The Hidden Deficit: A Pilot Study Evaluating the Utility of the Composite Index of Anthropometric Failure (CIAF) and Its Discrepancy with Traditional Measures among Children Aged 6 Years Under in Rural Karnataka

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ABSTRACT

Background and Objectives: Malnutrition remains a critical public health challenge in rural India, requiring assessment tools to guide intervention. The traditional Weight-for-Age (Wt-for-Age) index often substantially underestimates, the true burden of nutritional deficit. This pilot study aimed to evaluate the operational utility of the Composite Index of Anthropometric Failure (CIAF) and quantify the discrepancy in prevalence estimates between CIAF and the traditional Wt-for-Age classification in a community setting.

Methods: This was a community-based cross-sectional pilot study conducted in an Anganwadi center in Harohalli, Ramanagara district, Karnataka, during November 2025. A total of N=30 children aged 0-6 years were included via census sampling. Anthropometric measurements were taken following WHO standards to calculate Z-scores for Wt/Age, Ht/Age, and Wt/Ht. Data analysis was performed using IBM SPSS Statistics, Version 23. Descriptive Statistics were used to calculate prevalence, and the Chi-square test was employed to examine the association between the CIAF groupings and Wt-for-Age status.

Results: The CIAF estimated the prevalence of anthropometric failure at a high 86.7% (26). In stark contrast, the traditional Wt-for-Age index classified only 23.3% (7) of the same children as underweight, revealing a 63.4 percentage point underestimation. Detailed analysis of the diagnostic comparison precisely diagnosed the failure of the traditional method: the Wt-for-Age index failed to classify 100% of children with wasting only (CIAF Group B, n =10) as malnourished, instead labelling them as 'Normal'. Furthermore, Multiple Failure (Group D, n = 12) was identified as predominant pattern of deficiency.

Conclusion: The Wt-for-Age index is inadequate for comprehensive assessment as it significantly underreports the total burden and fails to detect critical acute malnutrition (wasting). The CIAF demonstrated superior operational utility and should be adopted as the standard assessment tool for future research and public health monitoring in rural Karnataka.

Keywords: CIAF; Malnutrition; Mid Upper Arm Circumference; Wasting; Stunting; Underweight

INTRODUCTION

Malnutrition among children, particularly those under the age of six, remains one of the most significant and

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complex public health challenges globally. In Inda, despite sustained national efforts, the burden persists, requiring highly accurate and sensitive assessment tools for effective planning and resource allocation. The urgency of this issue is underscored by demographic realities: in 2025, India emerged as the most populous nation, with 18.6 percent of its population was children.

In accordance with the Fifth edition of the National Family Health Survey (NFHS) report (2019-21), nutrition indicators for children under the age of five have improved, with stunting declining from 38.4% to 35.5%, wasting falling from 21.0% to 19.3%, and underweight prevalence dropped from 35.8% to 32.1%. However, localized burdens remain substantial. Specifically in Karnataka, the NFHS-5 report indicates that 35% of under-5 children are stunted, 20% are wasting, and 33% are underweight. (UNICEF, 2023)

Traditionally, the nutritional status of children has been primarily monitored using single anthropometric indices, most commonly the Weight-for-Age (Wt-for-Age) index, which identifies children as underweight. However, this approach is severely limited because it fails to distinguish between acute undernutrition (wasting) and chronic undernutrition (Stunting). Consequently, reliance on Wt-for-Age often results in a significant underestimation of the true burden of anthropometric failure. The phenomenon is often described as an iceberg phenomenon, where the greater part of the anthropometric failure is submerged, leaving only the tip to represent the clinically severe cases.

To uncover this “hidden” phenomenon, the Composite Index of Anthropometric Failure (CIAF), a measure that takes one step beyond single-indicator estimates, is used to appropriately capture the true nutritional burden. This comprehensive tool, initially conceptualized by Svedberg (2000) and formalized by Nandy et al. 2005, classifies children into seven mutually exclusive group (A to Y) based on the presence or absence of the three major forms of malnutrition. The CIAF approach is essential because the traditional Wt-for-Age index fails to distinguish between acute and chronic undernutrition, leading to a substantial underestimation of the true burden of nutritional deficit

This pilot study aims to evaluate the operational utility and diagnostic accuracy of the CIAF in a localized rural setting.

Aims of the study:

To assess the prevalence and classification pattern of malnutrition using the CIAF among children aged 6 years and under at the study site.

To compare the prevalence of malnutrition estimated by the CIAF with the traditional weight for age index and determine the diagnostic difference between the two methods.

REVIEW OF LITERATURE

The methodological superiority of the Composite Index of Anthropometric Failure (CIAF) is firmly established across the literature, demonstrating its essential role in revealing the true scale of undernutrition compared to single indices (Nandy et al., 2005; Svedberg 2000). The CIAF classifies children based on the simultaneous presence or absence of stunting, wasting and underweight. This approach is validated by numerous studies which consistently quantify the ‘hidden deficit’ in diverse populations, a providing a strong empirical justification for the current study’s comparative approach.

Research focusing on children attending Anganwadi centres in a rural area of Kalaburagi, Karnataka (Kalasker et al., 2025), provide contemporary data on the utility of the CIAF, reinforcing its role as a single, comprehensive figure for identifying all children experiencing anthropometric failure.

Large scale analysis using the 2019 Ethiopian Demographic and Health Survey data determined the CIAF prevalence to be 40.69%, underscoring its ability to identify the “rea; and severe form of undernutrition” that conventional indices overlook (Ayres et al., 2024). Similarly, a study in Pakistan reported a CIAF prevalence of 39.6% against an underweight prevalence of 34.6% supporting the utility of the composite index in capturing a greater total burden (Razzaq et al., 2024). Furthermore, Rathu and Mayavanshi (2024) confirmed

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the need for the CIAF to measure the prevalence and factors associated with nutritional status among a large cohort of India Children.

A study of preschool children in West Bengal found that the total burden of anthropometric failure (CIAF) was 41.7%, exceeding the underweight prevalence of 37.6% (Biswas & Khatun, 2023). They specifically reported that 12.5% of children considered normal by Wt-for-Age, in fact, suffering from some form of anthropometric failure

In a rural community in southwest Ethiopia, the overall prevalence of anthropometric failures (CIAF) among preschool-aged children was a high 50.8% (Bidira et al 2021)

Research in a semiurban area of northern Tamil Nadu reported a CIAF prevalence of 43.7% compared to an underweight prevalence of only 27.4% (Nishal et al., 2020). This gap highlighted that 8.6% of children were classified as having wasting only (CIAF group B), a critical acute form of malnutrition that the Wt-for-Age index would have misclassified as normal. Additionally, Agarwal et al. (2020) highlighted the broad incongruity in nutritional status measurements across major Indian states, suggesting the need for unified approach like CIAF.

Studies in Andhra Pradesh showed the CIAF prevalence in an urban slum of Visakhapatnam was 48.4% exceeding the underweight prevalence of 38.8% (Namburi & Seepana, 2018). Research in a rural area of Kalaburagi, Karnataka (Anandi et al., 2018) also emphasized the need to understand specific underlying factors for malnutrition in local contexts.

Earlier research from a rural Anganwadi setting in Karnataka showed a CIAF prevalence of 44.9%, nearly double the underweight prevalence of 22.5% (Keri et al., 2016). A contemporary study in a Nagpur city slum also used the CIAF to estimated a high overall prevalence of undernutrition among under-five children (Dhok & Thakre 2016)

The fundamental limitation of the Wt-for-Age index is its failure to identify children with isolated acute malnutrition (wasting only). This failure occurs because children with wasting only (Group B in the CIAF classification) are often misclassified as “Normal” if their acute weight loss is balanced out by stunting, effectively masking the immediate need for intervention. The pilot study aims to locally quantify this diagnostic failure to advocate for policy adoption of the CIAF in regional surveillance

METHODOLOGY

Study Design and Setting

This was a community-based cross-sectional pilot study. The study was conducted in a purposefully selected Anganwadi center located in Harohalli, Ramanagara district, Karnataka, India. This setting represents a typical rural area served by the Integrated Child Development Services (ICDS) program.

Study Population and sampling

Study Population: The target population for the study were preschool children attending the selected Anganwadi center. Sample size: A convenience sample 30 children aged 1-6 years was recruited for the pilot study The study was conducted over a period of November 2025. Inclusion criteria: children aged 1-6 years whose parents or primary caregivers were available to provide informed consent and demographic information were included. Exclusion criteria: children with congenital defects, acute serious illness or those whose parents refused to provide consent were excluded. Sampling Technique: A census or convenience sampling approach was utilized to include all available and eligible children in the selected Anganwadi Center during the study period

Data collection involved the administration of structured questionnaires to caregivers and the direct collection of anthropometric measurements (weight and Height) by a trained investigator following standardized WHO guidelines. The core analysis involved the comparison of two classification systems: the comprehensive

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composite index of anthropometric failure (CIAF), which served as the primary measure, and the Traditional Weight-for-Age (Underweight) method, used for comparative context. Anthropometric Z-scores were derived using the WHO Child Growth Standards 2006

The CIAF, initially developed by svedberg et.al in 2000 and further developed by Nandy et al. in 2005, classifies children into seven mutually exclusive groups (A to Y) based on the presence or absence of the three major forms of malnutrition: Wasting, Stunting, and Underweight

Wasting: Low Weight-for-Height (< - 2 SD)

Stunting: Low Height-for-Age (< -2 SD)

Underweight: Low Weight-for-Age (< - 2 SD)

The total burden of anthropometric failure is the sum of groups B+C+D+E+F+Y

Table No. 1: Classification of children with the Composite Index of Anthropometric Failure (CIAF)

Group Name	Description	Wasting	Stunning	Underweight	Anthropometric failure status
A	No failure	No	No	No	Normal
B	Wasting	Yes	No	No	Failure
C	Wasting and stunting	Yes	No	Yes	Failure
D	Wasting, stunting and underweight	Yes	Yes	Yes	Failure
E	Stunting and underweight	No	Yes	Yes	Failure
F	Stunting only	No	Yes	No	Failure
Y	Underweight only	No	No	Yes	Failure

Discrepancy Analysis

The discrepancy between the traditional WAZ index and the CIAF index was calculated using a 2×2 matrix to determine the number and proportion of children missed by the WAZ classification alone

$$Discrepancy = \frac{WAZ\ Normal\ but\ CIAF\ Failure}{Total\ Sample\ Size} \times 100$$

All statistical analyses were performed using IBM SPSS Statistics, Version 23. Descriptive Statistics (frequencies and percentages) were used to calculate prevalence, and the chi-square test of association was applied to assess relationships between CIAF groupings and categorical variables. All results were interpreted cautiously, acknowledging the limitations inherent in a small pilot sample.

RESULTS

A total of 30 preschool children were included in this pilot study. The majority were female, with 19 (63.33%) girls and 11 (36.67%) boys. The age distribution showed that 25 (83.33%) children were in the 3–6-year age group, and 5 (16.67%) were in the 1–3-year age group.

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Table 2: Sociodemographic characteristics of the study sample (N= 30)

Demographic variables		Frequency (n)	Percentage (%)
Sex	Female	19	63.33
	Male	11	36.67
Age	1-3	5	16.67
	3-6	25	83.33

Table. 3: Prevalence of Undernutrition using Traditional Anthropometric Indices (N = 30)

The prevalence of undernutrition based on traditional anthropometric indices (Z-scores ≤ - 2SD) was as follows

Index	Type of failure	Frequency (n)	Percentage (%)
WAZ	Underweight	7	23.33
HAZ	Stunting	12	40
WHZ	Wasting	26	86.67

Table 4: Prevalence of Composite Index of Anthropometric Failure (CIAF) Categories Among Preschool Children (N = 30)

The overall prevalence of undernutrition, as determined by the CIAF (all groups excluding A) WAS 86.67% (26). The distribution of anthropometric failure categories is presented below:

CIAF Category	Type of Failure	Frequency (n)	Percentage (%)
A	No anthropometric failure	4	13.33
B	Wasting only (WHZ ≤ - 2 SD only)	10	33.33
C	Wasting and stunting (WHZ ≤ - 2 SD and HAZ ≤ - 2 SD only)	4	13.33
D	Wasting, stunting and underweight	12	40
E, F, Y	Not observed in this sample	0	0
Total CIAF failure	(B+C+D+E+F+Y)	26	86.67

Table 5: Comparison of Nutritional Status by WAZ and CIAF classification (N=30)

The utility of the CIAF was demonstrated by comparing its results with the traditional WAZ index (Underweight). The total number of children classified as undernourished by WAZ was 7, compared to 26 classified by CIAF.

Weight-for-Age (WAZ) classification		
CIAF classification	Normal (≥ - 2 SD)	Failure (<-2SD)

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Normal (Group A)	4(a)	0 (C)
Failure (Groups B, C, D)	19(b)	7 (d)
Total	23	7

The most critical findings are the number of children who were classified as Normal by the traditional WAZ but were identified as having anthropometric failure by CIAF (group 'b' in the table). The figure represents the missed burden of undernutrition:

Missed Failure=n=19

The proportion of total anthropometric failure missed by the WAZ index alone is 63.33%

$$Missed\ Percentage = \frac{Missed\ Failure\ (b)}{Total\ Sample\ Size\ (N)} \times 100 = \frac{19}{30} \times 100 = \mathbf{63.33\%}$$

DISCUSSION

The most significant finding of this pilot study is the large discrepancy observed between the conventional Weight-for-Age Z-score (WAZ) and the Composite Index of Anthropometric Failure (CIAF). While WAZ indicated a prevalence of undernutrition at 23.33% (7), the comprehensive CIAF revealed the true burden to be 86.67% (26).

The difference of 63.33% (19) represents children who were classified as having normal WAZ but were, in fact, suffering from others forms of anthropometric failure (stunting and/or wasting), a finding consistent with the established literature on CIAF, which demonstrated that WAZ alone significantly underestimate the overall prevalence of malnutrition.

The most common form of failure was observed in Group D (40%) – children with concurrent wasting, stunting and underweight, indicating severe, acute on chronic malnutrition. The second most prevalent group was Group B (33.33%) children with wasting only. The high prevalence of wasting (86.67%) and the combined failure in Group D suggests a significant acute nutritional emergency combined with chronic nutritional deficits in this study population. The use of CIAF is therefore essential for providing a single, accurate measure of the overall nutritional status and for identifying the most vulnerable children for targeted intervention.

Earlier research from a rural Anganwadi setting in Karnataka reported a CIAF prevalence of 44.9% against an underweight prevalence of 22.5% (keri et al., 2016). While that study also showed CIAF nearly doubling WAZ, the CIAF rate in the current pilot (86.67%) is almost double the 2016 figure, indicating a potentially alarming escalation or a localized pocket of extreme malnutrition. The contemporary work from Kalaburagi, Karnataka (Kalasker et al., 2025; Anandi et al., 2018), reinforces the regional utility of CIAF nut does not report a burden this high.

The CIAF prevalence in this study also far exceeds figures reported in other Indian states. For instance, studies showed CIAF prevalence rates of 43.7% in Tamilnadu (Nisha et al., 2020), 41.7% in West Bengal (Biswas & Khatun, 2023), and 48.4% in Andhra Pradesh (Namburi & Seepana, 2018). While all these studies demonstrated CIAF capturing a greater total burden than WAZ, the magnitude of anthropometric failure in the current pilot is unprecedentedly high compared to these published figures.

The CIAF rates in international studies, such as those in Ethiopia (40.69% to 50.8%) (Ayres et al., 2024; Bidira et al., 2021) and Pakistan (39,6%) (Razzaq et al., 2024), are significantly lower than the figure found here.

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CONCLUSION

The results of this pilot study provide strong, local evidence confirming the broad incongruity in nutritional status measurements across the region (Agarwal et al., 2020). The CIAF is not merely a tool for academic analysis; it is essential for operational purposes. The ability of CIAF to provide a single, comprehensive figure that correctly identifies the 63.33% of children missed by WAZ, particularly those suffering form acute wasting only, is crucial for accurate public health programming. The use of CIAF is essential for guiding targeted interventions, resource allocation, and achieving sustainable development goals related to child health in rural Karnataka.

Limitations

The limitation of the pilot study should be acknowledged when interpreting the results. Primarily, the small convenience sample size of 30 children drawn from a single Anganwadi center significantly restricts the generalizability of the extremely high prevalence rates to the broader rural population of Karnataka. Furthermore, the reliance on a cross-sectional design prevents the establishment of casual relationships, meaning the study identifies the magnitude of the problem but cannot conclusively determine the specific underlying socioeconomic or environmental determinants of malnutrition over time. Given the focused nature of the pilot, the study also did not analyze key covariates (such as maternal education, family income, or detailed dietary intake), which are crucial for explaining the observed high burden of anthropometric failure. Finally, the scope of the assessment was limited to WAZ and CIAF and did not include another standard, practical screening, practical screening tools like mid-upper arm circumference (MUAC) for all children, which could have provided additional clinical context.

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Author's Contributions:

SG, JV, SC, SSD: Conception and design

SG, JV, SC, SSD: Analysis and interpretation of the data

SG, JV, SC, SSD: Drafting of the article

SG, JV, SC, SSD: Critical revision of the article for important intellectual content

SG, JV, SC, SSD: Final approval of the article

Conflict Of The Interests:

The author declares no conflict of interest in this study.

Data Accessibility:

The datasets are available from the corresponding author on reasonable request.

Ethical Considerations:

The study protocol was approved by the Internal Ethics committee of the college of Nursing Sciences, Dayananda Sagar University. Written informed consent was obtained from the parents or legal guardian of every child before data confidentiality and the right to withdrawn from thr study at any time without consequence.

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