	2.237	1	0.135	1.297	(0.922,1.824)	
Place residence (Urban)	0.184	0.099	3.5	1	0.061	1.203	(0.991,1.459)	15,425.96
Breast Feeding (No)	-1.011	0.7	206.2	1	0	0.364	(0.317,0.418)	15,219.02
The value -2LL for the null model is 15429.621								
MElevel=Mother Education Level, NAVDP=Number of antenatal visits during pregnancy, AMFbirth=Age of mother at first birth, Pbinterval=Preceding birth interval, Tfacility=Toilet Facility, SD water=Source of drinking water, Father Education, Pdelivery=Place of Delivery								

Table 3: Summary of univariate cox regression model.

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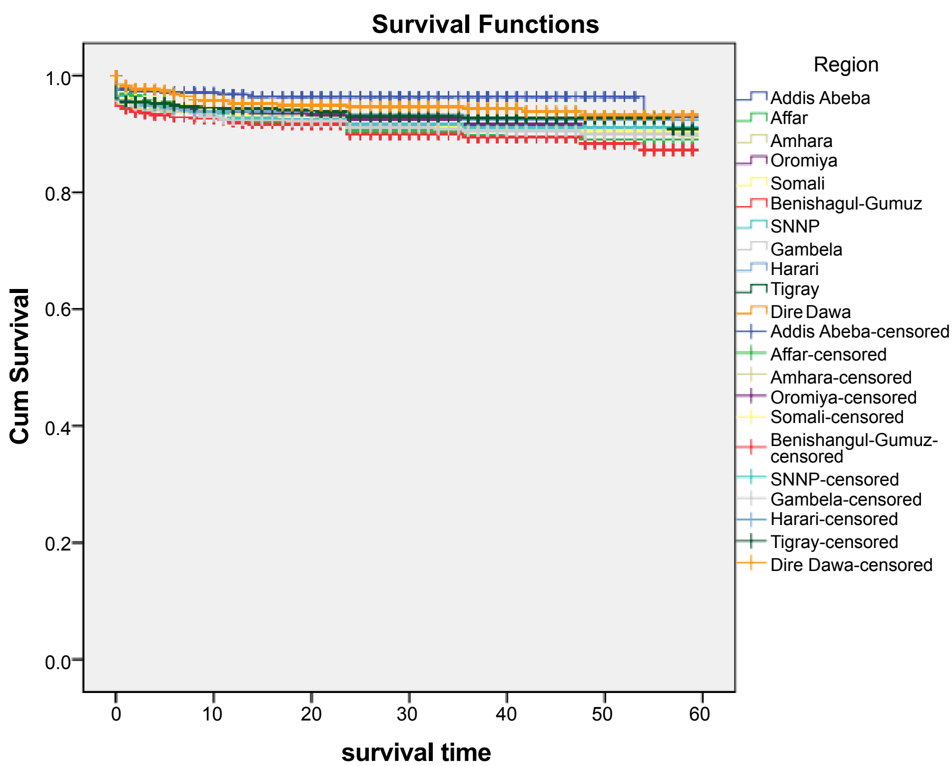

Figure 2: Kaplan meier curve for covariates region.

Covariates (Reference)	β	S.e(β)	Wald	d.f	Sig	HR	95% CI for HR
Region (Addis Ababa)			32.689	10	0		
Afar	0.644	0.309	4.343	1	0.037	1.903	(1.039-3.487)
Amhara	0.9	0.307	8.572	1	0.003	2.46	(1.347-4.494)
Oromiya	0.818	0.303	7.302	1	0.007	2.265	(1.252-4.099)
Somali	0.507	0.313	2.62	1	0.106	1.661	(0.899-3.069)
Benishangul Gumuz	0.985	0.304	1.474	1	0.001	2.677	(1.474-4.859)
SNNP	0.892	0.303	8.644	1	0.003	2.439	(1.346-4.419)
Gambela	0.757	0.31	5.976	1	0.015	2.132	(1.162-3.912)
Harari	0.665	0.32	4.325	1	0.038	1.945	(1.039-3.640)
Tigray	0.596	0.308	3.748	1	0.053	1.816	(0.993-3.321)
Dire Dawa	0.226	0.33	0.47	1	0.493	1.254	(0.657-2.394)
Contraceptive use(No)	-0.554	0.105	28.126	1	0	0.574	(0.468-0.705)
MElevel (No education)			9.394	2	0.009		
Primary	-0.012	0.087	0.019	1	0.89	0.988	(0.833-1.171)
Secondary+	-0.73	0.24	9.232	1	0.002	0.482	(0.301-0.722)
Child Twin (single)	1.43	0.11	169.589	1	0	4.179	(3.369-5.182)
Sex (Male)	-0.157	0.7	5.129	1	0.024	0.854	(0.745-0.979
Father occupation (No)	-0.847	0.139	37.318	1	0	0.429	(0.327-0.563)
Place of delivery (P sector)			16.664	2	0		
Home	0.396	0.196	4.062	1	0.044	1.485	(1.011-2.183)
Private sector	-0.263	0.126	4.373	1	0.037	0.769	(0.601-0.984)
PBinterval (≤24months)			65.609	2	0		
25-48 months	-0.658	0.084	61.007	1	0	0.581	(0.439-0.611)
49 and above	-0.514	0.9	32.882	1	0	0.598	(0.502-0.713)
Breast feeding (No)	-1.029	0.072	205.817	1	0	0.357	(0.311-0.411)

Table 4: Multivariable cox proportional hazard model after backward selection.

not significant, then the PH assumption is satisfied. If such variable is statistically significant then it can be concluded that the assumption of proportional hazards is not satisfied for the given covariate (Table 6).

From the above table we observe that two variables do not satisfy the PH assumption, child twin and Birth order because their p-value is less than 0.05. When the proportional-hazards assumption is not

Covariates (Reference)	β	S.e(β)	Wald	d.f	Sig	HR	95% CI for HR
Region(Addis Ababa)			32.308	10	0		
Afar	0.55	0.312	3.099	1	0.078	1.733	(0.940-3.197)
Amhara	0.833	0.311	7.178	1	0.007	2.301	(1.251-4.233)
Oromiya	0.726	0.306	5.642	1	0.018	2.067	(1.135-3.764)
Somali	0.425	0.317	1.805	1	0.179	1.53	(0.823-2.847)
Benishangul Gumuz	0.896	0.308	8.461	1	0.004	2.45	(1.339-4.480)
SNNP	0.844	0.306	7.608	1	0.006	2.325	(1.227-4236)
Gambela	0.698	0.312	5.006	1	0.025	2.01	(1.090-3.706)
Harari	0.573	0.323	3.151	1	0.076	1.773	(0.942-3.336)
Tigray	0.512	0.311	2.719	1	0.099	1.669	(0.908-3.068)
Dire Dawa	0.152	0.322	0.209	1	0.648	1.164	(0.607-2.229)
Contraceptive use (No)	-0.525	0.105	25.062	1	0	0.591	(0.481-0.726)
Melevel(No education)			10.643	2	0.005		
Primary	-0.074	0.088	0.711	1	0.001	0.928	(0.781-1.104)
Secondary or above	-0.785	0.241	10.587	1	0.003	0.456	(0.284-0.732)
Child Twin(single)	1.491	0.113	174.604	1	0	4.442	(3.561-5.541)
AMFbirth (≤19)			6.769	2	0.034		
20-34	-0.616	0.712	0.75	1	0.387	0.54	(0.459-0.785)
35-49	-0.198	0.082	5.858	1	0.016	0.82	(0.698-0.963)
Pdelivery(P sector)			5.556	2	0		
Home	0.383	0.197	3.797	1	0.051	1.467	(0.998-2.157)
Private sector	0.255	0.127	4.006	1	0.045	0.775	(0.604-0.995)
NAVDP(No Visit)			6.326	3	0.007		
1	0.176	0.081	4.782	1	0.029	1.193	(1.018-1.397)
02-Mar	0.019	0.118	0.027	1	0.869	1.02	(0.809-1.285)
4 and above	-0.038	0.124	0.095	1	0.668	0.963	(0.757-1.225)
Pbinterval (≤ 24 month)			74.971	2	0		
25-48months	-0.643	0.085	57.689	1	0	0.526	(0.445-0.621)
49 and above months	-0.821	0.123	44.719	1	0	0.44	(0.346-0.560)
Father occupation (No)	-0.849	0.139	37.299	1	0	0.428	(0.326-0.560)
Sex (Male)	-0.157	0.07	5.119	1	0.024	0.854	(0.745-0.979)
Breast feeding (No)	-1.055	0.072	214.346	1	0	0.348	(0.302-0.401)
Birth order (First)			22.237	2	0		
2-3	-0.55	0.139	15.546	1	0	0.577	(0.439-0.758)
4 and above	-0.672	0.137	23.948	1	0	0.51	(0.390-0.668)

Table 5: Final model of multivariable cox regression.

Covariates (Reference)	B	S.e(β)	Chi-square	d.f	Sig
Region*Time	-0.00019	0.000770	0.0614	1	0.8044
Mother Education level*Time	-0.00273	0.00790	0.1199	1	0.7292
NAVDpregenacy*Time	-0.00115	0.00356	0.1034	1	0.7477
Child Twin *Time	-0.04627	0.01657	7.7945	1	0.0052
Place of delivery*Time	0.00086	0.0007463	1.3384	1	0.2473
Sex *Time	0.00718	0.00666	1.1604	1	0.2814
Preceding Birth interval*Time	-0.00459	0.00505	0.8232	1	0.3642
Father occupation*Time	-0.00606	0.01322	0.2099	1	0.6468
Contraceptive use*Time	-0.00580	0.01072	0.2932	1	0.5882
Breast feeding*Time	0.002114	0.00678	0.09961	1	0.2741
Birth order*Time	0.01213	0.005550	4.8629	1	0.0274
Age mother at first*Time	0.001092	0.00364	0.08967	1	0.3451

Table 6: Result after fitting the interaction of time and each covariate in the final model.

met there are different ways of handling the covariate that violates the assumption that is Cox extended model and Staratifed Cox model. So in this study Staratifed Cox model is applied that is by stratification to remove the covariate that not satisfy the assumption from the model statement and put it into a strata statement.

The Staratifed cox regression model

The Staratifed Cox regression model is a modification of the Cox regression model by the stratification of a covariate that does not satisfy the proportional hazards assumption. Covariates that are assumed to satisfy the proportional hazards assumption are included in the model, whereas the predictor being Staratifed is not included (Tables 7 and 8).

Model comparison is to select the model that minimizes the negative likelihood penalized by the number of parameters. So from the above table comparison of model using the AIC criteria is the model that minimizes the negative likelihood penalized by the number

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Covariates (Reference)	B	S.e(β)	Wald	d.f	Sig	HR	95% CI for HR
Region (Addis Ababa) (Ref)			31.9096	10	0.0004		
Afar	0.5747	0.31254	3.3819	1	0.0659	1.777	(0.963-3.278)
Amara	0.8429	0.3112	7.3365	1	0.0068	2.323	(1.262-4.275)
Oromiya	0.7375	0.3059	5.8234	1	0.0158	2.091	(1.149-3.806)
Somali	0.4337	0.31642	2.9323	1	0.1705	1.543	(0.830-2.869)
Benishangul Gumuz	0.893	0.30793	8.4099	1	0.0037	2.442	(1.336-4.466)
SNNP	0.8457	0.3059	7.643	1	0.0057	2.33	(1.279-4.243)
Gambela	0.726	0.31164	5.4227	1	0.0198	2.067	(1.122-3.807)
Harari	0.5731	0.32249	3.159	1	0.0755	1.774	(0.943-3.338)
Tigray	0.5319	0.31066	2.9323	1	0.0868	1.702	(0.926-3.129)
Dire Dawa	0.1421	0.33148	0.1838	1	0.661	1.153	(0.602-2.207)
Contraceptive use (No) Ref	-0.5331	0.10516	25.6919	1	0.0001	0.587	(0.478-0.721)
ME (No education) (Ref)			13.6615	2	0.0001		
Primary	-0.0754	0.08835	0.729	1	0.3932	0.927	(0.780-1.103)
Secondary or above	-0.9045	0.24498	13.6322	1	0.0002	0.405	(0.250-0.654)
Sex (male)	-0.1529	0.0696	4.8256	1	0.028	1.165	(1.017-1.335)
AMFbirth (≤19)			6.0677	2	0.0481		
20-34	-0.4873	0.07143	46.54	1	0.0495	0.614	(0.401-0.803)
35-49	-0.1921	0.08205	5.4815	1	0.0192	0.825	(0.703-0.969)
Place of delivery (Public sector) (Ref)			16.6915	2	0.0002		
Home	0.5549	0.12837	18.732	1	0.047	1.741	(1.603-1.997)
Private sector	0.4114	0.19723	4.352	1	0.037	1.509	1.404-1.739)
NAVDP(No Visit)(Ref)			6.2105	3	0.018		
1	0.1808	0.08068	5.0272	1	0.025	1.198	(1.023-1.404)
2-3	0.0407	0.11798	0.1194	1	0.7297	1.042	(0.827-1.313)
4 and above	-0.4873	0.71439	7.4655	1	0.0495	0.614	(0.401-0.803)
Pbinterval (≤24 month) Ref			75.7987	2	0.0001		
25-48 months	-0.6401	0.12336	57.0708	1	0.0001	0.527	(0.447-0.622)
49 and above months	-0.8414	0.08835	0.45206	1	0.0001	0.431	(0.339-0.549)
Father occupation (No) Ref	-0.8378	0.13928	36.1866	1	0.0001	0.433	(0.329-0.568)
Breast feeding (No) Ref	-1.0674	0.07213	218.979	1	0.0001	0.344	(0.299-0.396)
ME=Mother Education, AMFbirth=Age of mother at first Birth, NAVDP=Number of antenatal visits during pregnancy							

Table 7: The final stratified cox proportional model after checking the PH assumption.

	-2Log L	AIC	SBIC
Cox Regression	14868.735	14924.7	15057.3
Stratified cox Regression	12524.13	12574.1	12692.5

Table 8: Model comparison.

of parameters is the Staratifed cox regression model is the model that highly minimizes the -2Log L or the model that smallest AIC. Our result showed that, according to the AIC, using the Staratifed Cox regression model (no-interaction model) gives more suitable results for survival data in the presence of non-proportional hazards. Staratifed cox regression model is the model that best fit the under-five child mortality (Figures 3-10).

The above plot is graphical assessment of the PH assumption by plotting the Shoenfeld residuals of each covariate against time. On the basis of the above results it can be stated that proportional hazard assumption approximately seems to be satisfied for all covariates. Furthermore, the smoothed curve is an approximately horizontal line around zero.

Overall assessment of the model adequacy

The last step in the process of assessment of model adequacy is an overall assessment of the model. There are some well-developed methods of relative model evaluation.

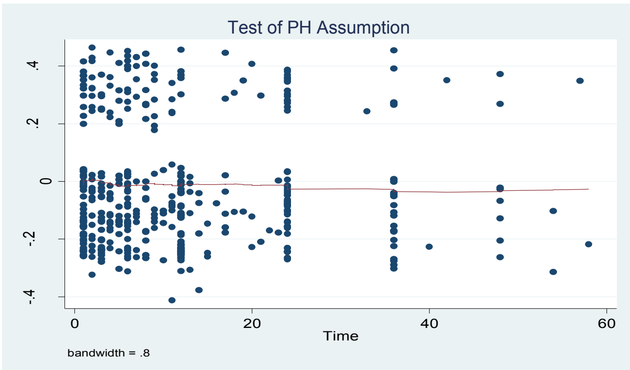

Figure 3: Shoenfeld residual plots for region.

Goodness of fit test: We use R^2 as a measure of overall goodness of model fit. As it is defined in chapter three, it is given as

$$R^2 = 1 - \exp(\frac{2}{n}(LL_0 - LL_{\hat{\beta}})) \quad (8)$$

Where,

- n = 11322 is the number of observation
- LL_0= 12949.392 is the log partial likelihood for model without any covariates

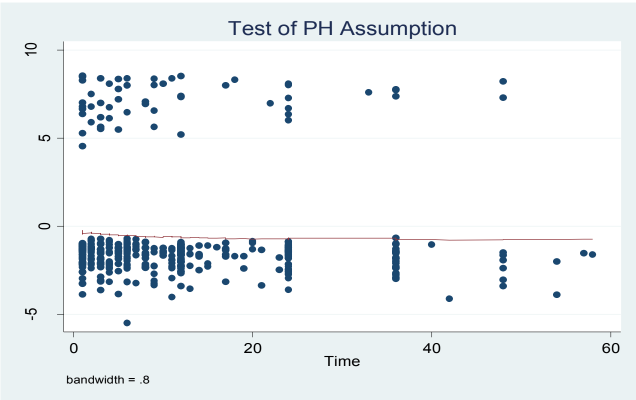

Figure 4: Shoenfeld residual plot for contraceptive use.

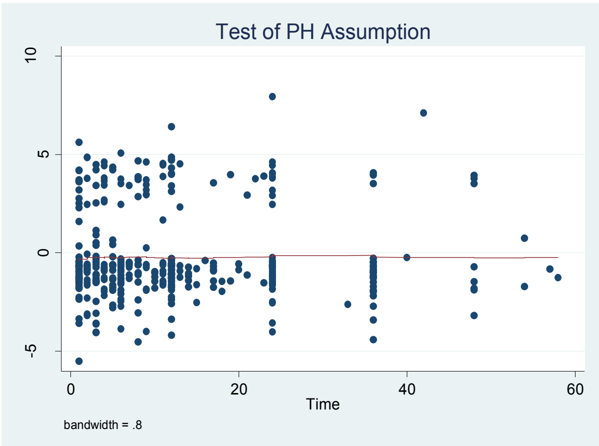

Figure 5: Shoenfeld residual plots for mother education level.

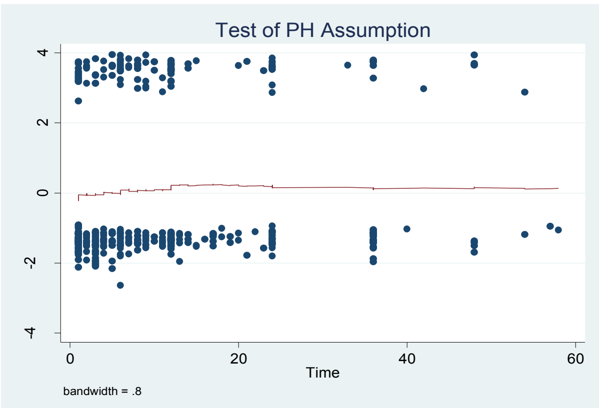

Figure 6: Shoenfeld residual age of mother at first birth.

- LL_β = 12524.130 is the log partial likelihood for model with covariates

Then $R_p^2 = 1 - \exp\left\{\frac{2}{11322}(12949.392 - 12524.130)\right\} = 0.036864$

For the fitted model in the Staratifed we obtain $R^2 = 0.036864$ which are terribly very low due to high percentage of censored data. However the model has passed all tests for a good fitting model.

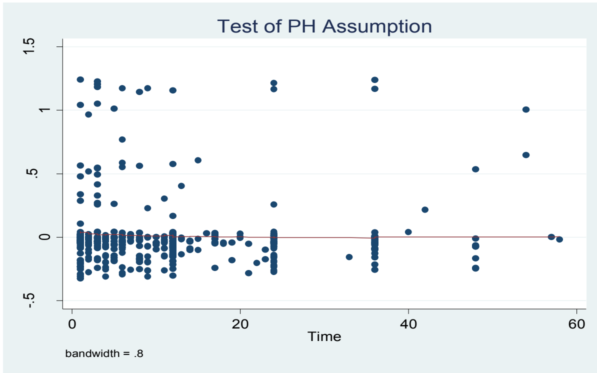

Figure 7: Shoenfeld residual plots for Place of delivery.

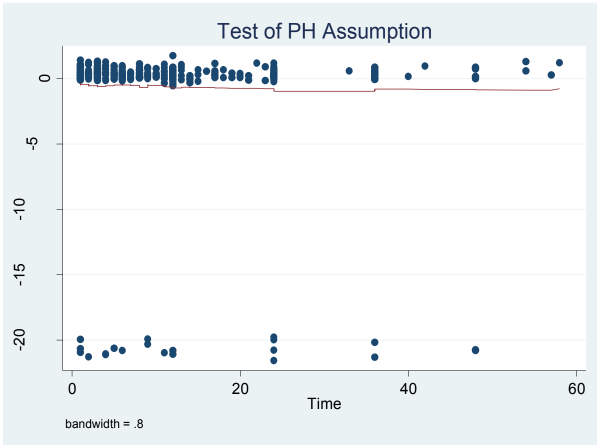

Figure 8: Shoenfeld residual plots for father occupation.

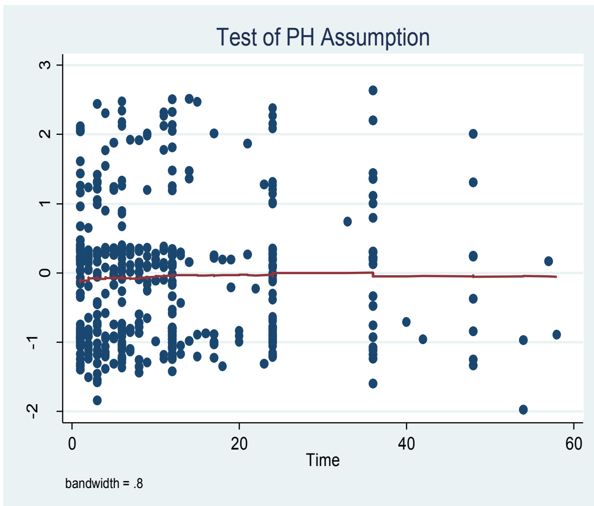

Figure 9: Shoenfeld residual plots for number of antenatal visits during pregnancy.

Interpretation of the results

The primary goal of the study was to assess the risk factors of under-five mortality in Ethiopian by applying an appropriate survival model to provide valid estimates for correct statistical inference needed for

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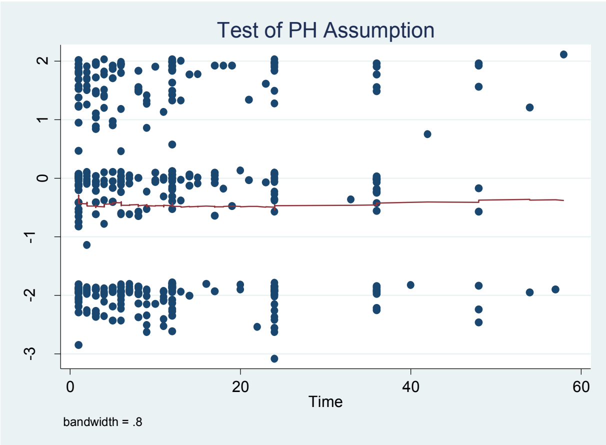

Figure 10: Shoenfeld residual plots for preceding birth interval.

policy decision making. We found that region has the most significant risk factor for child mortality. Benishangul Gumuz had higher risk of dying before age five, followed by children born in Gambela, Amhara and SNNP as compared to Addis Ababa. These states require health interventions that target under-five mortality reduction, particularly in rural areas.

Next, mother's education and preceding birth interval emerge as powerful background covariates of under-five mortality in the Ethiopia states, for the reason that both are known to be associated with better child care practices. Thus, the study urges the policy makers to focus on educating illiterate mothers about the child care; however, policy aiming at improving maternal education and increasing birth interval.

Contraceptive use is found one of the important significant predictors of under-five mortality. The estimated hazard ratio of Contraceptive use by mother is 0.587, [95% CI 0.478-0.721] and it infers that risk of child death is 58.7% less in those children born to mother using contraceptive than those children born to mother not using contraceptive, throughout the study period. One of the important possible reasons for lower under-five mortality may be the longer birth intervals among the users. The relative risk of under-five mortality for children born to mothers aged 25-34 is 0.614 [95% CI: 0.401-0.803] or 38.58 % times lower than the babies born to mothers of age less than 20 years and the difference is found significant. Also children of mothers whose age between 35 and 49 years have about 0.825 [95% CI: 0.703-0.969] times or 17.5% lower risk of under-five mortality compared to babies of mothers aged 15-19. The findings indicate that babies of relatively youngest mothers have highest under-five mortality.

Place of delivery is also an important significant factor of child mortality. The estimated hazard ration of child delivered at home and private sector 1.7417 [95% CI: 1.023-1.404] and 1.509 [95% CI:1.404-1.739]. The result reveals that babies delivered at home and private sector had 1.7417 and 1.509 higher risk of under-five mortality compared to the babies delivered at public sector. Number of antenatal check or antenatal visit during pregnancy is found significant association with child survival. The estimated hazard ration for child whose mothers visited at least 4 times during pregnancy is 0.977 [CI: 0.768-1.243]. The result reveals that the relative risk of child whose mothers visited at least 4 times during pregnancy of is 0.977 times lower compared to child whose mothers who have not received any antenatal check during pregnancy. So the recommended antenatal visit during pregnancy is at least 4 or more. Father's occupation is also found to have significant effect on child mortality. The estimated hazard ration of child whose father has occupation is 0.344, [95% CI: 0.329-0.568]. The child mortality is 0.344 times or 65% lower for the children whose father engage in any type of job business, service and others job respectively as compare to the children whose father not engage any type of work. Breast feeding is often considered risk factor of child mortality in Ethiopia. The hazard analysis of this study shows that breast feeding has a strong significant effect on under-five mortality.

Conclusions

In this study, we tried to explore and show which factors are associated with the risk of under-five mortality of child in Ethiopia and also identifies regional differential of child survival among different regions in Ethiopia using survival (time-to-event) analysis. Under-five survival of child is greatly affected by many factors including socio economic, demographic, environmental, nutrition and health related factors. Using the Kaplan Meier non-parametric and Cox proportional hazard model the difference of child survival among different region and covariates that significantly influence the survival of child are identified. The Kaplan mier method revealed that the survival time of child in Benishangul Gumuz, Gambela, and SNNP and Afar is less survival time as compared to the reference categories (Addis Ababa). Also using the Staratifed cox regression model the hazard of Benishangul, Gambela and SNNP region is high as compared to the reference region Addis Ababa. Further, the result of Staratifed cox regression model showed that mothers' education, mothers' age at first birth, sex, fathers' occupation, preceding birth interval, place of delivery, number of antenatal visit during pregnancy, breast feeding and contraceptive use are were found to be statistically significant effect on child survival in Ethiopian.

Acknowledgment

I would like to greatly acknowledge my Advisor Dr. Yehenew Getachew for his invaluable comments, suggestions and patience from the start of this work until now. Also My special thanks goes to the Central Statistical Authority of Ethiopia for providing me the Ethiopia Demographic and Health Survey (EDHS) 2011 data used in this study and its data management staff for their technical assistance.

References

1. National strategy for child survival in Ethiopia family health department federal ministry of health 2005.
2. Angeles G, Guilkey DK, Mroz TA (2005) The Impact of Community-Level Variables on Individual-Level Outcomes: Theoretical Results and Applications. Sociological Methods Research 34: 76-121.
3. Deribew A, Tessema F, Girma B (2005) Determinants of under-five mortality in Gilgel Gibe Field Research Center, Southwest Ethiopia. Ethiop J Health Dev 21: 1-8.
4. Mekonnen D (2011) Infant and Child Mortality in Ethiopia: The Role of Socioeconomic, Demographic and Biological Factors in the previous five years period of 2000 and 2005. Lund University, Sweden. pp: 1-68.
5. Alex M (2007) Multilevel Analysis of Factors Associated with Child Mortality in Uganda.
6. Adedin SA, Odimegwu CO, Pono DO, Ibisomi L, Elwange BC, et al. (2012) Regional Inequalities in Under-five Mortality in Nigeria: a Multilevel Analysis. Princeton.edu papers. pp: 1-32.
7. Muleta E (2003) Mother's Work Status and Infant Mortality in Ethiopia: a Study based on Demographic and Health survey data. Addis Ababa, Ethiopia. pp: 1-59.
8. Afzal AR, Alam S (2013) Analysis and comparison of under-five child mortality between rural and urban area in bangladesh. Journal of applied quantitative methods 8: 1-10.