OPEN ACCESS
Global Journal of Research in Business Management
Volume 02| Issue 01 | Jan-Feb | 2022
Journal homepage: https://gjrpublication.com/journals/

Original Research Article

Survival of Under-five Children in Sudan Based on Multi-Indicators Cluster Survey (MICS 2014)

*Khalafalla Ahmed Mohamed Arabi

College of Business King Khalid University, Saudi Arabia

Submission Date: 15th Feb 2022 | **Published Date:** 28th Feb 2022

***Corresponding author:** Khalafalla Ahmed Mohamed Arabi

Abstract

The purpose of this study is to determine what factors influence the survival of Sudanese children under the age of five, using data from the Multi-Indicators Cluster Survey (MICS 2014), which covers all 18 Sudanese states utilizing three questionnaires to each household: one for the child, one for the family, and one for the woman. The use of cox regression on these data yielded nine indications, but because the cox proportional hazard assumption was not fulfilled, so the time-varying method was relied on. Covariates may be divided into three categories. The first concerns feeding methods, the second concerns the mother's delivery practices, and the third concerns the child's health. Breast-feeding, consumption of a solid diet fall into the first category, besides they are the time-varying covariates. The second category includes the mother's age at first birth, birth order, and birth intervals. The third section covers the child has edema, body mass index, and child's weighing. All of these factors have an impact on the existence of children under the age of five who are statistically significant. To promote women's and children's health, the government should boost the number of counsel tours to encourage them to nurse their infants and feed them healthy food, strengthen the health sector allowing society the respond favorably to government efforts in terms of child-sheltering service coverage, vaccination, and advice.

Keywords: under-five children, feeding methods, health, child order, birth interval

Introduction

The international community devoted enough attention to the under-five mortality, which was included in the United Nations Member States' Millennium Development Goal 4, which calls for a two-thirds reduction in under-five death rates between 1990 and 2015. Decision-makers can use patterns and trends in causes of under-five mortality to assess programmatic requirements, identify interventions, and track performance (Shams El Arifeen et al. 2005. Ghazy et al. 2020). Under-five mortality has declined by 60% globally, from 93 deaths per 1000 live births in 1990 to 38 deaths per 1000 live births in 2019, while it has decreased by 54% in Sudan, from 138.3 to 63.3 deaths per 1000 live births over the same period (Abdalla et al. 2020, WHO 16/08/2021).

Abdalla et al. (2013) studied the characteristics of the Sudanese health system from 1990 to 2010, noting that after independence, Sudan saw steady development in health services and the health system as a whole, including the establishment of health institutions and the deployment of healthy human forces. The health system has been negatively and positively affected by the needs that Sudan suffered after independence from the conditions of war, disasters, drought, and the migration of the population from the rural to urban areas and beyond. Basic health care has been and continues to be the main component of strategic plans for the health sector since it first developed a strategic plan formulated in 1976 through the strategic plan that formulated in 1992 and based on the strategic plan drawn up in 2007. In the period before 1989, the financial system was based mainly on the tax system, in the case that the state carried out budgets that would free health services from the state's public resources, including taxes. Until the beginning of the 1990s, the service was provided free of charge, except for self-help contributions, which were fees paid in a hidden way. In 1991, the system of service fees was introduced in the health centers of Khartoum and then in all states, because of the deterioration in the quality of services in the previous period, followed by the transfer of fees for hospital services. There have been attempts to establish a system of exemptions within the hospitals, which is known as the mutually beneficial treatment system, which is carried out by social researchers to study cases and then provide the support required for each case.

Before becoming an independent country, South Sudan saw two prolonged civil wars, one from 1955 to 1972 and the other from 1983 to 2005. The Darfur region, South Kordofan, and the Blue Nile region also experienced unrest from 2003 to 2020. All these conflicts had enormous and clear regional dimensions, and they spread to the rest of Sudan. Although the political and social dimensions of the conflict were clear, the health dimension was one of the most dramatic outcomes of the conflict on the state's reaction to the conflict, because of its association with basic health indicators in any society such as maternal and child health indicators, mental health, mortality rate and other aspects (Abdalla et al. 2013). The mortality of mothers and children under the age of five has been and continues to be one of the biggest challenges of Sudan's health system. The mortality rates of children under 5 years in Sudan declined from 176 in 1960 that to 73 in 2014 and 63.3 in 2019 live births, the mortality rate for children less than a year is 33 deaths per thousand and one childbirth. According to statistics in 1990, the rate of deaths of children decreased from 125 deaths per 1,000 children born in the first quarter. The maternal mortality rate fell from 830 cases per 100,000 mothers in 1990 to 216 in 2009 (Abdalla et.al 2013).

In 1989, the total coverage of child-sheltering services was 40% of the total target children, and in 1995, the coverage reached rates ranging from 72% to 79% remained the same in the following years until the overall coverage sustained at levels ranging from 85% to 93% in 2004 and the years that followed. Despite the apparent decline in death rates, these indicators continue to present a challenge to the health system and its different levels. Sudan is still on the list of countries with a marked increase in mortality rates compared to the growth targets. We will later address the experience of the expanded immunization program as one of the programs implemented by the state to contribute to raising the level of health indicators for children in general. The program is one of the most successful in the region and on the continent of Africa and we will deal with some details of the inputs and outputs of this program in the past period (Abdalla et al. 2013). The social and environmental status of children, as well as the overall performance of a country's health system, is reflected in under-five child mortality.

Many academics have looked into the under-five mortality rate all around the world, including in Sudan and South Sudan for example (Ahmed et al. 2020, Mungo 2018, Mayai and Palloni 2016, Abdalla et al. 2009, and Spoorenberg and Pelletier 2007). The availability of abundant data, only a portion of which was used by Ahmed et.al, led to the desire to add new factors to those discovered by Ahmed et.al (2020) using the same MICS(2014) data, with age expressed in months rather than years. Another reason for dealing with this data is that several of the covariates included in Ahmed et al study did not have statistical significance, but this study bases its inclusion in the model on statistical significance.

This study is arranged as follows: The introduction followed by a literature review, which then followed by a theoretical framework in the third section, methods and data in the fourth section, results, and discussion in the fifth section, and lastly, the research concludes.

Literature Review

Many research papers have been written on the subject of under-five mortality; some have looked at multiple factors that affect death, while others have focused on a single factor, such as malnutrition. Many efforts have been made to minimize the rate of children under the age of five in Sudan and South Sudan, but with little success, as many articles have noted.

Ahmed, Elkarib, and Dinga (2020) utilizing the MICS (2014) found that type of birth, twin birth vs. single birth, household wealth index, previous birth interval, and region of residence as the most influential factors. The environment and conditions in which a child is born and lives, according to Mugo et al. (2018), play a role in under-five mortality, such as increased mortality among infants born to adolescent mothers. Indoor air pollution and the use of unimproved sources of drinking water are linked to an elevated risk of newborn mortality in South Sudan. Providing equal healthcare services to all underprivileged children in both urban and rural regions is critical, but it remains a struggle as long as violence persists. Mayai and Palloni (2016) used indirect estimation techniques to assess South Sudan's infant and under-five mortality rates and patterns across three regions, between 1969 and 2009 discovering declining mortality trends across the regions over time, demonstrating remarkable resilience even during times of brutal civil conflict. Abdalla et al. (2009) reviewed data for 150 children under the age of five in three villages in Sudan Gadarif state's El Fau rural area, to find that the influence of the social and economic aspect children's feeding patterns and nutritional status. The prevalence of nutritional anemia family's income, socioeconomic-demographic factors, and mothers' poor nutrition knowledge and feeding practices were the main causes of death. Intervals based on imputed dates of birth were not included in the research. François, Spoorenberg, and Pelletier (2007) realized that under-five mortality has fallen since the 1950s, in both Sudan and South Sudan, despite two lengthy civil wars (1955-1972 and 1983-2005). After a gradual fall from 1950 until the mid-1980s, the decline intensified, especially in South Sudan. In 2011, the mortality rate for children under the age of five was 80.2 per 1,000 and for children above the age of five was 117.4 per 1,000. These levels are 38 and 47 percent lower than in 1990. Sing et al. (2005) evaluated data from Northwestern Uganda and Southern Sudan using Mosely and Chen's (1984) methodology, analyzing the role of forced migration and subsequent housing arrangements on under-five mortality among long-term displaced and host populations. Forced migration and living arrangements had no long-term influence on under-five mortality, according to multivariate logistic regression.

Severe acute malnutrition (SAM) was studied by Ashine et al. (2021) who looked at a 48-month retrospective cohort of 346 infants aged 6 to 59 months who had. Simple random sampling was used to obtain data from patient charts, which were then analyzed with STATA 14. Edema, infection, hospital admission, and breastfeeding status at admission were the most important predictors of death. Therefore, it should be better to treat patients with TB, sepsis, edema according to SAM national protocol and promote breastfeeding practice. Léonie et al. (2019) assessed the anthropometric status of children under the age of five in the Cameroonian village of Bandja. A cross-sectional study with 388 children was conducted. Undernutrition is measured by wasting, stunting, and being underweight. Information on gender, age, and date of birth Undernutrition is extremely common in Bandja, and it is more prevalent among boys, younger children, and first-born children. Similarly, Pravana et al. (2017) considered the predictors of SAM and found that low socioeconomic level children aged 6–59 months in Nepal's Bara region, mother's age at birth; birth interval, illiterate father, and bottle-feeding all substantially linked with SAM.

Ekholuenetale et al. (2020) investigated the impact of household structure on child mortality in SSA using secondary data from birth histories collected in the recent Demographic and Health Survey (DHS) in 35 SSA countries. Infant and under-five-year-old mortality rates were greater in polygyny homes compared to monogyny households and families with a big number of children, and households with a large number of children. Baraki et al. (2020) looked examined the predictors of infant mortality using data from the Ethiopian demography and health survey (EDHS). The gender of the child, multiple births, preterm birth, and residency are all connected to infant mortality. Kassie and Workie (2020) employed the Generalized ordered logit model to investigate undernutrition in a sample of 9494 children aged 59 months from the Ethiopian Demographic and Health Survey 2016. (GOLM). The age and gender of the child, the mother's education, the region, the source of drinking water, the number of children under the age of five, the mother's BMI and wealth index, the child's anemia status, multiple births, and the child's fever within the first two months of the survey are all things to consider.

There have also been differences in the risk of infant death among geographies. Rutstein's (2008) research incorporates data from all 52 DHS surveys done between 2000 and 2005 in developing countries. For a variety of phases – early neonatal, neonatal, post-neonatal, infant, kid (one to four years), and under-age five years – the effects of the birth-to-pregnancy gap on baby and child mortality are explored using life tables and Cox hazard multivariate regression. The time between conceiving and being pregnant. The time between conception and delivery is divided into groups, which be compared to future research findings.

This study is comparable to others in terms of the data utilized for analysis, with survey data being the primary source. The major goal, however, is to discover factors that influence newborn and under-five mortality. For various studies, there are differences in the explanatory factors considered and the specific concentrate on malnutrition. Ahmed, Elkarib, and Dingo (2020) used the same data source and conducted cox regression for the same aim as we do, but the dependent variable and explanatory factors were chosen differently. The findings of Abdalla et al. (2009), who employed sample data in rural parts of Gedarif state, are similar to those of this study in terms of feeding practices that influence mortality. The policy implication is that the factors unique to this study are solely determined by societal perceptions, and mothers' child feeding and delivery behaviors. The government should increase the number of advice tours and use social media and official media to promote excellent practices while attempting to change problematic ones.

Theoretical Background

Mosely and Chen (1984) established an analytical framework for examining the social and biological determinants of child survival in developing nations, based on the assumption that all social and economic variables of child mortality, controlled by a single biological process. The five types of mortality determinants are maternal factors, environmental contamination, nutrient insufficiency, injury, purposeful accidents, and personal sickness control. The socioeconomic determinants influence maternal variables, environmental factors, nutrient shortage, and injury, all of which have an impact on health and disease. Personal illness is either prevented or treated when sick, while the latter has an impact on growth and death.

The World Health Organization (WHO 16/08/2021) indicates that the major causes of death among children under the age of five were preterm delivery problems, acute respiratory infections, intrapartum-related complications, organic malformations, and diarrhea. Improving access to skilled health professionals for antenatal, birth, and post-delivery care, improving access to nutrition and micronutrients, encouraging family members to recognize danger signs, improving access to water, sanitation, and hygiene, and providing immunizations are all ways to reduce preventable child deaths.

Methodology and Data

Basics of the Cox proportional hazards model

Cox's research (1972) focused on extending Kaplan and Meier's findings to life table comparison and, more broadly, the use of regression-like arguments in life-table analysis. They measure the time it takes for "failure," "loss," or filtering assuming that each individual had one or more explanatory factors with values of the hazard function$h(t)$, and unknown coefficients multiplied by an arbitrary and unknown time function. The conditional likelihood is calculated, allowing conclusions made about the unknown regression coefficients. This enables us to investigate how specific circumstances influence the rate at which a specific event (death) occurs at a specific point in time. The hazard rate is a term used to describe this rate. The hazard function h(t) represents e.g. the danger of dying at time t and is determined by a set of p covariates $(x_1 + x_2 + \cdots x_p)$, the coefficients $(b_1 + b_2 + \cdots b_p)$ measure the impact of covariates.

$$h(t) = h_0(t) \times exp\big(b_1x_1 + b_2x_2 + \cdots b_px_p\big) \quad (1)$$

Where *t* represents the survival time, the hazard function the term h_0 called the baseline hazard that corresponds to the value of the hazard if the entire x_i are equal to zero. The null hypothesis is that the hazard = 1. A positive coefficient indicates a positive relationship between the covariate and the hazard for the terminal event this means that a higher value on the covariate is associated with less survival time. A negative coefficient indicates a negative relationship between the covariate and the hazard for the terminal event this means that a higher value on the covariate is associated with a longer survival time**.**

Frailty Model with Survival Data

The essential assumptions of typical survival models are that the individuals under investigation are homogeneous and that survival durations are independent. However, these assumptions are rarely met; hence, the Frailty model extends the research when survival data are correlated. Because all of the relevant covariates are included in the model, which alters the survival time distribution and biases the parameter, the assumption of homogeneity is untenable. As a result, we will need to incorporate a random variable to account for the covariates that were overlooked. The random effect, i.e. frailty, which is either an individual variable or a variable shared by numerous individuals, causes variability in the survival statistics (Hougaard 1995). Consequently, it's referred to as hidden heterogeneity or frailty, a term that reflects survival changes induced by unobservable individual differences. Use frailty models to depict random effects or unexplained heterogeneity between individuals or groups.

Cox PH Model

$h(t) = h_0 e^{x\acute{}\beta} \quad (2)$

Unobserved Covariate U

$h(t) = h_0 e^{x'\beta + u'\beta^*}$ (3)

$h(t|z) = zh_0 e^{x\acute{}\beta}; z = e^{x'\beta}$ (4)

Conditional Survival function

$S(t|z) = \exp(-zH_0(t))\, e^{x'\beta}$ (5)

where $H_0(t)$ is the integrated hazard

Unconditional Survival Function

$S(t) = E_z\left[e^{-zH_0(t)e^{x\acute{}\beta}}\right] = L_z\left[zH_0(t)e^{x\acute{}\beta}\right]$ (6)

Time-varying Cox Regression

$\lambda(t|Z(t)) = \lambda_0(t)exp(\beta'x + \gamma'Xg(t))$ (7)

Where β', γ' are coefficients of time fixed, and time-varying respectively, let Z(t) represents time covariate (Zhongheng et al 2018):

$Z(t) = x_1, x_2, \cdots, x_P, X_1g(t), X_2g(t), \cdots, X_Qg(t)$(8)

Data and Variables Description

The Bureau of Statistics in Sudan executed Multi-Indicators Survey (MICS 2014) with the collaboration of the Ministry of Health and UNICEF covering all the 1000 households of each state in Sudan. Three questionnaires were used for this purpose. One for the child, one for the mother's characteristics, and one for the household. There are 13065 children under the age of five, 1016 of whom are dead. The number of subjects = 7525, the number of failures = 539, and the at-risk are 127829 months. Cases that have been censored = 6986. Cases with missing values are 50442 removed from consideration. The age of under-five children in months (CAGE), which is the time to death, is the dependent variable; the time variable still alive (BH5) indicates whether the child is alive or dead. Answers include yes or no for breastfeeding (BD2), solid food (BD8C), consumption of green leafy vegetables (BD8F), trouble breathing during cough disease (CA8), ever had vaccinated (IM1), Area (HH6), child undressed to the minimum (AN3A), and Child have edema (AN5). The number of times a child ate solid food (BD11) varies between 0 and 7. Answers range from 0 to 4 for mothers' age at first birth (magebrt), the birth interval (Birthint) and birth order (Brthord), Child's weight in kilograms (AN3), and state (HH7). Finally, here are three alternatives for the body index (ZBMI): measurement out of range, z score out of range, and not measured, and continuous variables: body mass index (BMI), and Child's weight (kilograms AN3).

RESULTS AND DISCUSSION

The model was estimated with Cox proportional hazard and Weibull PH methods through Stata 16, and the results were quite similar as depicted in Table (1) stratified by states (HH7). The Kaplan-Mayer equality tests in Annex (2) show that 18 variables are eligible for inclusion in the model because the tests have a probability less than 0.05, and nine of them have a significant effect on the death of under-five children as shown in Table (1). The Chi-Square Goodness of fit for the proportional hazard and Weibull has proven the models' adequacy (LR chi^2 (9) =215.12, Prob. =0.00 and Weibull LR Chi^2 (8) = 215.09, Prob. = 0.00).

Table -1: Estimation Results

	Proportional Hazard		Weibull	
	Coeff.	Haz. Ratio	Coeff.	Haz. Ratio
Child ever been breastfed (BD2)	-0.25***	0.78***	-0.19***	0.83***
Child ate grain foods (BD8C)	0.14***	1.16***	0.15***	1.16***
Child's weight (kilograms AN3)	-0.21***	0.81***	-0.21***	0.81***
Child has Edema (AN5)	0.10***	1.10***	0.08	1.08
Body Mass Index WHO (BMI)	0.01***	1.01***	0.01***	1.01***
Mother's age at birth (magebrt)	-0.31***	0.73***	-0.34***	0.71***
Birth order (brthord)	0.28***	1.31***	0.32***	1.38***
Previous birth interval (birthint)	-0.34***	0.71***	-0.35***	0.70***
Twins (Twins)	1.13***	3.10***	1.10***	3.01***
Constant			-7.58***	0.001***
/ln_p			0.68***	0.68***
p			1.97	1.97***
1/p			0.51	0.51

Source: researcher's calculation using Stata 16 (*** indicates rejection of the null hypothesis at 1%)

Table (1) displays the outcomes of using cox regression to analyze survey data from all states in the Republic of Sudan in 2014. The proportional hazard has nine highly significant variables, while Weibull PH confirms the significance of eight of them but rejects child has edema. Breastfeeding, child weighing, mothers' age at first birth, and birth intervals have all been shown to reduce the hazard of death with hazard ratios less than one. The second group is composed of child ate grain food; the child has edema, body mass index, birth order, and twins. Then, the proportionate hazard assumption was evaluated, which states that hazard proportionality from one case to the next should not change with time yielding significantly different from zero (Xue et al. 2013). Because the proportional hazard assumption is rejected (not fulfilled) by the global test and the covariate chi-squared with Chi (9) = 50.06, Prob. = 0.00 (Annex 3), time-varying covariates relied on to estimate the interaction between time and BD2 and BD8C, while the other model covariates are insignificant. Table (2) presents the estimation results of time-varying covariates.

Table-2: Time-varying Covariates of Cox Proportional Hazard

	Proportional Hazard	
Covariates	Coefficient	Hazard Ratio
Child ever been breastfed (BD2)	-0.61***	0.54***
Child ate grain foods (BD8C)	0.32***	1.38***
Child's weight (kilograms AN3)	-0.21***	0.81***
Child has Edema (AN5)	0.01***	1.10*
Body Mass Index WHO (BMI)	0.10***	1.01***
Mother's age at birth (magebrt)	-0.31***	0.73***

Birth order (brthord)	0.27***	1.31***
Previous birth interval (birthint)	-0.34***	0.71***
Twins (Twins)	1.14***	3.02***
Time Covariates		
Child ever been breastfed (BD2)	0.02***	0.02***
Child ate grain foods (BD8C)	-0.01***	-0.01***

Source researcher's calculation via Stata 16 (*,**,*** indicates rejection on H_0 at 10%, 5%,and 1%)

The time-varying coefficients of BD2 show two opposing effects: a reduction in the number of children breastfed by one child (from -0.61 to 0.02), while the hazard ratio reduces from 0.54 to 0.02. Unlike BD2, BD8C interacts with time, lowering the value of the coefficient from 0.32 to -0.01 and the hazard ratio from 1.38 to -0.01. The other non-time-varying variable changed little as well. When children are weighed to account for various impairments, their risk of death is reduced by 0.21 compared to those who are not weighed. Children with a BMI less than that recommended by the World Health Organization (WHO) had a 0.01 higher risk of dying accompanied hazard ratio greater than 1. As women's ages at first birth increase, the chance of child mortality reduces by 0.36; similarly, gaps between births reduce the risk by 0.35 when compared to births in less than one year. Since the birth, order of two or more children accounts for 78 percent of all births, and twins receive little care compared to a single child, child order and twins increase the risk by 0.32 and 1.14, respectively. When time-varying covariates are used, the magnitudes of factors that do not interact with time increase. The estimates are slightly altered when the Strata ID variable state (HH7) is applied. According to Mosely and Chen, the selected variables of this study are among social and economic variables of child mortality that are governed by a single biological mechanism (1984).

In both, the standard models, and models supplemented by frailty models and time-varying covariates, the hazard ratio computed by Cox proportional hazard and Weibull PH seem different. With lower theta of magnitude 0.05, and 1.94e07 respectively, the extra frailty models altered the estimates somewhat as apparent in Table (3), which shows the results of Weibull PH that included frailty models to account for the random effect as well as the hazard. The difference between the model is that Child has Edema (AN5) is significant in the first model and not in the second. The null hypothesis is rejected by the LR test of theta = zero in both Cox proportional hazards and Weibull PH, LR test of theta = 0: $chibar^2$ (01) = 20.76, Prob. >= $chibar^2$ = 0.00 a significant likelihood ratio test for the presence of heterogeneity. The Cox PH model is superior to Weibull PH; therefore, it is the favorite model.

Table -3: Frailty Estimation Results

	Cox Proportional Hazard		Weibull PH	
Covariates	Coefficient	Hazard Ratio	Coefficient	Hazard Ratio
Child ever been breastfed (BD2)	-0.64***	0.53***	-0.19***	0.83***
Child ate grain foods (BD8C)	0.32***	1.38***	0.15***	1.16***
Child's weight (kilograms AN3)	0.21***	0.81***	-0.21***	0.81***
Child has Edema (AN5)	-0.21*	1.10*	0.07	1.08
Body Mass Index WHO (BMI)	0.01***	1.01***	-0.10***	1.01***
Mother's age at birth (magebrt)	-0.33***	0.72***	-0.34***	0.71***
Birth order (brthord)	0.29***	1.33***	0.32***	1.38***
Previous birth interval (birthint)	-0.34***	0.71***	-0.35***	1.01***
Twins (Twins)	1.12***	3.07***	1.10***	0.70***
Child ever been breastfed (BD2)	0.02***	0.02***		
Child ate grain foods (BD8C)	0.01***	0.01***		
Constant (Baseline Hazard)			-7.42***	2.99***
Child ever been breastfed(BD2)	0.22***	2.59***		
Child ate grain food (BD8C)	-0.01***	-2.54***		
/ln_p			0.68***	0.68***
P			-15.31	-15.31
1/p			1.97	1.97
/lntheta -			0.51	0.51
theta	0.095**	0.095**	1.94e07	1.94e07

Source: researcher's calculation by Stata16. The rejection of the null hypothesis at 10%, 5%, and 1% respectively is a point to by (*,**,***).

Discussion

The nine identified variables that affect the mortality of under-five children have a significant divergence between the states, according to the univariate analysis of variance (Annex 2). In terms of breastfeeding, the three states of the Kordofan region, and the five states of the Darfur region differ significantly from the other ten states. Breastfeeding is more common among women; hence, the risk of child death among under-five children is likely to be lowered by 0.63, implying that children who are breastfed are projected to survive 2 months longer than those who are not. In terms of providing solid food to youngsters, the states of Gezira, Blue Nile, Gadarif, Kordofan region, and Darfur region are unique, as they are the main grain producers. Only 24 percent of children in urban areas do not consume solid food compared to 76 percent in rural areas, implying that children in urban areas are expected to live longer than children in rural areas do, which is compatible with the finding of Mugo et al. (2018). Referring to Léonie et al. (2019), weighing children to account for any inadequacies such as stunting and malnutrition reduces the risk of mortality this theory was confirmed by this study where the risk is supposed to be reduced by one month. The child gender implies that male children are expected to live 1.2 months less than females. There is a significant difference between the mean weight of males and females and the reported mean difference is 0.39 Kgs. In The weighting, children indicted that the states of River Nile, Kassala, Gadarif, Sinnar, Blue Nile, and Greater Darfur differ greatly from the others. In every state, the gender of children differs greatly. The percentage of dead children among women under the age of 20 is 28.3 percent, between the ages of 20 and 35 is 63.5 percent, and between the ages of 35 and above is 8.3 percent. A single dead child accounts for 23%, two to three dead children for 29.5 percent, four to six dead children for 29.5 percent, and seven or more dead children for 13.5 percent. Dead children born in the first year of marriage account for 24.1 percent of all dead children, while dead children born in less than two years account for 43 percent. Dead children for women of age less than one born in the first year of marriage account for 60.5 percent.

The effect of war and displacement was observed in the Darfur region, and Kordofan region, as well as the Blue Nile. Darfur is divided into five states, with the following ratios of dead male, and female children: North Darfur (10.5, 6.7), West Darfur (7.2, 6.2), South Darfur (8.7, 6.6), Central Darfur (5.4, 5.9), and East Darfur (5.4, 6.7) respectively. The number of children who have died is higher in war-torn and displaced states than in other states. Similarly, the Kordofan region has three states with dead children: North Kordofan (6.6, 5.3), South Kordofan (7.6, 7.8), West Kordofan (6.6, 5.4), and Blue Nile (7.1, 9.4) respectively. The total ratios of dead children by gender are Darfur region (36, 32), Kordofan region (20.8, 18.5) which means male children are exposed to the risk more than females.

It's worth mentioning that four variables were left out by Ahmed et al (2020) included in this study that is the breastfeeding, children ate fed meals made of solid and grain, weighing children, and WHO body mass index.

Absenteeism and refusal to provide information were among the challenges faced by the enumerators, resulting in a large number of missing data points: 84.2 percent of breastfeeding, solid food 84.2 percent, child weight 75.2 percent, and body mass 73.1 percent.

Conclusion

The use of Stata 16 to apply cox regression to the MICS data (2014) produced nine factors that influence the death of children under the age of five. The proportional cox assumptions are accepted, and the results were chosen based on statistical significance. Three of the characteristics discovered by Ahmed et al. (2020) are well-matched with the study, namely mother's age at birth, child order, birth interval, and twins; however, the other four considered in that study so can provide a new dimension. The four components are breastfeeding, a child consumes solid food composed of grain, a child weighing to address any health issues such as malnutrition or stunting. Weighting child to cater for any health problems such as malnutrition or stunting, and the body mass index. The frailty approach was used, however, the predicted coefficients did not increase much, and as well, the acceptance of zero-theta, hence, the standard cox method was used. The World Health Organization's recommendations are valid in the case of Sudan. They are applicable as mothers' levels of education rise, improving access to skilled health professionals for pregnancy, birth, and post-delivery care, improving access to nutrition and vaccination, educating family members to detect danger indicators, and improving access to water, sanitation, and hygiene are all things that may be done.

Annex

Annex (1)	Chi-Square	Df	Sig.
Log Rank (Mantel-Cox)	182.763	3	.000
Test of equality of survival distributions for the different levels of Child ever been breastfed.			
Log Rank (Mantel-Cox)	1210.044	3	.000
Test of equality of survival distributions for the different levels of Child ate foods made from grains.			
Log Rank (Mantel-Cox)	371.318	3	.000
Test of equality of survival distributions for the different levels of Child ate green leafy vegetables.			
Log Rank (Mantel-Cox)	78.278	7	.000
Test of equality of survival distributions for the different levels of Times child ate solid or semi-solid food.			
Log Rank (Mantel-Cox)	621.298	3	.000
Test of equality of survival distributions for the different levels of Child ever received any vaccinations.			
Log Rank (Mantel-Cox)	18.437	3	.000
Test of equality of survival distributions for the different levels of Difficulty breathing during illness with cough.			
Log Rank (Mantel-Cox)	22686.109	199	.000
Test of equality of survival distributions for the different levels of Child's weight (kilograms).			
Log Rank (Mantel-Cox)	18.008	2	.000
Test of equality of survival distributions for the different levels of Child undressed to the minimum.			
Log Rank (Mantel-Cox)	2750.198	552	.000
Test of equality of survival distributions for the different levels of Height for age percent of reference median NCHS.			
Log Rank (Mantel-Cox)	3836.577	1083	.000
Test of equality of survival distributions for the different levels of height for age z-score NCHS.			
Log Rank (Mantel-Cox)	3305.634	982	.000
Test of equality of survival distributions for the different levels of Height for age percentile NCHS.			
Log Rank (Mantel-Cox)	7316.004	942	.000
Test of equality of survival distributions for the different levels of Weight for age percentile NCHS.			
Log Rank (Mantel-Cox)	5989.809	853	.000
Test of equality of survival distributions for the different levels of Weight for age z-score NCHS.			
Log Rank (Mantel-Cox)	5989.809	853	.000
Test of equality of survival distributions for the different levels of Weight for age z-score NCHS.			
Log Rank (Mantel-Cox)	3123.347	981	.000
Test of equality of survival distributions for the different levels of Weight for height percentile NCHS.			
Log Rank (Mantel-Cox)	3476.127	887	.000
Test of equality of survival distributions for the different levels of Weight for height z-score NCHS.			
Log Rank (Mantel-Cox)	3825.699	901	.000
Test of equality of survival distributions for the different levels of Weight for height percent of reference median NCHS.			
Log Rank (Mantel-Cox)	5685.548	1314	.000
Test of equality of survival distributions for the different levels of Body Mass Index WHO.			
Log Rank (Mantel-Cox)	2307.664	840	.000
Test of equality of survival distributions for the different levels of Body Mass Index z-score WHO.			
Log Rank (Mantel-Cox)	54.642	14	.000
Test of equality of survival distributions for the different levels of What is the highest educational level (name) has attended?.			
Log Rank (Mantel-Cox)	4.655	2	.098
Test of equality of survival distributions for the different levels of the main water source.			
Log Rank (Mantel-Cox)	12.751	4	.013
Test of equality of survival distributions for the different levels of Previous birth interval.			
Log Rank (Mantel-Cox)	11.905	1	.001
Test of equality of survival distributions for the different levels of Twins.			
	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	151.140	1	.000
Test of equality of survival distributions for the different levels of Twins.			
	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	120.103	4	.000
Test of equality of survival distributions for the different levels of Previous birth interval.			
	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	7.212	3	.065
Test of equality of survival distributions for the different levels of Birth order.			

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	34.377	2	.000
Test of equality of survival distributions for the different levels of Mother's age at birth.			
	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	4746.526	1314	.000
Test of equality of survival distributions for the different levels of Body Mass Index WHO.			
	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	4368.248	199	.000
Test of equality of survival distributions for the different levels of Child's weight (kilograms).			

ANOVA

Annex (2)

		Sum of Squares	df	Mean Square	F	Sig.
Child ever been breastfed	Between Groups	115.307	17	6.783	6.935	.000
	Within Groups	8064.586	8246	.978		
	Total	8179.894	8263			
Child ate foods made from grains	Between Groups	278.726	17	16.396	11.927	.000
	Within Groups	11335.748	8246	1.375		
	Total	11614.474	8263			
Child ate green leafy vegetables	Between Groups	139.949	17	8.232	7.819	.000
	Within Groups	8681.677	8246	1.053		
	Total	8821.626	8263			
Vaccination card for child	Between Groups	414.537	17	24.385	22.525	.000
	Within Groups	8926.865	8246	1.083		
	Total	9341.403	8263			
Child's weight (kilograms)	Between Groups	1593.596	17	93.741	2.990	.000
	Within Groups	405770.889	12941	31.355		
	Total	407364.485	12958			
Sex	Between Groups	7.597	17	.447	1.790	.024
	Within Groups	3678.999	14733	.250		
	Total	3686.595	14750			
Combined wealth score	Between Groups	5103.638	17	300.214	605.135	.000
	Within Groups	7309.200	14733	.496		
	Total	12412.838	14750			
Mother's education	Between Groups	1977.439	17	116.320	160.025	.000
	Within Groups	10709.194	14733	.727		
	Total	12686.632	14750			

Annex (3) Results of Proportional Hazard Assumption

rho	chi^2	df	$Prob>chi^2$	
BD2	0.11	5.19	1	0.02
BD8C	-0.15	5.64	1	0.02
AN3	0.05	24.65	1	0.00

AN5	0.04	0.63	1	0.43
BMI	-0.10	4.84	1	0.03
magebrt	0.01	0.09	1	0.76
brthord	-0.08	3.74	1	0.05
birthint	0.07	2.76	1	0.10
BH2	0.07	2.39	1	0.12
global test		44.38	9	0.00

Source: researcher own calculation via Stata 16

	Cox Proportional Hazard			Weibull PH		
main	Coeff.	Haz. Ratio	P>|z|	Coeff.	Haz. Ratio	P>|z|
Twins (BH2)	0.611	1.84	0.10	1.20	3.33	0.00
Area (HH6)	-0.177	0.84	0.07	-0.16	0.85	0.06
Weight for age percentile (HAP)	0.003	1.00	0.01	0.00	1.00	0.00
Sex of child (BH3)	-0.181	0.83	0.03	-0.18	0.83	0.03
Education Level (welevel)	-0.238	0.79	0.00	-0.26	0.77	0.00
Birth Order (brthord)	0.256	1.29	0.00	0.28	1.32	0.00
Mother's age at Birth (magebrt)	-0.259	0.77	0.01	-0.26	0.77	0.01
Birth Interval (birthint)	-0.321	0.73	0.00	-0.33	0.72	0.00
Child ever been breastfed (BD2)	-0.110	0.90	0.01	-0.07	0.93	0.09
constant				-7.80	0.00	0.00
Time-varying covariate (tvc)						
Twins (BH2)	1.04					
/ln_p				0.57	0.57	0.00
p				1.77	1.77	
1/p				0.57	0.57	
				Stratified by HH7		

References

1. Abdalla, Essameldeen Mohamed, Mustafa Salih Mustafa, and Widatalla Amjad Mohamed (2013). Features of the Health System in Sudan between 1990 and 2010 mlamh-mn-msyrt-alnzam-alshy-by-alswdan.pdf (Arabic Version) http://koha.iua.edu.sd/cgi-bin/koha/opac-detail.pl?biblionumber=18517&shelfbrowse_itemnumber=80040
2. Abdalla, Muna A., Sulieman, Saad A. El Tinay, Abdullahi H.and Khattab, Abdul Gader H. (2009). Socio-Economic Aspects Influencing Food Consumption Patterns Among Children under Age of Five in Rural Area of Sudan Pakistan Journal of Nutrition 8 (5): 653-659
3. AHMED, H. M. M., ELKARIB, H. A. O., & DIGNA, M. F. M. O. (2020). Survival status and determinants of under-five mortality in Sudan: Evidence from the Multiple Indicator Cluster Survey 2014. Journal of Health and Social Sciences, 5(3), 369-386.
4. Ashine, Yonatan Eshete Ayele, Belete Achamyelew Aynalem Yared, Asmare and Yitbarek Getachew Yideg (2021). Time to Death and its Predictor Among Children Under Five Years of Age with Severe Acute Malnutrition Admitted to Inpatient Stabilization Centers in North Shoa Zone, Amhara Region, Ethiopia https://www.dovepress.com/ by 95.185.149.241 on 08-Aug-2021
5. Baraki, A. G., Akalu, T. Y., Wolde, H. F., Lakew, A. M., & Gonete, K. A. (2020). Factors affecting infant mortality in the general population: evidence from the 2016 Ethiopian demographic and health survey (EDHS); a multilevel analysis. BMC pregnancy and childbirth, 20(1), 1-8.
6. Cox, D. R. (1972). Regression models and life-tables. Journal of the Royal Statistical Society: Series B (Methodological), 34(2), 187-202.
7. Ekholuenetale, M., Wegbom, A. I., Tudeme, G., & Onikan, A. (2020). Household factors associated with infant and under-five mortality in sub-Saharan Africa countries. International Journal of Child Care and Education Policy, 14(1), 1-15.
8. Ghazy, R. M., Fekry, M. M., Omran, A. R., & Tahoun, M. M. (2020). Causes of under-five mortality using verbal autopsy and social autopsy studies (VASA) in Alexandria, Egypt, 2019. Journal of Global Health Reports, 4, e2020080.

9. Hougaard, P. (1995). Frailty models for survival data. Lifetime data analysis, 1(3), 255-273.
10. Kassie, G. W., & Workie, D. L. (2020). Determinants of under-nutrition among children under five years of age in Ethiopia. BMC Public Health, 20(1), 1-11.
11. Dapi Nzefa, L., Monebenimp, F., & Äng, C. (2019). Undernutrition among children under five in the Bandja village of Cameroon, Africa. South African Journal of Clinical Nutrition, 32(2), 46-50.
12. Mayai, A. T., & Palloni, A. (2016). Infant and Under-five Mortality Levels and Patterns in South Sudan, 1969.
13. Mosley, W. H., & Chen, L. C. (1984). An analytical framework for the study of child survival in developing countries. Population and development review, 10, 25-45.
14. Mugo, N. S., Agho, K. E., Zwi, A. B., Damundu, E. Y., & Dibley, M. J. (2018). Determinants of neonatal, infant and under-five mortality in a war-affected country: analysis of the 2010 Household Health Survey in South Sudan. BMJ global health, 3(1), e000510.
15. Pravana, N. K., Piryani, S., Chaurasiya, S. P., Kawan, R., Thapa, R. K., & Shrestha, S. (2017). Determinants of severe acute malnutrition among children under 5 years of age in Nepal: a community-based case–control study. BMJ open, 7(8), e017084.
16. Rutstein, S. O. (2005). Effects of preceding birth intervals on neonatal, infant and under-five years mortality and nutritional status in developing countries: evidence from the demographic and health surveys. International Journal of Gynecology & Obstetrics, 89, S7-S24.
17. El Arifeen, S., Akhter, T., Chowdhury, H. R., Rahman, K. M., Chowdhury, E. K., & Alam, N. (2005). Causes of death in children under five years of age. Chapter, 9, 125-133.
18. Singh, K., Karunakara, U., Burnham, G., & Hill, K. (2005). Forced migration and under-five mortality: A comparison of refugees and hosts in North-western Uganda and Southern Sudan. European Journal of Population/Revue européenne de Démographie, 21(2), 247-270.
19. Spoorenberg, T., & Pelletier, F. (2011). Under-five mortality estimates for Sudan and South Sudan. Sudanese Journal of Public Health, 6(4), 135-142.
20. Xue, X., Xie, X., Gunter, M., Rohan, T. E., Wassertheil-Smoller, S., Ho, G. Y., ... & Strickler, H. D. (2013). Testing the proportional hazards assumption in case-cohort analysis. BMC medical research methodology, 13(1), 1-10.
21. World Health Organization: The Global Health Observatory (WHO 16/08/2021) https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/child-mortality-and-causes-of-death
22. Zhang, Z., Reinikainen, J., Adeleke, K. A., Pieterse, M. E., & Groothuis-Oudshoorn, C. G. (2018). Time-varying covariates and coefficients in Cox regression models. Annals of translational medicine, 6(7).