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A New Paradigm For Malnourished Under – Five Children in Bauchi State Using Cox – Regression Model

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Abstract
Malnutrition is a significant global public health burden with a greater concern among children under five (Simon et al., 2020). It is estimated to contribute directly or indirectly to more than 33% of all child deaths globally (WHO, 2020). Several indicators serve as major public health problem globally with weight-for-height (wasting), height-for-age (stunting) and weight-for-age (underweight) are three important parameters for assessing nutritional status in children. Malnutrition is estimated to contribute directly or indirectly to more than 33% of all child deaths globally (Gosh, 2020). Data was gathered using a structured and closed ended questionnaire that was validated with Cronbarch's Alpha = 0.83. All the variables that are believed to be the proxies of malnutrition were captured, tested and verified to be statistically significant at 5% level of significance on the nutrition status of under-five children using SPSS (V. 23). A modified cox - proportional hazard model containing all the predictor variables was fitted and found that 104 (28.4%) are stunted, 130 (35.5%) are wasted and 132 (36.1%) are underweight. Findings shows that various socio-demographic and health service covariates are significant determinants of malnutrition. Finally, it has been recommended that access to education for both parent should be given due emphasis, and Children from mothers age range from 15-25 years are at the higher risk of malnutrition. Thus, educating women about the adverse effect of early marriage is of paramount importance.
Key Word: *Malnutrition, Public Health, Factors, Status, Under-Five Children*

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I. Introduction

Malnutrition in children is an important public health issue especially for developing countries like Nigeria that needed an urgent attention. Several indicators serve as major public health problem globally with weight-for-height (wasting), height-for-age (stunting) and weight-for-age(underweight) are three important parameters for assessing nutritional status in children. Malnutrition is estimated to contribute directly or indirectly to more than 33% of all child deaths globally (Gosh, 2020). Wasting implies that children are too thin for height, stunting indicates that children are too short for age while underweight means children are too thin for age.

Malnutrition is the intake of an insufficient, surplus or disproportionate amount of energy and/or nutrients (WHO 2020). Malnutrition is a significant global public health burden with greater concern among children under five years (Simonyan et al.2020). In an attempt to address this global challenge of malnutrition, the World Health Organization (WHO) member states recently signed into effect a commitment to nine global targets by 2025, including a 40% reduction in childhood stunting, a less than 5% prevalence of childhood wasting, to ensure no increase in the number of children who are overweight (WHO 2020), and to end all forms of malnutrition by 2030, With less than five years to the target date, the progress has remained relatively slow, with no country working toward full actualization of the nine targets (Global Nutrition report 2020). Though there has been considerable global decline that has been noticed in childhood stunting, there are over 150 million, 50 million and 38 million children remaining stunted, wasted and overweight.

II. METHODOLOGY

2.1 Statistical Model: Proportional Hazard Model Description

$$m(t|x) = m_0(t)exp(\beta' x) \quad 1.1$$

with $m(t|x)$, the population hazard function given covariate x; $m_0(t)$ is the baseline hazard function (i.e. the hazard function condition on $x = 0$) and $\exp(\beta' x)$ is the multiplicative term with covariate x. In model (1.3), $m_0(t)$ is usually unspecified. It is assumed that the covariate effects act multiplicatively on the hazard function.

$m_0(t)$ is the **baseline hazard function**, and reflects the underlying hazard for subjects with all covariates $x_1, x_2, \ldots, x_p$ equal to 0 (i.e., the "reference group"). The general form is:

$m(t|\mathbf{X}) = m_0(t)\exp(\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p)$ 1.2

So when we substitute all of the $x_j^{'s}$ equal to 0, we get:

$m(t|\boldsymbol{X} = \boldsymbol{0}) = m_0(t)exp(\beta_1 * 0 + \beta_2 * 0 + \cdots + \beta_p * 0) = m_0(t)$

In the general case, we think of the i^{th} individual having a set of multivariate $X_i = (x_{1i}, x_{2i}, \ldots, x_{pi})$, and we model their hazard rate as some multiple of the baseline hazard rate as follows:

$$m(t/x) = m_0(t)exp(\beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_p x_{pi})$$

where $x = 1$ for treated and $x = 0$ for control. Then if we think of $m_1(t)$ as the hazard rate for the treated group, and $m_0(t)$ as the hazard for control, then we have:

$m_1(t) = m(t|X = 1) = m_0(t)\exp(\beta X) = m_0(t)\exp(\beta)$ 1.3

This implies that the ratio of the two hazards is a constant, e^{β}, which does NOT depend on time, *t*. In other words, the hazards of the two groups remain proportional over time.

$$\frac{m_1(t)}{m_0(t)} = e^{\beta} \quad 1.4$$

Where e^{β} is the hazard ratio (HR) or relative is risk and β is log hazard ratio (RR). This is applicable to any of $X_{j's}$, as they are the (log) HR for one unit increase in the value of X. Then we take the log. of the hazard ratio for the i^{th} individual to the baseline as:

$$log\left(\frac{m_1(t)}{m_0(t)}\right) = \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_p x_{pi} \quad 1.5$$

By Cox Proportional Hazard model, we can estimate the parameters β without the estimate of $m_0(t)$ and, we don't have to assume that $m_0(t)$ which is an exponential model, or Weibull model, or any other particular parametric model. The second part of the above model is what makes it semi-parametric.

2.2 Modified Cox Proportional Hazards Model

$$H(t|\boldsymbol{X}) = h_0(t)e\beta' \boldsymbol{x_0 x_1 x_2 x_3 x_4 x_5 x_6 x_7 x_8 x_9 x_{10} x_{11}} \quad 1.6$$

Where $\boldsymbol{x_0}$ is the hazard function that depends on stunted, wasted and underweight, $H(t|\boldsymbol{X})$ is hazard function that depend on time 't' and vector of covariates x, $h_0(t)$ is the *baseline* hazard function (i.e. the hazard function condition on $x = 0$). Here $\boldsymbol{X}$ is a vector of multivariate of interest, which may include:

x_0 = nutritional status, x1 = age, x2 = sex, x3 = age of mother at birth, x4 = marital status of mother, x5 = mode of delivery, x6 = water supply, x7 = feeding practice, x8 = immunization, x9 = vitamin A, x10 = ANC attendance, x11 = weight, x12 = height, x13 = muac and x14 = birth order; with x0 as the dependent variable while $x_1, x_2, \ldots, x_{14}$ are the independent variables.

III. Result

3.1 Categorical Variable Coding

		Frequency	(1)	(2)
Nutritional status	1.00=stunted	104	1	0
	2.00=wasted	130	0	1
	3.00=underweight	132	0	0

a. Category variable: Nutritional status (nutrition status)

		Chi-square	Df	Sig.
Step1	Step	43.149	21	.003
	Block	47.408	21	.001
	Model	47.408	21	.001

The omnibus test shows the significance of the model, block and the steps since the p-values (in each case) is less than 0.05, the chi-square value shows that all the variables included in the model are significant in explaining the nutritional status of children under – five.

3.2 Variables in the Equation

	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B) Lower	Upper
Mothers age at first birth	.187	.155	1.441	1	.230	1.205	.889	1.634
Education of the father	-.109	.108	1.011	1	.315	.897	.725	1.109
Education of the mother	.126	.146	.748	1	.387	1.135	.852	1.511

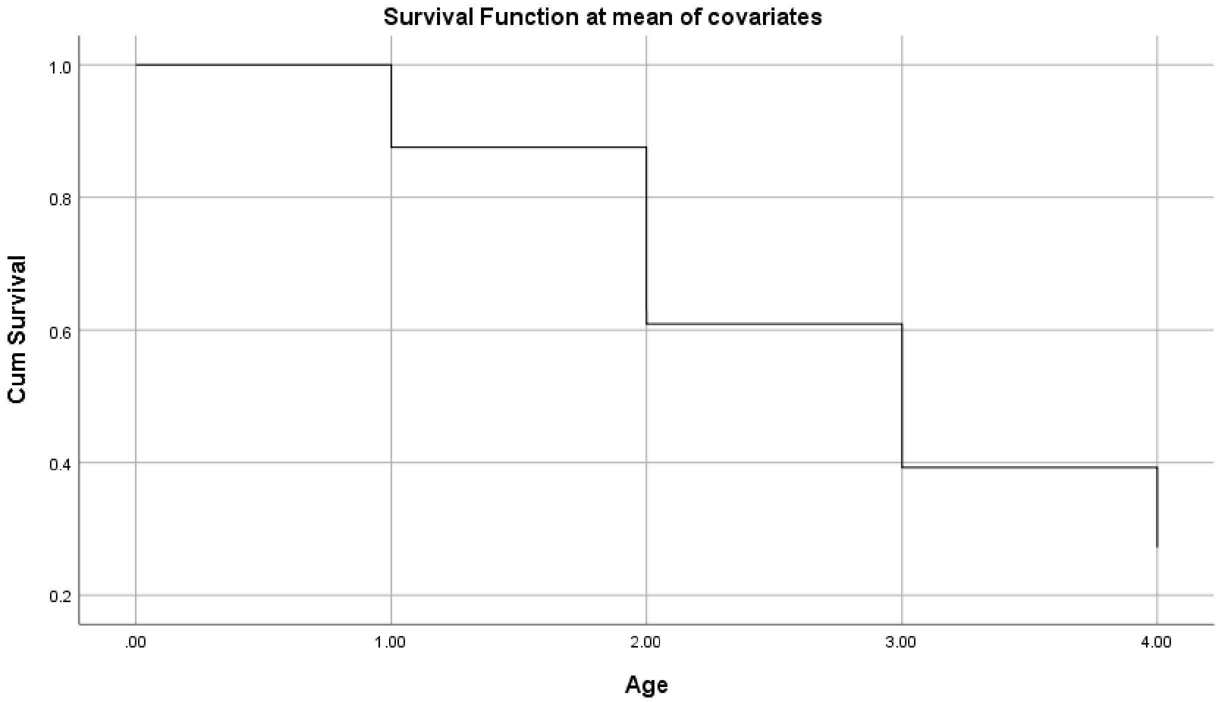
Occupation of the father	-1.013	.380	7.097	1	.008	.363	.172	.765
Occupation of the mother	.305	.099	9.406	1	.002	1.357	1.116	1.649
Family type	.009	.199	.002	1	.965	1.009	.683	1.491
Mode of delivery	-.734	.729	1.012	1	.314	.480	.115	2.006
Source of drinking water	.100	.096	1.086	1	.297	1.105	.916	1.333
type of breast feeding	-.216	.128	2.856	1	.091	.806	.627	1.035
Immunization status	-.109	.206	.279	1	.597	.897	.599	1.343
Was the child given vitamin A supplementation	-.022	.125	.031	1	.860	.978	.766	1.249
Number of time mother attended (ANC)	.184	.172	1.145	1	.285	1.202	.858	1.685
Weight	-.207	.173	1.440	1	.230	.813	.580	1.140
Height	-.292	.238	1.506	1	.220	.747	.468	1.190
Muac	-.144	.224	.414	1	.520	.866	.558	1.343
Oedema	11.010	165.007	.004	1	.947	60479.137	.000	1.721E+145
Marasmus	.112	.535	.044	1	.834	1.119	.392	3.190
Birth order of the child	-.233	.308	.572	1	.449	.792	.433	1.449
Household member	.073	.268	.074	1	.786	1.076	.636	1.820
Nutritional status			3.070	2	.215			
Nutritional status(1)	-.381	.237	2.595	1	.107	.683	.429	1.086
Nutritional status(2)	-.006	.207	.001	1	.975	.994	.663	1.490

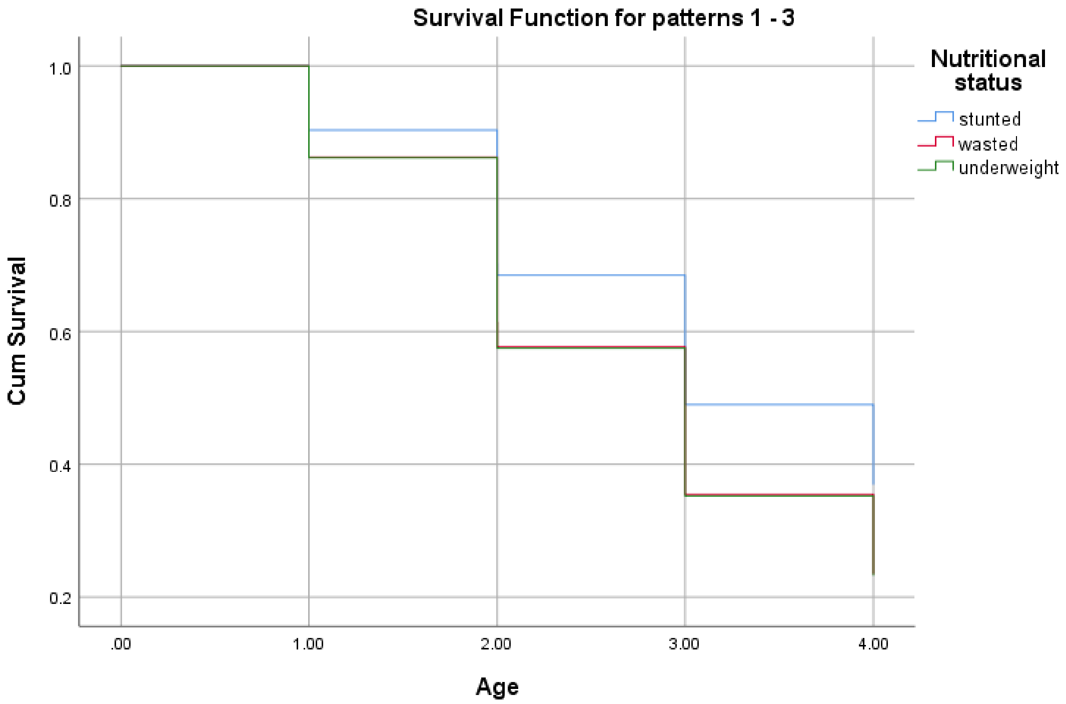
$$H(t/x) = ho(t)x\ exp\ (b_{mothers\ age}\ mothers\ age + b_{education\ of\ the\ father}\ education\ of\ the\ father + \ldots + b_{household\ member}\ household\ member$$

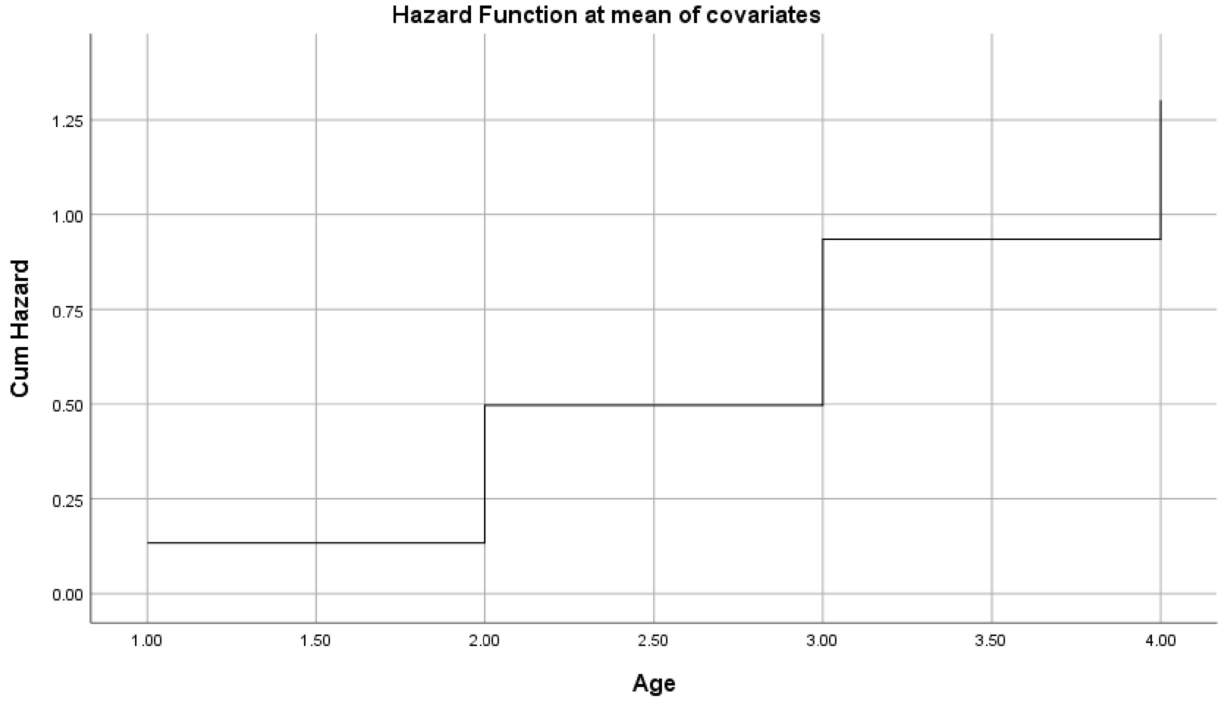
$$H(t/x) = \mathbf{-0.381exp(0.187 - 0.109 + 0.126 - 1.013 + 0.305 + 0.009 - 0.734 + 0.100 - 0.216 - 0.109 - 0.022 + 0.184 - 0.207 - 0.292 - 0.144 + 11.010 + 0.112 - 0.233 + 0.073}$$

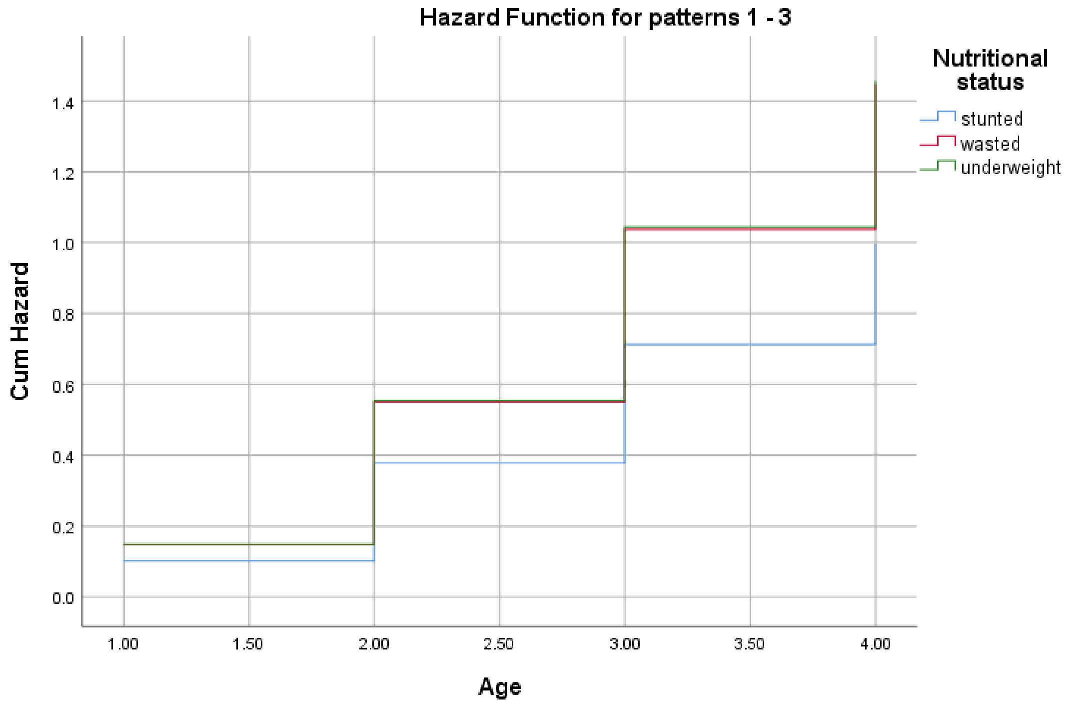
$$H(t/x) = \mathbf{-0.381exp(0.187 * mothers\ age - 0.109 * fathers\ education + 0.126 * mothers\ education - 1.013 * fathers\ occupation + 0.305 * mothers\ occupation + 0.009 * family\ type - 0.734 * mode\ of\ delivery + 0.100 * source\ of\ water - 0.216 * types\ of\ breast\ feeding - 0.109 * immunization\ status - 0.022 * vitamin\ A + 0.184 * ANC\ attendance - 0.207 * weight - 0.292 * height - 0.144 * muac + 11.010 * oedema + 0.122 * marasmus - 0.233 * birth\ order + 0.073 * household\ member}$$

The regression coefficients predict the hazard for the terminal event as a function of the covariates in the model. Positive coefficients are associated with the increase in hazard and decrease survival time, i.e. as the predictor increases the hazard of the event increases and the predicted survival duration decreases and vice – versa.


Survival Function at mean of covariates
Cum Survival
1.0
0.8
0.6
0.4
0.2
.00
1.00
2.00
3.00
4.00
Age


Survival Function for patterns 1 - 3
Nutritional status
stunted
wasted
underweight
Cum Survival
1.0
0.8
0.6
0.4
0.2
.00
1.00
2.00
3.00
4.00
Age





IV. Discussion of Result

Mother's age at birth has a significant impact on the nutritional status of the child according to findings; mothers' age at birth has been associated with malnutrition among children below five years. This is corroborated with the findings of Khan et al., (2011) in Bangladesh where children whose mothers were less than 20 years at the time of birth were 1.22 times more likely to be stunted, wasted and underweight compared to children whose mothers were 20 years and above at the time of birth.

Literacy level of mothers plays a vital role on the nutritional status of the children. According to Babatunde (2011) educated mothers are better aware about the nutrition requirements of their children and by providing improved health care. This study also revealed that education plays an important role to improve knowledge of medical and health care enhances more effective health care practices that increases their productivity and influence infant and child mortality; marital status of the child positively impacted the nutritional status of a child. About mothers' marital status and under-five child nutrition, findings in Ethiopia revealed that child's malnutrition is significantly associated with marital status.

Findings revealed that under-five child malnutrition is higher among unmarried rural and divorced/separated women compared to married ones (Teller, 2000). Being a married mother was positively associated with good nutritional status among children below five years in the Volta region of Ghana (Appoh et al; 2005). Source of drinking water and accessibility from the households makes basic hygiene somewhat unattainable (Mzumara et al., 2018). Children whose source of drinking water was non-improved were likely to be stunted compared to children whose source of water was improved and hygienically wise. This may be attributed to the fact that non-improved water sources may be contaminated and thus may increase risk of infection such as diarrhoea

Anti-natal care significantly impacted the children on malnourishment. Children whose mothers attended antenatal sessions were at a lesser risks of malnutrition when compared with those whose mothers did not (Adeyemi et al., 2019; Ahinkorah et al., 2021). Thus, it is supposed that education has the potential to improve the nutritional practices (Kandala et al., 2011)

V. Conclusion and Recommendations

It is concluded that, various socio - demographic and health service covariates are significant determinants of malnutrition. Finding shows that age, sex source of drinking water, mother's age at first birth, education status of the parent, occupation of the mother, family type, marasmus and household members of the child are statistically significant proxies of the nutritional status of children under-five with education being the most important factor for enhancing the odds of child malnutrition. No gender difference among the malnourished children and socio – economic status of the family are significant determinants.

Education of mother is important because if the mother is educated she will know how to take care of the child so that the child will not be malnourish as well as the age of the mother as well as her occupation also contribute to the malnourishment of the child . The child that come from a large family are likely to be more malnourish due to size of the family, the child that come from a polygamous family are more malnourish because the father has many children so he wouldn't care for the child nutrient. The parent should endeavor to be educated, early marriage should be reduced and the parent should try to attend ANC regularly so as to reduce the rate of malnutrition in children under-five years of age

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