District level child and women nutritional status in Andhra Pradesh state of India- Food based intervention options for improvement and associated issues

Abstract

In this study an attempt has been made to analyse changes in district level child and women nutritional status in Andhra Pradesh using two latest National Family Health Survey (NFHS) data pertaining to years 2015-16 and 2019-20. Computing standardized undernutrition, over nutrition and anaemia index, priority districts under the three nutritional issues were identified. Regression analysis indicated that per capita income was able to explain only very low percentage of variation in various nutritional indicators across the districts. Then progress in ongoing efforts towards addressing nutritional status through distribution of fortified rice, and development of bio-fortified varieties are documented and associated issues were discussed. Need for co-ordination between different food-based programs for nutritional security, building specific value chains targeting specific consumer category, enforcement of food safety and monitoring mechanisms for proper compliance and implementation of the programs were identified, for accelerating improvement in nutritional status in the state.

Keywords: Nutritional security, fortification, bio-fortification, under-nutrition, over-nutrition.

Introduction

India is largest producer of milk in the world and second largest producer of fruits and vegetables in the world. India is ranked third in egg production and eighth in meat production

in the world. In spite of these achievements, nutritional security achievement remains a challenge in India. As per National Family Health Survey (NFHS)-5, during 2019-20,35.5 percent of children below 5 years were stunted (against 21.3 percent in 2019 at global level, (UNICEF,2020)) and 32.1 percent of children below 5 years were of underweight in India in 2019-20. Further 67.1 percent of children of age 6-59 months were anaemic in India and 57 percent women were anaemic. Malnutrition slows economic growth and perpetuates poverty. Specifically stunting is associated with risks of potentially irreversible loss of growth and cognitive functions, increased morbidities and mortalities (Soliman et al,2021). Further there are evidences that different kinds of malnutrition like stunting and wasting, stunting and obesity are closely associated (Soliman et al,2021). Hence at global level now emphasis is being placed on addressing the issue of malnutrition through multiple strategies. 2016-25 period has been named as the United Nations Decade of Action of Nutrition. World Health Assembly (WHA) set six global nutrition targets for year 2025. In recently adopted Sustainable Development Goals (SDGs), UN has declared the objective of ending all forms of hunger. Accordingly, 12 out of 17 SDGs, contain indicators that are relevant for nutrition (IFPRI,2016).

Nutritional security is determined by availability, accessibility and absorption of nutrients from food. Thus, underlying causes for nutritional insecurity may be different in different regions and different category of population of India. Accordingly needed interventions may be different in different states and people. Chichaibelu et al, (2021) based on review of literature identified 22 intervention options available for addressing nutritional issues at global level, out of which 14 interventions are agriculture related investments. Others are investment in social protection and nutritional programmes, infrastructure, trade, and female education. These interventions spread across availability, accessibility, absorption/ utilization

dimensions of food and nutritional security. Majority of agricultural investment options identified by Chichaibelu et al, (2021) are focussing on availability dimension of nutritional security.

For addressing nutritional security, dietary diversity (cutting across availability and accessibility dimension) is the option identified in several studies (Noopur et al, 2023, Gulyas and Edmondson, 2023; Liu et al 2024). At global level EAT-Lancet reference diet was developed to promote healthy eating habits. In Indian Context National Institute of Nutrition (NIN), emphasizing this Dietary Diversity (DD) concept has given the concept of (My plate for the day) suggesting quantity of different types of food to be consumed in order to prevent hidden hunger. But to practice the DD, availability and accessibility of these food groups is prerequisite. In this backdrop an attempt is made in this paper to study district level nutritional security status in the state of Andhra Pradesh (AP), identify food based intervention options available and associated issues.

Data and methodology

The study is based on secondary data published by various public agencies. District wise data on various nutritional indicators of Andhra Pradesh was taken from two latest National Family Health Surveys (NFHS) data, namely NFHS-4 (pertaining to year 2015-16) and NFHS-5 (pertaining to year 2019-20) factsheets published by Ministry of Health and Family welfare, Government of India. Data on district-wise production of various commodities were collected from AP-Season and Crop reports, Statistical Abstract of AP and AP-Districts at a glance, published by Directorate of Economics and Statistics, Government of Andhra Pradesh for the specific years. Data on district wise per-capita income and estimated population (in order to calculate per capita availability of different food commodities) were taken from the publication titled 'Gross State Domestic Product and District Domestic Product" published by

Directorate of Economics and Statistics, Government of Andhra Pradesh. Data on iron fortified rice was accessed from rice fortification portal at http://annavitran.nic.in/FR/avFortifiedRice accessed on 08-02-2024.

Simple tabular analysis was used for analysing data. Single variable linear regression model was fitted to analyse effect of per capita income on various nutritional indicators. The data on nutritional indicators were obtained from NFHS-4 and NFHS-5 and the nutritional indicators are (i) percentage of children of age 6-23 months receiving an adequate diet (ii) percentage of children under 5 years who were stunted (iii) percentage of children under 5 years who were wasted (iv) percentage of children under 5 years who were underweighted(v) percentage of children under 5 years who were overweighted (vi) percentage of children of 6-59 months age who were anaemic (vii)percentage of women with Body Mass Index (BMI) below normal (viii) percentage of women who were overweight or obese and (ix) percentage of women who were anaemic. Following Dutta (2022), Nutritional Achievement Score (NAS) was computed for the selected nine indicators. For indicators where the higher value means better performing districts, NAS was computed using the formula

$$NAS = \frac{x - \min(x)}{\max(x) - \min(x)} * 100$$

For indicators where the higher value means poor performing districts, NAS was computed using the formula

$$NAS = \frac{\max(x) - x}{\max(x) - \min(x)} * 100$$

where x is a nutritional indicator value

max(x) is maximum value observed with respect to indicator x

and min(x) is minimum value observed with respect to indicator x

NAS were aggregated to calculate 3 overall standardized nutritional achievement scores namely, under nutrition, over nutrition and anaemia. Five indicators namely share of children receiving an adequate diet, share of stunted children, share of wasted children, share of underweight children and share of women with below normal BMI were used in computing NAS for under nutrition. Overweight in children and women were the indicators used in computing NAS for over nutrition. Anaemia in children and women were the indicators used in computing NAS for anaemia. Equal weight is given to each indicator. Value of each of the three aggregate NAS ranged between 0 to 100. Lower score indicates poor performance of a district.

Results and discussion:

Andhra Pradesh is a state in Southern India, with a per-capita income of 114324 rupees in 2019.20. Per capita income of AP was higher than per capita income of India (Rs 85110) in 2019-20. AP state is the topmost state in egg production in India, top 4th state in meat production and top 5th state in milk production in 2019-20 and 2021-22 also. In spite of this AP state was poor performer in terms of some nutritional indicators as is evidenced from table.1. The share of children receiving adequate diet in A.P in 2019-20 was lower (9.3%) compared to all India level figure (11.3%). But shares of stunting, wasting, underweight and overweight in children were lower in AP compared to India in 2019-20 (table.1). On the other hand, obesity in adults was higher in AP compared to all India level (table.1). Anaemia in women is higher in AP compared to India, as per NFHS-5 data.

Table.1 Nutritional indicators in 2019-20 as per NFHS-5

Child Feeding Practices and Nutritional Status of Children	Andhra Pradesh	India
Children under age 3 years breastfed within one hour of birth (%)	52	41.8

Children under age 6 months exclusively breastfed (%)	68	63.7
Children age 6-8 months receiving solid or semi solid food and breast-milk (%)	50.8	45.9
Breastfeeding children age 6-23 months receiving an adequate diet (%)	8.2	11.1
Non-Breastfeeding children age 6-23 months receiving an adequate diet (%)	12.1	12.7
Total Children age 6-23 months receiving an adequate diet (%)	9.3	11.3
Children under 5 years who are stunted (%)	31.2	35.5
Children under 5 years who are wasted (%)	16.1	19.3
Children under 5 years who are severely wasted (%)	6	7.7
Children under 5 years who are underweight (%)	29.6	32.1
Children under 5 years who are overweight (%)	2.7	3.4
Nutritional Status of Adults (age 15-49 years)		
Women whose Body Mass Index (BMI) is below normal (%)	14.8	18.7
Men whose Body Mass Index (BMI) is below normal (%)	16.5	16.2
Women who are overweight or obese (%)	36.3	24
Men who are overweight or obese (%)	31.1	22.9
Anaemia among Children and Women		
Children age 6-59 months who are anaemic (%)	63.2	67.1
Non pregnant women age 15-49 years who are anaemic (%)	59	57.2
Pregnant Women age 15-49 years who are anaemic (%)	53.7	52.2
All women age 15-49 years who are anaemic (%)	58.8	57
All Women age 15-19 years who are anaemic (%)	60.1	59.1

Dynamics of nutritional status in Andhra Pradesh

Table.2 Nutritional indicators in Andhra Pradesh in 2019-20 and 2015-16			
	2019-20	**2015-16**	**Difference**
Children under age 3 years breastfed within one hour of birth (%)	52	40	12
Children under age 6 months exclusively breastfed (%)	68	70.2	-2.2
Children age 6-8 months receiving solid or semi solid food and breastmilk (%)	50.8	56.1	-5.3
Breastfeeding children age 6-23 months receiving an adequate diet (%)	8.2	6.5	1.7
Non-Breastfeeding children age 6-23 months receiving an adequate diet (%)	12.1	11.9	0.2
Total Children age 6-23 month receiving an adequate diet (%)	9.3	7.6	1.7
Children under 5 years who are stunted (%)	31.2	31.4	-0.2
Children under 5 years who are wasted (%)	16.1	17.2	-1.1
Children under 5 years who are severely wasted (%)	6	4.5	1.5

Children under 5 years who are underweight (%)	29.6	31.9	-2.3
Children under 5 years who are overweight (%)	2.7	1.2	1.5
Women whose Body Mass Index (BMI) is below normal (%)	14.8	17.6	-2.8
Men whose Body Mass Index (BMI) is below normal (%)	16.5	14.8	1.7
Women who are overweight or obese (%)	36.3	33.2	3.1
Men who are overweight or obese (%)	31.1	33.5	-2.4
Children age 6-59 months who are anaemic (%)	63.2	58.6	4.6
Non pregnant women age 15-49 years who are anaemic (%)	59	60.2	-1.2
Pregnant Women age 15-49 years who are anaemic (%)	53.7	52.9	0.8
All women age 15-49 years who are anaemic (%)	58.8	60	-1.2
All Women age 15-19 years who are anaemic (%)	60.1	61.1	-1
Men age 15-49 years who are anaemic (%)	16.2	27	-10.8
Men age 15-19 years who are anaemic (%)	18.7	29.3	-10.6

Source: NFHS-4 and NFHS-5

In AP state there were improvements in some nutritional dimensions in NFHS-5 compared to NFHS-4 (table.2). Share of children receiving adequate diet increased in 2019-20 in AP (9.3%) compared to that in 2015-16 (7.6%). In spite of this AP was poor performer in this indicator when compared to all India in 2019-20. In AP, there was decline in wasting and underweight children share in NFHS-5 compared to that in NFHS-4. But share of overweight children and severely wasted children in AP increased in 2019-20 compared to 2015-16 (NFHS-4). There was very negligible decline in share of stunted children in 2019-20(31.2%) compared to that in 2015-16(31.4%). Obesity in women, anaemia in children and anaemia in pregnant women increased in AP in 2019-20 compared to 2015-16.

District level nutritional status in Andhra Pradesh

In AP, 13 districts were there in 2019-20. Hence further analysis was carried out focusing on these 13 districts to (i) identify districts contributing to improvement and deterioration in selected nutritional indicators at AP level. (ii) identify district level nutritional issues. The analysis was carried out focusing on 12 nutritional/health indicators.

In 2019-20, share of children below 2 years age receiving adequate diet was more than state average in 7 out of 13 districts there by contributing positively to the state level outcome (Table.3). On the other hand, in 5 districts, share of stunted children was more than state level value. Maximum stunted children percentage (50.5%) was observed in case of Kurnool district of Rayalseema, a drought prone region, and is 1.6 times of state level figure (31.2%). Further in 3 out of 4 districts of Rayalseema (Anantapur, Kurnool and Y.S.R Kadapa) stunted children share was more than state level value. In 6 districts, share of wasted children was lower than state level value of the indicator. Maximum wasting in children below 5 years was observed in the case of Visakhapatnam (21.5%) and minimum was observed in Prakasam district (8.7%). In 4 districts share of children with underweight was more than at state level. Maximum share of children with underweight was reported in the case of Kurnool district (46.3%). Thus, in the case of Kurnool simultaneous occurrence of maximum share of children with stunting (indicating chronic hunger) and maximum share of children with underweight was observed.

In 2019-20, overweight children share in AP state stood at 2.7 percent. In 8 districts, share of overweight children was more than state level figure and all these 8 districts fall under coastal zone of Andhra Pradesh. Maximum share with respect to overweight children was noticed in the case of West Godavari district (5.2%), almost double the state level figure, and was closely followed by Prakasam district (5.1%).

In 2019-20, share of obese women ranged between 23.8 percent (in Vishakhapatnam) to 46.4 percent (in Guntur) across various districts of AP state in 2019-20. In 6 coastal districts, obese women share figure was more than state level figure. On the other hand, share of women whose Body Mass Index (BMI) was below normal, ranged between 9.6 (in Guntur) to

21.9 percent (in Anantapur) across different districts of Andhra Pradesh state. In 7 out of 13 districts, share of women with BMI below than normal was higher than state level outcome.

In 2019-20, anaemia among children below 5 years was more than 50% in all the 13 districts of AP, ranged between 54.9 percent (in Chittoor district) to 72.6 percent (in Vishakapatnam). In 6 districts, anaemia among children was more than state level outcome, out of which one district was from Rayalseema region (Kurnool district with 70.8 percent anaemic children). Similar to anaemia in children, anaemic women share was more than 50 percent in all the districts of Andhra Pradesh. Maximum share of anaemic women in 15-49 years' age category was observed in the case of Vizianagaram (64%) and was closely followed by East and West Godavari districts. From the table 3, not only information regarding nutrition indicator wise poor performing districts, but also information regarding district wise nutritional indicators which needs attention are identifiable.

In table 4 details of district level change in selected nutritional indicators in 2019-20 (NFHS-5) compared to 2015-16 (NFHS-4) are presented. In 9 districts share of children receiving adequate diet improved in 2019-20 compared to 2015-16 (table.4). In Anantapur, Nellore, Vizianagram and Y.S.R.Kadapa there was a decline in share of children receiving adequate diet in 2019-20, compared to 2015-16. Share of Stunted children and wasted children increased in 5 districts in 2019-20 compared to 2015-16. Out of these 5 districts, 4 were coastal districts and one was district of Rayalseema region. Share of severely wasted children and overweight children increased in 9 districts in 2019-20 compared to 2015-16. Obesity in women increased in 11 districts in 2019-20 compared to 2015-16, which includes all four districts of Rayalseema region. Similarly, anaemia in children increased in 10 districts out of total 13 districts of Andhra Pradesh state (table.4).

Table 3. Nutritional indicators in different districts of Andhra Pradesh in 2019-20 (NFHS-5)												
	Total children age 6-23 months receiving an adequate diet(%)	Children under 5 years who are stunted (%)	Children under 5 years who are wasted (%)	Children under 5 years who are severely wasted (%)	Children under 5 years who are underweight (%)	Children under 5 years who are overweight (%)	Women who are overweight or obese (%)	Women whose Body Mass Index (BMI) is below normal (%)	Children age 6-59 months who are anaemic(%)	Non pregnant women age 15-49 years who are anaemic(%)	All women age 15-49 years who are anaemic(%)	All Women age 15-19 years who are anaemic(%)
Anantapur	2.9	36	19.3	4	40.6	0.3	29.3	21.9	55.8	50.3	50.5	50
Chittoor	6	27.1	14.8	6.3	27.9	0.5	33.4	20.1	54.9	51.8	51.8	43.9
East Godavari	10.2	23.1	14.3	3.8	22.4	3.4	44.4	10.2	66.8	63.2	63	65.2
Guntur	11.2	23.8	17.8	8.1	26.9	3.6	46.4	9.6	59.3	59.8	59.5	54.6
Krishna	23.4	29.8	14.3	5.2	21.1	4.2	40.6	10.5	65.7	60.4	60.3	59
Kurnool	9.6	50.5	16.7	6	46.3	1.1	29	20.6	70.8	58.3	58.6	61.1
Prakasam	13.4	22.6	8.7	3.3	24.7	5.1	39.5	14.4	62.6	60.6	60.4	64.8
SPS Nellore	6.9	29.2	17.2	6.9	27.8	0.5	39.5	15.2	67.5	59.6	59.4	68.6
Srikakulam	16.1	19.7	19.5	7.4	21.4	4.5	27.2	13.8	59.6	62.8	62.6	59.2
Vishakapatnam	11.8	31	21.5	11.2	33.5	4.8	23.8	17.4	72.6	58.6	58	58.9
Vizianagarm	1.8	36.4	19.2	8.3	32.2	4.7	28.8	16.9	66.7	64.6	64	73.9
West Godavari	3.5	31.4	11.7	4.7	22.5	5.2	45.3	10.1	62.3	63.1	63	66.8
Y.S.R. Kadapa	5.5	34.4	14.1	4.2	26.7	0.2	33.9	15.9	60.6	56.1	56.1	60.2
Andhra Pradesh state	9.3	31.2	16.1	6	29.6	2.7	36.3	14.8	63.2	59	58.8	60.1
Number of districts with >AP state value	7	5	7	7	4	8	6	7	6	8	8	7
Number of districts with <AP state value	6	8	6	6	9	5	7	6	7	5	5	6

Table.4 Change in Nutritional Indicator value in 2019-20 (NFHS-5) when compared to 2015-16 (NFHS-4)												
	Total Children age 6-23 months receiving an adequate diet (%)	Children under 5 years who are stunted (%)	Children under 5 years who are wasted (%)	Children under 5 years who are severely wasted (%)	Children under 5 years who are underweight (%)	Children under 5 years who are overweight (%)	Women whose Body Mass Index (BMI) is below normal (%)	Women who are overweight or obese(%)	Children age 6-59 months who are anaemic(%)	Non pregnant women age 15-49 years who are anaemic(%)	All women age 15-49 years who are anaemic(%)	All Women age 15-19 years who are anaemic(%)
Anantapur	-13.5	-4.3	4.1	-0.5	1.3	-0.3	1.7	2.8	2.8	-2.5	-2.2	-1.2
Chittoor	1.6	-4.3	-3.3	1.7	-4.5	0.5	-0.9	4.9	8.3	3.4	3	-8.1
East Godavari	3.5	-4.6	-1	0.8	-4.7	0.7	-5.7	8	3.7	-1.7	-1.6	-0.7
Guntur	0.3	1.7	-0.1	-1.7	-2.2	-0.3	-1.7	1.3	-8.8	0.8	1.6	0.9
Krishna	17.2	7.2	-6.4	0.1	-6.6	2.4	-3	-4.9	7.6	0.7	0.9	-5.9
Kurnool	8.2	6.4	-2.1	1.3	8.8	0.5	-1	4.1	16.3	3.7	4.1	6.9
Prakasam	2.1	-5.6	-6.6	-0.3	-5.6	4.3	-2.5	7	6.3	2.9	2.7	5.8
SPS Nellore	-1.8	-0.2	0.3	2.6	-0.9	-1	-1.8	4.5	17.1	0.5	0.3	6.6
Srikakulam	12.3	-8.3	3.9	3.5	-7.3	3.5	-6.7	2.8	-11	-9.3	-9.2	-11.9
Vishakapatnam	1.6	0.9	4.3	9.7	0.4	4.8	-1.5	-5	8.1	-8	-8.4	-13
Vizianagarm	-8.7	-0.4	0.4	3.6	-2.2	4.2	-8.9	6.4	-12	-11.1	-11.5	-6.7
West Godavari	1.1	2.9	-3	1.5	-7.6	4.6	-4.4	5.3	7.2	2.8	3.1	7.2
Y.S.R. Kadapa	-1.2	-1.9	-3.8	-1.6	-7.7	-1.2	-2.8	6.8	4.8	-1.5	-1.6	14.6
Andhra Pradesh	1.7	-0.2	-1.1	1.5	-2.3	1.5	-2.8	3.1	4.6	-1.2	-1.2	-1
Number of districts with increase in value of nutritional Indicator	9	5	5	9	3	9	1	11	10	7	7	6

Table.5 Nutritional Achievement Scores of different districts of AP state in 2019-20			
District	NAS under-nutrition	NAS Overweight	NAS anaemia
Anantapur	18	87	97
Chittoor	47	76	95
East Godavari	75	22	20
Guntur	67	16	54
Krishna	83	23	33
Kurnool	17	79	25
Prakasam	78	16	42
SPS Nellore	51	62	31
Srikakulam	69	49	42
Visakhapatnam	39	54	22
Vizianagaram	32	44	17
West Godavari	67	2	33
YSR Kadapa	51	78	63
Source: computed using NFHS-5 data			

From the analysis it is evident that malnourishment (under nutrition and over nutrition) and anaemia are the key nutritional issues that needs attention in different districts of Andhra Pradesh. To identify nutritional issue wise priority districts, three Nutritional Achievement Scores (NAS) were computed and the details are presented in the table.5. If a cut-off score is taken as 50, districts with score below 50 are the districts which need priority focus.

As far as under-nutrition is concerned 5 districts (three from Rayalseema that is Kurnool, Anantapur, and Chittoor, two from Coastal Andhra, i.e Vizianagarm and Visakhapatnam) needs focus (table.5). With respect to overweight, 7 districts (all from coastal Andhra Pradesh excluding SPS Nellore and Vishakapatnam) are the priority districts needing attention. 9 out of 13 districts (except Anantapur, Chittoor, YSR Kadapa and Guntur) are with NAS score below 50 with respect to Anaemia. Vizianagarm is the poor performer in all three dimension

i.e, under-nutrition, over nutrition and anaemia. Kurnool, West Godavari and Vizianagarm are the top most priority districts for under-nutrition, overweight and anaemia respectively.

Intervention options available for handling nutritional issues

Results of analysis of district wise per capita availability of different food items in Andhra Pradesh, computed based on district level production is presented in the table 6 and is contrasted with NIN-my plate recommendation.

Table.6. Per capita availability of various food groups based on production during 2018-20 (Tons/year)

District	Cereal and Millets	Pulses	Other sources of meat	Chicken	Pulses+ meat+chicken	Eggs (No.)	Milk
Ananthapur	0.05	0.02	0.01	0.00	0.03	72.93	0.21
Chittoor	0.07	0.01	0.01	0.01	0.03	193.99	0.35
East Godavari	0.47	0.00	0.00	0.01	0.02	1192.49	0.24
Guntur	0.41	0.02	0.00	0.01	0.04	393.26	0.31
Krishna	0.41	0.04	0.01	0.01	0.06	684.53	0.37
Kurnool	0.24	0.04	0.01	0.01	0.06	52.55	0.21
Prakasam	0.13	0.04	0.02	0.01	0.07	80.12	0.44
SPS Nellore	0.41	0.01	0.01	0.00	0.02	100.59	0.27
Srikakulam	0.36	0.01	0.00	0.01	0.02	81.67	0.25
Visakhapatnam	0.08	0.00	0.00	0.01	0.02	306.28	0.18
Vizianagaram	0.31	0.01	0.01	0.01	0.02	220.71	0.30
West Godavari	0.73	0.00	0.00	0.01	0.02	953.97	0.33
YSR Kadapa	0.08	0.03	0.01	0.01	0.05	410.59	0.40
Andhra Pradesh	0.30	0.02	0.01	0.01	0.03	408.58	0.29
My plate (NIN)	0.09	0.03					0.11

Source: computed from data collected from publications of Directorate of Economics and Statistics, Government of Andhra Pradesh.

Cereals availability was lower than NIN-my plate recommendation in only four districts of Andhra Pradesh viz., Anantapur, Chittoor, Y.S.R. Kadapa (of rayalseema region) and Vishakapatnam (table.6). Protein availability from pulses and other flesh foods and milk availability was adequate as per NIN-my plate recommendation in all the districts of AP

state. But per capita availability of vegetables and fruits also need to be considered for getting full information regarding nutritious diet availability. Per capita availability of vegetables at state level in AP during 2018-2020 was 399 grams per day against NIN-Myplate figure 400 gms/ day. However, availability will not automatically lead to accessibility. It is the accessibility and actual consumption that influences nutritional status of people which can be determined by income of households and share of income spent on food. Further export/import policy of a country will also determine availability and prices of different food groups. Liu et al (2024) through a cross-country analysis observed that a 10 percent decline in dairy tariff rates reduces the risk of stunting in children. Headey et al (2023) in the context of Sub-Saharan Africa observed that poverty, higher relative food prices and weak preferences for healthy foods acted as barriers to convergence with EAT-Lancet diet. In the context of India, Raghunathan et al (2021) reported that healthy diets that met national food based dietary guidelines were unaffordable to two thirds to three fourth of rural population in 2011. Minimum cost nutritious diet was unaffordable to 75 percent of households in the state of Uttar Pradesh state in India (Kachwaha et al,2020).

Table .7 Effect of per capita income on different nutritional indicators

Indicators	Intercept	Per Capita Income effect	R Square
Total Children age 6-23 months receiving an adequate diet (%)	1.4689 (0.660665436)	7.41755E-05 (0.035333851	0.171
Children under 5 years who are stunted (%)	36.4007 (1.13222E-07)	-5.89177E-05 (0.243629408)	0.056
Children under 5 years who are wasted (%)	17.3170 (5.71336E-09)	-7.56795E-06 (0.705997204)	0.006
Children under 5 years who are underweight (%)	39.0175 (4.22187E-10)	-9.19204E-05 (0.026791208)	0.188
Women whose Body Mass Index (BMI) is below normal (%)	23.6648 (2.6963E-09)	-7.38432E-05 (0.00909828)	0.251
Children under 5 years who are overweight (%)	-0.9267 (0.421352733)	3.13304E-05 (0.011194283)	0.239

Women who are overweight or obese (%)	25.1146 (5.07876E-05)	9.09358E-05 (0.089345624)	0.115
Children age 6-59 months who are anaemic (%)	54.4657 (1.22999E-10)	7.4249E-05 (0.159210051)	0.080
All women age 15-49 years who are anaemic(%)	59.7456 (3.17519E-13)	-7.55342E-08 (0.998583956)	1.34E-07
Source: Authors estimation using data collected from publications of Directorate of Economics and Statistics, Government of Andhra Pradesh and NFHS-4 and NFSH-5			

* Figures in parenthesis are p values

In the current study the relationship between district wise per capita income and nutritional indicators in AP state using both NFHS-4 and NFHS-5 data are examined and results are presented in table.7 From the table.7 it is evident that, increase in income is leading to improvement in share of children (below 2yrs age) receiving adequate diet, decline in stunting, wasting, and underweight in children, decline in share of women with BMI below normal and decline in share of anaemic women. Contrary to expectation, increase in income led to increase in share of anaemic children. Explanatory power of per capita income is very low in explaining the selected indicators as evidenced from low R square. This is in line with the observation made by Chand and Jumrani (2013) that " income growth and elimination of poverty is a 'necessary' but not a ' sufficient' condition for reducing under nourishment and malnourishment in India". Further per capita income does not capture income distributional issue and its impact on nutritional indicator. Jumrani (2023) observed in her study in the context of India, that the relationship between demand for nutrients and income is indeed non-linear and non-monotonic. Further she reported that (i) relative to protein, fat and micronutrient intake, caloric intakes were less sensitive to change in income (ii) calcium happens to be the most income responsive micronutrient and zinc was the least income responsive micronutrient. Thus, interventions of direct nutrients supply besides income improvement are necessary for addressing hidden hunger.

From the table 7 it is evident that the share of overweight women is positively related with per capita income but share of overweight children is negatively related with per capita income. Positive relation between per capita income and obesity in women observed in the current study is in line with Wunderlich and Kohler (2022) hypothesis of sinking food prices and a higher income may lead to rising obesity. Wunderlich and Kohler (2022) in a cross-country study observed that higher proportion of female in labour force, increasing opportunity cost of time, in turn less time to prepare meals at home, and there by higher demand for fast foods lead to higher obesity among population. This could be the other reason for increase in overweight in women with increase in income.

Tackling under-nutrition and anaemia through food/nutrition-based interventions

In Indian context schemes like Mid Day Meal (MDM) and Breakfast scheme (Tamil Nadu, Telangana) for school children, Food Kits (with 17 items in Kerala), Pradhan Mantri Garib Kalyan Yojana (PMGKY), School Nutrition Gardens are some important nutrition-based interventions trying to address affordability issue and promote dietary diversification. Micronutrient supplementation, food fortification and public health and disease control are the others interventions through which efforts are being made at global level for combating micro-nutrient deficiencies (Bechoff et al,2023) like zinc deficiency (causing stunting), iron deficiency (causing anaemia), calcium and vitamin-A deficiency (affecting vision). Micronutrient supplementation is effective only for specific targeted population but not for population level intervention due to cost and distributional challenges (Lowe, 2024). Thus, for handling population level nutritional issues, food fortification is being viewed as an option. Fortification can be through bio-fortification or chemical fortification.

Chemical Fortification

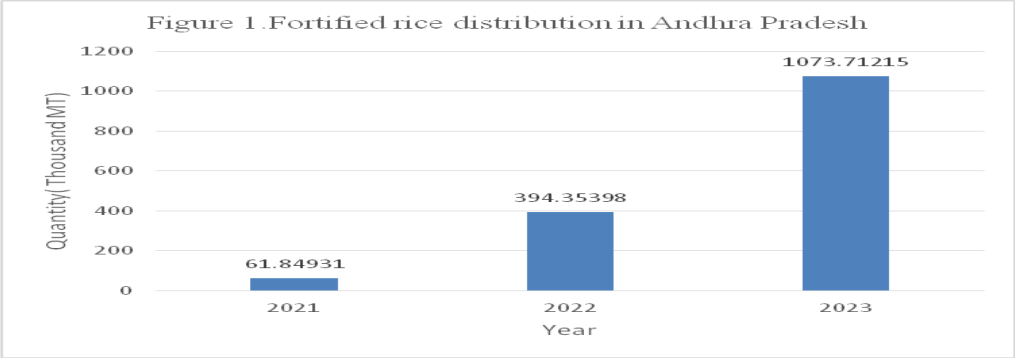
Chemical fortification involves addition of micronutrients to food during processing or at the point of use. In India some fortification programmes (like fortification of salt with Iodine, rice fortification with Iron) are mandatory and some are voluntary. The programme of distributing rice (chemically) fortified with iron was implemented on pilot basis initially in eleven states (which includes Andhra Pradesh) for 3 years starting from 2019-20, with one district per state, and it was extended to additional 3 states later. Government of India is targeting to extend this distribution in a phased manner to all districts of India by 2024 through Targeted Public Distribution System (TPDS), ICDS, PM POSHAN and other welfare schemes. Annual estimated cost of this program is around 2700 crore rupees. In ex-ante framework Quershy et al (2023) estimated benefit cost ratio of this program as 8.9:1.

In 2023, AP share in total fortified rice distributed in India, was 4.61 per cent. In AP state, Vizianagaram district which happens to be a poor performer in all the three nutritional Indicators (table.5) was chosen in pilot stage. AP government planned to distribute fortified rice in all districts from September, 2023. Details regarding fortified rice distribution in different districts of AP in 2023 are presented in the table 8. Quantity of fortified rice distributed in AP state in the year 2023 increased by 17.36 times compared to the year 2021 (Figure.1). In AP state 1509 rice mills with annual blending capacity of 146.832 lakh metric tons and 5 Fortified Rice Kernel (FRK) suppliers constituted the infrastructure in chemical fortification program till 2023.

Table 8. District wise quantity of Iron fortified rice distributed in Andhra Pradesh state in the year 2023

S. No.	District	Iron Fortified rice distributed (MT)	S. No.	District	Iron Fortified rice distributed (MT)
1	Anantapur	140969	14	Sri Satya Sai	16562
2	Kurnool	132459	15	Anakapalli	14547
3	Vizianagaram	119988	16	Nandyal	14498

4	Y.S.R. Kadapa	106171	17	Annamayya	14356
5	Chittoor	78314	18	Sri Balaji	13442
6	Vishakapatnam	77805	19	Alluri Sitharama raju	10839
7	Prakasam	67849	20	Manyam	9459
8	Srikakulam	58189	21	Eluru	7135
9	East Godavari	40069	22	Palnadu	6214
10	SPSR Nellore	39727	23	NTR	5747
11	Krishna	30018	24	Konaseema	5348
12	Guntur	29608	25	Kakinada	4719
13	West Godavari	24964	26	Bapatla	4715
Source: Rice fortification portal http://annavitran.nic.in/FR/avFortifiedRice accessed on 08-02-2024					



Source: Rice fortification portal http://annavitran.nic.in/FR/avFortifiedRice accessed on 08-02-2024

Regarding this distribution of chemically fortified rice with iron, several concerns are being raised. They are quality control and food safety (due to lack of labs in some states), lower shelf-life, health risk due to excess consumption, health risk due to consumption by vulnerable population (like people with diseases viz, sickle cell anaemia, thalassemia, malaria and tuberculosis) (Dogra,2022; Prasad, 2022), predisposing children and adults to some diseases (like diabetes, hypertension, and dyslipidaemia) and confusion among consumers (because fortified rice is not offered in open market). Some other concerns are centralization of rice milling by a few big business, creation of new markets of multinational vitamin companies and Fortified Rice Kernel (FRK) manufacturers with dependency of rice millers

(i.e creating corporate dependencies), challenges in making FRK suitable to mix with different varieties of rice (Yadav,2023a,2023b,2023c). Kurpad and Sachdev (2022) argued that in the context of India, where in iron deficiency is cause for less than half of anaemic cases, nutrition policy could not be based on assumption that causes of anaemia were same in all its diverse regions. They reported that deficiency of folic acid and vitamin B12 also contributed to anaemia in India. In that context supply of rice fortified with iron, Vitamin B12 and folic acid as being done in India, can be viewed as a comprehensive strategy. On the other hand, to avoid excess consumption risk from multiple foods fortified with same micro-nutrient, NAAS (2022) suggested restricting fortification to one food per nutrient. Quality checking, monitoring and creating awareness among consumers in order to enhance their acceptability are some steps that need to be taken up for improving the effectiveness of this program.

Bio-fortification

In bio-fortification micro-nutrient content is increased in edible part of a crop using conventional breeding, biotechnology, transgenic approaches and genome editing, and through use of micro-nutrient enhanced fertilizers (Agronomic fortification) and microorganisms (Yadav et al,2020). Several studies reported cost effectiveness of bio-fortification (Tan et al,2023). In India also, under public sector, 87 bio-fortified varieties are developed in 16 crops not only encompassing cereals and millets but also oil seeds, vegetables and some fruits with enhancement for proteins, specific amino-acids, vitamins and micronutrients like Zinc and Iron (Yadava et al, 2022). Among these 87 bio-fortified varieties, 63 varieties (which include 8 rice varieties) are varieties of cereals and millets fortified for proteins, micro-nutrients like Zinc, iron and calcium and vitamins like vitamin-A and Vitamin-C. Some of these bio-fortified rice varieties are suitable for cultivation in

Andhra Pradesh state. Singh et al (2024) estimated that if 5 percent of population in India consume bio-fortified rice, a monthly savings to the extent of 203 and 81 crore rupees on zinc supplementation and iron supplementation respectively can be made. Further they estimated that consumption of zinc fortified rice can lead to annual per capita savings of Rs 2933 because of saving DALYs (Disability Adjusted Life years).

The underlying rationale in developing bio-fortified cereals and millets (constituting 72 percent of 87 bio-fortified varieties in public sector in India) is that as staple grains are consumed in substantial quantity, their fortification will lead to nutritional enhancement of consumers, even consumers of lower income as they fully rely on these staples for their nutrition (Yadava et al, 2020). But rationale for bio-fortification of fruits and vegetables is questionable unless these are supplied with subsidized price in adequate quantities to income poor consumers or specific vulnerable population category like children through specific targeted programs. Thus, there is need for planning and building specific value chains for different bio-fortified crop varieties from seed to end product involving different stakeholders (from farmers to consumer). In case of staple crops with respect to which public procurement is operational in India, mechanisms to easily detect bio-fortified crops in-order to pay premium price need to be developed. Ensuring bio-availability in consumable product through targeting for low phytate trait (Gupta et al,2020), ensuring higher yields, improving shelf life, ensuring safety, promoting consumer acceptance (through creating awareness) are the other key issues to be handled to scale up the efforts through bio-fortification (Yadava et al. 2020; Ramdas et al,2020, Chowdhury et al, 2022). Besides this in case of agronomic-fortification there is need for development of standard package regarding mineral fertilizer application in different contexts (Teklu et al, 2023) and designing better input support program (Gupta et al,2020). Srinivas et al (2023) suggested for establishment of an

international institution on bio-fortification and development of intergovernmental committee for regulatory system with respect to bio-fortification. In Indian Context Food Safety and Standards Authority of India (FSSAI) has notified standards for fortification which includes bio-fortification.

Tackling over-nutrition/over-weight/obesity

Policy measures like rationalization of farm subsidies, taxing unhealthy foods, subsidising healthy foods are some fiscal measures suggested and studied in literature for handling obesity problem. Mireles et al. (2021) assessed potential impact of removing subsidies on Butter, Cheese, and Sugar (BCS) on obesity prevalence in the Canary Islands. They observed that removal of BCS subsidy can lead to decrease in share of obese population by 0.7 percent and 4 percent of population with obesity was attributed to prevalence BCS subsidy. They further indicated that removal of BCS subsidy can lead to shift in consumption towards healthier foods like vegetables and fruits. Jumrani and Meenakshi (2023) in three states of India observed that subsidy on palm oil led to more consumption of palm oil, substituting traditional oils. Jumrani and Meenakshi (2023) further observed that there was no significant change in overall edible oil consumption and there was only weak evidence of spill over income effects on other food groups. Hence the potential of policy of tax and subsidy in bringing behavioural change in consumption in order to check rise in obesity need to be explored. Thus, there is need for studying consumption pattern in the districts of AP for identifying commodities to be taxed and commodities to be subsidized. It is reported that stunted children have an increased risk of becoming over-weighted or obese later in life (WHO,2014). Hence addressing childhood stunting can also contribute to addressing the issue of obesity.

Conclusions and way forward

In the context of Andhra Pradesh state, three major food-based interventions are being promoted towards nutritional security. They are dietary diversification, distribution of chemically fortified staples (rice) and bio-fortified varieties. Each of these three interventions involve different stakeholders and different food systems. Hence there is need for effective monitoring mechanisms for ensuring compliance and ensuring effectiveness of these programs. There is some overlap in terms of focus on specific micronutrients in chemical fortification and bio-fortification. Hence proper co-ordination must be there between these programs so as to avoid toxic effects due to overconsumption of a micronutrient. Clear focus must be there in defining who are the targeted consumers for different programs and appropriate value chain and delivery mechanisms needs to be built.

Limitations of the study.

The study focused only on availability and accessibility dimension of food and nutritional security. Absorption dimension of nutritional security (creation of improved sanitary conditions, safe drinking water and improved health facilities, knowledge creation on good eating practices), trade-off effect between women's economic empowerment and child care giving time, not received due focus in the present study. Thus in future studies simultaneous focus on availability, accessibility and absorption may yield some more insights.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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