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APPLICATION OF ORDINAL LOGISTIC REGRESSION ANALYSIS IN DETERMINING RISK FACTORS IN CHILDREN WITH MALNUTRITION

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Abstract

Malnutrition remains a significant public health concern, particularly affecting children in many developing countries. Identifying the risk factors associated with malnutrition is crucial for implementing effective interventions and reducing its prevalence. In this study, we aimed to employ ordinal logistic regression analysis to identify the risk factors contributing to malnutrition in children by using the data of children aged 6 months to 60 months visiting the General Paediatrics department of Amrita Institute of Medical Sciences, Kochi. After the ethical committee approval.

Methods: Based on weight-for-age anthropometric index (*Z*-score) child nutrition status is categorized into three groups-severely undernourished (< -3.0), moderately undernourished (-3.0 to -2.01) and nourished (≥ -2.0). Since nutrition status is ordinal, an OLR model – proportional odds model (POM) is used to find predictors of malnutrition.

Results: The OLR (POM) model showed that four significant risk factors associated with child malnutrition are parity with more than 2 children, Household status with ≤ 6 members, presence of Infectious or Non-infectious disease, and Socio-economic status with upper class family, Among the four factors, parity with more than 2 children showed most significant predictor of malnutrition.

Keywords and phrases: ordinal logistic regression, malnutrition, children, risk factors, nutritional status, undernutrition, statistical modelling, child health, socioeconomic determinants, public health nutrition.

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Conclusion: Ordinal logistic regression analysis proved to be a valuable tool in determining the risk factors contributing to malnutrition in children. The identified risk factors highlight the importance of addressing socioeconomic disparities, improving maternal education, and implementing nutrition-focused interventions to combat childhood malnutrition effectively. Policymakers and healthcare providers can utilize these findings to design targeted strategies that address the complex nature of malnutrition and its underlying risk factors, ultimately leading to improved health outcomes for vulnerable children.

Background

Malnutrition remains a significant public health concern, particularly affecting children in many developing countries [1]. Malnutrition is a health condition resulting from eating food that contains either insufficient or too many calories, carbohydrates, vitamins, proteins or minerals. It is a state of under- or overnutrition, evidenced by a deficiency or an excess of essential nutrients [2, 3]. Malnutrition occurs in people who are either undernourished or over nourished. Undernutrition occurs when not enough essential nutrients are consumed or when they are excreted more rapidly than they can be replaced. Overnutrition occurs in people who eat too much, eat the wrong things, don't exercise enough or take too many vitamins or other dietary replacements. Good nutrition is the basic need for children to thrive, grow, learn, play and participate. Access of every child to sufficient food may be the responsibility of parents and child to determine the fulfillment of this right. Malnutrition often steals dreams from their young lives and hangs their future in the balance. It remains a major public health concern for children under the age of 5 years in many low- and middle-income countries because it is still the leading underlying cause of child mortality in these countries [4]. The identification of factors for child malnutrition is still the interest of many researchers. Various methods are applied to uncover the factors of child malnutrition. Among them logistic regression analysis has got most preference in previous studies. In most of the studies, the response variable was considered as binary (nourished and undernourished); consequently, the binary logistic regression model was applied in all the cases. However, the nutrition status of a child is usually classified as nourished, moderately malnourished and severely malnourished [5, 6]. The primary objective of the study was to identify the determinants of severity in malnutrition among children using the ordinal logistic regression. In this study, we aimed to employ ordinal logistic regression analysis to identify the risk factors contributing to malnutrition in children by using the data of children aged 6 months to 60 months visiting the General Paediatrics department of Amrita Institute of Medical Sciences, Kochi.

Ordinal Logistic Regression Model

Ordinal logistic regression or (ordinal regression) is used to predict an ordinal dependent variable given one or more independent variables [7, 8]. An ordinal variable is a categorical

variable in which the levels have a natural ordering (e.g., depression categorized as Minimal, Mild, Moderate, Moderately Severe, and Severe). Ordinal logistic regression can be used to assess the association between predictors and an ordinal outcome [9]. Ordinal regression will enable us to determine which of our independent variables (if any) have a statistically significant effect on our dependent ordinal variable. For continuous independent variables we are able to interpret how a single unit increase or decrease in that variable, is associated with the odds of our dependent variable having a higher or lower value. We can also determine how well our ordinal regression model predicts the dependent variable [10]. The most frequently used ordinal logistic regression model in practice is the constrained cumulative logit model called the proportional odds model [11]. The POM is widely used in epidemiological and biomedical applications but POM relies on strong assumptions that may lead to incorrect interpretations if the assumptions are violated. If the data fail to satisfy the proportional odds assumption, a valid solution is fitting a partial proportional odds model [12]. Another simple and valid approach to analyze the data is to dichotomize the ordinal response variable by means of several cut-off points and use separate binary logistic regression models for each dichotomous response variable [13, 14]. However, some scholars suggested that the second procedure should be avoided, if possible, because of the loss in statistical power and the reduced generality of the analytical solution [15].

Study Design and Setting

It was a hospital based cross-sectional study. The data during the period from 2020 January to 2023 June of children of age 6 to 60 months who had registered in the department of General Paediatrics at Amrita Institute of Medical Sciences, Kochi was collected. Paediatric patients from age 6 months to 60 months were included in the study and Patients who did not have the complete information in their medical record. Patients who did not respond at the time of contact were excluded from the study.

Data and Variables

The data during the period from 2020 January to 2023 June of children of age 6 to 60 months who had registered in the department of General Paediatrics at Amrita Institute of Medical Sciences, Kochi was collected, The IBM SPSS and R statistical package were used for the analysis of data. The collected data contained 302 subjects aged 6 months to 60 months. The nutritional status of children was calculated using Child growth standards published by the World Health Organization (WHO). weight for age anthropometric indicator is used in the study (WAZ). The weight- for -age-*Z*-score is a statistical measure used to assess a child's nutrition status in relation to their age. According to the weight for age *Z*-score the dependent variable, child nutrition status is categorized into (i) severely under-nourished

(*Z*-score < -3.0), (ii) moderately under-nourished (*Z*-score between -3.0 and -2.01) and (iii) nourished (*Z*-score ≥ -2.0).

Thus, nutrition status is an ordinal response variable. Explanatory variables used are variables that are expected to potentially affect/determine the response/dependent variables, which is the nutritional status of the child. Socio-economic, demographic and maternal and child health characteristics are considered as the independent variables to develop the proportional odds model (POM).

Statistical Analysis

All statistical analysis were performed using IBM SPSS 26 and R 4.2.1 software. Categorical variables are expressed using frequency and percentage. Continuous variable is presented by mean and standard deviation. Percentage of malnourished children will be assessed based on *Z*-score. To test the statistical significance of the association of categorical variables with children's nutrition status, Pearson Chi-Square (χ^2) test will be used. To find the most significant predictors of malnutrition an OLR model-proportional odds model (POM) will be developed and odds ratio will be computed with 95% of confidence interval. Forest plot was used to represent odds ratio.

Results

The dietary patterns, anthropometric measurements socioeconomic indicators, and maternal characteristics for 302 patients included in this study are presented in Table 1. 155(51.3%) were males while 147(48.7%) were females. The mean age of study sample was 2.278 ± 0.775 months while the mean weight was 10.570 ± 3.780 Kg and the mean height of the study sample was 82.350 ± 18.037cm, 192(63.6%) were from middle and lower class family, 274(90.7%) children were with household size of less than or equal 6, 195 (64.6%) had parity 1, 232(76.8%) were the first children, 80.1% children was initial status of breastfeed within 1 hour. 129(42.7%) children ate vitamin A rich food in less than or equal to 2 days per week, 296(98.0%) children were fed in 2 or more times in a day.

Table 1. Dietary patterns, Anthropometric measurements socioeconomic indicators, and maternal characteristics of participants

Variable	Category	Frequency	Percentage
Gender	Male	155	51.3
	Female	147	48.7
Age of child (months)	0-11	60	19.9
	12 to 23	98	32.5
	> 23	144	47.7
Mothers BMI	Normal	294	97.4
	Thinness	8	2.6
Mother's education	UG	240	79.5
	≥ PG	62	20.5
Socio-economic class	Upper	110	36.4
	Middle and Lower	192	63.6
Mothers Occupation	Employed	152	50.3
	Unemployed	150	49.7
Household size	≤ < = 6	274	90.7
	> 6	28	9.3
Parity	1	195	64.6
	≥ 2	107	35.4
Birth order	1	232	76.8
	≥ 2	70	23.2
Current status of breast feeding	Yes	137	45.4
	No	165	54.6
Initial status of breast feeding	Within 1 hour	242	80.1
	1-23 hours	53	17.5
	> 23 hours	7	2.3
Duration of breast feeding	≤ 6 months	54	17.9
	6-23 months	231	76.5
	≥ 24 months	17	5.6
Bottle feeding status	Yes	126	41.7
	No	176	58.3
Dietary diversity	< 4 food items	61	20.2
	≥ 4 food items	241	79.8
Type of family	Joint	33	10.9
	Nuclear	269	89.1
Birth weight	< 2.5	30	9.9
	≥ 2.5	272	90.1
Dairy products given in a week	1 day	22	7.3
	≥ 2 days	160	53
	Not giving	120	39.7
Carbohydrate rich food given in a week	≤ 2 days	28	9.3
	≥ 3 days	249	82.5
	Not eating	25	8.3

Fish given in a week	< 5 days	65	21.5
	≥ 5 days	202	66.9
	Not eating	35	11.6
Egg	< 5 days	69	22.8
	≥ 5 days	144	47.7
	Not eating	89	29.5
Vitamin A rich vegetables and fruits given in a week	≤ 2 days	129	42.7
	≥ 3 days	118	39.1
	Not eating	55	18.2
Other vegetables and fruits	≤ 2 days	129	42.7
	≥ 3 days	117	38.7
	Not eating	56	18.5
Feeding frequency	1	6	2
	≥ 2	296	98
Infectious or non-infectious diseases	Yes	120	39.7
	No	182	60.3

Table 2. Children's nutrition status according to selected independent variables

Variables	**category**	**Nutrition status**			***p*-value**
		Severely undernourished (*n*%)	**Moderately undernourished (*n*%)**	**Nourished (*n*%)**	
Age of the child (in months)	0-11(60)	4 (6.7)	3(5.0)	53	**0.02**
	12-23(98)	18(18.4)	13(13.3)	67	
	> 23(144)	17(11.8)	24(16.7)	103 (71.5)	
Mothers BMI	Normal (294)	38(12.9)	39(13.3)	217(73.8)	0.997
	Thinness (8)	1(12.5)	1(12.5)	6 (75.0)	
Socio economic class	Upper (110)	11(10.0)	6(5.5)	93 (84.5)	**0.003**
	Middle and lower (192)	28(14.6)	34(17.7)	130 (67.7)	
Mothers education	≥ PG (62)	6(9.7)	11(17.7)	45 (72.6)	0.398
	UG (240)	33(13.8)	29(12.1)	178(74.2)	
Mothers occupation	Unemployed (150)	17(11.3)	19(12.7)	114 (76.0)	
	Employed (152)	22(14.5)	21(13.8)	109(71.7)	0.657
Household size	≤ 6 (274)	32(11.7)	32 (11.7)	210 (76.6)	**0.002**
	> 6 (28)	7(25.0)	8 (28.6)	13 (46.4)	
Parity	1(195)	13(6.7)	16 (8.2)	166 (85.1)	**< 0.001**
	≥ 2(107)	26(24.3)	24 (22.4)	57(53.3)	
Initiation of breast feeding	Within 1 hour (242)	26(10.7)	28(11.6)	188(77.7)	**0.048**
	1-23 hours (53)	11(20.8)	10(18.9)	32(60.4)	
	>23 hours (7)	2(28.6)	2(28.6)	3(42.9)	
Vitamin A rich vegetables and fruits	≤ 2 days (129	15(11.6)	9(7.0)	105(81.4)	**0.022**
	≥ 3 days (118)	13(11.0)	22(18.6)	83(70.3)	
	Not eating (55)	11(20.0)	9(16.4)	35 (63.6)	
Non-infectious or infectious diseases	Yes (120)	24(20.0)	17(14.2)	79(65.8)	**0.008**
	No (182)	15(8.2)	23(12.6)	144(79.1)	

It was observed that the factors that were significant for child nutrition status was Age $(p = 0.020)$, Socio-economic class $(p = 0.003)$, House hold size $(p = 0.002)$, Parity $(p =< 0.001)$, Initiation of breast-feeding $(p = 0.048)$, Vitamin A Vegetables and Fruits given in a week $(p = 0.022)$, Infectious or Non-infectious diseases $(p = 0.008)$.

Table 3. Multivariate analysis of variables

Parameter	Estimate	SE	Wald	*p*-value	Odds ratio at 95% of CI
Intercept 3 1	-2.01	0.57	12.5	0.0004	
Intercept 2 1	-0.95	0.56	2.85	0.0913	
Socio economic status (upper)	0.8	0.33	5.73	0.0167	2.22(1.15 - 4.3)
Household status (< = 6)	1.21	0.44	7.73	0.005	2.37 (1.4 - 7.92)
Initiation of breast feeding (within 1 hr)	1	----	-----	-----	
Initiation of breast feeding (1-23hr)	0.66	0.81	3.64	0.056	
Initiation of breast feeding (> 23 hr)	-0.32	0.47	0.15	0.694	
Age (0-11)	1	----	----	----	
Age (12-23)	-0.41	0.47	1.78	0.182	
Age (> 23)	1.41	0.32	1.67	0.1961	
Parity(> =2)	1.43	0.3	22.98	< 0.001	4.16(2.32 - 7.5)
Infectious or non-infectious disease (yes)	0.86	0.29	8.84	0.0029	2.37(1.34 - 4.2

The above table showing the results of multiple ordinal logistic regression. The variables with $p < 0.1$ included in the multivariate analysis. The results showed that the four factors such as parity with more than 2 children ($p = < 0.001$, OR (95% CI) = (4.16(2.32 - 7.5))), household status with ≤ 6 members ($p = < 0.001$(3.37 (1.4 - 7.92))), presence of infectious or Noninfectious disease ($p = < 0.001$(2.37(1.34 - 4.2))) and socio-economic status with upper class family ($p = < 0.001$(2.22(1.15 - 4.3))). Among the four factors Parity with more than 2 children showed most significant predictor of malnutrition.

Discussion

Proper nutrition is necessary for growth and development at young age. This will lead to mortality and morbidity consequences. Looking for etiology and treating children by primary care physicians at its acute stage by checking wasting and advising on correcting nutritional deficiencies is essential to prevent complications at all levels of prevention.

This study shows that, according to age factor 12- to 23 months old children were more severely malnourished than other age group. The study conducted by Chuc D. Van et al. showed that the children in the age group of 12 - 23 months were severely malnourished [16].

It is found that the children of socioeconomic class middle and lower have more percentage of severely undernourished. A study done by Anuradha et al. says that as socioeconomic status increased, malnourishment decreases. Thus, lower socioeconomic group have more chances of malnourished [17]. Significant association was found between family size and nutritional status of the children. Mudkhedkar et al., found that relationship between family size and nutritional status was inversely proportionate when size of family was large [18]. The present study compared maternal factor-like parity and revealed parity is a significant factor for malnutrition. Similar to the present study, some other studies [19, 20] found maternal factors associated with malnutrition in children. Breastfeeding during sickness was found to be related to malnutrition. Our analyses indicate that breastfeed between 1 to 23 hrs has higher proportion of severely undernourished. In the present study severely undernourished was higher in children who did not eat vitamin A rich vegetables and fruits and proportion of severely undernourished is higher in children who is infected. When the present study is compared with the previous study [21] done by Okoromah et al. showed that poor dietary intake and infectious diseases causing malnutrition.

In our study POM seems to be an appropriate model for analyzing the considered data. The *p*-value was 0.05 for the chi-square test for the proportional odds assumption. The study revealed the parity with more than 2 children showed most significant predictor of malnutrition. The study is compared to other studies conducted in Bangladesh and Ethiopia. The first study conducted by Das and Rahman revealed that that age of child, birth interval, mothers' education, maternal nutrition, household wealth status, child feeding index, and incidence of fever, ARI and diarrhoea were the significant predictors of child malnutrition [22] and the second study conducted by Berhanu et al. revealed that according to the fitted partial proportional odds model the mother's education level (secondary or higher) was positively correlated with the nutritional status of primary school students, given that in this case the students ate three or more times per day and had a high dietary diversity score (OR = 5.94; CI: 2.2 - 16.0). Nevertheless, there was a negative correlation between larger family size (OR = 0.56; CI: 0.32-0.97), unprotected groundwater (OR = 0.76; CI: 0.6-0.96), and severely food insecure households (OR = 0.3; CI: 0.14 - 0.68) [23].

Our findings also showed that at Multivariate analysis level, the factors significant for child nutrition status were parity with more than 2 children ($p = < 0.001$, OR (95% CI) = (4.16(2.32 - 7.5)), household status with ≤ 6 members ($p = < 0.001$(3.37 (1.4 - 7.92)), presence of infectious or Non-infectious disease ($p = < 0.001$(2.37(1.34 - 4.2)) and socio-economic status with upper class family $p = < 0.001$(2.22(1.15 - 4.3)). Among the four factors parity with more than 2 children showed most significant predictor of malnutrition.

Conclusion

The study shows that parity with more than 2 children, household status with less than or equal 6 members, presence of infectious or non-infectious disease, socio-economic class of upper-class family, were statistically significant various determinants of malnutrition. The POM had proved adequate for data analysis of child nutritional status, due to the nature of the response variable (ordered continuous variable), in addition, POM was fitted better for the data. From the results of POM, it was clear that parity, presence of infectious or noninfectious disease, socio-economic class and household size were statistically significant predictors of child malnutrition. Moreover, these findings clearly justify that OLR models (POM) were appropriate to find predictors of malnutrition.

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