RESEARCH PAPER

Application Of Ordinal Logistic Regression Analysis In Determining Risk Factors In Children With Malnutrition

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Abstract

Background: Malnutrition remains a significant public health concern, particularly among children in developing countries. Identifying the risk factors associated with varying severity levels of malnutrition is essential for designing effective interventions and reducing its burden.

Methods: This study employed ordinal logistic regression analysis to identify risk factors contributing to malnutrition among children aged 6 to 60 months attending the General Paediatrics Department of Amrita Institute of Medical Sciences, Kochi, following ethical committee approval. Nutritional status was assessed using the weight-for-age anthropometric index (Z-score) and categorized into three ordered groups: severely undernourished (< -3.0), moderately undernourished (-3.0 to -2.01), and nourished (≥ -2.0). Given the ordinal nature of the outcome variable, an ordinal logistic regression proportional odds model was applied to determine predictors of malnutrition.

Results: The proportional odds model identified four significant risk factors associated with increasing severity of malnutrition: parity of more than two children, household size of six or fewer members, presence of infectious or non-infectious disease, and socioeconomic status. Among these factors, parity of more than two children emerged as the most significant predictor of malnutrition severity.

Conclusion: Ordinal logistic regression proved to be an effective analytical approach for identifying determinants of malnutrition severity in children. The findings underscore the importance of addressing family size, household conditions, disease burden, and socioeconomic factors in nutrition-focused interventions. These results can inform policymakers and healthcare providers in developing targeted strategies to reduce childhood malnutrition and improve health outcomes

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

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Introduction

Malnutrition remains a significant public health concern, particularly among children in many developing countries. It is a health condition resulting from the intake of food containing insufficient or excessive calories, carbohydrates, proteins, vitamins, or minerals. Malnutrition represents a state of undernutrition or overnutrition and is characterized by either a deficiency or an excess of essential nutrients [1-3].

Malnutrition affects individuals who are undernourished as well as those who are overnourished. Undernutrition occurs when essential nutrients are not consumed in adequate amounts or are lost more rapidly than they can be replaced. Overnutrition, on the other hand, occurs when individuals consume excessive amounts of food, follow unhealthy dietary patterns, engage in insufficient physical activity, or consume excessive vitamin or dietary supplements. Good nutrition is fundamental for children to grow, thrive, learn, play, and actively participate in daily life.

Ensuring access to adequate and nutritious food for every child is a shared responsibility of caregivers and society to fulfill this basic right. Malnutrition often compromises the physical and cognitive potential of children, placing their future health and development at risk. It continues to be a major public health concern among children under five years of age in low- and middle-income countries, where it remains a leading underlying cause of childhood mortality [4].

Identifying the determinants of child malnutrition has therefore remained an important area of research. Various analytical methods have been used to explore factors associated with child malnutrition, with logistic regression analysis being the most commonly employed approach. In many previous studies, nutritional status has been treated as a binary outcome, categorized as nourished or undernourished, leading to the use of binary logistic regression models. However, a child's nutritional status is more appropriately classified into ordered categories such as nourished, moderately malnourished, and severely malnourished, which better reflect the progression and severity of malnutrition [5,6].

Materials and methods

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Aim: To apply ordinal logistic regression analysis to determine the risk factors associated with malnutrition among children.

Study design and setting

This hospital-based cross-sectional study was conducted using data collected between January 2020 and June 2023 from children aged 6 to 60 months who were registered in the Department of General Pediatrics at Amrita Institute of Medical Sciences, Kochi. All Pediatric patients within the specified age group were eligible for inclusion. Children with incomplete medical records and those who did not respond at the time of contact were excluded from the study.

Sample size

As a formal sample size calculation specific to ordinal logistic regression was not feasible, a minimum sample size of 302 children was included in the study to ensure adequate statistical power for the analysis.

Data and variables

Data were collected for children aged 6 to 60 months who were registered in the Department of General Pediatrics at Amrita Institute of Medical Sciences, Kochi, during the period from January 2020 to June 2023. The final dataset comprised 302 children. Data analysis was performed using IBM SPSS and the R statistical software.

The nutritional status of children was assessed using the World Health Organization child growth standards. The weight-for-age anthropometric indicator (WAZ) was used to evaluate nutritional status. Weight-for-age Z-score is a standardized measure that reflects a child's nutritional status relative to age.

Based on the weight-for-age Z-score, the dependent variable, child nutritional status, was categorized into three ordered groups: (i) severely undernourished (Z-score < -3.0), (ii) moderately undernourished (Z-score between -3.0 and -2.01), and (iii) nourished (Z-score ≥ -2.0). Accordingly, nutritional status was treated as an ordinal outcome variable.

The explanatory variables included factors expected to influence child nutritional status. Socioeconomic, demographic, maternal, and child health characteristics were considered independent variables for developing the proportional odds model.

Statistical analysis

All statistical analyses were performed using IBM SPSS version 26 and R version 4.2.1. Categorical variables were summarized using frequencies and percentages, while continuous variables were expressed as mean and standard deviation. The prevalence of malnutrition was assessed based on weight-for-age Z-scores.

The association between categorical variables and children's nutritional status was examined using the Pearson chi-square (χ^2) test. To identify significant predictors of malnutrition severity, an ordinal logistic regression proportional odds model was fitted. Odds ratios with 95% confidence intervals were estimated. A forest plot was used to visually represent the odds ratios.

Ordinal logistic regression model

Ordinal logistic regression (also known as ordinal regression) is used to model an ordinal dependent variable based on one or more independent variables [7,8]. An ordinal variable is a categorical variable with a natural ordering of categories, such as depression classified as minimal, mild, moderate, moderately severe, and severe. Ordinal logistic regression allows assessment of the association between explanatory variables and an ordinal outcome variable [9].

This method enables identification of independent variables that have a statistically significant effect on the ordinal outcome. For continuous predictors, the model allows interpretation of how a one-unit increase or decrease in the predictor influences the odds of being in a higher or lower category of the outcome variable. In addition, ordinal regression models can be used to evaluate the overall predictive performance of the model [10].

The most commonly applied ordinal logistic regression model is the constrained cumulative logit model, known as the proportional odds model (POM) [11]. The POM is widely used in epidemiological and biomedical research; however, it relies on the proportional odds assumption, which may lead to misleading conclusions if violated. When this assumption is not satisfied, an alternative approach is to fit a partial proportional odds model [12].

Another commonly used approach is to dichotomize the ordinal outcome variable using multiple cut-off points and apply separate binary logistic regression models [13,14]. However, this strategy is generally discouraged, as it leads to loss of statistical power and reduced interpretability of results [15].

Results

Among the 302 children included in the study, 155 (51.3%) were male. Nearly half of the children were older than 23 months (144, 47.7%). Most mothers had normal body mass index (294, 97.4%) and undergraduate-level education (240, 79.5%). The majority of participants belonged to middle or lower socioeconomic class (192, 63.6%), lived in nuclear families (269, 89.1%), and had household size ≤ 6 members (274, 90.7%). Breastfeeding was initiated within one hour of birth in 242 children (80.1%), and 137 (45.4%) were currently breastfed. Dietary diversity of four or more food items was observed in 241 children (79.8%). Most children had normal birth weight (272, 90.1%) and were fed at least twice daily (296, 98.0%). Infectious or non-infectious diseases were reported in 120 children (39.7%). **These findings are illustrated in Table 1.**

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

Variable	Category	Values
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%)

A significant association was observed between nutritional status and age of the child (p = 0.02), with a higher proportion of undernutrition among children aged 12–23 months. Socioeconomic class (p = 0.003), household size (p = 0.002), and parity (p < 0.001) were also significantly associated with nutritional status, where children from lower socioeconomic groups, larger households, and higher parity mothers showed higher levels of undernutrition. Early initiation of breastfeeding within one hour was significantly associated with better nutritional status (p = 0.048). Dietary intake of vitamin A–rich vegetables and fruits (p = 0.022) and the presence of infectious or non-infectious diseases (p = 0.008) were significantly related to undernutrition. No significant association was observed with maternal BMI**,** maternal education, or maternal occupation. **These findings are illustrated in Table 2.**

Table 2. Children's Nutritional Status According to Selected Independent Variables

Variables	**category**	**Nutrition status**			**Total**	**Chi-square value**	**p-value**
		Severely Undernourished(n %)	Moderately Undernourished(n %)	Nourished n (%)			
Age of the child (in months)	0 to 11	4 (6.7)	3(5.0)	53(88.3)	60(19.9)	10.768	0.02*
	12 to 23	18(18.4)	13(13.3)	67(68.4)	98(32.5)		
	>23	17(11.8)	24(16.7)	103 (71.5)	144(47.7)		
Mothers BMI	Normal	38(12.9)	39(13.3)	217(73.8)	294(97.4)	0.006	0.997
	Thinness	1(12.5)	1(12.5)	6 (75.0)	8(2.6)		
Socio economic class	Upper	11(10.0)	6(5.5)	93 (84.5)	110(36.4)	11.751	0.003*
	Middle and lower	28(14.6)	34(17.7)	130 (67.7)	192(63.6)		
Mothers' education	≥PG	6(9.7)	11(17.7)	45 (72.6)	62(20.5)	1.841	0.398

	UG	33(13.8)	29(12.1)	178(74.2)	240(79.5)		
Mothers' occupation	Unemployed	17(11.3)	19(12.7)	114 (76.0)	150(49.7)	0.84	0.657
	Employed	22(14.5)	21(13.8)	109(71.7)	152(50.3)		
Household size	≤ 6	32(11.7)	32 (11.7)	210 (76.6)	274(90.7)	12.105	0.002*
	>6	7(25.0)	8 (28.6)	13 (46.4)	28(9.3)		
Parity	1	13(6.7)	16 (8.2)	166 (85.1)	195(64.6)	6.129	<0.001*
	≥2	26(24.3)	24 (22.4)	57(53.3)	107(35.4)		
Initiation of breast feeding	Within1 hour	26(10.7)	28(11.6)	188(77.7)	242(80.1)	10.449	0.048*
	1-23 hours	11(20.8)	10(18.9)	32(60.4)	53(17.5)		
	>23 hours	2(28.6)	2(28.6)	3(42.9)	7(2.3)		
Vitamin A rich vegetables and fruits	≤2 days	15(11.6)	9(7.0)	105(81.4)	129(42.7)	11.429	0.022*
	≥3 days	13(11.0)	22(18.6)	83(70.3)	118(39.1)		
	Not eating	11(20.0)	9(16.4)	35 (63.6)	55(18.2)		
Non-infectious or infectious diseases	Yes	24(20.0)	17(14.2)	79(65.8)	120(39.7)	9.599	0.008*
	No	15(8.2)	23(12.6)	144(79.1)	182(60.3)		

Table 3. Odds ratio estimates for factors associated with malnutrition among children

Variables with a p-value < 0.10 in the univariate analysis were included in the multivariate model. Four factors were found to be statistically significant predictors of children's nutritional status: parity (≥2), household size (≤6 members), presence of infectious or non-infectious disease, and upper socioeconomic status. Among these, higher parity (≥2) emerged as the strongest predictor of malnutrition (p < 0.001; OR = 4.16, 95% CI: 2.32–7.50). Children from households with ≤6 members had higher odds of malnutrition (OR = 3.37, 95% CI: 1.40–7.92), as did those with infectious or non-infectious diseases (OR = 2.37, 95% CI: 1.34–4.20). Upper socioeconomic status was also significantly associated with nutritional status (OR = 2.22, 95% CI: 1.15–4.30). **These findings are illustrated in Table 3.**

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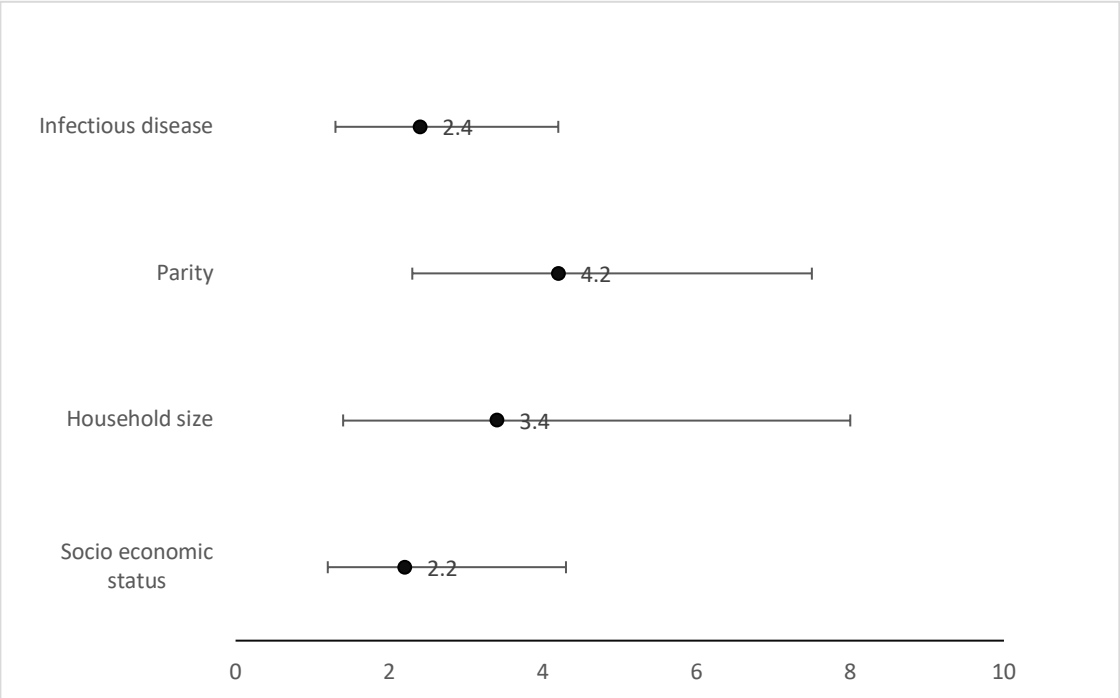
Variables	**β**	**OR**	**95% C I**	
			Lower	**Upper**
Parity (≥2)	1.43	4.16	2.32	7.5
Infectious disease or Non-infectious disease (yes)	0.86	2.37	1.34	4.2
Socio-economic class(upper)	0.8	2.22	1.15	4.3
Household size (≤6)	1.21	3.37	1.43	7.92

Figure 1. Forest plot of adjusted odds ratios for significant predictors of childhood malnutrition

Figure 1 illustrates the adjusted odds ratios with 95% confidence intervals for significant predictors of childhood malnutrition obtained from the multivariate ordinal logistic regression model. Higher parity (≥2) emerged as the strongest predictor, followed by household size (≤6 members), presence of infectious or non-infectious disease, and upper socioeconomic status.

In the Figure the black dots represent the Adjusted Odds Ratios calculated from a multivariate ordinal logistic regression model. The horizontal lines indicate the 95% Confidence Intervals (CI) for each estimate. These values show the strength and precision of the association between each factor—Infectious disease, Parity, Household size, and Socio-economic status—and the study outcome.



Discussion

Adequate nutrition during early childhood is essential for optimal growth, development, and survival. Poor nutritional status during this critical period can result in long-term morbidity and increased mortality. Early detection of malnutrition by primary care physicians, through routine assessment of wasting and timely correction of nutritional deficiencies, is essential to prevent complications at primary, secondary, and tertiary levels of prevention.

In the present study, children aged 12-23 months were found to be more severely malnourished compared with other age groups. Similar findings were reported in previous studies, where children in this age group showed a higher prevalence of severe malnutrition [16]. This period corresponds to the transition from exclusive breastfeeding to complementary feeding, which may often be inadequate in quality, quantity, or frequency, thereby increasing the risk of undernutrition.

Socioeconomic status was significantly associated with nutritional status. Children belonging to middle and lower socioeconomic classes showed a higher proportion of severe undernutrition. A study by Anuradha R and Sivanandham R reported that malnutrition decreases with increasing socioeconomic status, indicating that children from economically disadvantaged households are at greater risk [17]. Limited access to nutritious food, healthcare, and education in lower socioeconomic groups may contribute to this disparity.

Family size also showed a significant association with nutritional status. Children from larger families had poorer nutritional outcomes, which may be due to resource dilution and reduced caregiver attention. Similar findings were reported and observed an inverse relationship between family size and child nutritional status [18].

Maternal factors were important determinants of child nutrition in this study. Parity greater than two children was significantly associated with malnutrition. Previous studies have also identified maternal characteristics such as education level, birth spacing, and maternal nutritional status as key predictors of child malnutrition [19,20]. Higher parity may reduce maternal attention and available household resources for each child.

Breastfeeding practices during illness were associated with nutritional outcomes. Children breastfed for shorter durations during sickness showed a higher prevalence of severe undernutrition. In addition, children who did not consume vitamin A-rich fruits and vegetables and those with infections had higher levels of malnutrition. These findings are consistent with earlier studies reporting that poor dietary intake and infectious diseases are major contributors to child malnutrition [21].

In this study, the Proportional Odds Model (POM) was appropriate for analyzing ordinal nutritional status data, as the chi-square test for the proportional odds assumption showed a p-value of 0.05. Parity greater than two children emerged as the most significant predictor of malnutrition.

Comparable findings were observed in studies conducted in Bangladesh and Ethiopia. Das S and

Rahman R identified child age, birth interval, maternal education, maternal nutrition, household wealth status, child feeding practices, and episodes of fever, acute respiratory infection, and diarrhoea as significant predictors of child malnutrition [22]. Similarly, Berhanu G et al. reported that maternal education and dietary diversity were positively associated with improved nutritional status, while larger family size, unsafe water sources, and household food insecurity were negatively associated [23].

Multivariate analysis in the present study identified several significant predictors of child malnutrition: parity greater than two children ($p < 0.001$, OR = 4.16, 95% CI 2.32-7.5), household size ≤6 members ($p < 0.001$, OR = 3.37, 95% CI 1.4-7.92), presence of infectious or non-infectious disease ($p < 0.001$, OR = 2.37, 95% CI 1.34-4.2), and socioeconomic status ($p < 0.001$, OR = 2.22, 95% CI 1.15-4.3). Among these, parity greater than two children was the strongest predictor of malnutrition.

These findings highlight the multifactorial nature of child malnutrition and emphasize the need for integrated interventions focusing on maternal education, family planning, infection control, dietary diversification, and socioeconomic improvement to effectively reduce the burden of malnutrition.

Limitation

This study was conducted at a single tertiary care center (Amrita Institute of Medical Sciences), so the findings may not represent the general population. The cross-sectional design limits the ability to establish cause-and-effect relationships. Some information, such as breastfeeding practices and illness history, relied on caregiver recall and may be affected by recall bias. Nutritional status was assessed only using weight-for-age Z-scores, and other indicators like height-for-age and weight-for-height were not included. In addition, factors such as household food security, sanitation, were not measured and may have influenced the results.

Conclusions

This study identified important determinants of child malnutrition, including maternal parity greater than two children, household size of six members or fewer, presence of infectious or non-infectious diseases, and socioeconomic status. Among these variables, higher parity emerged as the strongest predictor of malnutrition. These findings highlight the multifactorial nature of child malnutrition and emphasize the need for integrated interventions focusing on maternal education, family planning, infection prevention, and improved household living conditions to reduce the burden of malnutrition.

Ordinal logistic regression was found to be an appropriate statistical approach for analyzing child nutritional status due to the ordinal nature of the outcome variable, and the model provided a good fit for the data. The analysis confirmed parity, disease status, socioeconomic class, and household size as significant predictors of malnutrition. These results support the use of ordinal logistic regression models for identifying determinants of malnutrition in similar public health research settings.

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