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A comparative cross-sectional study on early childhood development through anthropometric measurements among urban and rural Anganwadi children.

Ms. Amancha Nirvignyasree[1]*, Dr. Fawwad M Shaikh[2], Dr. Bollampalli Babu Rao[3], Dr. N. Jayalatha[4]
[1]Final Year MBBS Student, Government Medical College, Suryapet, Telangana, India
[2]Associate Professor, Department of Community Medicine, Government Medical College, Suryapet, Telangana, India
[3]Professor and Head, Department of Community Medicine, Government Medical College, Suryapet, Telangana, India
[4]Principal and Professor of Radiology, Government Medical College, Suryapet, Telangana, India

Abstract

Background
Early childhood is a crucial period for cognitive, physical, and emotional development. Nutritional status during this phase plays a significant role in shaping a child's growth and development.

Objectives
To assess early childhood development through anthropometric measurements among Anganwadi children in urban and rural areas, and to compare the nutritional status between the two groups.

Methods
A comparative cross-sectional study was conducted from 25th November 2023 to 25th January 2024 among 254 children under five years attending Anganwadi centres, 129 from rural areas and 125 from urban areas. Anthropometric parameters such as weight, height, Body Mass Index (BMI), Mid-Upper Arm Circumference (MUAC), and head circumference were recorded. Developmental milestones were also assessed. The data were analysed using WHO growth standards, and Chi-square tests were applied for statistical significance.

Results
The study revealed that 77.5% of rural and 68.0% of urban children had normal weight-for-age, though the difference was not statistically significant ($p = 0.233$). Stunting was present in 37.2% of rural and 37.6% of urban children ($p = 0.204$). BMI analysis showed that 94.6% of rural and 87.2% of urban children were within the normal range ($p = 0.118$). Developmental delays were observed in 2.4% of rural and 8.0% of urban children. MUAC was normal in 99.2% of children across both groups ($p = 0.982$). No significant differences were found in head circumference ($p = 0.926$) or weight-for-height ($p = 0.328$) between the groups.

Conclusion
Children with lower anthropometric measurements were more likely to exhibit developmental delays. Rural Anganwadi children were relatively better nourished compared to urban children. Early detection of malnutrition through growth monitoring is vital for ensuring proper childhood development.

Recommendations
Regular anthropometric monitoring, nutrition education for caregivers, and strengthening Anganwadi services are essential to identify at-risk children early and implement timely interventions.

Keywords: *Early childhood development; Anthropometry; Malnutrition; Anganwadi children; Urban-rural comparison; Growth monitoring; Developmental milestones.*
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Corresponding Author: *Ms. Amancha Nirvignyasree*
Email: ***nirvignyasree@gmail.com***
Final Year MBBS Student, Government Medical College, Suryapet, Telangana, India

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Introduction

The phase of early childhood, extending from the prenatal period up to about eight years of age, represents a vital window for growth in physical health, cognitive abilities, emotional regulation, and social skills. According to UNICEF, the foundations laid during this period shape the future health, learning ability, and well-being of an individual, highlighting the need for optimal care and nurturing in the earliest years of life [1]. Rapid brain development occurs in this phase, with millions of neural connections forming each second. Adequate nutrition is essential for proper brain growth, neuronal connectivity, and cognitive development [2].

Physical activity during early childhood not only strengthens musculoskeletal health but also contributes to better long-term physical well-being [3]. Simultaneously, this period is essential for the development of emotional competence, as children learn to recognize, express, and manage emotions—skills that are crucial for social functioning and resilience [4]. Social development also flourishes in early childhood through interactions, play, and positive relationships, enabling children to build foundational skills like cooperation, empathy, and communication [5].

The concept of nurturing care, which encompasses health, nutrition, early learning, responsive caregiving, and security, has been emphasized as central to achieving optimal early childhood development [6]. The absence of such care, coupled with malnutrition and poor environmental factors, can lead to impaired growth, delayed developmental milestones, and long-term cognitive and emotional deficits.

In India, Anganwadi centres under the Integrated Child Development Services (ICDS) play a pivotal role in delivering essential services related to health, nutrition, and preschool education to children under six years. Despite these efforts, malnutrition remains a pressing concern, especially in resource-limited settings. The present study aims to assess early childhood development through anthropometric measurements among Anganwadi children in rural and urban areas and to compare their nutritional status and developmental outcomes.

Methodology

Study design and setting

A community-based, comparative cross-sectional study was conducted over a period of two months, from 25th November 2023 to 25th January 2024, in the field practice areas of Government Medical College, Suryapet, Telangana, India. The rural setting comprised Anganwadi centres under [insert village/mandal name(s)] and the urban setting included Anganwadi centres within Suryapet town limits.

Study population

The study included children under five years of age who were attending Anganwadi centres during the data collection period. Children with congenital anomalies or any specific disease conditions that could affect growth were excluded from the study.

Sample size and sampling technique

The sample size was calculated using the formula:

$n=Z2\times p(1–p)/d2$

where n = required sample size, Z = 1.96 at 95% confidence interval, p = expected prevalence of malnutrition (taken as 20% from NFHS-5 Telangana data), and d = allowable error of 5%.

Substituting values, n ≈ 246. Considering a 3% non-response rate, the final sample size was 254 children.

A total of 254 children were included, comprising 129 children from rural Anganwadi centres and 125 children from urban Anganwadi centres. Convenience sampling was used based on the availability of children at the centres on the days of the visits.

Data collection tools and techniques

Anthropometric measurements, including weight, height/length, Body Mass Index (BMI), Mid-Upper Arm Circumference (MUAC), and head circumference, were recorded using standard procedures and calibrated equipment:

Weight: Measured using a digital weighing machine.

Height: Measured using a stadiometer or infantometer for children under two years.

MUAC: Assessed using a colour-coded Shakir's tape.

Head Circumference: Measured with a non-stretchable measuring tape.

BMI: Calculated using weight (kg) divided by height squared (m^2).

Developmental milestones were assessed through caregiver interviews and observation.

Bias

To minimize bias, standardized and calibrated instruments were used for anthropometric measurements, and data collection was performed by trained investigators following

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WHO protocols. Recall bias in developmental milestone assessment was reduced by combining caregiver interviews with direct observation whenever possible. Selection bias was minimized by including all eligible children present at Anganwadi centres during the study period. Data entry was double-checked to avoid transcription errors.

Data analysis

The collected data were entered into Google Sheets and analysed using WHO growth standards and classifications. Statistical analysis was performed using SPSS version 25. The Chi-square test was used to assess the association between anthropometric measures and the groups (urban vs. rural). A p-value of less than 0.05 was considered statistically significant.

Ethical considerations

The research proposal, bearing Reference No. IEC/GMCS/2023/014 dated 24th November 2023, was approved by the Institutional Ethics Committee (IEC) of Government Medical College, Suryapet, Telangana. Written informed consent was obtained from the Anganwadi teachers after clearly explaining the purpose and objectives of the study. The confidentiality and privacy of all participants and collected data were strictly maintained throughout the study.

Results

Participant flow

During the study period, 268 children under five years were listed across selected Anganwadi centres of Government Medical College, Suryapet. Of these, 14 were excluded: 4 had congenital anomalies, 6 had specific disease conditions likely to affect growth, and 4 were absent on the day of data collection. Thus, 254 children were examined for eligibility, all of whom were confirmed eligible, consented, and included in the final analysis. No participants were lost, and complete data were available for all 254 children.

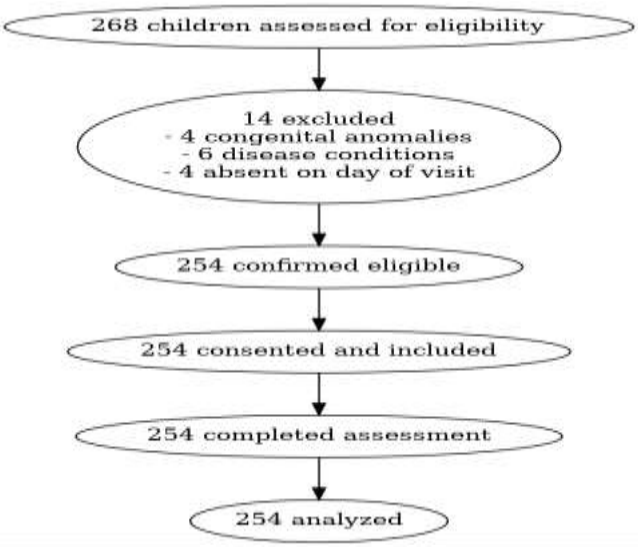

Figure 1. Participant flow diagram

Participant characteristics

A total of 254 children participated in the study, comprising 129 (50.8%) from rural Anganwadi centres and 125 (49.2%) from urban centres. The mean age of the participants was 36.4 ± 12.2 months, with 134 (52.8%) males and 120 (47.2%) females. The majority of mothers (61.5%) had completed at least primary education, while 38.5% had no formal schooling. Based on the modified Kuppuswamy socioeconomic classification, 48.0% of households were in the lower class, 34.0% in the middle class, and 18.0% in the upper class. Most families (72.4%) were nuclear households.

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Table 1. Baseline characteristics of participants (n = 254)

Variable	Rural (n = 129)	Urban (n = 125)	Total (n = 254)
Age (months), mean ± SD	36.8 ± 11.9	36.0 ± 12.5	36.4 ± 12.2
Sex			
Male (%)	69 (53.5)	65 (52.0)	134 (52.8)
Female (%)	60 (46.5)	60 (48.0)	120 (47.2)
Maternal education			
No schooling (%)	45 (34.9)	53 (42.4)	98 (38.5)
Primary & above (%)	84 (65.1)	72 (57.6)	156 (61.5)
Socioeconomic status			
Upper class (%)	22 (17.1)	24 (19.2)	46 (18.0)
Middle class (%)	46 (35.7)	41 (32.8)	87 (34.0)
Lower class (%)	61 (47.3)	60 (48.0)	121 (48.0)
Type of family			
Nuclear (%)	91 (70.5)	93 (74.4)	184 (72.4)
Joint (%)	38 (29.5)	32 (25.6)	70 (27.6)

Weight-for-age

The analysis of weight-for-age revealed that 77.5% of rural children and 68.0% of urban children had normal weight-for-age (> -2SD). The prevalence of moderately underweight children was higher in the urban group (25.6%) compared to the rural group (17.8%). Severely underweight children constituted 4.7% of rural and 6.4% of urban populations. However, this difference was not statistically significant (p = 0.233) (Table 2).

Table 2: weight for age comparison

WHO Classification	Rural (n=129)	Urban (n=125)	p-value
Normal (>-2SD)	77.5%	68.0%	0.233
Moderately underweight (<= -2SD & >= -3SD)	17.8%	25.6%	
Severely underweight (<-3SD)	4.7%	6.4%	

Height-for-age

Assessment of height-for-age indicated that 62.8% of rural children and 60.0% of urban children had normal stature. Mild to moderate stunting was present in 37.2% of rural children and 37.6% of urban children. Notably, tall stature (>+2SD) was observed only in the urban group (2.4%). No severe stunting was reported in either group. The difference was statistically non-significant (p = 0.204) (**Table 3**).

Table 3: height for age comparison

WHO Classification	Rural (n=129)	Urban (n=125)	p-value
Normal (-2SD to +2SD)	62.8%	60.0%	0.204
Mild to moderate stunting (-2SD to +2SD)	37.2%	37.6%	
Tall (>+2SD)	0%	2.4%	
Severe stunting (<-3SD)	0%	0%	

Bmi-for-age

The Body Mass Index (BMI) assessment showed that 94.6% of rural children had normal BMI compared to 87.2% of urban children. Underweight status was more common in urban children (6.4%) than in rural children (3.1%). The prevalence of overweight children was also higher in urban areas (6.4%) than in rural areas (2.3%). The observed

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difference was not statistically significant (p = 0.118) (**Table 4**).

Table 4: bmi for age comparison

WHO Classification	Rural (n=129)	Urban (n=125)	p-value
Normal (-2SD to +2SD)	94.6%	87.2%	0.118
Underweight (<-2SD)	3.1%	6.4%	
Overweight (>+2SD)	2.3%	6.4%	

Developmental milestones

Developmental milestones were achieved on time by 97.6% of rural children and 92.0% of urban children. Developmental delays were observed in 2.4% of rural children and 8.0% of urban children, indicating a higher occurrence of delayed milestones in urban settings (**Table 5**).

Table 5: developmental milestones achievement

Developmental Milestones	Rural (n=129)	Urban (n=125)
Achieved on time	97.6%	92.0%
Delayed	2.4%	8.0%

Muac status

Mid-Upper Arm Circumference (MUAC) measurements showed that 99.2% of children in both rural and urban groups had normal MUAC (>12.5 cm). Moderate Acute Malnutrition (MUAC between 11.5 and 12.5 cm) was found in only 0.8% of children in both groups. There were no cases of severe acute malnutrition, and the difference between rural and urban children was statistically insignificant (p = 0.982) (**Table 6**).

Table 6: muac status comparison

MUAC Classification	Rural (n=129)	Urban (n=125)	p-value
Normal (>12.5 cm)	99.2%	99.2%	0.982
Moderate Acute Malnutrition (11.5 - 12.5 cm)	0.8%	0.8%	

Head circumference

Normal head circumference was recorded in 93.0% of rural and 92.0% of urban children. Macrocephaly was slightly more prevalent in urban children (4.0%) than in rural children (3.1%), while microcephaly was almost similar in both groups (3.9% rural vs. 4.0% urban). The difference was not statistically significant (p = 0.926) (**Table 7**).

Table 7: head circumference status

WHO Classification	Rural (n=129)	Urban (n=125)	p-value
Normal (-2SD to +2SD)	93.0%	92.0%	0.926
Macrocephaly (>+2SD)	3.1%	4.0%	
Microcephaly (<-2SD)	3.9%	4.0%	

Weight-for-height (wasting)

When assessed for weight-for-height (wasting), 94.6% of rural children and 89.6% of urban children were within normal limits. Moderate wasting was observed in 3.9% of rural children and 8.0% of urban children. Severe wasting was slightly higher in urban children (2.4%) compared to rural (1.6%), though these differences were not statistically significant (p = 0.328) (**Table 8**).

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Table 8: weight-for-height status (wasting)

WHO Classification	Rural (n=129)	Urban (n=125)	p-value
Normal (>-2SD)	94.6%	89.6%	0.328
Moderate Wasting (<=-2SD to >=-3SD)	3.9%	8.0%	
Severe Wasting (<-3SD)	1.6%	2.4%	

Discussion

In this study, rural children exhibited relatively better nutritional status and fewer developmental delays compared to their urban counterparts, despite the general perception that urban populations have superior access to healthcare and nutrition. This advantage among rural children may be linked to higher physical activity, greater consumption of locally available fresh foods, reduced exposure to environmental pollution, and possibly more effective functioning of rural Anganwadi centres. In contrast, the higher prevalence of underweight and developmental delays in urban children may reflect dietary shifts toward processed foods, increased sedentary lifestyles, and socioeconomic disparities common in urban slum settings [6,7]. Similar disparities between rural and urban children have been observed in previous studies assessing the nutritional status of Anganwadi children in different regions of India [14,15]. The higher prevalence of underweight and delayed milestones in urban children may reflect the influence of urban poverty, sedentary lifestyles, limited access to outdoor spaces, and inadequate dietary practices. Malnutrition, including stunting, wasting, and micronutrient deficiencies, has been consistently identified as a major contributor to impaired growth and developmental outcomes in children [12]. The World Health Organization reports that undernutrition contributes to nearly half of all deaths in children under five globally [12].

Anthropometric measurements, including weight-for-age, height-for-age, BMI-for-age, MUAC, and head circumference, provide simple yet powerful tools for assessing growth and identifying malnutrition [9,10]. Regular growth monitoring, as recommended by Indian and global guidelines, plays a pivotal role in early detection and timely intervention to prevent adverse health outcomes [7,11].

The observed association between malnutrition and developmental delays reinforces findings from longitudinal research showing that poor early growth is linked to reduced cognitive function, lower educational attainment, and diminished productivity in adulthood [13]. Additionally, nurturing care, which includes responsive caregiving, early learning opportunities, and adequate nutrition, has been shown to significantly improve child development outcomes [6,8].

Genaralizability

The findings of this study are most applicable to children attending Anganwadi centres in similar semi-urban and rural areas of Telangana. Since Anganwadi centres follow a uniform national program (ICDS), the results may be reasonably generalized to other regions of India with comparable socio-demographic contexts. However, caution should be exercised when extrapolating these results to populations outside the ICDS framework, to children in private preschool settings, or to states with substantially different dietary patterns, socioeconomic structures, or program implementation levels.

Conclusion

This study highlights the close association between anthropometric measures and early childhood development. While the majority of children in both urban and rural Anganwadi centres were well-nourished, rural children demonstrated slightly better nutritional status and fewer developmental delays compared to urban children. Malnourished children were at higher risk for delayed developmental milestones, underscoring the importance of early detection and intervention. Strengthening Anganwadi services, ensuring consistent nutritional support, and enhancing caregiver awareness are essential to promote optimal growth and development. Regular monitoring using simple anthropometric tools can serve as an effective strategy to identify at-risk children and implement timely corrective measures.

Limitations

The study was limited by its cross-sectional design, which captured anthropometric data at a single point in time without long-term follow-up. The sample size was relatively small and limited to selected Anganwadi centres, potentially affecting the generalizability of the findings. Nutritional assessments were based solely on anthropometric indicators without detailed dietary intake evaluation. Additionally, developmental milestones were assessed through

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observation and caregiver recall, which may be subject to reporting bias. Future longitudinal studies are recommended for more comprehensive evaluation.

Recommendations

Regular growth monitoring through anthropometric assessments should be implemented uniformly across all Anganwadi centres. Training programs for Anganwadi workers and caregivers on the importance of nutrition, early child stimulation, and developmental milestone tracking are essential. Community participation and awareness campaigns can improve early identification of malnutrition and developmental delays. Introducing child-friendly nutrition programs, fortified foods, and periodic health check-ups can further enhance child well-being. Special focus must be given to urban slum populations, where the risk of undernutrition and developmental delays appears higher. Data-driven policy interventions can ensure equitable child health outcomes across diverse populations.

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Abbreviations

ICMR: Indian Council of Medical Research
STS: Short Term Studentship
UNICEF: United Nations International Children's Emergency Fund
ICDS: Integrated Child Development Services
MUAC: Mid-Upper Arm Circumference
BMI: Body Mass Index
NFHS: National Family Health Survey
WHO: World Health Organization
IEC: Institutional Ethics Committee
SPSS: Statistical Package for the Social Sciences

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Conflicts of interest

The Author declares no conflict of interest.

Data availability

Data available on request

Author's contribution

AN-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. **FMS** -design of the study, results interpretation, review of literature, and preparation of the first draft of the manuscript. Statistical analysis and interpretation.**BBR** -results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation.**NJ**-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript.

Author biography

Ms. Amancha Nirvignyasree is currently a final-year MBBS student at Government Medical College, Suryapet, Telangana, India. She is an enthusiastic and dedicated young researcher with a deep interest in public health, community medicine, pediatrics, and fetal care medicine. Ms. Nirvignyasree has been actively involved in research activities throughout her undergraduate studies and was selected for the prestigious Short Term Studentship (STS) Project awarded by the Indian Council of Medical Research (ICMR), Government of India.

Her research focuses on improving health outcomes through evidence-based interventions, particularly among underserved populations, with a growing interest in maternal and child health, developmental pediatrics, and prenatal care. She is highly committed to continuing her academic journey with an emphasis on research, innovation, and advancing healthcare delivery through patient-centered and community-oriented approaches. **ORCID ID:** https://orcid.org/0009-0008-6844-7489

Dr. Fawwad M Shaikh is currently serving as an Associate Professor in the Department of Community Medicine at Government Medical College, Suryapet, Telangana, India. He holds over 10 years of teaching and research experience in the field of Community Medicine and Public Health. Dr. Shaikh has actively contributed to medical education,

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healthcare delivery, and community-based research, with numerous research publications in indexed national and international journals to his credit. His academic interests include epidemiology, non-communicable diseases, health education, and preventive medicine. He is dedicated to advancing community health through evidence-based practice and innovative public health interventions. **ORCID ID:** https://orcid.org/0000-0002-9641-9097

Dr. Bollampalli Babu Rao is currently serving as Professor and Head of the Department of Community Medicine at Government Medical College, Suryapet, Telangana, India. With extensive experience in teaching, research, and public health practice, Dr. Rao has been instrumental in guiding both undergraduate and postgraduate students in the field of preventive and social medicine. His academic contributions include numerous research publications in reputed national and international journals. His areas of interest span epidemiology, health promotion, disease prevention, and community-based healthcare interventions. Dr. Rao remains dedicated to advancing community health through education, research, and outreach programs.

Dr. N. Jayalatha is currently serving as the Principal and Professor of Radiology at Government Medical College, Suryapet, Telangana, India. With a distinguished career in medical education, leadership, and clinical radiology, Dr. Jayalatha has contributed significantly to the academic growth and institutional development of the college. She has vast experience in teaching, administration, and diagnostic imaging and has mentored numerous undergraduate and postgraduate students. Her areas of expertise include advanced imaging techniques, cross-sectional radiology, and academic leadership. Dr. Jayalatha is committed to fostering excellence in medical education, research, and patient care. **ORCID ID:** https://orcid.org/0000-0002-8294-2223

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