Research Paper

Estimated Deficits in Nutrient Intake of ICDS Beneficiaries Who Receive Take Home Ration at Two North Karnataka Districts

VAISHNAVI CHEVVU,[1] CHAITRA A KILPADY,[1] AKSHATA A KAMATH,[1] SMITHA JOSEPH,[2] ARUN DAS R,[1] HARSHPAL SINGH SACHDEV,[3] CHANDRASHEKAR R BANAPURMATH,[4] TINKU THOMAS,[2] ANURA V KURPAD,[5] NIRUPAMA SHIVAKUMAR[1]

From [1]Division of Nutrition, St. John's Research Institute, St. John's National Academy of Health Sciences, Bangalore, Karnataka; [2]Department of Biostatistics, St. John's Medical College, St. John's National Academy of Health Sciences, Bangalore; [3]Pediatrics and Clinical Epidemiology, Sitaram Bhartia Institute of Science and Research, New Delhi; [4]JJM Medical College, Davanagere, Karnataka; [5]Department of Physiology and Division of Nutrition, St. John's Medical College, St. John's National Academy of Health Sciences, Bangalore, Karnataka.

Correspondence to: *Dr Nirupama Shivakumar, Division of Nutrition, St. John's Research Institute, Bangalore, Karnataka. nirupama.s@sjri.res.in*

Received: Janury 07, 2022; *Initial review*: February 09, 2022; *Accepted*: April 29, 2022.

Trial Registration: CTRI/2020/03/024183.

PII: S097475591600426

Note: This early-online version of the article is an unedited manuscript that has been accepted for publication. It has been posted to the website for making it available to readers, ahead of its publication in print. This version will undergo copy-editing, typesetting, and proofreading, before final publication; and the text may undergo minor changes in the final version.

ABSTRACT

Background: The current estimates of energy and protein to bridge nutrient gap in the beneficiaries of the Integrated Child Development Services (ICDS) supplementary nutrition program use sub-optimal methodology for deficit calculation.

Objective: To estimate the nutrient deficit and the risk of inadequate nutrient intake in beneficiaries of the ICDS, aged 6-36 months, using individual 24-hour diet recalls, from districts of Chitradurga and Davanagere in Karnataka.

Study design: Cross-sectional design.

Participants: Children aged (6 to 36 months) registered as beneficiaries of the ICDS in these districts.

Methods: Data were collected on socio- demographic factors, child feeding patterns, perception and usage of Take-home ration (THR), between August to October 2019. Three non-consecutive days' 24-hour diet recall data of children were obtained from mothers, and anthropometric measurements were taken. The proportion of children at risk of inadequate nutrient intakes was estimated using the probability approach. Assuming that 50% of a healthy population will be at risk of nutrient inadequacy such that intake and requirement distributions overlap, the proportion at actual risk of nutrient inadequacy (≥50%) was calculated.

Results: A combined district analysis showed a median energy deficit of 109 kcal and 161 kcal in children belonging to the age groups of 6-12 month and 13-36 month, respectively. The actual risk of inadequate intake for both age groups ranged between 12-47% for fat and other micronutrient (iron, calcium, zinc, folate, vitamin B_{12} and vitamin A), despite breastfeeding, complementary feeding and reported THR use.

Conclusion: Children who receive supplementary nutrition as part of the national program fail to meet their nutrient requirements that are essential for growth and development. This study results may help in strengthening the IYCF counselling and in modification of the existing THR, with quality and cost implications.

Keywords: *Complementary feeding, IYCF, Take Home Ration*.

India's flagship program, the Integrated Child Development Services (ICDS) aims at tackling malnutrition in children, pregnant and lactating mothers, as one of its core objectives with a broader policy focus on child development [1]. The services that promote child growth in particular, includes Supplementary Nutrition Program (SNP), Infant and Young Child Feeding (IYCF) and Water, Sanitation and Hygiene (WASH) counseling, immunization and regular growth monitoring. Among infants, complementary feeding practices such as time of initiation, frequency, diet diversity, quantity, quality, and responsive feeding were reported to be sub-optimal, resulting in a deficit of nutrient requirements [2].

To address this nutrient gap, the SNP delivers take home-ration (THR) to children aged between 6 to 36 months, containing measured quantities of grains and pulses in the form of a powdered multigrain mix or raw ration [3]. However, there have been complaints of poor quality, safety and usage of THR, which may fail to bridge this nutrient gap [3,4]. The prevalence for stunting, underweight and wasting in India is 35%, 33% and 17%, with the state of Karnataka reporting 32%, 32% and 19% respectively [5]. It appears that the SNP is far from successful, with a low decline in stunting and underweight prevalence rates of 1% and 0.7% per year and no change in wasting in under-5 children [6].

The current ICDS recommendation to bridge the nutrient gap through the THR is 500 kcal for energy and 12-15 g of protein per day per child [7]. This estimation; however, fails to apply robust and nutritionally sound principles of deficit calculation. The nutrient intake values were taken from National Nutrition Monitoring Bureau report 2004-2006, and the nutrient requirements from Indian Council of Medical Research report, 1989, both of which are outdated [8,9]. Second, the computation of the energy and protein gaps did not consider the distribution of the intake, which entails the use of an Estimated Average Requirement (EAR), a mean value as opposed to the Recommended Daily Allowance (RDA), a safe intake value, which is EAR plus 2 SD). Third, the intake data are calculated using consumption units for children from household diet recalls, that are less than accurate [9]. Finally, there is no recommendation for dietary fats or micronutrients. Therefore, the primary objective of this study was to estimate the daily nutrient intake using individual 24-hour diet recalls, and to compute the nutrient deficit, in ICDS beneficiaries aged 6-36 months from two districts of Karnataka.

METHODS

Young children between the ages of 6 to 36 months registered as beneficiaries of the ICDS, from Chitradurga and Davanagere districts of Karnataka, were selected for participation in the study. These districts were chosen as they differed in the type of THR distributed, socioeconomic status, geographical conditions, and had proximity to each other. Eligibility for participation was based on whether the children were receiving THR from their respective anganwadi centers (AWCs), that was supplied by self-help groups at the taluk level. Children diagnosed with congenital syndromes, chronic medical or surgical conditions impairing growth, and those with severe acute malnutrition were excluded.

A total sample size of 270 (from both districts) was required to observe a 30% risk of protein inadequacy with 20% relative precision (assumed), 95% confidence interval and 20% complete response rate (for completion of diet recalls). A 30% protein inadequacy estimated from unpublished pilot data of around 40 children (from peri-urban slums) was used for the sample size calculation. Stratified random sampling was adopted for participant recruitment within a multistage sampling of AWCs. Chitradurga and Davanagere have seven and five taluks, respectively. The ICDS program divides each taluk into an average of 12 circles, with multiple villages and a minimum of 20 AWCs. Five circles within each taluk and two AWCs within each circle, were randomly sampled and those AWCs with fewer than 20 beneficiaries were not considered. Two participants were chosen from each AWC, one from 6-12 month age group and the other aged between 13-36 month. In case the selected participant had siblings and both children matched the study criteria, the younger child was chosen (Fig. 1).

The study protocol was approved by the institutional ethical review board and the Technical advisory committee of the State's Health and Family Welfare department. The study was also approved and assisted by the state's Department of Women and Child Development. Written informed consent was obtained from primary caregivers of the participants, who were also the primary respondents to assess eligibility and answer the questionnaires administered. Data were collected between August to October 2019.

The pre-designed and piloted questionnaires were filled using the Computer Assisted Personal Interview (CAPI) tool 'Open data kit' on Android operating system tablet computers (Lenovo Tab4 10, Bengaluru). The questionnaires captured data on socio-demographic information, respondent details, IYCF practices, form of THR received by the households, perception of quality and quantity, usage and sharing, commonly prepared recipes and preferences of the form of THR. The socioeconomic status was categorized into groups using the Kuppuswamy classification [10].

Three non-consecutive days' 24-hour diet recall data for the form of nutrients and food groups on a questionnaire were collected on two weekdays and one weekend. A 24-hour recall kit with standard portion sizes for bowl, glass, tablespoon and teaspoon was used along with models of chapatis or rotis of standard sizes, to aid in better understanding of the portion sizes used. The recalls provided information on frequency of breastfeeding, whether THR was used as part of feeding, and commercial foods consumed. Data from the recalls were entered into a validated software with standardized recipes linked to the Indian Food Composition Table that generated output on individual nutrients and food groups [11].

Anthropometric measurements included weight, length or height, mid-upper arm circumference (MUAC) and head circumference (HC). The Seca 874 digital flat scale (Seca GmbH & Co) was used to measure the weight of the infant to the nearest 10 g and the Seca 417 infantometer (Seca GmbH & Co) measured recumbent length of infants less than 2 years of age to the nearest 1 mm. Stadiometer (Prestige HM 006 A) was used to measure the height of children above two years of age to the nearest 1 mm. The HC and MUAC were measured using the Seca 212 tape to the nearest 1 mm. The Seca 874 digital flat scale was calibrated every day, before use, by a standard weight of 2 kg before measuring the infants. The inter- and intra-observer variability for the four anthropometric variables was assessed, and the coefficients of variation were noted to be <2%. In the field, minimum three consecutive measurements were taken. If the three consecutive measurements differed from the acceptable limits (weight 100 g; MUAC and HC 5 mm; length/height 7 mm) [12], readings were repeated, till there were two recurring readings, which more than used for analysis.

Statistical analysis: Analyses were performed using the R software version 3.6.3 and SPSS version 25. The usual intake of study participants was obtained from the 24-hour dietary recalls of three non-consecutive days and hence adjustments to the distribution of observed intakes were needed to partially remove the day-to-day variability in intakes (within-person variation). The statistical adjustment for within-person variability was performed using the approach proposed by the National Research Council and recommended by IOM [13]: Observed daily intake = usual intake + deviation from usual intake. Thus, usual intake = Group mean + $\frac{\sigma_b}{\sqrt{\sigma_b^2+\sigma_w^2}}$* (Individual mean – Group mean), where ω_b is the between individual variability, ω_w is the within individual variability. Daily intake data of certain nutrients were log-transformed for the usual intake computation and intake data were summarized by district and overall.

The population prevalence of inadequate intake was calculated for fat as detailed in the *Web Appendix I*. EAR was used for the deficit calculation of protein and micro-nutrients as per the Indian Council of Medical Research (ICMR) report [14], and few from the Institute of Medicine (IOM) report [13] when ICMR values were not available. The whole-body daily EAR was obtained for nutrient requirements that were expressed per kilogram body weight by multiplication of these values with the age- and sex-specific median weight from the WHO growth standard [12]. The details of calculation of the dietary nutrient deficit are provided in *Web Appendix I. C*rude protein was corrected for its quality using the Digestible Indispensable Amino Acid Score (DIAAS) for the analysis of the dietary protein deficit. The DIAAS of rice was used in general for all cereals, while that of finger millet was used for millets, that of mung bean for all legumes and that of egg for all animal source foods, as previously detailed [15].

The deficit in the intakes of protein, and selected micronutrients such as calcium, iron, zinc, vitamin A, vitamin B12 and folate were calculated using the probability approach [16,17] (*Web Appendix*). The EAR being the mean or average requirement will yield a proportion of 50% who are theoretically at risk of dietary nutrient inadequacy and should be the target of adequacy when evaluating population intakes. Then, the actual proportion of the population who are at risk of inadequacy is over and above 50%; for example, if the proportion at risk of inadequacy is calculated at 75%, then the proportion at actual risk of dietary inadequacy will be 25%. The required supplementary intake of protein and micronutrients was therefore computed to bring the risk of inadequacy to ≤50% while simultaneously ensuring that no intake exceeded the Tolerable Upper Limit (TUL) of intake at which point the risk of toxicity increases. The details of the 95% CI calculation for the estimated supplementary nutrients is provided in *Web Appendix I*.

Reported from the questionnaire (as a yes or no response to the use of THR) versus diet recall usage (based on the documented ingredients) of THR were compared for the two districts separately, using Chi-square test. The dietary nutrient intake was compared based on THR usage within districts by generalized linear mixed models assuming log normal distribution for micronutrient and food group intake, with taluk of sampling considered as a random effect. The potential confounding of socio-economic status was considered by including it as an additional factor in the model. Additionally, an estimate was made of the current THRs (as Nutrimix in Davanagere, which was quantifiable) contribution to the diet of beneficiaries, to bridge the energy and protein gap as per recommendation.

RESULTS

The district-wise and combined demographic, anthropometric characteristics, and habitual macro- and micro-nutrient intakes categorized by age, are provided in Tables I and II, respectively.

Age-wise dietary deficit and risk of inadequate intakes analyzed district-wise and combined, are provided in Table III. The estimated supplementary intake of nutrients to bridge the gap in dietary intake through complementary feeding, is provided in Table IV. If these supplementary intakes are added to the habitual intakes, <3% of children (for 13-36 month age) from Chitradurga or the combined districts would exceed the TUL for iron, calcium and zinc.

It was also observed that 72% and 51% of the respondents reported usage of THR whereas the diet recalls revealed that only 37% and 19% included the THR in their child's diet at Chitradurga and Davanagere, respectively. All nutrients and food group intakes were comparable between THR consumers and non-consumers in both districts except folate (Web Table I). Vegetable intake was lower in the THR consumers (*P*=0.001) in Davanagere district. The comparisons were adjusted for the socioeconomic status of the children and any intra-cluster correlation among children residing in the same taluk. THR distributed in the form of Nutrimix (in Davanagere) contributed minimally to the child's diet, with energy at a median (IQR) value of 60 (45,120) kcal/day, protein at 1.7 (1.2,3.3) g/day and 0.4 (0.3,0.8) g/day of fat.

DISCUSSION

This study provides details on nutrient intakes, their deficit, and the risk of nutrient inadequacy in children aged 6-36 month, who were beneficiaries of the ICDS, from two districts of Karnataka. A deficit in energy intake, and a risk of fat, iron, calcium, zinc, folate vitamin B_{12} and vitamin A inadequacy, with breastfeeding, complementary feeding, and consumption of THR was reported. The estimated median energy deficit values, for 6-36 month (districts combined), was low by nearly one third of the current energy recommendation of 500 kcal/day. Although the THR was distributed to the households, the usage in the child's diet was low and it failed to deliver the currently recommended energy (500 kcal/day) and protein (12-15 g/day) content. In Davanagere, children who consumed THR had a lower intake of folate, probably owing to observed lower intakes of vegetables indicating poor diet diversity.

A recent evaluation of the composition of THR by the World Food Program [18] focuses its recommendations on increasing fat content, adding micronutrients and including milk solids to improve protein quality. Evidence to support the need for improvement in THR composition was shown through an 'enhancement' of macro- and micronutrients along with SNP monitoring, in children aged 6-30 months, which proved to be beneficial for childhood undernutrition indicators (stunting, wasting and underweight) in a rural area of Rajasthan [19]. The supplementary intake of nutrients required as estimated in this study, could guide the IYCF counselling on complementary feeding or the development of a modified (fortified) THR through the ICDS, to match the deficit in micronutrients. Inclusion of oil or ghee, green leafy vegetables and animal source foods will help bridge the deficit in macro- and micro-nutrients. Furthermore, the observation of low usage of the current THR and its failure to bridge the recommended gap, possibly owing to family sharing and poor acceptability related to quality, points to the need for improvement in the sensory quality of the THR.

This study emphasizes the need to apply appropriate statistical methods in identifying nutrient deficits at the population level, with the following merits. The SNP presently is heavily cereal-based, and efforts should be made to ensure that there is an adequate fat:energy and protein:energy ratio for the SNP, with micronutrients to fill any gaps that may exist. The observed median energy deficit, which is lower by one third of the current supplementary energy recommendation with no protein deficit, could present considerable quality and cost implications. The recommended energy content of the THR is 500 kcal per child/day and meeting this requirement with quality foods within a unit cost of Rs. 8 per child/day may be difficult. This forces the procurement of substandard commodities which coupled with poor infrastructure of self-help groups results in an inedible THR and consequently, poor acceptability and utilization [18]. If the supplementary nutrition followed the norm of filling the energy gap as calculated, the multi-grain mix production could be made cost-neutral in time, allowing for reallocation of resources for improving packaging, storage, quality control and assurance, timely delivery and tracking, thus ensuring improved THR receipt, making the system cost-effective and scalable. In addition, there is need to strengthen the counselling on the importance and necessity of THR at AWCs [20].

The strength of this study lies in its rigorous approach to identify child nutrient inadequacy through carefully administered diet recalls. However, due to the relatively small sample size and sampling restricted to just two districts, it may lack generalizability to other districts or the State and needs further confirmation in larger number of children. It would be beneficial for the ICDS to perform periodic assessments, probably once in three years, sampling at Taluk or district level in each State, formulate recommendations to target aspirational districts and the rest of the State. Another caveat is the use median WHO body weights as the standard to calculate requirements, which may over- or under-estimate the actual requirements for those children tracking along a *Z*-score below or above the median, respectively.

In conclusion, the present study provides a platform for change to the existing IYCF counselling and THR nutrient recommendations, with quality and cost implications that will prove beneficial in executing the SNP through the ICDS, especially in concert with the Poshan Abhiyaan's improved and innovative efforts [21].

Ethics clearance: Institutional Ethical Review Board of St. John's Medical College and Hospital (No. 83/2019 dated April 12, 2019) and Technical Advisory Committee of the State Department of Health and Family Welfare Services (No. NPG/13/2019-20 dated August 1, 2019).

Contributors: AVK,NS: conceived the idea; VC,CAK,AAK,ADR: collected the data; TT, SJ: analyzed the data; VC,CAK,AAK, NS: drafted the initial manuscript; HSS and CRB: revised it critically for important intellectual content. All reviewed the drafts and approved the final manuscript.

Funding: Tata Trusts (TINI/MIYCN-MH/0289/SJRI/2018-19/01/GR/ss); *Competing interest*: None stated.

WHAT IS ALREADY KNOWN?

- The Supplementary Nutrition Program helps to bridge the gap in nutrient intakes of children between 6-36 months, in the form of take-home ration.

WHAT THIS STUDY ADDS?

- This study details the preferred method, and estimates risk of inadequate nutrient intake and the supplemental nutrients that are required to bridge the nutrient gap in young children, through a prospective survey.

REFERENCES

1. Sachdev Y, Dasgupta J. Integrated child development services (ICDS) scheme. Med J Armed Forces India. 2001;57:139-43.
2. Abeshu MA, Lelisa A, Geleta B. Complementary feeding: review of recommendations, feeding practices, and adequacy of homemade complementary food preparations in developing countries–lessons from Ethiopia. Front Nutr. 2016; 3:41.
3. Programme Evaluation Organisation (PEO) Planning Commission. Evaluation Report on Integrated Child Development Services; 2011. Accessed: Feb 25, 2022. Available from: *https://dmeo.gov.in/sites/default/files/2019-10/Evaluation%20Report%20on%20Integrated %20Child %20Development%20Services%20Volume%201.pdf*
4. Avula R, Oddo VM, Kadiyala S, Menon P. Scaling-up interventions to improve infant and young child feeding in India: What will it take? Matern Child Nutr. 2017;13:e12414.
5. Comprehensive National Nutrition Survey (CNNS) National Report. Ministry of Health and Family Welfare (MoHFW), Government of India, UNICEF and Population Council; 2019. Accessed: Feb 25, 2022. Available from: *https://www.popcouncil.org/uploads/pdfs/2019 RH_CNNSreport.pdf*
6. International Institute for Population Sciences (IIPS) and ICF. National Family Health Survey (NFHS-4), 2015-16: India. Int Inst Popul Sci ICF. 2017:1-92.
7. Ministry of Law and Justice. The Gazette of India; 2013. Accessed: Feb 25, 2022. Available from: *https://www.egazette.nic.in/WriteReadData/2013/E29 2013_429.pdf*
8. Indian Council of Medical Research: Nutrient Requirements and Recommended Dietary Allowances for Indians. A report of the Expert Group of the Indian Council of Medical Research, ICMR, 1990.
9. National Nutrition Monitoring Bureau (India). India Rural Survey of Diet and Nutritional Status; 2004-2006. Accessed: Febr 25, 2022. Available from: *https://www.nin.res.in/ downloads/NNMBReport06Nov20.pdf*
10. Mohd Saleem S. Modified Kuppuswamy socioeconomic scale updated for the year 2019. Indian J Forensic Community Med. 2019;6:1-3.
11. Bharathi AV, Kurpad AV, Thomas T, et al. Development of food frequency questionnaires and a nutrient database for the Prospective Urban and Rural Epidemiological (PURE) pilot study in South India: methodological issues. Asia Pac J Clin Nutr. 2008;17:178- 85.
12. WHO Multicentre Growth Reference Study Group, de Onis M. Reliability of anthropometric measurements in the WHO Multicentre Growth Reference Study. Acta Paediatr. 2006; 95:38-46.
13. Institute of Medicine (US) Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. DRI Dietary Reference Intakes: Applications in dietary assessment. National Academies Press; 2000:1-267
14. Nutrient Requirements and Recommended Dietary Allowances for Indians. Indian Council of Medical Research; 2020. Accessed: Feb 25, 2022. Available from: *https://www.nin.res.in/ RDA_short_Report_2020.html*

15. Shivakumar N, Kashyap S, Kishore S, *et al*. Protein-quality evaluation of complementary foods in Indian children. Am J Clin Nutr. 2019;109:1319-27.
16. National Research Council. Nutrient Adequacy: Assessment Using Food Consumption Surveys; 1986. Accessed Feb 25, 2022. Available from: *https://www.ncbi.nlm.nih.gov/ books/NBK221370/*
17. Carriquiry AL. Assessing the prevalence of nutrient inadequacy. Public Health Nutr. 1999;1:23-34.
18. World food Programme. Review of Take-Home Rations under the Integrated Child Development Services in India; 2019. Accessed Feb 25, 2022. Available from: *https://www.wfp.org/publications/review-take-home-rations-under-integrated-child-development-services-india*
19. Avula R, Frongillo EA, Arabi M, et al. Enhancements to nutrition program in Indian integrated child development services increased growth and energy intake of children. J Nutr. 2011;141:680-4.
20. The India Nutrition Initiative. Compendium: Take Home Rations in Integrated Child Development Services; 2020. Accessed Feb 25, 2022. Available from: *https:// sightandlife.org/wp-content/uploads/2020/09/Take-Home-Rations-compendium-2020.pdf*
21. Poshan Abhiyaan Transforming Nutrition in India. NITI aayog, (National Institution for Transforming India). Progress report; 2018. Accessed: Feb 25, 2022.. Available from: *https://www.niti.gov.in/sites/default/files/2020-02/POSHAN_Abhiyaan_first_progress_report _6_Feb_2019.pdf*

Table I Characteristics of Enrolled Children Receiving Take Home Ration from ICDS at Chitradurga and Davanagere Districts, Karnataka, 2019

Characteristics	*Chitradurga*		*Davanagere*		*Both districts*	
Age	6-12 mo	13-36 mo	6-12 mo	13-36 mo	6-12 mo	13-36 mo
n	77	77	61	55	138	132
Boys	43 (56)	41 (53)	28 (46)	27 (49)	71 (51)	68 (52)
Family size[a]	6 (5,8)	6 (5, 8)	6 (5, 9)	6 (5, 8)	6 (5, 8)	6 (5, 8)
Socioeconomic status						
Upper middle and above	8 (10)	7 (9)	9 (15)	9 (16)	17 (12)	16 (12)
Lower middle	38 (50)	46 (60)	45 (74)	33 (60)	83 (60)	79 (60)
Upper lower	31 (40)	24 (31)	7 (11)	13 (24)	38 (28)	37 (28)
Anthropometry[b]						
N	76	76	61	54	138	130
Height for age *z*-score	-0.7 (1.2)	-1.2 (1.2)	-0.7 (1.1)	-1.2 (1.0)	-0.7 (1.2)	-1.2 (1.1)
Weight for age *z*-score	-0.9 (1.2)	-1.2 (1.1)	-1.0 (1.0)	-1.3 (0.9)	-1.0 (1.1)	-1.2 (1.0)
Weight for height *z*-score	-0.7 (1.0)	-0.8 (1.1)	-0.8 (1.0)	-1.0 (0.9)	-0.7 (1.0)	-0.9 (1.0)
Mid-upper arm circumference *z*-score	-0.3 (0.9)	-0.4 (0.9)	-0.7 (0.9)	-0.7 (0.8)	-0.5 (0.9)	-0.6 (0.9)
Head circumference *z*-score	-1.0 (0.9)	-1.2 (1.0)	-1.0 (1.1)	-1.5 (0.9)	-1.0 (1.0)	-1.3 (0.9)

Values expressed as no. (%) or as [a]median (IQR) or [b]Mean (SD).

Table II Macro- and Micro-nutrient Intakes of Enrolled Children Calculated From Diet Recalls in Chitradurga and Davanagere Districts, Karnataka, 2019

	Chitradurga		*Davanagere*		*Both districts*	
Age	*6-12 mo*	*13-36 mo*	*6-12 mo*	*13-36 mo*	*6-12 mo*	*13-36 mo*
n	72	75	57	54	129	129
Macronutrients						
Energy, kcal/d	533 (471,650)	845 (695,1019)	644 (497, 782)	729 (623,874)	564 (485,715)	777 (644, 974)
Protein, g/d	9 (8,13)	21 (16,26)	12 (8,14)	17 (13,21)	10 (8,14)	19 (14,25)
Fat, g/d	23 (22,27)	28 (22,38)	25 (22,30)	24 (17,30)	24 (22,28)	26 (21,34)
Micronutrients						
Iron, mg/d	1.0 (0.4, 1.8)	3.5 (2.3, 4.7)	1.4 (0.6, 2.5)	3.2 (2.1, 4.6)	1.2 (0.5, 2.1)	3.4 (2.3, 4.7)
Calcium, mg/d	240 (189, 321)	374 (254, 617)	273 (216, 424)	282 (202, 393)	261 (202, 384)	349 (223, 518)
Zinc, mg/d	1.1 (0.8, 1.6)	2.6 (2.2, 3.4)	1.5 (0.9, 2.0)	2.2 (1.8, 2.9)	1.2 (0.8, 1.8)	2.5 (2.0, 3.1)
Folate, µg/d	8 (3, 20)	70 (41, 123)	16 (7, 31)	67 (40, 86)	13 (4, 27)	68 (42, 114)
Vitamin B12, µg/d	0.13 (0.13,0.35)	0.69 (0.32,1.15)	0.23 (0.13, 0.49)	0.50 (0.20,0.80)	0.18 (0.13, 0.43)	0.61 (0.30, 1.02)
Vitamin A RAE, µg/d	12 (3, 43)	100 (51, 179)	27 (9, 74)	75 (41, 117)	18 (6, 57)	90 (48, 151)

Values expressed as median (IQR). RAE-retinol activity equivalence.

Table III Risk of Inadequate Nutrient Intake in Enrolled Children in Chitradurga and Davanagere Districts, Karnataka, 2019

	Chitradurga		*Davanagere*		*Both districts*	
Age	6-12 mo	13-36 mo	6-12 mo	13-36 mo	6-12 mo	13-36 mo
N	72	75	57	54	129	129
Macronutrients						
Energy, kcal[a]	150 (36, 205)	121 (-27, 250)	28 (-72, 154)	244 (56, 416)	109 (-23, 192)	161 (-3, 327)
Protein[b]	0	0	0	0	0	0
Fat[b]	22 (11, 32)	8 (0, 19)	8 (0, 21)	30 (19, 40)	16 (8, 24)	17 (9, 25)
Micronutrients[b]						
Iron	28 (28, 37)	34 (24, 41)	12 (0, 24)	36 (23 ,43)	21 (13, 29)	35 (28, 40)
Calcium[c]	-	4 (0, 16)	-	24 (10, 35)	-	12 (3, 20)
Zinc	36 (26, 43)	0 (0, 6)	23 (10, 34)	9 (0, 22)	30 (22, 36)	0 (0, 9)
Folate	47 (40, 50)	8 (0, 20)	48 (41, 50)	26 (12, 37)	47 (42, 49)	15 (6, 23)
Vitamin B12	36 (26, 43)	12 (1, 24)	35 (22, 43)	25 (12, 36)	36 (28, 41)	17 (8, 25)
Vitamin A RAE	40 (31, 46)	17 (5, 27)	35 (22, 43)	28 (14, 38)	38 (31, 43)	22 (14, 30)

[a]Values expressed as median (IQR).[b]Values expressed as %(95% CI). [c]Estimated average requirement not available for 6-12 mo, thus not calculated. RAE-retinol activity equivalence.
For the risk of inadequate intake, the energy deficit was calculated as a difference between the Estimated Energy Requirement for standard weight based on age and sex of the participant and daily energy intake. For fat, the population prevalence of inadequate intake is the proportion of participants with intake below the fat requirement. For the rest of the nutrients, the probability approach was used as detailed in Web Appendix 1.

Table IV Estimated Supplementary Intake of Nutrients to Reduce Risk of Inadequacy to ≤50% in Enrolled Children in Chitradurga and Davanagere Districts, Karnataka, 2019

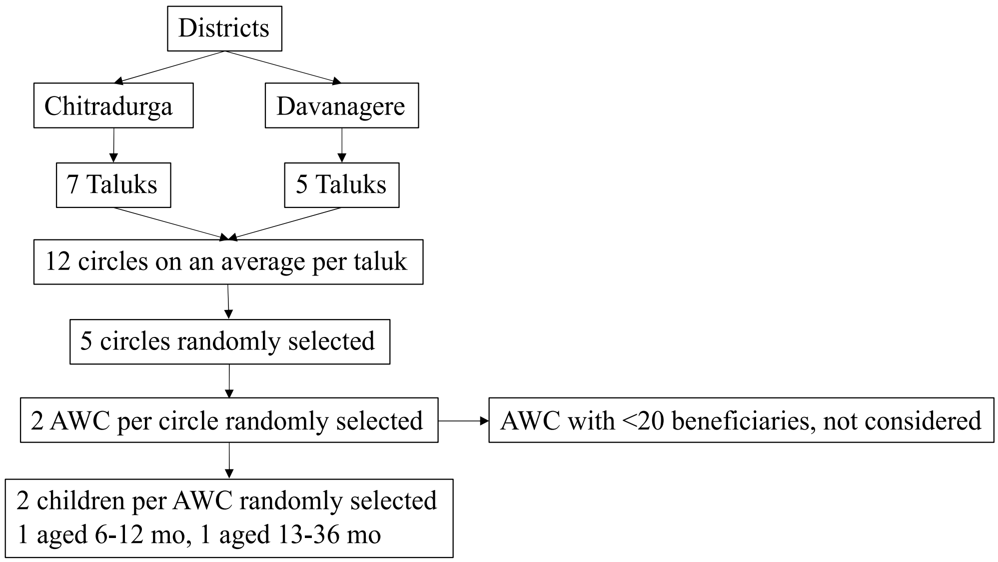
Nutrients	*Amount of nutrient added*	*Risk of inadequacy after addition of extra nutrients (%)*[a]					
		Chitradurga		*Davanagere*		*Both districts*	
		6-12 mo (n=72)	*13-36 mo (n=75)*	*6-12 mo (n=57)*	*13-36 mo (n=54)*	*6-12 mo (n=129)*	*13-36 mo (n=129)*
Fat, g	2.5 (2.3,2.7)	0 (0,11)	0 (0,10)	0	20 (7,32)	0 (0,1)	8 (0,17)
Protein, g	2.7 (1.9,3.4)	0	0	0	0	0	0
Iron, mg	3.5 (3.3,3.6)	0	0	0	0	0	0
Calcium, mg	223 (202,243)	-	0	-	0	-	0
Zinc, mg	1.3 (1.1,1.5)	0	0	0	0	0	0
Folate, μg	67 (64,70)	0	0	0	0	0	0
Vitamin B12, μg	0.5 (0.48,0.52)	13 (0,24)	0	8 (0,21)	0 (0,8)	11 (0,19)	0
Vitamin A RAE, μg	108 (105,111)	12 (1,23)	0	5 (0,18)	0 (0,9)	9 (1,17)	0

[a]*Values in parenthesis are 95% CI.*

Web Table I District-wise Comparison of Nutrient and Food Group Intake Between THR Consumer and Non-Consumers in Chitradurga and Davanagere Districts, Karnataka, 2019-2020

	Chitradurga			*Davanagere*		
Usage of THR	Yes	No	*P* value	Yes	No	*P* value
n	57	90		21	90	
Macronutrients						
Energy, kcal/d	721 (536, 896)	656 (510, 872)	0.21	734 (571, 875)	681 (504, 814)	0.79
Protein, g/d	16 (10, 21)	14 (9, 22)	0.53	12 (9, 14)	14 (11, 18)	0.11
Fat, g/d	24 (21, 33)	25 (22, 31)	0.74	25 (23, 36)	25 (21, 29)	0.19
Micronutrients						
Iron, mg/d	2.8 (1.1, 4.3)	2.0 (0.8, 3.5)	0.08	1.5 (0.8, 2.7)	2.5 (1.2, 3.8)	0.31
Calcium, mg/d	297 (200, 442)	288 (212, 548)	0.93	239 (198, 362)	289 (215, 417)	0.42
Zinc, mg/d	1.9 (1.1, 3.0)	1.9 (1.0, 2.6)	0.28	1.6 (0.9, 2.0)	2.0 (1.3, 2.6)	0.09
Folate, (µg/d)	38 (10, 112)	30 (7, 80)	0.38	25 (8, 39)	33 (14, 75)	0.03
Vitamin, B12, µg/d	0.31 (0.13, 0.70)	0.37 (0.13, 1.04)	0.47	0.23 (0.13, 0.40)	0.40 (0.15, 0.75)	0.15
Vitamin A RAE, µg/d	51 (10, 112)	46 (12, 120)	0.79	40 (23, 113)	55 (19, 98)	0.85
Food Groups						
Cereals, g/d	63 (27, 97)	49 (21, 90)	0.14	49 (31, 65)	87 (31, 97)	0.19
Legumes, g/d	1.9 (0.3, 4.7)	0.5 (0, 4.7)	0.07	8.3 (3.1, 13.7)	3.1 (0.4, 7.3)	0.10
Vegetable,g/d	3.21 (0.34, 11.70)	0.88 (0, 11.06)	0.07	0.11 (0, 4.51)	6.04 (1.18, 12.89)	0.001
GLV, g/d	0.18 (0, 0.67)	0.04 (0, 0.53)	0.24	0.01 (0, 0.65)	0.23 (0.03, 0.64)	0.11
Nuts, g/d	0.17 (0, 1.24)	0 (0, 1.54)	0.29	0.14 (0, 1.02)	0.34 (0, 2.47)	0.24
Fats & Oils, g/d	4.5 (0.9, 12.4)	3.4 (0.8, 9.1)	0.11	3.5 (2.3, 11.2)	3.7 (1.4, 9.3)	0.25
Milk & milk products, g/d	616 (369, 649)	591 (477, 634)	0.18	616 (552, 711)	565 (234, 635)	0.43

Values expressed as Median (IQR). Data based on dietary recalls. P value based on generalized linear mixed models adjusted for socio-economic status and intra-cluster correlation among children residing in the same taluk. THR, take home ration; RAE- retinol activity equivalence; GLV- green leafy vegetables.



AWC- anganwadi center

Fig. 1 Sampling strategy flow chart.

WEB APPENDIX I

Details of nutrient deficit calculation

The energy deficit was calculated as a difference between the Estimated Energy Requirement and daily energy intake.

$$EER\ for\ energy\left(\frac{kcal}{d}\right) = EER\left(\frac{kcal}{kg/d}\right) * age\ and\ sex\ specific\ body\ weight\ (kg)$$

The fat requirement was the fat in g that would contribute to 35% of the energy requirement in kcal/d for the age group 6 – 24 months and 25% for 24-36 months. The population prevalence of inadequate intake is the proportion of the age group with intake below the fat requirement.

$$Fat\ requirement\ (g|d) = \frac{EER\ for\ energy\ (kcal|d) * 0.35}{9}$$

where 9 is the calories in kcal per g of fat, in the equation for 24-36 months 0.35 was replaced by 0.25 as the fat requirement for this age group is 25% of the energy.

The probability approach relates individual intakes to the distribution of requirements. A risk curve was constructed using the information on the requirement distribution of the group (median and variance) that specifies the probability that any given intake is inadequate for the individual consuming that intake and thereby gives the expected risk of inadequacy in the population. This method is robust to errors in shape specifications. Thus, if $F_R(.)$ represents the cumulative density function of requirements for a nutrient in the population [17] then $F_R(a) = P(requirements \leq a)$ and will take values from 0 to 1. Then the risk curve of $\rho(a)$ is defined as

$$\rho(a) = 1 - F_R(a) = 1 - P(requirements \leq a)$$

where, P is probability, a is an individual's intake and $\rho(a)$ is the risk of an individual with an intake a.

Details of confidence interval (CI) calculation for extra nutrients added

Let the extra nutrient required by the population to meet the nutrient requirement conditions be denoted as δ. The estimate of δ is calculated as the minimum value of δ which satisfy the condition

$$P(requirement > Intake + \delta) < 0.5 \quad (1)$$

Additionally, for a uniform distribution of δ, the lower limit is that value of δ which satisfies the condition

$$P\ (Intake + \delta > 2.5th\ percentile\ of\ requirement\ distribution) > 0$$

That is $\delta\ min = max(2.5th\ percentile\ of\ requirement\ distribution - Intake)$ (2)

$$\delta\ max \leq TUL \quad (3)$$

As the next step 1000 random values for U (δ_{min}, δ_{max}) are generated, where U is uniform distribution (4)

The estimate of δ is identified as the minimum value which satisfies condition 1 and denoted as $\hat{\delta}$.

To find the confidence interval for $\hat{\delta}$ its standard error is calculated as follows: random values of intake distribution were generated using normal or lognormal distribution. For each simulated distribution of intake, the value of δ is identified by repeating step (4) and applying condition (1). Using these values of δ standard error is calculated and obtained confidence interval using the formula $\hat{\delta} \pm 1.96 * SE(\hat{\delta})$.