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Factors Associated with Infant and Child Mortality in Malakal in Upper Nile State South Sudan

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Abstract: ***This study sought to identify the factors associated with infant and child mortality in Malakal, using primary data from a random sample of 1317 women aged (15-49 years). The Multivariate Cox's regression findings showed - that place of delivery, breastfeeding duration, mother's employment and family income were significantly associated with infant and child mortality. Zone of residence, parity, birth order and sex of the infant were significantly associated with infant mortality. Age of the mother, preceding birth interval, drinking water source, source of cooking fuel and type of the floor were significantly associated with child mortality. The study recommends for encourage delivery at hospitals, improve breastfeeding duration, augment maternity leave for employed mothers, increase family income, encourage antenatal care for mothers aged 30+ years, longer preceding birth interval and use of improved water supply.***

Keywords: Determinants, Infant mortality, Child mortality, Cox proportional hazard model, Malakal

1. Introduction

Infant and child mortality have received renewed attention as a part of the United Nation's sustainable development goals (SDGs). They are frequently used as indicators of the socioeconomic development of a nation and quality of life [1]. According to Espo report [2], nearly 10 million children still die each year worldwide before reaching their fifth birthday, with great disparities in infant and child death and trends across areas and nations.

According to Val [3], infant and child death rates had dropped whole over the globe in the past 55 years. Between the end of the World War II and near the beginning of the 1970s, infant and child mortality rates even in less developed nations were decreased by halve [3]. A major dealing of these gainings was done through interferences targeted childhood diseases which have main causes of infant and child mortality.

Despite huge literatures exists on infant and child mortality, facts on reason infant and child mortality stay very high in different Sub-Saharan African nations in spite of initiative policies and interferences made is still meager [4].

Although several studies on determinants of infant and child mortality have been undertaken in some parts of South Sudan particularly in Malakal, they did not include all factors that are often associated with infant and child mortality [5], [6] and [7]. For instance, the study by Abol et al [6] did not include environmental, maternal health seeking behavioral and nutritional factors, and no study to date has addressed their effects on infant and child mortality in Malakal. Furthermore, the study used a relatively small sample (N=384) to permit robust analysis of infant and child mortality determinants in Malakal.

Many studies had confirmed significance of these factors on infant and child death in developing countries. For example, evidence indicates that the effects of environmental risk factors identified leading mortality risks in infants and young children [8], [9], [10], [11] and [12]. Scientific evidence indicates that the place of delivery is a vital factor which affects the health and safety of mother and newborn and is a significant predictor of infant mortality [13], [14], and [15]. Also, evidence supports strongly the importance of breastfeeding factor in promoting healthy development of children and is a significant factor in child survival [16], [17], [18] and [19]. Also, effects of factors on infant and child mortality change over time [20], [21], [22], [23] and [24]. However, it is possible that the effects of some of the factors included in the previous studies [5] and [6] may have changed by now due to the social and structural changes taking placing in South Sudan in the last five years. In addition, there are contradictory findings and the limitations of the previous studies in South Sudan regarding the effects of some key factors (maternal education, employment status of the mother, family income and mother place of residence) on infant and child mortality.

Therefore, the current determinants of infant and child mortality in Malakal are largely unknown and thus poorly understood. This is the focus of this study. The specific objective of this study was to identify the factors associated with infant and child mortality in Malakal.

2. Literature Review and Theoretical Framework

Several research works had been conducted using survey and census data at different levels and different places across the developing world in an attempt to find out how determinants in a population influence the infant and child mortality.

Kittur [25] conducted a study aimed to establish the factors influencing infant mortality in Kenya, using data from the 2008/9 (KDHS) by employed Cox proportional hazard model. The results showed that birth order and wealth index have significant effects on infant mortality. The study

concluded that future study should focus on infant mortality using qualitative methods in different urban settings.

Buli [26] conducted a study to identify the impacts of factors on child mortality in Ethiopia; utilizing data from the 2005 EDHS by employed Cox proportional hazard model. The results showed that mother education, father education, wealth index, family size, birth order, sex, breastfeeding and drinking water source have significantly associated with child mortality in Ethiopia. The study concluded that government should improve society services to reduce child mortality.

Lemani [27] conducted a study to establish the variables of infant and child mortality in Malawi, utilizing data from the 2010 (MDHS) by employed Logistic Regression Model to analyze the data. The results showed that mother education, father education, wealth index, and woman's age at first delivery, previous birth interval, delivery order and sex have important effects on infant and child death. This study concluded that rising knowledge on importance of mother education to decrease infant and child death.

Dede [28] his study aimed to investigate the determinants of infant mortality in Tanzania. Data from the 2010 TDHS was used. The binary logistic regression was conducted at 95% confidence level to examine the independent effect of background variables on infant mortality. The results obtained indicated that zones of residence, place of delivery, breastfeeding and previous birth interval have the most significant effects on infant mortality. The study recommends that, the individual-level variables should be considered in future studies of infant mortality.

Paul and Damien [5] used three different proportional hazards regression models to analyze the factors related to infant and child mortality in South Sudan. The findings cited that maternal education has insignificantly associated with infant and child mortality, while wealth has significantly linked with child mortality. On the other hand, age of the mother, birth order; birth interval and sex of child have significant effects on infant and child death.

Buwembo [20] conducted a study to investigate whether the relationship of a specific factor to child mortality persists over time in South Africa using data from the 1997 October Household Survey and the 2002 General Household Survey. The results of logistic regression showed that mother education, mother place of residence, and mother's age at firth delivery, delivery order, previous birth interval, sex, nutrient deficiency, and place of delivery have significant relationship with infant and child death for the duration (1993-1997). However, for the duration (1998-2002), the results showed that mother education, sex of child, preceding birth interval, type of dwelling and mother place of delivery have significant relationship with infant and child death for the duration (1993-1997). The study showed that changing in factors has related to infant and child death for the duration (1993-2002). Therefore, government should monitor and evaluate existing programs regularly in order to revise programs which are more relevant to the factors which are predominant in determining child survival.

Kembo and Ginneken [29] their study aimed to establish the impacts of variables on infant and child mortality in Zimbabwe, utilizing data from the 2006 ZDHS survey by employed Cox proportional hazards model. The results revealed that preceding interval and birth order have significant effects on infant and child death. The study concluded that use of contraceptive methods supposed to be increased to decrease infant and child mortality.

Sarah and Stephen [30] conducted a study to establish the probability that Uganda will meet the MDG of halving infant mortality by year 2015, using data from Uganda Demographic and Health Surveys (1974-1999) by employed logistic regression. The results showed that family income has significantly associated with infant mortality. The study concluded that government and rule makers want to intensify their potentials to decrease infant and child mortality by half.
Kishor and Parasuraman [31] conducted a study to examine the impact of woman employment on infant and child mortality in India applying data from the 1993 National Family Health Survey. The results show that mother employment has significant impacts on infant and child mortality.

The study used analytical framework proposed by Mosley and Chen [32] as a guide to establish determinants of infant and child mortality in Malakal. This framework is established on the assumption that socio-economic determinants for instance mother's education; mother's employment status; family income; family size; and zone of residence do not straight influence the outcome variable but rather have to work through proximate determinants to have an effect on infant and child survival [32]. In this condition, the proximate determinants comprise maternal factors (age at first birth of the mother, parity; preceding birth interval, birth order; and sex of the child) environmental factors (source of drinking water; type of toilet facility; source of cooking fuel and type of floor of the house), health-seeking behavioural factor (place of delivery) and nutritional factor (breastfeeding).

3. Data and Methods

This study was a cross-sectional study through primary data collected from a random sample of 1317 mothers aged (15-49 years) in Malakal, 2016, using two stage sampling procedure (design). The study population for this analysis consisted of 1109 infant live births out of which 80 were infant deaths and 2229 child live births out of which 202 were child deaths born within five years preceding the survey. Two kinds of questionnaires were used for this study: the household questionnaire and the individual questionnaire. The individual questionnaire was utilized to obtain information on the background characteristics and entire maternity histories. The entire birth histories of mothers consist of data on the number of childbirths a mother has ever had and for every live born baby, the sex and the month of childbirth was registered in addition to whether the baby is still survives at the period of the survey or interview. If a baby had died, the age of baby's decease was also registered. The household questionnaire was employed to obtain information regarding the household characteristics which consisted of housing structure and housing facilities, for example the drinking

water source, type of toilet facilities, fuels used for cooking and material used to construct the house.

The independent variables
Socioeconomic variables: (mother education, mother employment, family income, family size, place of residence).
Proximate variables: (age of the mother, parity, birth order, previous birth interval, sex of the infant, source of drinking water, type of toilet facility, source of cooking fuel, type of floor of the house, place of delivery, duration of breastfeeding).

The dependent Variables
Infant Mortality (0-11 months): the likelihood of dying between birth and the first birthday.

Child Mortality (12-59 months): the likelihood of dying between the precise age one and the fifth birthday.

Data analyses were carryout using Cox regression [33] in aim to identify the effects of the selected covariates on infant and child mortality. The utilizing of Cox proportional hazards regression model in studying child survival in developing countries is clearly in the literatures [34] and [35].

The hazard ratio is the proportion increment or decrement in the risk of mortality linked with the particular category of variable when compared to the reference category for that variable.

The hazard ratio (the risk) was computed using the following formula:

$$\lambda(t) = \lambda_0(t) \times \exp(b_0 + b_1 x_1 + b_2 x_2 + ... + b_k x_k) \text{ -- (1)}$$

Wherein: $x_1, ..., x_k$ are covariates (denote the socioeconomic and proximate factors of infant or child mortality) and $\lambda_0(t)$ is the risk function at time t. Dividing (1) by $\lambda_0(t)$, and taking logarithms, the formula (1) was become:

$$\text{Log}\left(\frac{\lambda(t)}{\lambda 0(t)}\right) = b_0 + b_1 x_1 + b_2 x_2 + ... + b_k x_k \text{ ---------- (2)}$$

Where: $\log\left(\frac{\lambda(t)}{\lambda 0(t)}\right)$ is the hazard ratio (HR) (the risk of death for a child at time t before reaching the age of five years) the coefficients $b_1, ..., b_k$ are estimated as the coefficient of the independent variables). A positive coefficient (HR>1) for an interpreter covariate means that the risk of dying is higher. On the other hand, a negative coefficient (HR<1) for an interpreter covariate means that, the risk of dying is lower. The analysis was conducted using Statistical Package for Social Sciences (SPSS) version 23. Further, the analyses were run separately for infant mortality and separately for child mortality to identify the factors affect infant and child mortality.

Models
Two models were fitted for every of the two time that is infant mortality (0-11 months) and child mortality (12-59 months).
Model I: includes only the proximate variables.
Model II: includes proximate variables+ socioeconomic variables.

4. Results and Discussion

4.1 Multivariate Analysis for Factors Associated with Infant Mortality

This section represents the results of multivariate analysis using the Cox regression. It consisted of two models where the first model (Model I) was fitted by including only proximate determinants in order to establish the gross effects and the main model (Model II) was fitted by including proximate and socioeconomic determinants to establish the net effects on infant mortality guided by the Mosley and Chen framework on analysis of child survival. These results were presented in (**Table 1a and Table 1b)** below, respectively.

The results of **Model I in (Table 1a)** show that that age of the mother was positively and insignificantly associated with infant mortality at 95% confidence level. As expected, the risk of dying for infants to mothers aged 30 years or more was around (1.410 times) higher than infants to mothers aged (15-19 years) in the reference category. Parity was positively and significantly linked with infant mortality. The risks of dying for infants belonged to parity 4-5 and 6 children or more were (36.792 and 70.683 times) higher, respectively than infants belonged to parity 1-3 children in the reference category. Birth order was positively and significantly associated with infant death. The risk of dying for infants belonged to first order of births was (175.772 times) higher compared to infants belonged to birth orders 4 or more in the reference category. Preceding birth space was negatively and insignificantly associated with infant death. Unexpected, the risk of dying was (0.736 times) lower among infants of preceding birth space of less than 24 months compared to infants of preceding birth space of 24 months or more in the reference category. Sex of the infant was positively and insignificantly associated with infant mortality. As expected, the risk of dying among male infants was (1.563 times) higher when compared to female infants in the reference category. This finding is consistent with findings in study by [4].

Drinking water source was negatively and insignificantly associated with infant mortality at 95% confidence interval. Unexpected, the risk of dying for infants residing in households used non-improved water was about (0.723 times) lower compared to infants residing in households used improved water in the reference category. Type of toilet facility was negatively and insignificantly associated with infant death. As expected, the risk of dying among infants living in households used improved toilet was (0.608 times) lower compared to infants living in households used non-improved toilet facility in the reference category. Source of cooking fuel was negatively and insignificantly associated with infant death. Unexpected, the risk of dying for infants residing in households used high polluting fuel for cooking was (0.679 times) lower than infants residing in households used low polluting fuel in the reference category. Type of floor of the house was negatively and insignificantly associated with infant mortality. As expected, the risk of dying amongst infants residing in households with furnished floor (0.623 times) lower when compared to infants living in households with natural floor the reference category. Place

of delivery was negatively and significantly associated with infant mortality at 95% confidence interval. As expected, the risk of dying was (0.035 times) lower amongst infants delivered at hospitals when compared to infants delivered at home in the reference category. Duration of breastfeeding was negatively and significantly associated with infant mortality. As expected, the risk of dying for infants who have breastfed 6 months or more was (0.069 times) lower compared to infants who have breastfed less than 6 months in the reference category. This result is concurred with the results of several prior studies [20], [26] and [28].

Table 1a: Model I: Results of the Multivariate Cox's regression for Factors Associated with Infant Mortality

Variables	*B*	*SE.*	*Sig.*	*HR*	*95% CI*	
					Lower	*Upper*
Mother's age at first birth (**RC**=15-19 yrs)						
20 – 24 years	0.104	0.365	0.776	1.110	0.542	2.271
25 – 29 years	- 0.056	0.396	0.887	0.945	0.435	2.054
30 + years	0.343	0.420	0.414	1.410	0.619	3.212
Parity (RC = 1 - 3 infants)						
4 - 5 infants	3.605	1.176	0.002	36.792	3.670	368.884
6 + infants)	4.258	1.203	0.000	70.683	6.689	746.877
Birth order (**RC** = 4+ birth order)						
first birth order	5.169	1.572	0.001	175.772	8.073	3826.876
2-3 birth order	0.591	1.439	0.681	1.806	0.108	30.327
Preceding birth interval (RC=24+months)						
First birth	5.169	1.572	0.001	175.772	8.073	3826.876
< 24 months	- 0.307	1.040	0.768	0.736	0.096	5.648
Sex of infant (RC = Female)						
Male	0.447	0.240	0.062	1.563	0.977	2.501
Drinking water source (**RC**= Improved)						
Non-improved sources	- 0.325	0.401	0.419	0.723	0.329	1.587
Type of toilet facility (RC=Non improved)						
Improved toilet facility	- 0.497	0.379	0.190	0.608	0.289	1.279
Cooking fuel source (RC= Low polluting)						
Medium polluting	0.792	0.472	0.093	2.208	0.875	5.568
High polluting	- 0.387	0.503	0.441	0.679	0.253	1.819
Type of floor of the house (RC = Natural floor)						
Furnished floor	- 0.473	0.357	0.185	0.623	0.310	1.254
Place of Delivery (RC=At home)						
At hospitals	- 3.366	0.617	0.000	0.035	0.010	0.116
Breastfeeding duration (RC=<6 months)						
6 + months	- 2.680	0.352	0.000	0.069	0.034	0.137

The results of **Model II in (Table 1b)** showed that education level of the mother was a positive insignificant relationship with infant mortality at 95% confidence interval. Surprisingly, infants for mothers with at least secondary education level have higher risk (2.571 times) than those with no education. As expected, infants for mothers with primary education have lower risk of dying (0.920 time) than infants for mothers with no education. This consistent with the findings obtained by Paul and Damien [5] that mother education has no significant association with infant mortality. Mother's employment was positively and significantly associated with infant mortality. Unexpected, infants for mothers who were employed have higher risk (1.923 times) of dying as compared to mothers who were not employed. Employed mothers

especially those who go out for work give less time to the rearing of their infants and therefore expose them to a greater risk of sickness and death.

Family income was negatively and significantly associated with infant mortality. As expected, the risk of dying for infants belonged to households with high income was around (0.169 times) lower as compared to infants belonged to households with low income in the reference category. This is owing to affordability of high-quality nourishment and health check attention for both mother and the infant. This finding is consistent with the findings by Sarah and Stephen [30] who established that household income has a negative significant association with infant mortality. Family size was negatively and insignificantly associated with infant mortality at 95% confidence interval.

The risks of dying among infants belonged to family size ≤ 4 persons was (0.895 times) lower compared to infants belonged to family size 7 or more. Zone of residence was positively and significantly associated with infant mortality. Infants born to mothers living in Northern and Central zones have higher risk of dying at infancy (2.238 and 2.721 times respectively) compared to those born to mothers living in Southern zone. This it might be due to imbalanced distribution of health infrastructures between these zones. This finding is consistent with the findings by Buwembo [20] and Dede [28] who found that zone of residence was significantly linked with infant mortality.

Age of mother at first delivery was positively and insignificantly associated with infant mortality. As expected, the risk of dying for infants born to mothers aged 30+ years was about (1.445 times) higher than infants for mothers aged

(15-19 years). Infants born to mothers aged (20-24 years) higher infant mortality by (1.033 times). Infants for mothers aged (25-29 years) lower mortality by (0.885 times) than infants for mothers aged 30+ years. Parity was positively and significantly associated with infant mortality. The risk of dying for infants belonged to parity 6+ was (33.549 times) higher than those belonged to parity 1-3. Birth order was positively and significantly linked with infant mortality. As expected, the risk of dying for infants belonged to first birth order was about (98.794 times) higher as compared to those belonged to birth order 4 or more. This finding is consistent with the outcomes found in numerous developing nations as indicated earlier in studies [5], [20], [25] and [27].

Table 1b: Model II: Results of the Multivariate Cox's regression for Factors Associated with Infant Mortality

Variables	*B*	*S.E.*	*Sig.*	*HR*	*95% CI*	
					Lower	*Upper*
Mother education (RC = No education)						
Basic/Primary	- 0.082	0.396	0.832	0.920	0.423	1.997
Secondary +	0.944	0.714	0.186	2.571	0.634	10.427
Mother employment (RC=Not Employed)						
Employed	0.654	0.283	0.021	1.923	1.104	3.351
Family income (**RC** = Low income)						
Medium income	- 0.240	0.279	0.390	0.787	0.456	1.359
high income	- 1.779	0.777	0.022	0.169	0.037	0.774
Family size (RC = 7+ persons)						
≤ 4 persons	- 0.111	0.704	0.875	0.895	0.225	3.556
5 – 6 persons	0.065	0.329	0.845	1.067	0.559	2.034
Zone of Residence (RC = Southern zone**)**						
Northern zone	0.801	0.322	0.013	2.238	1.186	4.187
Central zone	1.001	0.348	0.004	2.721	1.375	5.383
Mother's age at first birth (**RC** =15-19 years)						
20 – 24 years	0.032	0.398	0.935	1.033	0.473	2.255
25 – 29 years	- 0.122	0.435	0.780	0.885	0.378	2.077
30 + years	0.368	0.459	0.422	1.445	0.588	3.549
Parity (**RC** = 1-3 infants)						
4 - 5 infants	2.921	1.313	0.026	18.569	1.415	243.603
6 + infants	3.315	1.317	0.008	33.549	2.537	443.690
Birth order (**RC**= 4+ birth order)						
First births order	4.593	1.718	0.008	98.794	3.408	2864.043
2-3 birth order	0.168	1.565	0.915	1.183	0.055	25.417
Preceding birth interval (RC=24+ months **)**						
First births	4.593	1.718	0.008	98.794	3.408	2864.043
< 24 months	0.216	1.003	0.829	1.242	0.174	8.870
Sex of the infant (RC = Female)						
Male	0.549	0.249	0.028	1.731	1.062	2.823
Drinking water source (RC = Improved)						
Non-improved	- 0.239	0.452	0.597	0.787	0.325	1.909
Type of toilet facility (RC = Non-improved)						
Improved toilet facility	- 0.346	0.428	0.418	0.707	0.306	1.635
Cooking fuel source (RC=Low polluting)						
Medium polluting	0.941	0.515	0.068	2.562	0.934	7.027
High polluting	- 0.393	0.543	0.469	0.675	0.233	1.957
Type of floor of the house (RC = Natural floor)						
Furnished floor	- 0.239	0.396	0.546	0.787	0.362	1.712
Place of Delivery (RC= At home)						
At hospitals	- 3.670	0.722	0.000	0.025	0.006	0.105
Breastfeeding duration (RC= < 6 months)						
6 + months	- 2.820	0.387	0.000	0.060	0.028	0.127

Preceding birth interval was positively and insignificantly associated with infant mortality. As expected, the risk of dying for infants of preceding birth interval of less than 24 months was (1.242 times) higher as compared to infants of preceding birth interval of 24 months. This finding is consistent with Kembo and Ginneken [29] that infants delivered at short previous birth spaces are at higher hazard of death. Sex of infant was positively and significantly associated with infant mortality. As expected, male infants have a higher risk (1.731 times) of dying as compared to female infants. This agrees with findings of most African countries that male infant fatality is higher owing to biological difficulties [5], [20] and [27].

Drinking water source was negatively and insignificantly associated with infant mortality at 95% confidence interval. Surprisingly, the risk of dying for infants residing in households used non-improved water lower (0.787 times) as compared to those residing in households used improved water. Type of toilet facility was negatively and insignificantly associated with infant mortality at 95% confidence interval. As expected, infants residing in households used improved toilet have lower hazard (0.707

times) of dying as compared to those residing in households used non-improved toilet facility. Type of cooking fuel was negatively and insignificantly associated with infant mortality at 95% confidence interval. Surprisingly, infants residing in households used higher polluting fuel have lower risk (0.675 times) of dying than those residing in households used low polluting fuel.

Type of floor of the house was negatively and insignificantly linked with infant mortality at 95% confidence interval. As expected, the hazard of dying among infants residing in households with furnished floor (0.787 times) lower compared to those residing in households with natural floor. This finding is consistent with Dede [28] that people residing in houses with natural floor are more expected to be attacked by diseases due to high possibility of the floor to be the host of germs.

Place of delivery was negatively and significantly linked with infant mortality. As expected, the risk of dying for infants delivered at hospitals (0.025 times) lower as compared to infants delivered at home. This finding is consistent with Buwembo [20] and Dede [28] that infant mortality is lower among infants whose mothers' delivery places are at hospitals than those delivery places are at home. Duration of breastfeeding was negatively and significantly associated with infant mortality. Infants who have breastfed 6+ months have lower risk (0.060 times) of dying compared to those who have breastfed less than 6 months. This finding is consistent with [20], [27] and [28].

4.2. Multivariate Analysis for Factors Associated with Child Mortality

This section consisted of two models where the first model (Model I) was fitted by including only proximate determinants in order to establish the gross effects and the main model (Model II) was fitted by including socioeconomic and proximate determinants to establish the net effect on child mortality guided by the Mosley and Chen framework on analysis of child survival. The results of **Model I in (Table 2a)** show that age of the mother was positively and significantly linked with child death at 95% confidence interval. As expected, the risk of dying for children to mothers aged 30 years or more was (1.777 times) higher compared to children for mothers aged (15-19 years) in the reference category. This result is concurred with the results of several prior studies [5], [20] and [27]. Parity was negatively and insignificantly associated with child mortality. The risks of dying for children belonged to parity 6 or more were (0.837 times) lower compared to children belonged to parity 1-3 in the reference category.

Birth order was positively and insignificantly associated with child death. As expected, the risk of dying was (2.863 times) higher among children belonged to first birth order compared to children belonged to birth orders 4 or more in the reference category. Previous birth space was positively and significantly associated with child death. As expected, the risk of dying for children of preceding birth interval less than 24 months was about (3.614 times) higher when compared to children of previous birth space 24 months or more in the reference category. This finding consistent with the findings of numerous prior studies [6], [20], [26], [27] and [29] which demonstrated that short birth space less than 24 months have augmented death. Sex of the child was positively and insignificantly associated with child mortality. As expected, the risk of dying for male children was (1.057 times) higher than female children in the reference category.

Drinking water source was positively and significantly associated with child mortality at 95% confidence interval. As expected, the risk of dying for children residing in households used non-improved water was (1.873 times) higher than children residing in households used improved water in the reference category. This result is consistent with earlier study by Buli [26]. Type of toilet facility was negatively and insignificantly associated with child mortality. As expected, the risk of dying for children residing in households used improved toilet was (0.693 times) lower than children residing in households used non-improved toilet in the reference category. Consequently it is supposed that child death rate decreases when hygienic circumstance improves [36]. Source of cooking fuel was negatively and insignificantly associated with child mortality at 95% confidence interval**.** Unexpected, the hazard of dying for children residing in households used high polluting fuel for cooking was (0.481 times) lower compared to children residing in households used low polluting fuel in the reference category. This result was similar to study [37] who found that children residing in households used high polluting fuel as their major cooking source had higher death compared to children residing in households used low polluting fuels. Type of floor of the house was negatively and significantly associated with child mortality at 95% confidence interval. As expected, the hazard of dying for children residing in households with furnished floor was (0.417 times) lower than children residing in households with natural floor in the reference category. This result is regular with prior study [20] that type of floor was significantly associated with child death.

Place of delivery was negatively and significantly associated with child mortality at 95% confidence interval. As expected, the risk of dying for children delivered at hospitals was (0.047 times) lower compared to children delivered at home in the reference category. This finding is consistent with the earlier findings reported by [20], [38] and [39]. Duration of breastfeeding was negatively and significantly associated with child mortality at 95% confidence interval.

Table 2a: Model I: Results of the Multivariate Cox's regression for Factors Associated with Child Mortality

Variables	*B*	*SE.*	*Sig.*	*HR*	*95% CI*	
					Lower	*Upper*
Mother's age at first birth (**RC** = 15-19 years)						
20 – 24 years	- 0.818	0.213	0.000	0.442	0.291	0.670
25 – 29 years	- 1.302	0.247	0.000	0.272	0.168	0.441
30 + years	0.575	0.195	0.000	1.777	1.212	2.607
Parity (RC = 1-3 children)						
4 - 5 children	- 0.130	0.568	0.819	0.878	0.289	2.673
6 + children)	- 0.178	0.619	0.774	0.837	0.249	2.816
Birth order (**RC** = 4+ birth order)						
first birth order	1.052	0.621	0.090	2.863	0.848	9.670
2-3 birth order	- 2.373	0.407	0.000	0.093	0.042	0.207
Preceding birth interval (RC=24+ months)						
First birth)	1.052	0.621	0.090	2.863	0.848	9.670
< 24 months	1.285	0.206	0.000	3.614	2.412	5.416
Sex of the child (RC = Female)						
Male	0.055	0.146	0.704	1.057	0.794	1.406
Drinking water source (RC = Improved)						
Non-improved	0.628	0.315	0.047	1.873	1.009	3.476
Type of toilet facility (RC = Non-improved)						
Improved toilet facility	- 0.367	0.290	0.205	0.693	0.392	1.222
Cooking fuel source (RC = Low polluting)						
Medium polluting	- 0.045	0.308	0.884	0.956	0.523	1.747
High polluting	- 0.732	0.303	0.016	0.481	0.266	0.871
Type of floor of the house (RC = Natural floor)						
Furnished floor	- 0.874	0.219	0.000	0.417	0.272	0.641
Place of Delivery (RC=At home)						
At hospitals	- 3.057	0.346	0.000	0.047	0.024	0.093
Breastfeeding duration (RC= < 6 months)						
6 + months	- 2.656	0.454	0.000	0.070	0.029	0.171

As expected, the risk of dying for children breastfed 6 months or more was about 0.070 times lower compared to children breastfed less than 24 months in the reference category. This result is concurred with the results of several prior studies by [20], [26], [36], [39], [40] and [41].

The results of **Model II in (Table 2b)** showed that education of the mother was found to have a positive insignificant connection with child mortality at 95% confidence interval. Surprisingly, children for mothers with at least secondary education level have higher risk (1.114 times) of dying than children for mothers with no education. Children for mothers with primary education have higher hazard (1.700 times) of dying than children for mothers with no education. This finding consistent with earlier study by [5] that mother education was insignificantly linked with child mortality. Mother's employment was negatively and significantly associated with child mortality at 95% confidence interval. As expected, children for mothers who were employed have lower risk (0.668times) of dying compared to children for mothers who were not employed. This finding is concurred with earlier study [31] that working mothers were significantly linked with child mortality.

Family income was negatively and significantly associated with child mortality. As expected, the risk of dying for children residing in households with high income was (0.562 times) lower as compared to those residing in households with low income. This is owing to affordability of good quality food and therapy for both mother and the child. Family size was positively and insignificantly associated with child mortality at 95% confidence interval. Surprisingly, the risk of dying for children belonged to family size ≤ 4 was (1.483 times) higher than those belonged to family size 7 persons or more. This finding is established by [26] that small family size has a positive effect on child mortality. Zone of residence was positively and insignificantly associated with child mortality. Children residing in Northern and Central zones have higher hazard (1.019 times and 1.659 times, respectively) compared to those residing in Southern zone.

Age of mother at firth delivery was positively and significantly associated with child mortality at 95% confidence interval. As expected, the risk of children dying for mothers aged (30 years or more) was (1.565 times) higher compared to children for mothers aged (15-19 years). On other hand, the risks of children dying for mothers aged (20-24 years) and (25-29 years) were about (0.449 and 0.290 times) lower, respectively than children for mothers aged 30 years or more. This finding is consistent with earlier studies [5], [20] and [27]. Parity was negatively and insignificantly associated with child mortality at 95% confidence interval. The risk of dying for children belonged to parity 6 children or more was about (0.765 times) lower than those belonged to parity 1-3. Birth order was positively and insignificantly associated with child mortality at 95% confidence interval. As expected, the risk of dying for children belonged to first birth order was (2.714 times) higher as compared to those belonged to birth order 4 or more. Previous birth space was positively and significantly linked with child mortality at 95% confidence interval. As expected, children of preceding birth interval (less than 24 months) have higher hazard (4.025 times) of dying than those of preceding birth interval of 24 months or more. This finding is concurred with earlier studies [5], [20], [27] and [29]. Sex of the child was

positively and insignificantly associated with child mortality at 95% confidence interval. As expected, the risk of dying among male children was (1.033 times) higher than female children.

Table 2b: Model II: Results of the Multivariate Cox's regression for Factors Associated with Child Mortality

Variables	*B*	*S.E.*	*Sig.*	*HR*	*95% CI*	
					Lower	*Upper*
Mother's education (RC = No education)						
Basic/Primary	0.530	0.196	0.007	1.700	1.157	2.496
Secondary +	0.108	0.412	0.973	1.114	0.497	2.496
Mother's employment (RC=Not employed)						
Employed	- 0.374	0.167	0.025	0.668	0.496	0.953
Family income (**RC** = Low income)						
Medium income	0.190	0.172	0.271	1.209	0.863	1.694
high income	- 0.557	0.292	0.049	0.562	0.317	0.996
Family size (RC = 7+ persons)						
≤ 4 persons	0.394	0.363	0.277	1.483	0.728	3.022
5 – 6 persons	- 0.112	0.195	0.568	0.894	0.610	1.312
Zone of residence (**RC** = Southern zone**)**						
Northern zone	0.019	0.186	0.918	1.019	0.707	1.469
Central zone	0.506	0.193	0.009	1.659	1.137	2.421
Mother's age at first birth (**RC** = 15–19 years)						
20 – 24 years	- 0.801	0.219	0.000	0.449	0.292	0.690
25 – 29 years	- 1.239	0.255	0.000	0.290	0.176	0.478
30 + years	0.448	0.206	0.029	1.565	1.046	2.341
Parity (**RC** = 1-3 children)						
4 - 5 children	- 0.146	0.561	0.794	0.864	0.288	2.593
6 + children	- 0.268	0.615	0.663	0.765	0.229	2.552
Birth order (**RC** = 4 + birth order)						
First birth order	0.998	0.622	0.108	2.714	0.803	9.176
2-3 birth order	- 2.406	0.418	0.000	0.090	0.040	0.205
Preceding birth interval (RC = 24+ months)						
First births	0.998	0.622	0.108	2.714	0.803	9.176
< 24 months	1.393	0.210	0.000	4.025	2.670	6.070
Sex of the child (RC = Female)						
Male	0.032	0.145	0.824	1.033	0.777	1.373
Drinking water Source (RC = Improved)						
Non-improved	0.666	0.323	0.039	1.947	1.033	3.668
Type of toilet facility (RC = Non-improved)						
Improved toilet facility	- 0.288	0.296	0.331	0.750	0.420	1.339
Cooking fuel Source (RC = Low polluting)						
Medium polluting	0.050	0.326	0.879	1.051	0.555	1.992
High polluting	- 0.678	0.311	0.029	0.508	0.276	0.935
Type of floor of the house (RC = Natural floor)						
Furnished floor	- 0.906	0.224	0.000	0.404	0.261	0.627
Place of Delivery (**RC** = At home)						
At hospitals	- 3.256	0.365	0.000	0.039	0.019	0.079
Breastfeeding duration (RC = < 6 months)						
6 + months	- 2.746	0.466	0.000	0.064	0.026	0.160

Drinking water source was positively and significantly associated with child mortality at 95% confidence interval. As expected, children residing in households used non-improved water have higher risk (1.947 times) of dying than those residing in households used improved water. This finding is concurred with [26] that unimproved water is positively and significantly linked with child death. Type of toilet facility was negatively and insignificantly associated with child mortality at 95% confidence interval. As expected, the risk of dying for children residing in households used improved toilet facility was (0.750 times) lower than those residing in households used non-improved toilet facility. Source of cooking fuel was negatively and significantly associated with child mortality at 95% confidence interval. Surprisingly, the risk of dying for children residing in households used high polluting fuel was about (0.508 times) lower as compared to children residing in households used low polluting fuel. Type of floor of the house was negatively and significantly associated with child mortality at 95% confidence interval. As expected, the hazard of dying for children residing in households with furnished floor was (0.404 times) lower than those residing in households with natural floor. This finding is established by [20] that type of floor of the house was significantly associated with child mortality.

Place of delivery was negatively and significantly associated with child mortality at 95% confidence interval. As expected, the risk of dying for children delivered at hospitals was about (0.039 times) lower as compared to those delivered at home. This finding is consistent with earlier study by [20]. Duration of breastfeeding was negatively and significantly associated with child mortality at 95% confidence interval. As expected, the risk of dying for children breastfed 6 months or more was

about (0.064 times) lower as compared to children breastfed less than 6 months. This finding is consistent with [20] and [26].

5. Conclusions and Recommendations

The findings of Multivariate Cox's proportional hazard model (Model II) showed that family income, place of delivery, and duration of breastfeeding were significantly linked with a lower risk of both infant and child mortality. Furthermore, mother's employment, zone of residence, parity, birth order, and sex of the infant were significantly associated with higher risk of infant mortality. Mother's employment, source of cooking fuel and type of floor of the house were significantly associated with lower risk of child mortality. In addition, age of mother at firth delivery, previous birth interval and drinking water source were significantly associated with higher hazard of child mortality. The study recommends for increase maternity leave for employed mothers in order to improve breastfeeding status and increase preventive and therapeutic medical interferences to risk zones (northern and central) to decrease the risk of infant death.

Also, mothers aged 30 years or more should be encouraged to attend antenatal care from the start to the end and encourage delivery of babies at health facilities, also, longer preceding birth intervals and increase access to improved water supply in the town and for each family to decrease the risk of child death. Furthermore, hard work should be prepared to develop the quality of care in health facilities and improve social amenities. The study also recommends that similar studies should be carried out for various states in South Sudan.

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