Neonatal Mortality and its risk factors in Eastern Ethiopia: A Prospective Cohort Study in Kersa Health and Demographic Surveillance System (Kersa HDSS)

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ABSTRACT

Background: Neonatal mortality continues to be a major problem in Ethiopia though the country has registered a good progress in under five age child mortality in the last decade. This paper focuses on identifying the risk factors for neonatal mortality based on data from Kersa Health and Demographic Surveillance (Kersa HDSS), Eastern Ethiopia for the period from 2007 to 2012.
Methods: The analysis used data extracted from Kersa HDSS. Kersa HDSS was established in 2007 and uses an open cohort surveillance. Data extraction includes all live births recorded in the system. The main outcome was the occurrence of death within the first 28 days after birth. The survival time was calculated in days between the date of birth and the date of death. Kaplan-Meier survival curve was used to depict the pattern of death in the first 28 days and Cox-proportional hazard model was used to identify the risk factors of the neonatal death.
Results: The overall, the early and the late neonatal mortality rates were 28.37, 19.55 and 8.82 per 1000 live births, respectively. The person days Neonatal Mortality Rate was 1 per 1000 (95% CI, 0.87-1.15). The hazard of neonatal mortality was increased among twin born (HR=5.40; 95% CI, 3.64-8.02), preterm birth (HR=11.17; 95% CI, 7.17-17.40), and previous sibling death (HR=2.15; 95% CI, 1.39-3.33) and among women with no previous birth (HR=1.78; 95% CI, 1.17-2.72).
Conclusions: Neonatal mortality is high and is in line with the national average. Majority of the deaths occurred during the early neonatal period. Detecting risk factors such as twin pregnancy and previous child death during antenatal care (ANC) and promoting institutional delivery helps in identifying and dealing with the causes early.

Key words: Neonatal Mortality, Risk, Cohort, Kersa HDSS

INTRODUCTION

Children represent the future and ensuring their healthy growth and development ought to be a prime concern of societies. New-borns are particularly vulnerable to death; the majority of the causes can be effectively prevented providing that adequate medical care is sought during pregnancy and child birth. In Sub-Sahara Africa, neonatal mortality continues to be one of the major concerns, and in Ethiopia is all the same. The neonatal period, which refers to the first 28 days of life, is the most crucial time for a child's survival. In the world, nearly half of children death under the age of five years occur during this period [1, 2].

Every year about 3.8 million neonatal deaths occur globally, of which 98% occurred in developing countries. Per 1000 live births, the rates of the death in developing and developed countries were 28.2 and 3.5, respectively [3-6]. Africa is one of the two regions that show the smallest reductions in Neonatal Mortality Rate (NMR) of the millennia period. In Sub-Saharan Africa, neonatal mortality accounts 30 to 50 % of all the child deaths [7-9]. Ethiopia is one of the countries in Africa with the highest neonatal mortality. According to a study done in 2013 by Mekonnen and his colleagues, in the country the NMR, the Early Neonatal Mortality Rate (ENMR) and the Late Neonatal Mortality Rate (LNMR) were 36.7, 29.2 and 7.5 per 1000 population, respectively [10-13]

In many developing countries, where home delivery is a common practice, the rate of neonatal mortality is high and showed little sign of reduction. For example in the year from 1990 to 2015 the proportion of under-five deaths declined significantly, while neonatal mortality has decreased little or has not decreased at all in many countries. This has attracted the attention of many concerned bodies across the world to identify and address its major causes [6, 10, 12, 14, 15].

The major causes of neonatal mortality are severe infections, intra-partum and complications of preterm birth. In 2005, Joy E lawn and her colleagues reported that severe infection, tetanus, diarrhoea, complications of asphyxia, preterm birth and congenital abnormalities accounted for majority of neonatal deaths [9, 16, 17]. In Ethiopia, a study conducted in 2007 and 2013 indicated that pre-maturity (26.4%), pneumonia (22.6%), neonatal tetanus (9.4%) and sepsis (7.5%) were the leading causes of neonatal mortality [13]

In Ethiopia studies regarding neonatal mortality have focused on its trend and little has been done to identify its risk factors. A study in 2013 found that birth order, birth interval, maternal age, season of birth, child's sex and educational status of mothers were among the determinants of neonatal death. Anderson and his colleagues, in 2002, has also reported neonate of mother with poor previous delivery outcome and twin birth as risk factors of neonatal mortality [13, 18, 19].

In the era of SDG an increased focus is given to reduce child mortality by three fourth and particular focus is due to reduce neonatal mortality to 12 per 1000 live births in Ethiopia. The country is striving hard to address the health needs of pregnant women and children though universal health coverage. Hence, it is advisable to generate neonatal health information to guide decision at all levels of the health system. Therefore, the aim of this analysis was to identify risk factors for neonatal mortality based on data from Kersa HDSS, Eastern Ethiopia [12].

METHODS

Setting

Kersa HDSS is located in Kersa district, Eastern Hararge, Oromiya Regional State, Eastern Ethiopia. According to the Central Statistical Agency of Ethiopia, in 2007 its population was about 170,816 people; of whom 86,134 (50.4 %) were male and only 6.67% were urban dwellers [20]. The Kersa HDSS is operated by Haramaya University. In Kersa HDSS field site, there are a total of 30 health facilities; including 6 health centres, 19 health posts and 5 private clinics.

Surveillance system, design, and population

Kersa HDSS is established with the aim of generating community based health and demographic data in the Eastern part of Ethiopia. It is an open cohort set up in 12 sub-districts of Kersa district. The baseline census was done in 2007 and since then a continuous updates were done every six month. At the baseline 10,168 houses and 53,481 people were registered. Kersa HDSS is an INDEPTH member. INDEPTH is a network of Health and Demographic Surveillance Systems (www.INDEPTH. org).

Database and data extraction

Kersa HDSS uses HRS-2 database. The software is flexible and can export selected data to other software for analysis. For this study, all the births and the neonatal deaths occurred from 1st September 2007 to 31st August 2012 were used; data extraction for this analysis was done in January 2014.

Parameters of analysis

Estimates of neonatal mortality were based on

birth history section of the questionnaire administered to individual women. The age of the neonate was recorded in days. The NMR, ENMR and LNMR were estimated directly from the information about a child's date of birth, survivorship status and age at death. ENMR was defined as the probability of dying before 7 completed days of life; LNMR was defined as the probability of dying between 7 completed days and before 28 completed days; and overall NMR was defined as the probability of dying before 28 completed days. All live births (7,367) during the study period were included in this analysis, which were considered as a denominator to calculate the neonatal mortality rate. Total person-days (209,205) were also used as a denominator to calculate the neonatal mortality rate. All the neonatal deaths (209) in the study period were used for the analysis, which were considered as a numerator in the mortality rate calculation.

Variables

In this study, the variables used for analysis included Neonatal Mortality (count of neonatal mortality over the period), Date Of Birth and Date Of Death (which were used to set the data ready for the survival analysis in the software), Sex of the Neonate (categorised as male and female), Birth Type (categorised as being born as twin or singleton), Mother's Age at Birth (categorised into three: less than 18, 18 to 34, and greater than 35 years), Residence (categorised as urban and rural), Previous Infant Born Alive (categorised into three: Having previous live birth, not having previous live birth, and not having previous birth), Mother's Occupation (categorised into three: farmer, employee and merchant, and housewife), Number of Pregnancies (categorised into two: less than or equal to 5 and greater than 5 pregnancies), Mother's Educational status (categorised as being literate or illiterate), Mother's Marital status (categorised into four: only wife, not-only wife, divorced or widowed and never been married), Delivery Attendant (categorised into two: TTBA and health worker, and TBA), and Duration of Pregnancy (Categorised into three: 9, less than 9 and greater than 9 months).

Data quality management

Quality control followed from the field to the computer entry and archiving into hardcopy ware. The field supervisors inspected all the performances of the data collectors and managed errors. Before the data were entered, they were checked for completeness and consistency by the clerks. Upon finding inconsistencies, documents were returned back to the field for verification. The process of data generation and entry were under close supervision of the investigators.

Data analysis

The main outcome variable was neonatal death. The survival time was calculated in days using the time interval between the date of birth and the date of death. STATA Version 11 statistical software was used to perform the analysis. Cox-proportional hazard model was used to identify the risk factors of the neonatal death. Kaplan-Meier curve was used to depict the pattern of death and estimate the probability of the neonates' survival and to compare the survival curves. An initial univariate analysis of the individual variables with neonatal death was carried out to determine the possible significant explanatory variables to be included in the Cox-proportional hazard model. An explanatory Cox-proportional hazard model analysis was performed to explore the relations between the variables while simultaneously adjusting for all other variables that have influence on the neonatal death. After confounding variables were identified, the variables with p-values of 0.05 or less were retained in the final model analysis. All the statistical tests were two sided and $p<0.05$ was considered as a significant level of association. The neonate was censored if it is alive at the end of the follow-up period.

Ethical considerations

Ethical approval and clearance was obtained from the Haramaya University, College of Health Science Institutional Research Ethics Review Committee, Ethiopian Public Health Association Ethical Review Committee, and Centre for Disease Control Ethical Review Board. Kersa HDSS was a standing surveillance. It was started with the permission from local leaders and the University. Names of study participants were not utilised in analysis. Data were collected after informed consent of the participants was obtained, which included informed consent obtained from the next kin, caretakers, or guardians on behalf of the children enrolled in this study. The study participants were informed that the information they gave would not be used for any purpose other than the study. Confidentiality was also being assured.

RESULTS

Characteristics of live born infants

A total of 7,367 live born babies were included in this analysis, with a 100% response rate, as it is a regular surveillance system. There has been migration in the study area; however it doesn't affect this study since a mother of less than three month infant would not move out of home. The sex ratio was 1.09, and 2.71% of the births

were twins. Most of the mothers gave birth in the age range of 18 to 34 years (81.91%). About 527 (5.8%) of the mothers had previous stillbirth history. Majority of the mothers were housewife and illiterate. About 95.86% of the mothers delivered at home, and 73.34 % of the mothers gave birth to 5 or less number of children. About 2,093 (28.42%) of the deliveries were attended by trained traditional birth attendants (Table 1).

The neonatal mortality trend showed an irregular pattern in the six consecutive years. About 121 (57.89%) male neonatal deaths were observed. About 197 (94.26%) of the neonatal deaths has occurred among home attended deliveries (Table 2).

Neonatal mortality rate

During the follow up period of 209,205 person-days, 7367 live births occurred. There were 209 neonatal deaths, of which 144 and 20 were early and late neonatal deaths, respectively. The ENMR, LNMR and overall NMR were 19.55, 8.82 and 28.37 per 1000 live births, respectively. In person days the Neonatal Mortality Rate (NMR) was 1/1000 (95% CI 0.87 - 1.15). About 68.9% of the neonatal deaths occurred in the early neonatal period.

Neonatal survival

The Kaplan Meier curve clearly indicated that twin birth has less survival probability at the earlier neonatal period than singleton (Figure 1).

A review of literature was undertaken in order to identify variables for analysis. However, some of the variables showed non-significant association with time of death, even when included in the model. An explanatory Cox-proportional hazard model analysis was performed to explore the relations between the variables while simultaneously adjusting for all other variables included in the model.

While fitting the Cox-proportional hazard survival analysis model, the existence of an interaction effect was tested by including four combinations (i.e. (a) mother's age at birth and educational status (b) mother's educational status and marital status (c) number of pregnancy and previous child born and (d) mother's age at birth and number of pregnancy) into the model. However, none of the interaction tests showed statistical significance which worth an explanation.

Except birth type and mother's age at birth, the distribution of all the variables in the model was found to change significantly over the six years period. However, the distribution of neonatal mortality showed no change over the study period. In addition, the association between predictor variables and neonatal mortality showed no variation over the study period.

The survival analysis showed that twins had 5.4 times more risk of neonatal death than singleones. Neonates born in less than nine months of pregnancy had 11.17 times more risk of death than those born in their nine months of pregnancy. Neonates whose mother gave birth at the age range of 18 to 35 years and greater than 35 years had less risk of dying than neonates whose mother gave birth at the age of less than 18 years, even if the association lost its statistical significance after adjusted for the other covariates (Table 3).

Mother's education did not show protective effect for neonatal mortality. Mother's marital status did not show statistically significant association with neonatal mortality, particularly after adjustment. Neonates of mothers who had poor previous pregnancy outcome and who had not delivered previously had 2.15 and 1.78 more risk of death than those neonates' mothers who had favourable previous delivery outcome. Neonates of mothers who gave birth to more than 5 children till the end of the study period had more protective effect for mortality than those neonates of mothers who gave birth to less than or equal to 5 children, which lost its significance after adjustment. Delivery attendant showed no association with neonatal mortality (Table 3).

DISCUSSION

The overall NMR, ENMR and LNMR in this analysis were slightly lower than that of other studies done in Ethiopia. A possible explanation could be the aggressive expansion in the health care delivery in Ethiopia through the Health Extension Workers (HEWs). Similar to other studies done in Ethiopia, the findings of this study showed a higher ENMR than the LNMR. This is consistent with the increased risk of neonatal death during their early life [10-13, 21].

This analysis used person days to understand neonatal mortality in a better ways than the conventional analysis of rate. The main advantage of using person-years is that it takes into consideration the influence of loss to follow-up among the study cohorts. This clearly gave unbiased estimate of new death occurrence among the neonates. As this is a prospective cohort study, the finding could be very reliable particularly in identifying risk factors. The person days rate found in this analysis showed a slight reduction in the neonatal mortality over the years, which may be reflected with the increased access to health care by pregnant women through the health extension program and improved health institution delivery. The Health Extension Program is implemented in Ethiopia since 2003 G.C [19, 21].

Place of delivery, the commonly known risk factors for neonatal morality, was insignificant in this analysis. In addition, the interaction terms were also statistically

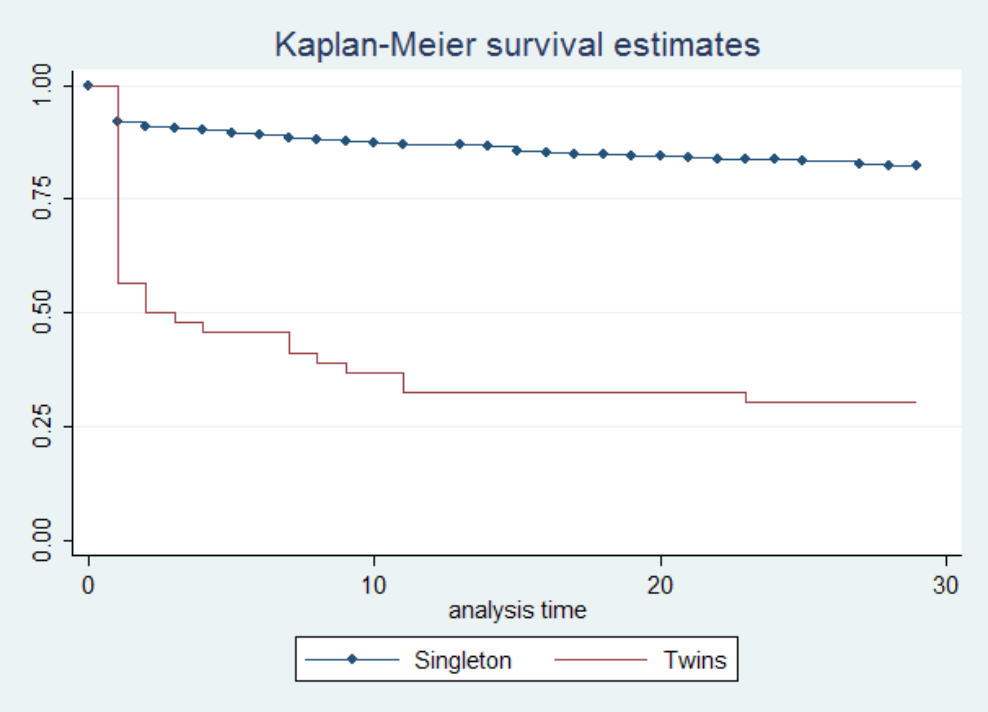
TABLE 1. Characteristics of live born infants in Kersa HDSS, Eastern Ethiopia, 2007-2012.

CHARACTERISTICS	NUMBER (UN-WEIGHTED)	% (WEIGHTED)
Sex		
Male	3,842	52.15
Female	3,525	47.85
Birth type		
Singleton	7,167	97.29
Twins	200	2.71
Mother's age at birth		
Less than 18 years	342	4.64
18 – 34 years	6,034	81.91
More than 35 years	991	13.45
Place of residence		
Rural	6,806	92.38
Urban	561	7.62
Previous infant born alive		
Yes	5,736	77.86
No	427	5.8
No previous birth	1,204	16.34
Mother's occupation		
Farmer	160	2.17
Employee and merchant	98	1.33
Housewife	7,109	96.5
Number of pregnancy		
Less than or equal to 5	5,403	73.34
Greater than 5	1,964	26.66
Mother's educational status		
Literate	1,319	17.9
Illiterate	6,048	82.1
Mother's marital status		
Married monogamous	6,932	94.1
Married polygamous	86	1.17
Divorced or widowed	63	0.86
Never been married	286	3.88
Delivery attended by		
TTBA	2,093	28.42
TBA	4,998	67.86
Health worker	238	3.23
No one around	36	0.49
Duration of pregnancy as perceived by the mother		
9 months	2,221	30.15
Less than 9 months	109	1.48
Greater than 9 months	5,037	68.37
Neonatal mortality outcome		
Died	209	2.84
Alive	7,158	97.18

TABLE 2. Neonatal mortality by basic characteristics of live born infants in Kersa HDSS, Eastern Ethiopia, 2007-2012.

CHARACTERISTICS		NEONATAL MORTALITY OUTCOME				TOTAL
		DIED		ALIVE		
		NUMBER	%	NUMBER	%	
Year	2007	1	0.48	340	4.75	341
	2008	35	16.75	1369	19.13	1404
	2009	51	24.4	1463	20.44	1514
	2010	61	29.19	1689	23.6	1750
	2011	33	15.79	1306	18.25	1339
	2012	28	13.4	991	13.84	1019
	Total	209	2.84	7158	97.16	7367
Sex	Male	121	57.89	3721	51.89	3842
	Female	88	42.11	3437	48.02	3525
Residence	Rural	198	94.74	6608	92.32	6808
	Urban	11	5.26	550	7.68	561
Location of delivery	Home	197	94.26	6865	95.91	7062
	Health institution	12	5.74	293	4.09	305
Total		209	100	7158	100	7367

FIGURE 1. Kaplan-Meier survival estimate for neonatal mortality by birth type in Kersa HDSS, Eastern Ethiopia, 2007-2012.



insignificant in the model. This might be due to the small sample size put in the analysis. An important variable that relates with neonatal survival is birth weight, yet in the regular demographic surveillance activity, this variable is not collected and can't be put in the model. Many research found that, the main proximal determinant of neonatal mortality are infection or prematurity [9, 16, 17, 22, 23].

In this analysis, twin born babies were at increased risk of death compared to babies born singleton. This is consistent with other studies done in Ethiopia. Twin born babies are at increased risk of prematurity and low birth

TABLE 3. Determinants of hazard of neonatal mortality in Kersa HDSS, Eastern Ethiopia, 2007-2012.

VARIABLES		HR* (95%) CI	
		CRUDE	ADJUSTED
Birth Type	Singleton	1.00	1.00
	Twins	6.76 (4.64, 9.81)	5.40 (3.64, 8.02)
Perceived duration of pregnancy	9 months	1.0	1.00
	< 9 months	15.53 (10.15, 23.77)	11.17 (7.17, 17.40)
	> 9 months	1.03 (0.74, 1.42)	1.00 (0.72, 1.40)
Mother's age at birth	<18 years	1.0	1.00
	18 – 34 years	0.49 (0.30, 0.79)	0.74 (0.44, 1.25)
	> 35 years	0.45 (0.25, 0.82)	0.93 (0.47, 1.84)
Mother's educational status	Literate	1.00	1.00
	Illiterate	0.87 (0.62, 1.21)	1.09 (0.76, 1.57)
Mother's marital status	Only wife	1.00	1.00
	Not only wife	0.84 (0.21, 3.39)	0.36 (0.09, 1.48)
	Divorced/Widowed	1.16 (0.29, 4.66)	0.78 (0.19, 3.19)
	Never married	1.79 (1.04, 3.09)	1.17 (0.65, 2.11)
Previous child born	Yes	1.00	1.00
	No	2.82 (1.85, 4.30)	2.15(1.39, 3.33)
	No previous birth	2.23 (1.63, 3.04)	1.78(1.17, 2.72)
Number of pregnancies	Less than or equal to 5	1.00	1.00
	Greater than 5	0.89 (0.84, 0.95)	0.96 (0.89, 1.03)
Delivery attendant	TTBA** & Health worker	1.00	1.00
	TBA***	1.15 (0.85, 1.55)	1.26 (0.92, 1.72)

**Hazard Ratio, **Trained Traditional Birth Attendant, ***Trained Birth Attendant*

weight, which makes them susceptible for the risk of infection, hypothermia and hypoglycaemia. Such neonatal complications required special and expensive medical care, which is hard to access in resource poor setting like Ethiopia [24][19]. In this analysis we were able to learn that, about one fourth of twin born neonates were able to survive (Figure 1), which may be due to the health care women received during their pregnancy, delivery and post-partum period. Thus, improving perinatal care for pregnant women expecting twin birth should be given attention.

In addition, preterm births were at increased risk of mortality compared to term births. Other studies has also found the same result in Ethiopia [25]. The risk of infection and sepsis is increased among preterm births that may lead to death if proper medical care is not sought the earliest possible.

Neonates whose mother gave birth at the age from 18 to 35 years and greater than 35 years had increased survival probability than neonates whose mother gave birth at the age of less than 18 years, even if it lost its statistical significance after adjustment to other covariates in the model. The finding is consistent to other studies done in Ethiopia and Tanzania. The possible explanation could be the fact that teenage mothers may face financial and social problems, and health problems in addition to the physiological immaturity of having small uterus or narrow bony pelvis, which leads to increased neonatal death [26, 27].

Neonates of mothers who had poor previous delivery outcome and who had not given birth before had increased the risk of neonatal death than those neonates of mothers with favourable previous delivery outcome. This is consistent with the findings from studies done in Ethiopia and Tanzania, which showed that neonates who have previous infant death among the siblings had an increased risk of death. This could be explained by the fact that women with poor previous obstetric outcomes are more likely to have some underlying factors affecting survival of the babies, which need high medical attention, which might not be available or affordable at resource poor settings like Ethiopia. Such women would try to replace for the lost baby immediately after losing the previous, which shorten the birth interval thereby increase exposing reduced physiological reserve for the incoming pregnancy [19, 27].

This study has analysed data from an established longitudinal surveillance system, which gives a good estimate of the problem in the rural setting. The less frequent visit to the households may have contributed for

the loss of some of the events otherwise it may have been increased the outcome. The limited number of variables under surveillance might have masked some of the predictors; this might have called the improvement in the data capturing mechanism in the surveillance.

In this analysis neonatal mortality rate was significantly high and majority of neonatal deaths occurred at the early neonatal period. Twin birth, preterm birth, neonate of mother with poor previous delivery outcome, neonates of mothers who gave birth at the age of less than 18 years and neonates from mothers who have 5 or more children were at increased risk of death. In reducing the burden of neonatal mortality and achieve the goals set for SDG, great focus should be given towards addressing universal antenatal care, and health institution delivery with much emphasis on preterm and small gestational size babies. The Federal Ministry of Health and other organisations should exert utmost effort towards improving the neonatal survival by addressing the important determinants of neonatal death.

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