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Original Research Article

A Cross-Sectional Study on Nutritional Deficiencies in School Children

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Abstract:

Background: Deficiency in nutrition has effects on growth, cognition and academic performance among school aged children. Although the programs on nutrition, targeting the general population, are present, micronutrient deficiencies persist, especially in less developed settings.

Aim: The objective of the study was to determine the prevalence and the effect of nutritional deficiencies among school children and the potential effect of the socioeconomic correlations and school-based interventions to nutritional status.

Methods: A cross-sectional study was conducted among 280 children (urban and rural schools that were associated with Department of Pediatrics, Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand, India, aged 6-12 years. The diet, anthropometry and biochemical iron, vitamin D and iodine data were collected and analyzed with the help of SPSS v25.

Result: 58.57% of children were also deficient in at least one [mostly of iron (33.57%), vitamin D (26.79%), and iodine (24.29%)]. The nutritional deficits had a major toll on growth and cognition ($p<0.01$). Socioeconomic factors, including parental education, household income, and access to adequate health care services were all correlated with nutritional status. Children in school-based programming, especially the Mid-Day Meal scheme, had significantly better nutritional indicators (73.57%, $p < 0.001$).

Conclusion: Nutritional deficiencies persist at high levels among school children, showing need for integrated nutritional, educational and socioeconomic approaches to support optimal growth and learning.

Keywords: Nutritional Deficiency, School Children, Iron Deficiency, Vitamin D, Iodine, Cross-Sectional Study, Socioeconomic Factors, School Nutrition Programs.

Introduction

Nutritional deficiencies, especially in the years of growth and schooling, entail significant risks to health, cognitive development, and academic achievements. The school-age period is indeed a transitional stage of growth that is very rapid and involves physical, mental, and emotional changes. It is regarded as the most important period for nutritional intake since the quality and quantity of intake at this stage influence the individual's general health, educational attainment, and productivity in later life. Proper nutrition ensures not only the growth of bones and tissues but also brain development, immune functions, and psychosocial development that are important for optimal outcomes in later adulthood.[1]

Malnutrition among school-aged children can be present in various forms, that is both undernutrition and micronutrient deficiencies. The latter are of special concern as most of the time they occur and remain asymptomatic until a complication can arise. Some of the common nutritional deficiencies include inadequate intake of essential vitamins and minerals like iron, vitamin D, calcium, iodine, and vitamin A. These may have unfortunate implications for health, such as anemia, stunted growth, immune impairment, and restricted learning ability. Iron deficiency anemia, for example, is considered one of the most common nutritional disorders in children worldwide and causes chronic fatigue, lack of concentration, and poor school performance. In addition, inadequate vitamin D and calcium results in poor skeletal growth along with a heightened chance of developing skeletal deformities, with deficient iodine intake contributing to goiter and delays in finding one's developmental milestones. These deficits diminish a child's full potential for physical and cognitive growth. [2]

The burden of malnutrition, repeated by each generation, has been of concern to such global health organizations as the WHO, UNICEF and FAO. All view the action to address nutritional deficiencies as a pressing need to resolve an issue of public health. Even though the burden of malnutrition has reduced due to some public health improvements and increases in food security in most of the world, it remains a serious challenge in much of the developing world. In this respect, lingering nutritional deficiencies are indicators of a complex relationship between inadequate dietary intake or infections, poor sanitation, and limited access to health and education. These relationships all suggest that nutrition-sensitive and nutrition-specific approaches are part of an overall holistic approach to address nutritional deficiencies.

Nutritional deficiencies in numerous developing countries are further complicated by socio-economic factors such as low income, low parental knowledge and awareness, food insecurity, and lack of access to a complete diet. Families with limited financial resources are particularly vulnerable to deficiencies primarily due to their limited dietary diversity and dependence on energy-dense, low-cost foods that are deficient in nutrients. Nutritional inequalities exist between children in varying socio-economic circumstances even in developed nations. Income, parental education, urban vs rural residence, and cultural food preferences all shape the dietary pattern of children. These inequalities lead to nutritional consequences that may lead to undernutrition and overnutrition in children. Additionally, school-age children are in a vulnerable phase of development based on their increased nutritional needs during growth spurts, peer behaviors, and the media's influence on food selection. [4]

As such, schools have a critical position in the prevention of nutritional deficiencies through their policies. Schools provide a broad-based platform where nutrition interventions can have a large-scale impact on many children from diverse backgrounds. School-based nutrition programs have been linked to improved dietary diversity, knowledge of healthy eating, and general health outcomes. These programs often provide fortified meals at school with dietary micronutrient supplementation, and nutrition education in the school curriculum. Regular screening and assessment of children's nutritional status in schools can also assist in early identification and management of deficiencies. In addition, parental, teacher, and community involvement in such initiatives increases their sustainability and effectiveness. [5]

In recent years, the place of school nutrition programs has become increasingly important in light of the global disruption brought about by the COVID-19 pandemic. To be sure, the pandemic has caused a significant impact on the nutrition of children through the closure of schools as an important access point to nutritious meals for millions of children across the world. For many children, mainly from poor families, school feeding programs provide a significant source of daily nutrient intake. In places where these programs were interrupted because of lockdowns, the threat of food insecurity and malnutrition particularly rose among the vulnerable population. The economic pressures brought about by the pandemic reduced the purchasing power of households and restricted consumption of nutrient rich foods by households. The unfair access to nutrient rich food underlines the importance of strong adaptable nutritional support systems which can be put into operation during times of crisis [6,7].

Against this background, the next important issue will be the occurrence and impact of nutrient deficiencies in school-going children. The awareness of the extent and nature of said deficiencies will offer valuable guidance to policymakers, practitioners and the public health professionals that will assist in setting up right interventions to correct those deficiencies in a community setting. Cross-sectional study is a serious methodological approach to investigating the nutritional status of children at any given time, whether the deficiencies have any possible correlations and how the nutritional status actually relates to academic performance. The policy and programmatic perspectives will definitely inform the evidence that will be used to form these findings.

It is hoped that the present research will determine the levels of deficits in nutrition among school-aged children; implications of the deficit on the early diagnosis and treatment; and emphasis on prevention as the point of intervention. Ultimately, the study will focus on establishing key determinants and consequences that will support the development of effective nutrition related policy and programming, to maximize growth and cognitive development, and overall well-being of school-aged children. Deficiencies of nutrition in childhood will not only improve health outcomes that are currently of concern but will create the necessary premise for the long-term health benefits of a healthier and more productive future society.

Methodology

Study Design: This study was implemented as a cross-sectional observational research project, to assess nutrition status and prevalence of nutritional deficiencies in school-aged children and examine the association of sociodemographic and dietary related factors with nutritional outcomes.

Study Area: This study was conducted by the Department of Pediatrics, Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand, India

Study Duration: The study was conducted over a period of 12 months.

Study Population: The study population consisted of school-going children aged 6–12 years studying in selected urban and rural primary schools within the jurisdiction of Department of Pediatrics, Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand, India

Sample Size: The selected sample consisted of 280 children in total. The participants for the research study were selected using a stratified random sampling method to obtain an adequate representation from different socio-economic backgrounds and geographic locations (urban and rural).

Inclusion Criteria

- Children aged 6 to 12 years enrolled in participating schools during the study period.
- Parental or guardian consent and child assent obtained prior to participation.
- Children who were apparently healthy and willing to participate in all assessments.

Exclusion Criteria

- Children with known chronic diseases affecting nutritional status (e.g., celiac disease, chronic kidney disease, malabsorption syndromes).
- Children on long-term medication that could influence growth or nutritional parameters.
- Children whose parents or guardians did not provide consent for participation.

Data Collection: Data was collected from selected primary schools through structured and standardized methods. Health and demographic information were obtained from school health records and parent interviews. Dietary intake was determined by a validated Food Frequency Questionnaire and 24-hour dietary recall in order to assess eating habits and nutrient intake. Anthropometric measurements of height, weight, and body mass index were measured using calibrated instruments in accordance with standard World Health Organization protocols. Venous blood samples were also taken from participants for biochemical analysis of micronutrient status, including iron, vitamin D, and iodine. Data collection was conducted by trained research assistants with oversight from pediatric faculty. Before data collection began, the researcher formally requested and received consent from school authority. Parents were also given information to describe the purpose and procedures of the study. The researcher obtained informed consent from parents before data collection, and assent was obtained from the children.

Sample Processing: Blood samples were collected aseptically and sent to Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand, India central laboratory. To determine iron status, serum vitamin D (25(OH)D), and iodine status on the urine, haemoglobin and serum ferritin were measured using standard laboratory procedures. Any blood samples have been properly processed and tested according to the quality control requirements to ascertain that right laboratory results would be obtained to make the study.

Procedure: Before data collection, school officials, families, and students were informed via a preemptive briefing about the study's purpose and procedures. Anthropometrics, dietary surveys, and biological sampling took place on established days by trained investigators at each participating school. All assessments were completed at morning times, under standardized conditions. Each child performed all the assessments separately with the best possible accuracy and reliability of information. Blood and urine samples were obtained under asepsis and were promptly identified and taken to a central laboratory for biochemical analyses after collection. Data were screened daily for completeness and accuracy and subsequently were entered into a data file for analysis.

Statistical Analysis: The data that were collected were all entered into and then analyzed using version 25.0 of the statistical analysis software (IBM SPSS Statistics). Characteristics of demographics, dietary, and biochemical parameters were summarized by descriptive statistics including means, standard deviations, frequencies, and percentages. A chi-square test was used to compute relationships between categorical variables. Independent t-tests and ANOVA were used to test mean differences of several groups. A multivariable regression analysis was performed to determine independent predictors of nutritional deficiencies accounting for potential confounding variables including socioeconomic status, dietary patterns, and area of residence. A p-value of 0.05 or less was determined to be statistically significant for all analyses."

Result

Table 1 presents the prevalence and overall effect of nutritional inadequacies in 280 school age children, which has an important nutritional deficiency burden for physical and cognitive growth and development. More than half of children, 164 (58.57%), were classified as having at least a nutritional inadequacy, 95% CI: 52.72%–64.19%, p = 0.001, reflecting that inadequate micronutrient uptake is common. The mean score for impairment to growth was 48.52, 95% CI: 136.29–147.71 p = 0.006, concluding that nutritional inadequacies lead to lower height, lower weight and lower overall growth indicators. Likewise, the mean score related to cognitive performance was 49.86, 95% CI: 146.13–157.87, p = 0.004, which indicated diminished attention, memory and academic performance because of nutritional inadequacy. In concert, most of the parameters made up of Constitutive Indicators were associated with significance (p value) represented the strong significance of the association between poor nutrition status and physiological and cognitive development of the children. This demonstrates the need for early identification and dietary intervention, including nutrition education to ameliorate the children's overall health and development.

Table 1: Prevalence and Impact of Nutritional Deficiencies (N = 280)			
Parameter	**Value / Mean (SD)**	**95% Confidence Interval**	**p-value**
Children with ≥1 deficiency (n, %)	164 (58.57%)	52.72% – 64.19%	0.001
Impact on Growth (score)	142 (48.52)	136.29 – 147.71	0.006
Impact on Cognitive Performance	152 (49.86)	146.13 – 157.87	0.004

Table 2 shows the overall prevalence of major micronutrient deficiencies among our participants (280 school-aged children) and demonstrates a significant burden of nutrition insufficiencies that are potentially affecting growth and health. Iron was by far the nutrient of utmost interest in relation to anemia and cognitive impairment in children with 33.57% of school-aged children having iron deficiency (95% CI: 28.30%39.29, p < 0.001). The vitamin D deficiency in children was reported as 26.79% (95% CI: 21.94% to 32.26, p = 0.001) and probable was the failure to provide sufficient sun exposure on children, as well as poor dietary adequacy and supplementation. The concern on iodine deficiency (urinary iodine <100 µg/L and average urinary iodine of replaced iodine <100 µg/L) also rose to 24.29% (95% CI of 19.63%29.63, p = 0.002) which may be explained by the ongoing lack of iodine fortification of the food supply and the awareness of the use of iodized salt in the population. All nutrients also had statistically significant p-values to indicate a strong justification for concluding that micronutrient deficiencies are common, and clinically concerning, within our sample. In sum, these findings highlight continued and increasingly urgent needs for strengthened school nutrition, fortified food models, and community-based public health and capacity-building programs to address these common vulnerabilities to preventable micronutrient deficiencies.

Table 2: Prevalence of Key Micronutrient Deficiencies (N = 280)				
Nutrient	**n**	**Prevalence (%)**	**95% Confidence Interval**	**p-value**
Iron Deficiency	94	33.57%	28.30% – 39.29%	<0.001
Vitamin D Deficiency	75	26.79%	21.94% – 32.26%	0.001
Iodine Deficiency	68	24.29%	19.63% – 29.63%	0.002

Table 3 depicts the influence of primary socioeconomic determinants on the nutritional status of 280 school-aged participants, consistent with the multi-dimensional nature of nutritional outcomes. The mean score reflecting impact of health care access was the highest at a score of 3.01 ± 0.47 (95% CI: 2.95–3.07, p = 0.0004), which logically indicates that access to, and use of, health care is particularly important to support and improve nutritional outcomes among children because of early detection and intervention for medical and nutritional problems. The mean impact score of parental education was 2.86 ± 0.43 (95% CI: 2.79–2.93, p = 0.002) which reflects degree of parental knowledge and understanding about nutrition, food choice, and health practices that encourages thinking about child health. Income at the household level was also a significant predictor of child nutritional status, with mean score of 2.81 ± 0.46 (95% CI: 2.74–2.88, p = 0.001), supporting the relationship between economic resources and food security and nutrition quality. Overall, the data suggest socioeconomic determinants are significantly related to child nutritional status; therefore, they suggest that policy should consider counseling of lower economic resources, as well as the ramifications of education and access to health care, for improvement of overall nutritional status and increased nutritional safety and stability among children.

Table 3: Impact of Socioeconomic Factors on Nutritional Status (N = 280)			
Socioeconomic Factor	**Mean Impact Score (SD)**	**95% Confidence Interval**	**p-value**
Household Income	2.81 (0.46)	2.74 – 2.88	0.001
Parental Education	2.86 (0.43)	2.79 – 2.93	0.002
Access to Healthcare	3.01 (0.47)	2.95 – 3.07	0.0004

In this study, Table 4 is a summary of the effectiveness of various school-based nutrition intervention programs among 280 students in the study. The most successful program was the Mid-Day Meal Program of which 73.57 percent of the students (95 percent confidence interval [CI] 68.11%78.39%], p = 0.0001) showed improvements in the child nutritional outcome and other key health indicators. The Nutrition Education Sessions was found to be effective 67.14 (95 percent confidence interval [CI] 61.44%72.38%, p = 0.0002,) and was grounded on the intervention being the gains in awareness and change of behavior about eating unhealthy foods. The School Health Check-up Program was effective with a 61.07 percent (95 percent confidence interval [CI] 55.25%66.60% p = 0.0008,) that was founded on early detection and subsequent monitoring of health indicators in children with an emphasis on increasing health and nutrition results. Overall, all the interventions proved to be effective and statistically significant, which additionally supports the idea that combinatorial school-based interventions are required in enhancing nutrition outcomes and eliminating the issue of hunger and malnutrition among school-going children, particularly when meals, education, and health monitoring are used.

Table 4: Effectiveness of School-Based Nutritional Intervention Programs (N = 280)

Intervention Program	n	Effectiveness (%)	95% Confidence Interval	p-value
Mid-Day Meal Program	206	73.57%	68.11% – 78.39%	<0.0001
Nutrition Education Sessions	188	67.14%	61.44% – 72.38%	0.0002
School Health Check-up Program	171	61.07%	55.25% – 66.60%	0.0008

Discussion

In the current research, our findings revealed that nutritional deficiencies were very prevalent in the screening children with the percentage of children with one or more vitamin or mineral deficiencies being 58.57. The facts of nutritional deficiencies coincide with Stormark et al. (2019) [8], where deficiencies were found to have a considerable impact on the physical and mental health outcomes of children, which is linked to the quality of diet and their further development. Dreger et al. (2015) [9] also documented the same as those children who were poorly fed showed developmental delay, poor academic performance, which were also similar to the already available findings that deficiencies were associated with the severely poor growth (mean 48.52, p=0.006) and the poor academic performance (mean 49.86, p=0.004). The fact that the similarities exist is suggestive of the fact that nutritional deficiencies are a prominent issue of health in the world with negative developmental effects primarily in children that are at the growing age.

Iron deficiency (33.57 of subjects) was the principal micronutrient deficiency in our study, followed by vitamin D deficiency (26.79 of the subjects) and iodine deficiency (24.29 of the subjects). This also aligns with what is being quoted by Suchert et al. (2015) [10]; a global prevalence of micronutrient deficiencies among school aged children specifically since the low-to-middle income setting. Simultaneously, at the same time the authors Ceri et al. (2017) [11] suppose that the deficiencies are a continuing issue that is negatively related to the stunted physical development and deteriorated cognitive prospects. The prevalence of deficiencies is high indicative of anemia that will probably refer to iron deficiency causing inability to think, pay attention to an object, and achieve high academic results. The lack of vitamin D is an indication of reduced exposure to sunlight and/or lack of food variety; vitamin deficiencies, as reported by Thornton et al. (2014) [12], are related to increased rates of infections and lower body protection in school aged children. Simultaneously, it could be the case that iodine deficiency is indicative of inadequate food consumption or non-regular use of iodine salt in cooking; it is also reported in the same economically-status society that consumption is well below the recommended levels. These data confirm the existence of multiple micronutrient deficiencies existing among child populations that in combination with each other have a compounding effect on the physical and cognitive development (Ceri et al., 2017) [11].

In our study, socioeconomic determinants played a major role in nutrition outcomes. As an instance, children with low-income backgrounds showed an increase in rates of nutritional deficiencies, as showed by the impact of income on the mean score (2.81, p = 0.001). This is in line with the claim by Thornton et al. (2014) [12] purporting that dietary diversity and consumption of nutrient-dense food was limited due to insufficient funding. Moreover, the education of parents also made a significant contribution to the status of nutrition with an average of 2.86 (p = 0.002) when also corresponding to the findings of Inchley et al. (2020) where children of educated parents usually showed better diets and health results (2.86) on average. Also, interestingly, access to health care, mean score = 3.01 and p = 0.0004 was the highest association to nutrition outcomes which have been postulated by other single studies seem to indicate that prevention health care and early nutritional interventions can prevent malnutrition in childhood. In general, the results constituted causative dependent variables of socio-economic determinants describing the multidimensionality of malnutrition, which is connected with inadequate resources, health literacy and access to medical resources to survive in generations.

When we compare our results with others we may point out some inconsistency. In one instance, Dreger et al. (2015) found that the simultaneous nutritional deficiencies were lower, which means that the discrepancies might be explained by the eating behavior, socio-economic structure, or a policy of regional fortification in various parts of the globe. Besides, the percentage of vitamin D deficiency reported by our sample (26.79) was more significant than the mean global reported by Suchert et al. 2015 [10]. This could be a symptom of environmental or cultural extent restricting the possibility of spending time outside, and proper food intake. In short, the general tendencies that can be observed in the above prevalence of deficiencies, and dependence on socio-economic status, a little international data which further splits the problem in the society, anywhere.

Our results showed interventions at school to be successful. The best intervention in education was the Mid-Day Meal Program where it reached 73.57% of children ($p < 0.0001$) and nutrition education session where it reached 67.14% and school health checks reached 61.07. In respect of these results, Sheftall et al (2016) [14] observed that a majority of the organized meal interventions, both in terms of nutrition education, led to a positive outcome measure of nutrient intake and dietary knowledge in children. The promise of comprehensive school-based models which integrated nutrition, health monitoring and education were also mentioned by Bor et al (2014) [15] to have significant impacts on the ability of better nutritional status and well-being. Overall, this research indicates that school-based programming is likely to be effective, which implies that various standardized, low-cost programs might be developed, and the significant population health initiative may be implemented to address nutritional deficiencies, especially in children of the underserved population.

In spite of the fact that our results generally coincide with the reported findings in the literature, these are regionally specific. We have shown a greater cumulative prevalence of micronutrient deficiencies than the world data synthesized by Ceri et al. (2017) [11] and is explained by the regional problem of food availability and food behavior. Although Inchley et al. (2020) [13] reported psychosocial and behavioral mechanisms influencing nutrition of adolescent, our findings suggested a more immediate influence of socioeconomic obstacles and built environments that influence the nutritional conditions of children.

To summarize, the results indicate that micronutrient deficiencies are a societal health emergency in children of school-going age that is dictated by biological and social factors. Overall, these results give some similarity of evidence with the past concerning the current research, though it has certain degree of universality, the contrasts clarify the contextual hurdles that must be reacted through local solutions. The long-term development of school-based nutrition program along with the elimination of socioeconomic factors can help to relieve the level of micronutrient deficiencies, enhance growth, and support the cognitive development and school-aged children.

Conclusion

This cross-sectional study shows that prevalence of nutrition deficiencies among school-aged children is a major burden with over half of the study population having at least one of the deficiencies. Also, deficiencies were strongly and negatively associated with both growth and cognitive ability, which suggests that inadequate nutrition still has an impact on the physical and intellectual growth of children. The most common were iron, vitamin D and iodine deficiencies, which showed how complications of malnutrition are not only insufficient calories, but they are also the lack of essential micronutrients that are required to maintain optimal health. Lower household income, parental education level, and poor access to healthcare were all important factors in determining the nutrition status of children, which is a reminder that other more social and economic injustices exist and have an influence on health. On an optimistic note, school-based nutrition interventions; more so Mid-Day Meal Program, nutrition education sessions and health checks seemed to be effective in nutrition outcomes and nutrition awareness. This study on the whole showed that there is the urgent necessity of community- and school-based interventions of an all-encompassing and multi-faceted nature to focus on dietary deficiencies and socioeconomic factors to promote good health, and both healthy physical and cognitive development and good health of school-aged children.

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