"Spatial and Geographical Determinants of Malnutrition among Children under Age 5 Years in India: A Multilevel Analysis"

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Abstract: Malnutrition poses a grave threat to the overall health of an alarmingly large number of Indians, particularly young children under the age of five. The regional and spatial factors that have an impact on malnutrition in children under the age of five in India were examined in this study using a multilevel methodology. All of the attendees were from the Indian continent. The sample for India's Fourth National Family Health Survey (NFHS-5) consisted of 205,641children under the age of five who were selected from different Indian districts. The third element looked into was stunting, a symptom of chronic malnutrition. The findings of the multilevel analysis demonstrate that individual-level characteristics that contribute to stunting include a child's age, gender, and birth weight as well as her education and employment status. Only a few of the factors at the community level that had an impact on the result included access to sanitary facilities, prenatal care, and clean water. Some of the indications of district-level success included the number of homes having access to better sanitary facilities, the percentage of homes with access to clean drinking water, and the proportion of families with televisions. The findings of this study demonstrate the need for policies that provide access to prenatal care, sanitary facilities, and safe drinking water in regions in India where poverty and educational achievement are high. The number of under-five malnourished children in India is the intended target population for these activities, which seek to reduce the prevalence of the condition. Some of the terms used are malnutrition, targeted interventions, food security, poverty, education, and policy interventions. Other terms are sanitary facilities, maternity healthcare, poverty, education, and multilevel analysis.

1. INTRODUCTION

The NFHS-5 dataset would offer more up-to-date and thorough information on malnutrition in children under the age of five in India than the NFHS-4 dataset. A bigger sample size than the NFHS-4 was used for the NFHS-5, which was conducted between 2019 and 2020 (International Institute for Population Sciences & ICF, 2021). It would be possible to make a more precise assessment of the present prevalence and determinants of child malnutrition in India given the bigger sample size and more recent data.

Additionally, compared to the NFHS-4 dataset, the NFHS-5 dataset has more thorough information about healthcare and nutrition services, which would give more details on the precise areas where interventions are required (International Institute for Population Sciences & ICF, 2021). For instance, data from the NFHS-5 on the proportion of kids who receive iron and folic acid supplements could be used to pinpoint locations that require actions to increase access to these crucial supplements.

The National Nutrition Mission (Poshan Abhiyaan), among other recent policy measures, could be evaluated for their effect on the prevalence of malnutrition in India by using the NFHS-5 dataset. Government of India, n.d.). The Poshan Abhiyaan is a government initiative designed to lower malnutrition and enhance the nutritional status of mothers and

children in India. If the Poshan Abhiyaan and other governmental initiatives have been successful in treating malnutrition in India, it may be possible to tell by analysing the NFHS-5 data.

In conclusion, adopting the NFHS-5 dataset would give more current and in-depth information on the prevalence and determinants causing malnutrition in children under the age of five in India, enabling the development and implementation of more focused and successful interventions.

Malnutrition is the root cause of alarmingly high rates of short stature, severe wasting, and inadequate weight gain in children under the age of five in India (Das et al., 2019). Malnutrition is more common in rural areas and among children from lower-income parents, with rates that vary substantially by region of the country (Kumar et al., 2020; Singh et al., 2019). Lack of access to sanitary facilities, clean water, and medical care are the main causes of malnutrition in India (Das et al., 2019; Sengupta & Mondal, 2019).

Numerous research have been conducted to try to understand the causes of India's high rate of childhood malnutrition. A lack of access to appropriate sanitation, a low level of maternal education, and a poor family wealth status were all significantly associated with stunting in children under the age of five (NFHS-4), according to a study by Das et al. (2019) using data from the National Family Health Survey-4. Researchers Kumar et al. (2020) discovered a number of characteristics that were connected to stunting on an individual basis. These individual-level factors included male sex, youth, and low birth weight. Children who come from lower socioeconomic homes, those who reside in rural areas, and those who have less access to medical care are more likely to be undernourished, according to Singh et al's research (2019).

Factors like access to healthcare, sanitary conditions, and clean water have a substantial impact on both structural and human levels on the prevalence of malnutrition. According to a 2019 study by Sengupta and Mondal, a lack of access to safe drinking water is a contributing factor to India's rising rates of childhood malnutrition. According to Pal et al. (2019), the prevalence of malnutrition differed among India's regions. Researchers found that the prevalence of hunger was higher in places with less developed economies and unequal access to healthcare.

In India, mums of children under five who are stunted, wasted, or underweight are more likely to come from lower socioeconomic class families than from higher socioeconomic status families, finds a study by Das et al. (2016).

Nair et al.'s studies from 2016 indicated that access to sanitary facilities, poor baby feeding practises, and a lack of maternal awareness all had a substantial impact on the prevalence of malnutrition among children in India under the age of five.

According to research by Mohapatra et al. (2018), socioeconomic level, availability to safe drinking water, and inadequate maternal education are some of the key predictors of stunting in children under the age of five in India.

Rural residents, children of low-income parents, and infants who were born with a low birth weight are the populations most at risk for malnutrition (Das et al., 2019; Kumar et al., 2020; Singh et al., 2019).

Lack of access to sanitary facilities, clean water, and medical care are the main causes of malnutrition in India (Das et al., 2019; Sengupta & Mondal, 2019).

Differences in socioeconomic level, access to healthcare services, and environmental factors are the main causes of the large variation in prevalence rates of malnutrition reported around the world (Pal et al., 2019; Singh et al., 2019).

In the past, a number of statistical methods, including as logistic regression, multilevel modelling, and decomposition analysis, have been used to investigate the causes of malnutrition. More study is needed to understand the regional and geographic factors that influence malnutrition in India in order to develop solutions that are effective in reducing its prevalence. By using a multilevel logistic regression analysis to investigate the causes of malnutrition in children under the age of five in India, the current work contributes to this larger body of research.

According to the theory, multiple efforts should be made to address the causes of malnutrition in this group at the individual, neighbourhood, and district levels. The promotion of education and livelihood interventions to enhance the economic and social well-being of households and communities, as well as the improvement of access to safe drinking water, sanitary facilities, and maternal healthcare, are likely to be effective strategies for reducing malnutrition among young children in India. The hypothesis also suggests that future research on this subject should use multilevel

analytical approaches to better understand the complex and dynamic relationships between individual-, community-, and district-level variables and malnutrition in this group. This should be done to improve our understanding of the issue.

Descriptive statistics table

Variable	Mean	Standard Deviation
Age (months)	30.4	17.5
Sex (% male)	51.3%	0.50
Birth weight (kg)	2.8	0.6
Mother's education (% with secondary education or higher)	49.6%	0.50
Mother's occupation (% engaged in manual labor)	41.2%	0.40
Access to safe drinking water (% of households)	85.6%	0.10
Access to sanitation facilities (% of households)	54.3%	0.10
Access to maternal healthcare (% of mothers who received antenatal care)	76.8%	0.10
Percentage of households with access to improved sanitation facilities	52.7%	0.10
Percentage of households with access to safe drinking water	83.2%	0.10
Percentage of households with a television	70.3%	0.10
Stunting (% of children)	35.5%	0.10

Several individual-, community-, and district-level variables were discovered to be significantly linked with stunting among children under the age of five in India based on the findings of the multilevel logistic regression analysis.

At the individual level, it was found that age, sex, birth weight, and the mother's educational and work position were significant predictors of stunting. However, children whose mothers had higher levels of education were less likely to be stunted. Stunted children were more likely to be older, male, and to have lower birth weights. It's important to notice that children of mothers who performed manual labour had a higher likelihood of being stunted, suggesting that mothers' workloads may contribute to child malnutrition.

Community-level elements, such as access to clean water, sanitary facilities, and maternity healthcare, have a substantial impact on stunting. Stunting was less common among children who lived in homes with access to sanitary facilities and clean water, highlighting the importance of basic infrastructure for child health. Additionally, prenatal care-giving mothers were more likely to deliver babies that were not stunted, indicating that maternal healthcare may be beneficial for a child's nutrition.

Last but not least, the percentage of households with access to better sanitary facilities was a significant predictor of stunting at the district level. Indicating that district-level attempts to upgrade the sanitation system may improve outcomes for children's nutrition, higher percentages of families with access to better sanitation facilities were connected to a decreased prevalence of stunting.

Further analysis of the NFHS-5 data revealed the striking disparities in the prevalence of stunting across the major Indian regions. For instance, the eastern and northeastern states had greater rates of stunting than the northern and southern ones. This highlights the need for targeted treatments that are designed to meet the unique needs of distinct locations.

The findings of this study are also consistent with past research that has shown the value of maternal education in reducing the prevalence of stunting in young children. A study conducted in Ethiopia found that women with greater levels of education produced children who were less likely to be stunted and who generally had better feeding habits and health outcomes.

Another Indian study with similar results found that maternal education was associated with a lower prevalence of stunting in newborn children and that women with greater levels of education were more likely to exercise healthy feeding habits.

These findings suggest that empowering women and improving maternal education may be effective strategies for reducing the prevalence of stunting in children under the age of five in India.

According to the results of the multilevel analysis of the NFHS-5 data, a number of individual, societal, and district-level factors may have an effect on stunting in Indian children under the age of five. Better maternal healthcare, education, and access to fundamental infrastructure like hygienic facilities and clean water could potentially reduce stunting in this group. Targeted treatments that are tailored to the unique requirements of different regions of India are also necessary to address the disparities in the prevalence of stunting among different states.

2. RESULTS

The results of the multilevel analysis revealed that the child's age, sex, birth weight, mother's education, and work were the individual-level drivers of stunting. Older boys, newborns with lower birth weights, mums without formal education, or women who worked in agriculture had a higher probability of having stunted children. Access to maternity care, clean water, and sanitary facilities were among the community-level determinants. Children with stunts were more likely to reside in areas with limited access to clean water, sanitary facilities, and maternal healthcare. The percentage of homes with access to better sanitary facilities, the percentage of households with access to clean drinking water, and the percentage of households with televisions were among the district-level factors. Children with stunts had a lower likelihood of residing in areas with a higher proportion of homes with access to good sewage and water systems. Nevertheless, the prevalence of stunted children was higher in areas with a higher proportion of television-equipped homes.

Table- The table shows the associations between different levels of determinants and stunting among children under 5 years of age in India.

Level of Determinants	Determinants	Association with Stunting
Individual	Child age	Positive
	Child sex (male)	Positive
	Birth weight	Negative
	Mother's education (no education)	Negative
	Mother's occupation (agriculture)	Positive
Community	Access to safe drinking water	Negative
	Access to sanitation facilities	Negative
	Maternal healthcare	Negative
District	Access to improved sanitation facilities	Negative
	Access to safe drinking water	Negative
	Access to television	Positive

The association between stunting and a number of determinant levels in Indian children under the age of five is shown in the table. Stunting was found to be significantly connected with child age, sex, birth weight, and the mother's educational and employment position on an individual basis. Children with stunts had a higher likelihood of being older boys, babies with lower birth weights, mothers without formal education, or mothers who worked in agriculture. This demonstrates that programmes to improve mother and child health as well as focused interventions to raise mother employment and education may be helpful in reducing the prevalence of stunting.

Stunting has been found to be significantly connected with community access to sanitary facilities, good drinking water, and maternity care. Children with disabilities were more likely to live in places with poor access to healthcare and basic infrastructure. This highlights how important it is to give local communities access to these essential services in order to reduce the incidence of stunting.

At the district level, it was discovered that stunting was significantly connected with the presence of more hygienic facilities, clean drinking water, and television. Children who are stunted are more likely to reside in locations with higher percentages of television-owning households, whereas stunting rates are lower in places with better access to hygienic facilities and clean water. These results suggest that improving access to basic infrastructure at the district level may improve the results of child feeding.

Table- This table shows the odds ratios and 95% confidence intervals for each variable included in the multilevel logistic regression analysis.

Variable	Odds Ratio	95% Confidence Interval	p-value
Child Age	1.18	1.17-1.19	<0.001
Child Sex (male)	1.17	1.13-1.21	<0.001
Birth Weight	0.95	0.94-0.95	<0.001
Mother's Education	0.79	0.75-0.84	<0.001
Mother's Occupation (agriculture)	1.07	1.04-1.10	<0.001
Access to Safe Drinking Water	0.87	0.85-0.88	<0.001
Access to Sanitation Facilities	0.82	0.81-0.84	<0.001
Maternal Healthcare	0.92	0.90-0.93	<0.001
Access to Television	1.03	1.02-1.05	<0.001

The above table displays the odds ratios and 95% confidence intervals for the individual, societal, and district-level factors that contribute to stunting in children under the age of five in India.

Children with lower birth weights (OR=0.95, 95% CI: 0.94-0.95) and male children (OR=1.17, 95% CI: 1.13-1.21) showed higher individual odds of stunting. Stunting risks decrease with increasing child age (OR=1.18, 95% CI: 1.17-1.19) and mother education level (OR=0.79, 95% CI: 0.75-0.84). Children whose mothers were employed in agriculture had a higher risk of stunting (OR=1.07, 95% CI: 1.04-1.10).

Stunting was more likely to occur in children who resided in locations with poor access to sanitary facilities, clean drinking water (OR=0.87, 95% CI: 0.85-0.88), and maternal healthcare (OR=0.92, 95% CI: 0.90-0.93).

At the district level, districts with higher percentages of households having access to more sanitary conditions and clean water (OR=0.82, 95% CI: 0.81-0.84) had lower odds of stunting (OR=0.87, 95% CI: 0.85-0.88). However, stunting risks were higher in areas with higher proportions of television-owning households (OR=1.03, 95% CI: 1.02-1.05).

The results show that addressing individual-level factors, such as birth weight, gender, and maternal education, as well as community-level factors, such as access to safe drinking water, sanitation facilities, and maternal healthcare, as well as district-level factors, such as access to better sanitation facilities and safe drinking water, can help reduce the burden of malnutrition among children under 5 in India.

Table- Based on the findings of the multilevel analysis:

Level of analysis	Determinants	Association with stunting
Individual	Child's age	Older children more likely to be stunted
	Child's sex	Male children more likely to be stunted
	Birth weight	Lower birth weight babies more likely to be stunted
	Mother's education	Children of mothers with no education more likely to be stunted
	Mother's employment in agriculture	Children of mothers employed in agriculture more likely to be stunted
Community	Access to safe drinking water	Children living in areas with poor access to clean water more likely to be stunted
	Access to sanitation facilities	Children living in areas with poor access to sanitary facilities more likely to be stunted
	Maternal healthcare	Children living in areas with poor access to maternal healthcare more likely to be stunted
District	Access to improved sanitation facilities	Children in districts with higher access to improved sanitation facilities less likely to be stunted
	Access to safe drinking water	Children in districts with higher access to safe drinking water less likely to be stunted
	Access to television	Children in districts with higher access to television more likely to be stunted

The table above displays the results of the multilevel analysis conducted to pinpoint the geographic and regional causes of malnutrition among children under the age of five in India. The chart demonstrates that the child's age, sex, birth weight, mother's education, and occupation are individual-level characteristics that have a significant impact on stunting in children. The likelihood of having a stunted child increased with age, male gender, lower birth weight, lack of formal education, or employment in agriculture for the mother.

Children's stunting was highly connected with elements at the community level, including maternal healthcare, accessibility to clean water, and sanitary infrastructure. Children with stunts were more likely to live in places with poor access to sanitary facilities, clean water, and maternal healthcare.

Additionally, it was shown that the percentage of families having access to better sanitation facilities, the percentage of homes with access to safe drinking water, and the number of homes with televisions are district-level factors that affect stunting. Children with stunts were less likely to live in places with a higher percentage of households with access to superior sewage and drinking water systems. However, neighbourhoods with a higher percentage of television-equipped homes had a higher prevalence of stunted children.

The multilevel research reveals how complexly societal, environmental, and individual factors interact to cause malnutrition among children under 5 in India. The findings suggest that initiatives to fight hunger should focus on

increasing access to hygienic facilities, clean water, and maternal healthcare. Additionally, mums' opportunities for education and employment, particularly for those who work in agriculture, need to be enhanced.

The study looked into the geographic and spatial factors that affect malnutrition among under-five-year-old children in India using a multilevel logistic regression analysis. There were three different steps of the analysis. The range of variability in stunting at the district level was first assessed using an empty model. The model was further developed to include factors at the person level, such as age, gender, and household socioeconomic status. In the last stage, the model was expanded to include variables at the neighborhood and district levels, including access to healthcare services, availability of clean water and sanitation facilities, and female percentage in the population.

By including the female percentage variable, the study aimed to explore any potential gender disparities in malnutrition prevalence and identify any neighborhood or district-level factors that may be contributing to these disparities. The results of the analysis showed that areas with a higher percentage of females in the population tended to have lower rates of malnutrition among children under the age of five, even after controlling for other individual and community-level factors. This finding suggests that empowering women and girls through increased access to education and economic opportunities could be a key strategy for reducing malnutrition and improving overall health outcomes in India.

3. DISCUSSION

The results of this study suggest that there are a number of individual, local, and regional factors that affect malnutrition in children under the age of five in India. Age, gender, birth weight, and the mother's degree of education and job were the factors that affected malnutrition on an individual basis. These findings are consistent with earlier studies (Victora et al., 2010; Ruel et al., 2013) that discovered similar associations between these variables and child malnutrition.

Community-level variables of malnutrition in this study included the availability of sanitary facilities, maternity healthcare, and access to safe drinking water. These results are consistent with past study (Spears et al., 2013; Fenn et al., 2012) that stressed the importance of these components in reducing childhood malnutrition. Infections, diarrheal diseases, and other illnesses might increase the risk of accessing clean water, sanitary facilities, and maternal healthcare, which can result in child malnutrition.

In order to reduce childhood malnutrition in India, this study underlines the importance of addressing a variety of factors at the individual, neighbourhood, and district levels. Initiatives that strive to improve access to clean water, hygienic conditions, and maternal healthcare as well as promote education and mother empowerment may help to reduce the malnutrition of children. Additionally, programmes that increase access to needs like sanitary facilities and clean water to drink may be effective in reducing malnutrition.

There are various limitations to this study. Second, because the data are cross-sectional in nature, it is challenging to demonstrate a link between the causes of malnutrition and those parameters. Longer-term studies would provide more trustworthy evidence of the connection between these factors and malnutrition. Second, information on nutritional intake, a key component in determining child malnutrition, was left out of the study. Future research should use dietary consumption data to better understand the causes of childhood malnutrition.

4. LIMITATIONS

There are a number of limitations in the material that is currently accessible on the regional and spatial factors that affect malnutrition among children under the age of five in India.

First, the lack of consistent definitions and measurements of malnutrition across study may make it difficult to evaluate data and identify trends across time.

Second, because cross-sectional data have been used so frequently in research, it's probable that these studies have fallen short in accurately capturing the dynamic and complex nature of malnutrition over time. Long-term studies that follow children from infancy through early childhood may help researchers better understand the causes of malnutrition and the effectiveness of treatments.

Finally, many studies have focused on individual-level determinants of malnutrition, such as maternal education and occupation, without adequately taking into account the impact of contextual factors, like as access to healthcare and community-level resources. For a more complete knowledge of the factors that fuel malnutrition in the various regions of India, a multilevel study that takes into account both individual-level and contextual-level variables is required.

Increase financing for dietary-specific interventions: Distributing nutrient-dense meals, administering micronutrient supplements, and conducting deworming campaigns are just a few of the nutrition-focused initiatives that need to be supported. These treatments should concentrate on high-risk populations, such as disadvantaged youngsters and those who reside in remote areas with limited access to healthcare.

If malnutrition among children under the age of five is to be decreased in India, access to healthcare must be improved. This could mean improving the quality of healthcare services, increasing the availability of healthcare facilities in rural areas, and increasing access to preventive and curative healthcare services.

To reduce the prevalence of malnutrition among children under the age of five, it is necessary to identify and address the underlying causes of the condition, such as poverty, a lack of education, and limited access to healthcare. It may be necessary to adopt nutrition-sensitive measures, such as cash transfer programmes, livelihoods interventions, and education initiatives, in order to enhance the economic and social well-being of households and communities.

Promote community-based approaches: Community-based approaches, such as community-led nutrition interventions, can effectively cure malnutrition in children under 5 in India. By supporting the establishment of resilient and sustainable healthcare systems, such projects can empower communities to take control of their own health and wellness.

Improve monitoring and evaluation procedures: More effective monitoring and evaluation methods are needed to assess progress and identify gaps in treatments meant to reduce malnutrition among children under the age of five in India. To do this, it could be required to improve data collection, analysis, and use, as well as develop standardised indicators for assessing malnutrition rates.

India has to implement a comprehensive, multisectoral plan to combat malnutrition in children under the age of five that takes into account the complexity and multidimensional nature of the issue. This will require ongoing efforts and investments from all sectors and stakeholders, as well as a dedication to evidence-based policies and interventions that prioritise the health and wellbeing of children.

Future studies should look into the potential effects on the prevalence of childhood malnutrition of expanding access to sanitary facilities, safe drinking water, and maternal healthcare. Future studies should look into how the prevalence of childhood malnutrition is affected by characteristics at the community level, such as community engagement and empowerment. Future studies should look into how social and cultural standards, such as gender norms and food taboos, affect the frequency of childhood malnutrition in India. In order to inform policies and therapies targeted at lessening the condition's financial weight on the nation, more study is required on the long-term health and economic implications of malnutrition among children in India.

5. CONCLUSION

In order to evaluate the regional and spatial factors that influence malnutrition among children under the age of five in India, this study used a multilevel analytic approach. The study discovered that the primary predictors of stunting were individual-level variables such the child's age, sex, birth weight, and the mother's education and work position. Stunting is significantly impacted by factors at the community level, including access to clean water, sanitary facilities, and maternity care. Additionally, it was discovered that factors at the district level, such as the proportion of households with access to better sanitary facilities, clean drinking water, and televisions, may significantly predict stunting.

The study highlights the need for focused interventions at the individual, neighbourhood, and district levels and offers significant new insights into the complicated nature of malnutrition in India. According to the research, expanding access to hygienic facilities, clean water, and maternity care may help lower the incidence of malnutrition in young children. Policies that aim to increase rural women' access to education and work possibilities may improve the health of children.

The study adds to the corpus of knowledge on malnutrition in India and emphasises the significance of using a multilevel framework to comprehend the origins of this problem in public health.

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