Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

Analysis of Determinants of Malnutrition in Children Under Five Years in India Using a Multivariate Approach

Naresh Chandra Kabdwal[1], *Niraj Kumar Yadav[2], Shazia Shafi[3],

[1,2]Department of Mathematics and Statistics, Banasthali Vidyapith, Rajasthan, India

[3]Department of Community Medicine, G S Medical College and Hospital, UP, India

For Correspondence Author: *Niraj Kmar Yadav,

(Received: 25 November 2025 Revised: 07 December 2025 Accepted: 27 December 2025)

KEYWORDS

Malnutrition, Anthropometric Measurements, Multivariate Analysis, Child Nutrition, National Family Health Survey

ABSTRACT:

Malnutrition is an important factor in maintaining good health and promoting human development. The nutritional status of children during their early years is vital for their growth and development, impacting not only their infancy but also their well-being in adulthood. Malnutrition is considered the most significant threat to global public health, particularly in developing countries. This status is assessed through anthropometric measures and results from a complex interplay of biological and socioeconomic factors. This study aimed to identify the significant determinants of child malnutrition in India. The analysis utilized data from the National Family Health Survey-5 (NFHS-5) conducted between 2019 and 2021, encompassing 232,920 children with available data on height, weight, age, and sex. Multivariate techniques were employed to identify the significant determinant contributing to child malnutrition. Factor analysis identified six key factors as covariates of malnutrition, with two being socioeconomic and the others biological and biosocial. To evaluate the effectiveness of these factors in predicting malnutrition, linear discriminant analysis was conducted, demonstrating that these factors accurately account for approximately 63.31% of the observations. The findings suggest that raising awareness is crucial. However, it's equally important to improve socioeconomic status and maternal health conditions, as these are comprehensive solutions that can significantly mitigate the risk of child malnutrition.

Introduction

Nutrition is crucial for maintaining good health and supporting human development. Maintaining a balanced diet is vital to preventing malnutrition, which can occur when there are deficits, excesses, or imbalances in calorie, protein, and nutrient intake. Malnutrition includes both undernutrition and overnutrition and affects individuals across various stages of life.

Malnutrition occurs when the diet is unbalanced, with certain nutrients being deficient, excessive, or improperly proportioned. The nutritional status of children is a crucial indicator of poverty within a population, and there is a strong interconnection between poverty, malnutrition, and disease.[1] Each year, malnutrition contributes to the deaths of approximately 2.6 million children, accounting for one-third of all child deaths globally.[2] Malnutrition is a critical factor in various forms of morbidity. It is associated with a heightened risk of mortality from conditions such as acute respiratory infections (ARI), diarrhea, measles, and other infectious diseases. It can also profoundly affect children's physical growth and cognitive development. Research shows that severely malnourished children are at a significantly higher risk of mortality.[3] However, moderate malnutrition also presents substantial risks, with the majority of nutrition-related deaths more frequently linked to moderate rather than severe malnutrition.[4]

The benefits of a healthy life are valued by individuals, as well as by society and the whole nation. A person's health is influenced by several interrelated elements, including social, economic, dietary, lifestyle-related, environmental, political, and government policies.[5] The burden of treatment costs, especially unforeseen out-of-pocket expenses, is particularly challenging for those living in poverty to manage.[6] Individuals from wealthy societies are showing a divergent tendency. Weight gain in such individuals often results from a sedentary lifestyle combined with unhealthy eating habits. These issues are due to malnutrition, according to medical professionals. The contradiction is that even

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

though India is the world's second-largest food provider, a sizable percentage of something like the world's undernourished children resides there.

Malnutrition remains a critical public health issue affecting millions of children globally, especially those under the age of five. It is a multifaceted problem encompassing undernutrition, overnutrition, and micronutrient deficiencies, each with severe implications for child health and development. Undernutrition, characterized by stunting (low height for age), wasting (low weight for height), and underweight (low weight for age), is the most prevalent form of malnutrition in low- and middle-income countries. Overnutrition, which leads to childhood obesity, is an emerging concern even in these regions. Micronutrient deficiencies, often called "hidden hunger," include the lack of essential vitamins and minerals like iron, iodine, and vitamin A, which are crucial for growth and immunity.

To assess nutritional status, both anthropometric measurements and biomarkers are commonly used. Three key indices of physical growth are utilized to describe the children's nutritional status: weight-for-height (wasting), height-for-age (stunting), and weight-for-age (underweight). Stunting, a height-for-age measurement that falls below two standard deviations from the median of a reference population, is typically seen as an indicator of chronic malnutrition.[7] Wasting, identified by a weight-for-height measurement, reflects acute malnutrition. Underweight, or undernutrition, is a composite measure defined by a weight-for-age indicator. These indices can be categorized into severe and moderate levels based on the cut-off points established by the World Health Organization (WHO).[7]

In the modern day, undernutrition and overnutrition contribute to malnutrition, a double burden. However, malnutrition is synonymous with undernutrition in India and middle and other low-income nations, which denotes an imbalance in the body's protein and energy intake to ensure adequate growth and function. Stunting affects approximately 149.2 million children under the age of five worldwide. Over 45.4 million children under the age of five were wasted in 2021, and nearly to 17 million of those were seriously wasted. Over 38.9 million children worldwide are overweight at present, a growth of 10 million since 2000.[8] Based on estimates that 25 million children more than there are now will be malnourished by 2050.[9]

India, as a developing country in Asia, faces significant challenges with child malnutrition. A substantial body of literature explores the determinants of child nutrition in developing countries, including India. Research has identified several factors closely associated with infant and child malnutrition, such as low dietary intake, low birth weight, large family size, lack of parental education, breastfeeding practices, incidence of diarrhea, preceding birth interval, the mother's body mass index (BMI), household economic status, and delayed weaning.[10, 11] The influence of a child's sex and birth order has also been shown to be significant in previous studies. Additionally, socio-economic factors and diseases are recognized as critical determinants of child nutrition.[12] Research in India has consistently highlighted malnutrition as a significant risk factor for death in childhood.[13] Recent studies indicate that malnutrition rates are higher in rural and hilly areas than in metropolitan and urban regions.[14] Additionally, gender inequality, driven by socio-economic structures, has been identified as a significant factor affecting the nutritional status of children. Some studies suggest that mother's antenatal care-seeking behavior and healthcare knowledge are vital determinants of child nutrition, especially during infancy.[15]

Most prior studies have utilized on regression models to pinpoint the factors linked with malnutrition, generally concentrating on conventional dichotomous outcome variables such as wasting, stunting, and underweight. In contrast, this study employed a multivariate approach to explore the underlying factors influencing nutritional status, rather than relying on traditional regression analysis.[16] This approach offers significant advantages, particularly in avoiding issues like multicollinearity and heteroscedasticity, common in studies involving socio-economic variables. We aim to uncover the most plausible underlying factors contributing to malnutrition by analyzing a set of potential explanatory variables.

MATERIAL AND METHODS

The study utilizes secondary data from the National Family Health Survey (NFHS-5), carried out between 2019 and 2021 by the Indian Institute of Population

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

Sciences (IIPS) under the Ministry of Health and Family Welfare. The survey employed a stratified multi-stage cluster sampling design, providing detailed information on 232,920 children aged 0-59 months.[17] The analysis focuses on various explanatory variables, including the respondent's age at first birth, birth order of the child, the child's sex, the mother's age at the child's birth, patterns of antenatal care (ANC) visits by the mother, current breastfeeding status, the interval between births, educational levels of both parents, type of residence (urban/rural and regional), wealth index, and the duration of breastfeeding.

In NFHS-5, malnutrition prevalence is calculated following the guidelines of the WHO working group. The use of Z-scores is recommended due to their advantages over alternative measures. These Z-scores, which indicate the proportion of individuals in the study population whose nutritional indices fall below minus 2 standard deviations from the WHO's reference population standards, are crucial in categorizing malnutrition. Based on these Z-scores, malnutrition is categorized as follows: moderately malnourished (Z-scores between -3SD and -2SD), well-nourished (Z-scores ≥ -2SD), and severely malnourished (Z-scores < -3SD).

This research will use factor analysis based on principal components to extract the important factors influencing the nutritional status of children under five in India. A factor can be viewed as a possible measure representing a collection of real measurements with strong correlations with one another but weak correlations with the other measurements in the set. The correlations between the real and theoretical measurements or factors are known as loadings. A factor is found by looking at the factors that heavily load (or strongly correlate) on it. Using principal component analysis, orthogonal rotation (varimax option) generates non-correlated factors after factor extraction.[16,18] The adequacy of the factors will be assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy.[18] To evaluate the relationship between the covariates and the factors, factor loadings greater than 0.5 are considered significant, while cross-loadings (negative loadings) below -0.4 are also considered.[19] The ratio of an eigenvalue to the total eigenvalues represents the proportion of variation explained by a given component. The factor analysis arranges the latent roots in descending order, making it easier to identify the main structural factors. The Kaiser Criterion, which identifies factors with eigenvalues greater than 1.0, is used alongside the Scree plot (or Eigen plot) to determine the number of factors in a factor analysis.[19]

Regression analysis, which aims to explain a dependent variable with a linear combination of various features or measurements, is closely linked to linear discriminant analysis (LDA).The dependent variable in regression analysis is a numerical measurement, whereas for LDA, it's a discrete variable (i.e. the class label). Additionally, LDA offers the advantage of not requiring the normality assumptions typically needed in regression methods. In regression analysis, the dependent variable is typically a numerical quantity, whereas in linear discriminant analysis (LDA), it is a categorical variable, also known as a class label.[19] An additional advantage of LDA is that it does not need the normality assumptions often associated with traditional regression techniques. The statistical analyses in this study were conducted using SPSS (version 27) and Stata 18.1 (Stata Corp, USA).

RESULTS

According to NFHS-5, stunting, which indicates chronic undernutrition, affects 35.5% of children, suggesting that a substantial proportion of children under five have suffered from prolonged nutritional deprivation, impacting their growth and development. Wasting, a sign of acute undernutrition, affects 19.3% of children who are underweight for their height, indicating recent and severe weight loss. Among these, 7.7% are classified as severely wasted, putting them at immediate risk of mortality. Underweight status, which reflects both acute and chronic undernutrition, is observed in 32.1% of children.[17] These statistics highlight the serious public health issue of child undernutrition in India, underscoring the urgent need for focused interventions to enhance child health and nutrition. The percentage distributions for all three nutritional indices are depicted in Figure 1, further emphasizing the need for targeted interventions.

The percentage distributions of stunting, wasting, and underweight among children aged 0-59 months across various states and union territories (UTs) in India, as depicted in Figure 1, reveal significant disparities in

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

child malnutrition based on data from NFHS-5. Stunting, an indicator of chronic malnutrition, shows considerable variation across the states and UTs, emphasizing the need for region-specific interventions. The lowest levels of stunting are observed in Puducherry (20%), Sikkim (22.3%), and Andaman & Nicobar Islands (22.5%). In contrast, the highest stunting rates are found in Bihar (42.9%) and Meghalaya (46.5%), indicating that nearly half of the children in these regions suffer from chronic malnutrition. The national average stands at 35.5%, underscoring the significant regional disparities. Wasting, which reflects acute malnutrition, also varies widely. The lowest rates are recorded in Chandigarh (8.4%), Mizoram (9.8%), and Manipur (9.9%). However, Maharashtra (25.6%), Gujarat (25.1%), and Bihar (22.9%) report the highest wasting rates, suggesting a critical need for interventions to address acute malnutrition in these regions. The national average for wasting is 19.3%. The percentage of underweight children, a composite indicator of both acute and chronic malnutrition, is lowest in Mizoram (12.7%), Sikkim (13.1%), and Manipur (13.3%). On the other hand, the highest prevalence of underweight children is observed in Bihar (39.7%), Jharkhand (39.7%), and Gujarat (39.7%). The national average is 32.1%, indicating widespread malnutrition across the country.

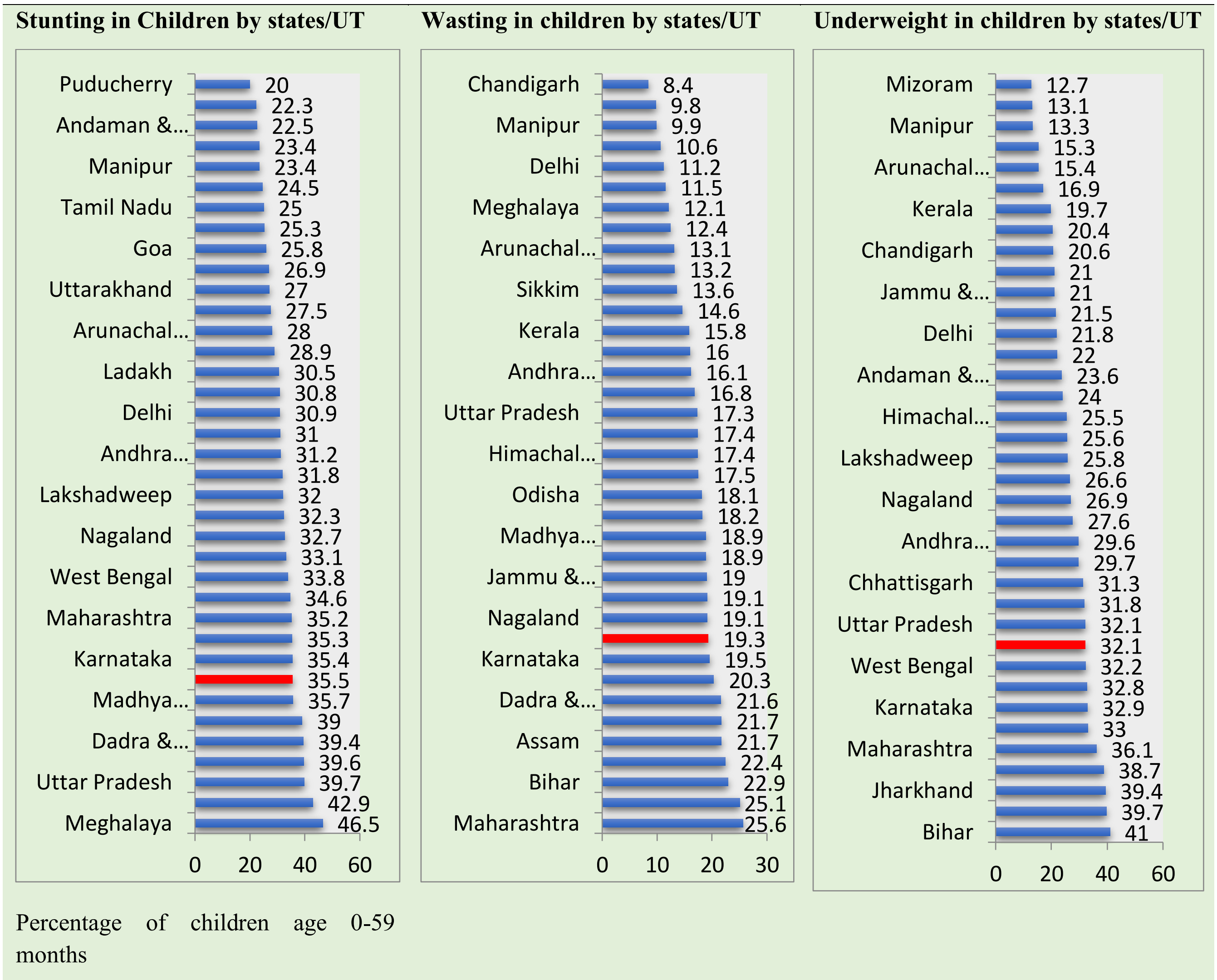

Figure 1: The percentage distributions all three nutrition indices of NHFS-5

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

In identifying significant factors affecting the nutritional status of under-five children, it is crucial to consider both socio-demographic and proximate covariates. These variables are diverse, and their strength and direction of influence on nutritional status may vary. The process involves two main steps: Identifying significant factors involves determining which factors are significantly associated with nutritional status. And determining the direction of influence involves understanding how these significant factors influence nutritional status (positively or negatively). The Rotated Component Matrix obtained from factor analysis helps identify significant factors by showing the loadings of each variable on the extracted components. Here is the provided Rotated Component Matrix (Table 1).

Table 1: Rotated Component Matrix for Assessing the Nutritional Status of Children Under Five in India (NFHS-5)

Variables	**Components**					
	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
Type of residence (urban or rural)	-0.3630	0.0288	0.0144	0.4511	-0.0602	0.0129
Mother’s level of education	0.4730	-0.2851	0.0349	0.2101	0.0372	0.0025
Wealth index	0.5328	-0.1069	0.0117	-0.1444	0.0211	0.0184
Mother's Age at Birth	0.1628	0.7026	0.0629	0.0370	-0.0141	0.0226
Age of respondent at 1st birth	0.3029	0.4362	0.3699	0.3782	-0.1797	0.0633
Birth Order of the Child	-0.1064	-0.0054	0.6272	-0.0223	0.1306	0.049
Sex of the Child	-0.0073	0.0011	0.2839	-0.0695	0.3986	-0.8293
Preceding birth interval(months)	0.1533	0.3743	-0.4425	-0.1985	0.5324	0.0497
Father’s level of education	0.4378	-0.2647	0.0184	0.2223	0.0667	0.0243
Frequency of antenatal care visits	-0.0059	-0.0322	0.4274	-0.565	0.1353	0.4112
Duration of Breastfeeding	-0.1258	-0.1069	0.0694	0.4168	0.6928	0.3643

** Rotation Method: Varimax with Kaiser Normalization. Extraction Method: Principal Component Analysis. Convergence: Rotation converged in 11 iterations

The direction of influence can be inferred from the sign of the loadings in the rotated component matrix. Positive loadings indicate a direct relationship, while negative loadings indicate an inverse relationship. Let's analyze each component's significant loadings (generally considered significant if they are greater than 0.4 or less than -0.4).

Type of place of residence shows the highest favorable loading on component 4 (0.4511), indicating it correlates most strongly with this component. Mother’s educational level has significant positive loadings on component 1 (0.473) and negative loadings on component 2 (-0.2851). Wealth index has the highest favorable loading on component 1 (0.5328), suggesting a strong correlation with this component. Mother’s age at birth loads most heavily on component 2 (0.7026). Age of respondent at 1st birth has notable loadings on component 2 (0.4362) and component 4 (0.3782). The birth order of index child loads strongly on component 3 (0.6272). Sex of child shows a strong negative loading on component 6 (-0.8293). Preceding birth interval (months) has notable loadings on component 5 (0.5324) and component 3 (-0.4425). Father’s education level has a solid favorable loading on component 1 (0.4378). Frequency/number of ANC visit shows notable loadings on components 3 (0.4274) and 4 (-0.565). Duration of

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

breastfeeding has the highest favorable loading on component 5 (0.6928).

The components are likely extracted to represent underlying dimensions such as socio-economic status, maternal and child health factors, and healthcare access/utilization, which influence the nutritional status of children. The rotation method used, Varimax with Kaiser Normalization, is instrumental in simplifying the interpretation by making the loadings of each variable on the extracted components more distinct.

Table 2: Summary of the Results from the Principal Component Analysis (PCA) for Nutritional Status of Under Five Children in India (NFHS-5)

Component	**Initial Eigenvalue**			**Extracted Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**Percentage of Proportion**	**Cumulative Percentage**	**Total**	**Percentage of Proportion**	**Cumulative Percentage**	**Total**	**Percentage of Proportion**	**Cumulative Percentage**
Comp1	2.203	20.000	20.000	2.203	20.000	20.000	2.134	19.575	19.575
Comp2	1.633	14.850	34.850	1.633	14.850	34.850	1.651	15.360	34.935
Comp3	1.072	9.750	44.600	1.072	9.750	44.600	1.090	9.563	44.498
Comp4	1.041	9.460	54.050	1.041	9.460	54.050	1.062	9.502	54.000
Comp5	1.018	9.260	63.310	1.018	9.260	63.310	1.030	9.320	63.320

The Principal Component Analysis (PCA) of the nutritional status of under-five children in India (NFHS-5) identified five key components that explain 63.31% of the total variance in the data. Component 1 is the most influential, accounting for 20% of the variance, with subsequent components explaining smaller portions. After rotation, the distribution slightly reduced to 19.575% of the variance among these components became more balanced, aiding in the interpretability of the results (Table 2).

Table 3: Summary Results of the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy of Factor Analysis for Nutritional Status of Under Five Children of India (NFHS-5)

Variables	***Kaiser-Meyer-Olkin measure of sampling adequacy (kmo)***
Type of residence (urban or rural)	*0.6547*
Mother's level of education	*0.6482*
Wealth index	*0.6859*
Mother's Age at Birth	*0.3875*

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

Age of respondent at 1st birth	*0.3912*
Birth Order of the Child	*0.6677*
Sex of the Child	*0.3179*
Preceding birth interval(months)	*0.2957*
Father's level of education	*0.7174*
Frequency of antenatal care visits	*0.4279*
Duration of Breastfeeding	*0.3049*
Overall	*0.5173*

The Kaiser-Meyer-Olkin (KMO) measure evaluates the suitability of data for factor analysis by assessing the proportion of variance among variables that might be common variance. The values range from 0 to 1, where higher values indicate that the data is more appropriate for factor analysis. A KMO value of 0.6 or above is generally considered acceptable for factor analysis. The KMO values for certain variables, such as Father's education level (KMO=0.7174), Wealth index (KMO=0.6859), Type of place of residence (KMO=0.6547), Mother's educational level (KMO=0.6482), and Birth order of index child (KMO=0.6677), were found to be above the acceptable threshold of 0.6. It indicates that these variables possess sufficient common variance to justify their inclusion in the factor analysis. However, other variables, including Mother's age at birth (KMO=0.3875), Age of respondent at first birth (KMO=0.3912), and Frequency/number of ANC visits (KMO=0.4279), Sex of child (KMO=0.3179), Preceding birth interval (months) (KMO=0.2957), and Duration of breastfeeding (KMO=0.3049) exhibited low KMO values below the threshold of 0.6, suggesting they may not be ideal for factor analysis. However, the low overall KMO value of 0.5173 for the dataset suggests that the variables might not be strongly interrelated, which could affect the robustness and interpretability of the factor analysis (Table 3).

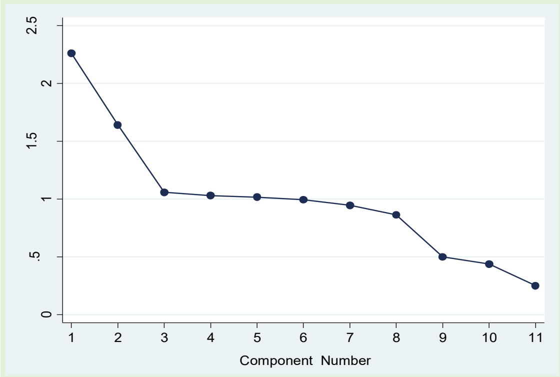

Figure 2: Scree Plot for Nutritional Status of Children under Five in India (NFHS-5)

The provided scree plot visually represents the eigenvalues for the components derived from the factor analysis of variables related to the nutritional status of under-five children. The horizontal line at an eigenvalue of 1.0 on the scree plot indicates that six factors were extracted for the nutritional status of children under five in the NFHS-5 (see Figure 2). The y-axis represents the eigenvalues, and the x-axis represents the component numbers. A horizontal line at an eigenvalue equal to 1 is a standard threshold to determine the number of factors to retain. Components with eigenvalues above this line are considered significant. The first two components have eigenvalues greater than 1, indicating they are significant and should be retained. Components 3 and 4 have eigenvalues close to or slightly above 1, suggesting they may also be considered significant. Components beyond the fourth component have eigenvalues below 1, indicating they explain less variance and might not be retained. Based on the scree

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

plot and the eigenvalue criterion, at least two components are significant for explaining the variance in the nutritional status of under-five children. There may be justification for considering up to four components based on the proximity of their eigenvalues to 1. The exact number of components to retain should be based on a combination of eigenvalue criteria, interpretability, and theoretical considerations. These significant components can then be further analyzed to understand their influence on nutritional status, aiding in developing targeted interventions to address malnutrition among under-five children.

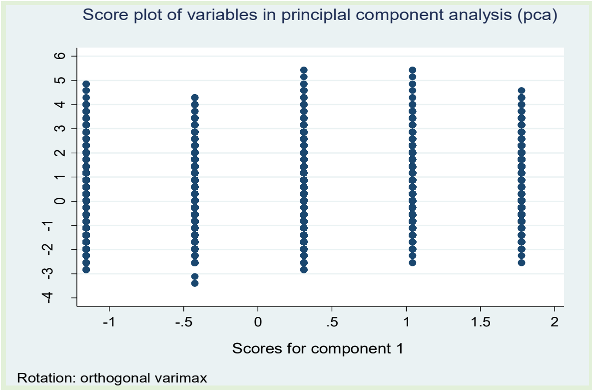

Figure 3: Score Plot of Variables in PCA for Nutritional Status of Children under Five in India (NFHS-5)

The provided image is a score plot from a Principal Component Analysis (PCA). This plot is a graphical representation showing how the observations (in this case, variables related to nutritional status) are distributed along the first two principal components (Figure 3). The score plot helps visualize the distribution and relationship of variables concerning the principal components. This visualization supports the interpretation of the PCA results, allowing us to understand the variance explained by the first two principal components and the relative positioning of the variables. Further analysis would involve examining the loadings (i.e., the contribution of each variable to the principal components) to understand better which variables are most influential in defining the principal components and, by extension, the factors affecting nutritional status.

The factor identified in the analysis plays a pivotal role as a crucial biological determinant of nutritional status. It exhibits a strong association with the mother's BMI, previous birth interval, and breastfeeding status. These variables have consistently been recognized in previous studies as key determinants of child nutrition. Research suggests that children born after a short birth interval of less than 24 months and those breastfed for less than 24 months are at a higher risk of malnutrition.[2,11] Longer birth intervals contribute positively to maternal health and enable parents to invest more time and resources in each child during their formative years, reducing financial strain and allowing parents to engage in other activities. Moreover, a mother's BMI serves as a significant indicator of child malnutrition. Considering these aspects, this factor is appropriately termed the 'mother's health and breastfeeding factor.

DISCUSSION

These findings highlight the significant regional disparities in the prevalence of stunting, wasting, and underweight across different states, and UTs highlight the uneven distribution of child malnutrition in India. States like Bihar, Uttar Pradesh, Jharkhand, and Gujarat consistently show higher percentages of stunting, wasting, and underweight, reflecting the severe nutritional challenges faced by children in these regions. Conversely, states such as Mizoram, Sikkim, and Manipur demonstrate better nutritional outcomes, suggesting the effectiveness of targeted interventions and better socio-economic conditions. The data underscores the need for state-specific strategies to address child malnutrition, focusing on regions where the indicators are most alarming. Understanding the underlying factors contributing to these disparities, such as food security, maternal health, healthcare access, and socio-economic conditions, will be crucial for developing effective policies and interventions to reduce malnutrition and improve child health outcomes across India.

According to the World Health Organization, Malnutrition is the most significant public health problem worldwide. Enhancing nutrition is one of the most effective forms of assistance. Studying the factors contributing to child malnutrition provides valuable insights for healthcare providers and public health planners, particularly in countries like India. In India, approximately 19.3% of children under five are wasted, 35.5% are stunted, and 32.1% are underweight, highlighting the urgent need for targeted interventions to address these issues.[17]

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

Although malnutrition poses a significant health risk for children under five, findings from both previous studies and the current research indicate that pre-birth factors, including the mother's age at childbirth, the preceding birth interval, and sufficient antenatal care, are crucial in determining an infant's physical condition and subsequent nutritional status. Special attention must be given to these areas to ensure infants are well-nourished and healthy. For promoting safe motherhood and ensuring neonatal health, earlier studies have recommended longer birth intervals and at least four antenatal care visits for the well-being of both the mother and the infant. It is well-established that adolescent mothers face a higher risk of delivering live births with severe health complications. Additionally, larger family sizes contribute to malnutrition, as higher parity is associated with an increased likelihood of malnourished births. The observed relationship between birth order and malnutrition supports this. One reason for this may be the difficulty in maintaining proper health and nutritional intake in larger families compared to smaller ones. While prolonged breastfeeding is common in India, the opposite is also observed. Therefore, breastfeeding should be emphasized, and healthcare providers should encourage mothers to feed colostrum immediately after birth, as it provides essential nutrients and protection for newborns.

The current study examines socio-economic and biosocial variables, utilizing multivariate techniques to ensure statistical significance. These methods are instrumental in addressing common issues in standard regression analysis, such as multicollinearity and heteroscedasticity. Through factor analysis, six distinct factors were identified, each named based on their loadings and cross-loadings from the rotated component matrix. These factors are labelled as 'consciousness factor,' 'birth history factor-1,' 'residence factor,' 'mother's capability factor,' 'mother's health and breastfeeding factor,' and 'birth history factor-2' in the order of the variation they explain. These six factors account for 63.3% of the total variation among 11 independent variables. The results suggest that these five components capture significant aspects of the nutritional status of children, with Component 1 being particularly dominant. However, the cumulative variance of 63.31% indicates that other factors are still not captured by these components. The PCA provides a valuable framework for understanding the multidimensional nature of child nutrition in India, which can guide further research and policy interventions. The Kaiser-Meyer-Olkin (KMO) values exceeding 0.6 are deemed acceptable. In this study, variables like Father's education level and Wealth index surpassed this threshold, making them suitable candidates for factor analysis. However, the overall KMO score of 0.5173 indicates that the interrelationships among the variables are relatively weak, which could compromise the robustness of the factor analysis.

Various common clusters also influence the nutritional status of children. In developing countries, regional disparities often influence public health indicators, a trend confirmed by the current study. The third factor identified was the residence factor, highlighting that children in rural areas are more affected by undernutrition. Additionally, the nutritional landscape varies across different regions. To address this issue, targeted campaigns are necessary in specific districts and rural areas to improve the situation. They encourage mothers in rural areas to seek childcare services at NGO satellite clinics and government facilities. Another significant distinction based on the wealth index shows that malnutrition rates are lower in wealthier families than in those with lower economic status.

Despite the various determinants and factors contributing to malnutrition, consciousness remains the most critical factor. Nearly all previous studies identify consciousness as the primary differentiator in a child's nutritional status. Education is crucial in fostering this awareness among mothers, enhancing their health-seeking behaviors for themselves and their children. Mass media can significantly contribute by promoting education and raising parents' awareness. Unfortunately, gender disparities still exist as a determinant of child malnutrition, with higher rates observed among female children, a situation that is unacceptable in the 21st century. Increasing women's education is essential to overcoming this issue. Additionally, the socio-economic challenges, such as gender and religious influences, can be effectively addressed through widespread mass media campaigns aimed at raising awareness about malnutrition and its consequences.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 3552-3562 | ISSN:2251-6727

Conclusion

Understanding the determinants of child malnutrition through studies like NFHS-5 provides valuable guidance for healthcare providers and public health planners. By focusing on key factors such as maternal education, socio-economic status, and healthcare access, targeted interventions can be designed to combat malnutrition effectively. These insights are particularly relevant for countries like India, where child malnutrition remains a critical public health issue. Addressing these challenges requires a comprehensive approach, combining immediate nutritional support with long-term socio-economic improvements.

Declarations

Availability of data: NFHS data is a nationally representative data set which available freely in public domain.

Funding: Authors did not receive any funding to carry out this research.

Ethics approval and consent to participate: The data is freely available in the public domain and survey agencies that conducted the field survey for the data collection have collected prior consent from the respondent. It also guaranteed that the participants' privacy was protected and that informed consent was obtained from respondents during the survey. Therefore, prior ethical approval for using the datasets was not required.

Consent for publication: Not applicable

Competing Interests: The authors declare that they have no competing interests.

Author's contribution: NKY and NCK contributed in conceptualizing the study. NKY, SS are responsible for the analysis. NKY, NCK, and SS were contributed to the interpretation of the data, and critically revised all versions of the manuscript and approved the final version.

Acknowledgements: Not applicable

REFERENCES

1. Rice AL, Sacco L, Hyder A, Black RE. Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. Bulletin of the World Health organization. 2000;78(10):1207-21.
2. McGregor GS, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B. Developmental potential in the first 5 years for children in developing countries. The lancet. 2007 Jan 6;369(9555):60-70.
3. Gomez P, Ramos Galvan RR, Frenk S, Cravioto Muñoz J, Chávez R and Vázquez J. Mortality in second and third degree malnutrition. Journal of Tropical Pediatrician 1956; 2(2):77-83.
4. Bairagi R, Chowdhury MK. Socioeconomic and anthropometric status, and mortality of young children in rural Bangladesh. International journal of epidemiology. 1994 Dec 1;23(6):1179-84.
5. Blossner M, De Onis M, Prüss-Üstün A. Malnutrition: quantifying the health impact at national and local levels. World Health Organization; 2005.
6. Thang NM, Popkin BM. In an era of economic growth, is inequity holding back reductions in child malnutrition in Vietnam?. Asia Pacific Journal of Clinical Nutrition. 2003 Dec 1;12(4).
7. WHO Working Group. Use and interpretation of anthropometric indicators of nutritional status. Bulletin of the World health organization. 1986;64(6):929.
8. UNICEF-WHO-World Bank: Joint Child Malnutrition Estimates (2021) edition. Available from: https://data.unicef.org/topic/nutrition/malnutrition.
9. Nelson GC, Rosegrant MW, Koo J, Robertson R, Sulser T, Zhu T, Ringler C, Msangi S, Palazzo A, Batka M, Magalhaes M. Climate change: Impact on agriculture and costs of adaptation. Intl Food Policy Res Inst; 2009.
10. Begin F, Habicht JP, Frongillo Jr EA, Delisle H. The deterioration in children's nutritional status in rural Chad: the effect of mothers' influence on feeding. American Journal of Public Health. 1997 Aug;87(8):1356-9.
11. Siddiqi MN, Haque MN, Goni MA. Malnutrition of under-five children: evidence from Bangladesh. Asian Journal of medical sciences. 2011 Sep 17;2(2):113-9.
12. Madzingira N. Malnutrition in children under five in Zimbabwe: effect of socioeconomic factors and

disease. Social Biology. 1995 Sep 1;42(3-4):239-46.

13. Chen LC, Chowdhury AA, Huffman SL. Anthropometric assessment of energy-protein malnutrition and subsequent risk of mortality among preschool aged children. The American journal of clinical nutrition. 1980 Aug 1;33(8):1836-45.
14. Muaz SS, Hasan MR, Shamim SA, Dev A, Kamar S. Nutritional status of 1-5 years children of the tea workers in Sylhet division. Bangladesh Journal of Child Health. 2010;34(1):11-6.
15. Cochrane SH, Leslie J, O'Hara DJ. Parental education and child health: intracountry evidence. Health policy and education. 1982 Mar 1;2(3-4):213-50.
16. Hair JF, Anderson RE, Tatham RL and Black WC. Multivariate Data Analysis with Reading. 4th ed. New Jersy: Prentice Hall, 1995.
17. IIPS, & ICF. National Family Health Survey (NFHS-5): 2019-21 India. Mumbai: International Institute for Population Sciences (IIPS). 2021.
18. Mardia KV, Kent JT, Taylor CC. Multivariate analysis. John Wiley & Sons; 2024 Aug 5.
19. Johnson RA, Wichern DW. Applied Multivariate Statistical Data Analysis. New Jersey: Prentice Hall, 2002.