What is the Malnutrition Problem in the Country?

Dr. Shally Awasthi,
Vice Chancellor, Bodhisattva University, U.P
Former Dean R & D
Prof. & Ex-Head, Department of Pediatrics,
King George's Medical University, UP,India

Introduction

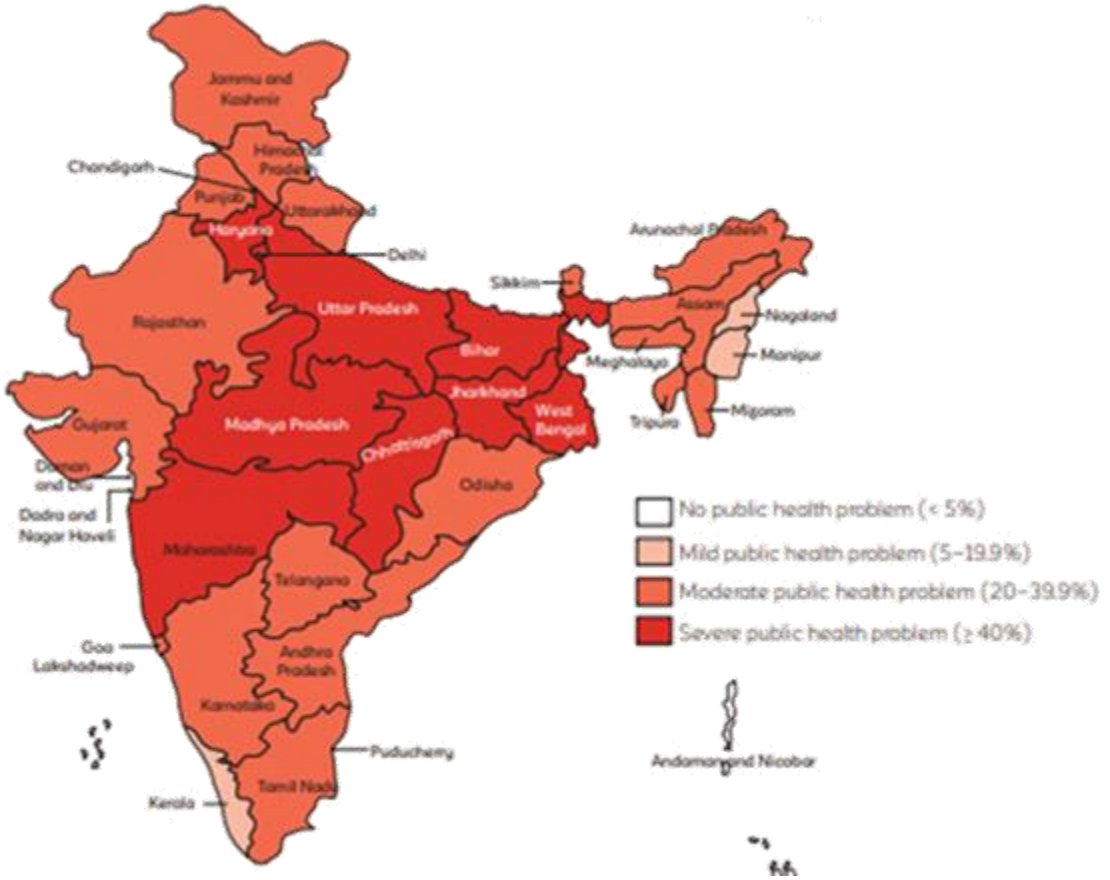
Malnutrition refers to deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients. The term malnutrition addresses 3 broad groups of conditions:

1. **undernutrition,** which includes wasting (low weight-for-height), stunting (low height-for-age) and underweight (low weight-for-age);
2. **micronutrient-related malnutrition**, which includes micronutrient deficiencies MND (a lack of important vitamins and minerals) or micronutrient excess; and
3. **overweight**, obesity and diet-related noncommunicable diseases (such as heart disease, stroke, diabetes and some cancers).

Fact sheets - Malnutrition (who.int)

Introduction

- MND affects almost one-third of the world's population.
- One or more MND is reportedly present in almost one half of school going children in India
- A large population of India is suffering from MND despite sustained efforts to ameliorate it at national and local levels.



Objective

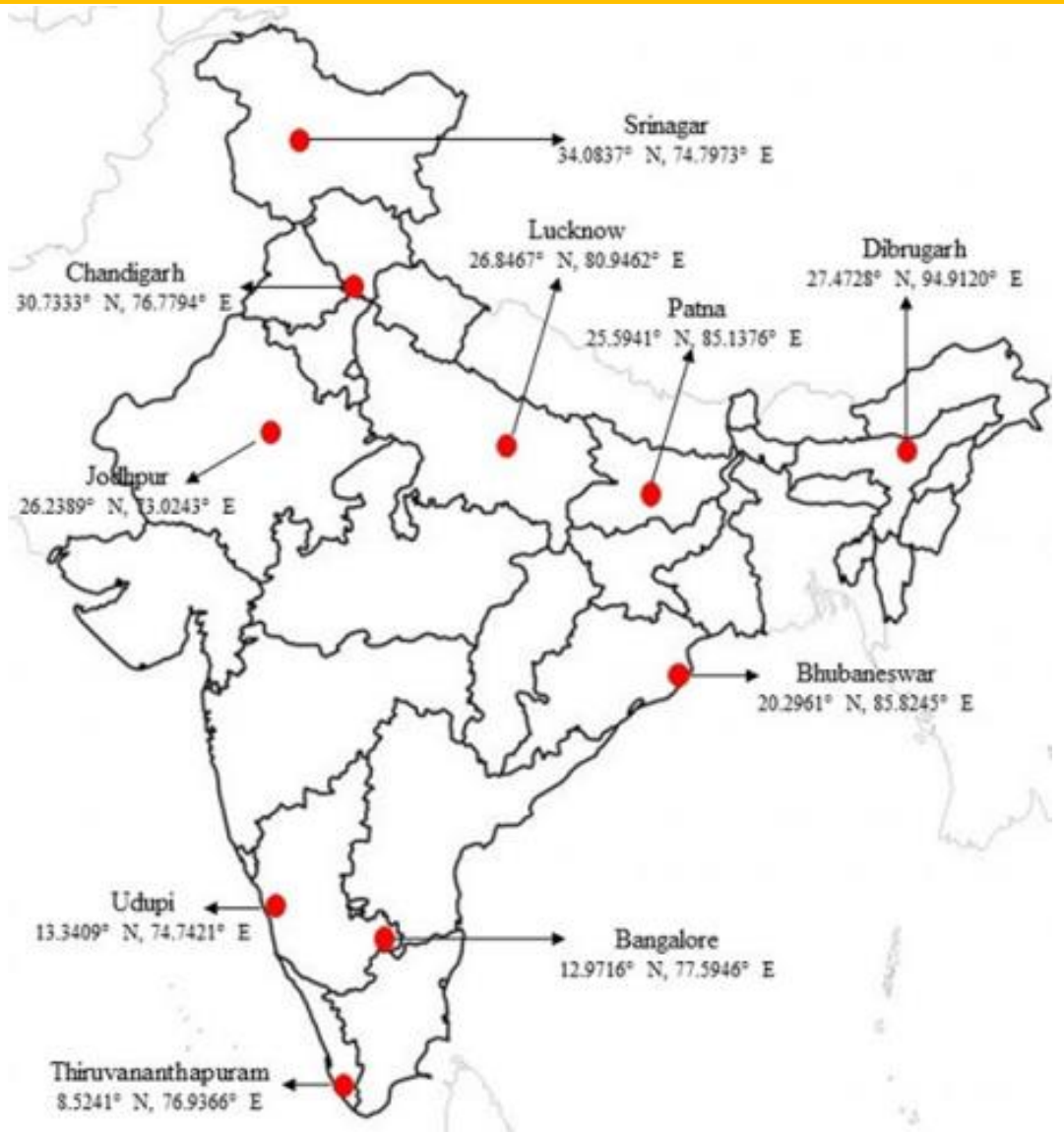
The objective of this presentation is to showcase association of MND with

- general intelligence and specific cognitive functions
- dietary intake of micronutrients

in urban school going children aged 6 to 16 years from ten cities of India.

Methodology

- Cross-sectional multicentric study (10 cities)
- Enrolled from randomly selected urban schools
- Inclusion criteria
  - age between 6–16 years,
  - residing within five km radius of school
  - Written informed consent by parents
- Exclusion criteria
  - BMI< 12.5



Data Collection by Trained Staff

- Demographic and socioeconomic details - interviewing participants and their primary care giver.
- Anthropometric measurement – by qualified and trained nutritionists.
  - Based on the BMI for age - categorized as severely thin, thin, normal, overweight, obese, and severely obese.
- Dietary Intake- 24 hours Recall method
- MN levels in Blood
- Cognitive Assessment – Administering battery of test

*Rahul Sharma. Revised Kuppuswamy's Socioeconomic Status Scale: Explained and Updated. Indian Pediatr 2017; 54:867–870. PMID: 29120335

Micronutrient Level Assessment

Method of estimation of micronutrient deficiency and anemia		
Micronutrient	**Method of estimation**	**Cut off levels**
S. Calcium	Fully automatic analyzer	<8.5 mg/dl
S. Iron		<70 µg/dl
S. Selenium	Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES)	< 5.5 µg/dl
S. Zinc		<70 µg/dl
S. Vitamin A	Enzyme Linked Immunosorbent Assay (ELISA)	<20.0 µg/dl
S. Vitamin D	Chemiluminescence	<12 ng/ml
S. Folate		<3 ng/ml
S. Vitamin B12		<203 pg/ml
Anemia (Blood)	Spectrophotometry	WHO defined hemoglobin levels

Cognitive Assessment

- Trained psychologists assessed all participants for
  - General intelligence - Colored / Standard Progressive Matrices (CPM/SPM).
  - Cognitive abilities
    - Attention-concentration - Digit span test
    - Working memory - Arithmetic test
    - Visual-spatial abilities - Coding test.
- Five performance categories
  - Borderline
  - Dull normal
  - Average
  - Above average
  - Superior

Borderline or Dull normal

Average or Above average or Superior

Dietary Assessment

- Trained Nutritionists by 24-hr recall method
- 2 consecutive weekdays and one Sunday (no fasting/feasting day)
- Cooked food items/recipe consumed - recorded by its ingredients
- DIETSOFT software – to calculate daily nutrient intake
- Mean of 3-day intake was calculated to obtain usual intake.
- Usual intake was compared with the EAR to obtain intake adequacy (IA)
- $IA = nutrient\ intake\ of\ a\ day / EAR\ of\ the\ respective\ nutrient$
  - Adequate intake (IA ≥ 1·0)
  - Inadequate intake (IA < 1·0).

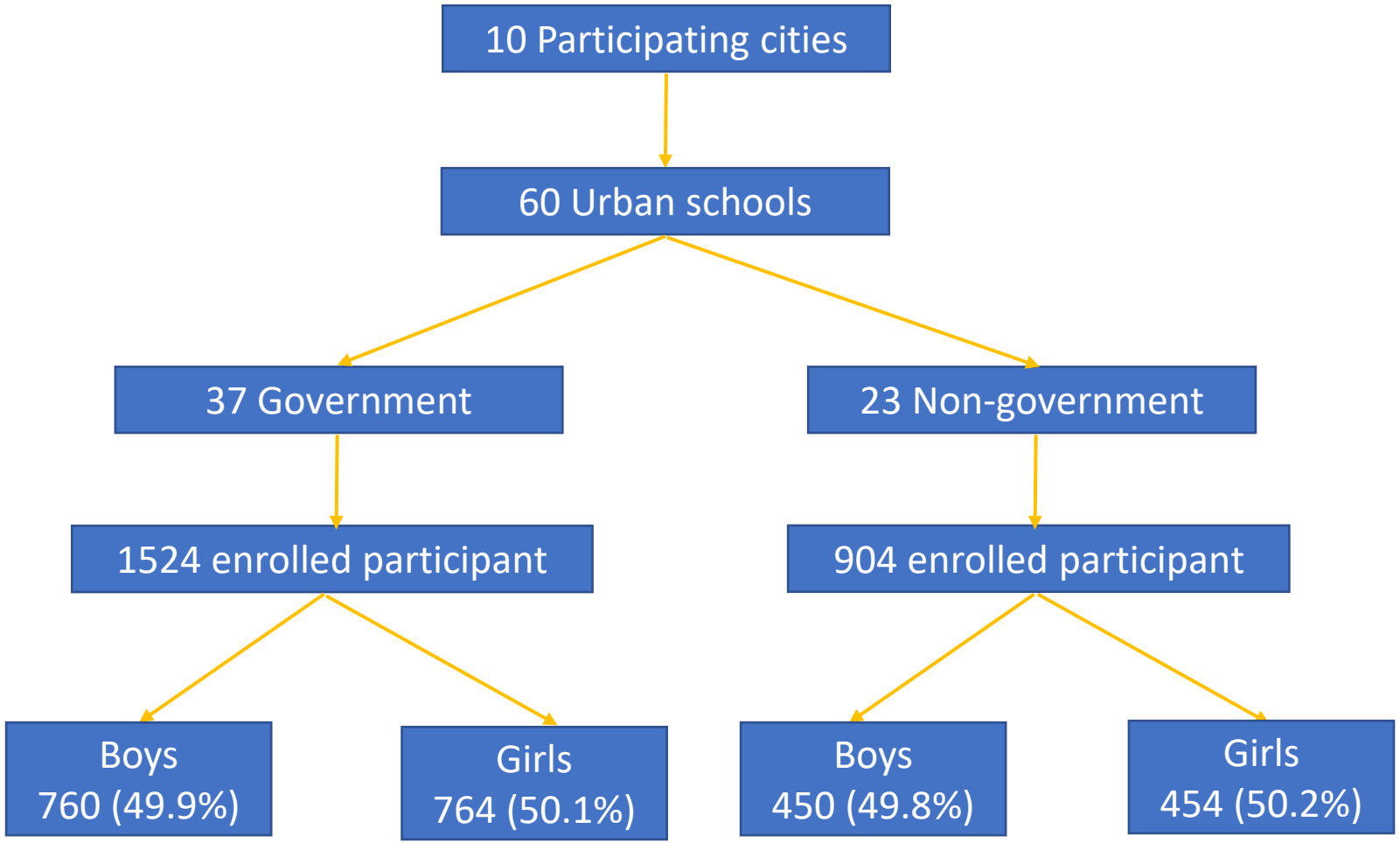
EAR cut-off*

Age group	Gender	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)	Selenium (µg/d)	Vitamin A (µg/d)	Vitamin B12 (µg/d)	Vitamin D (IU/d)	Folate (µg/d)
6 years	Boys & Girls	450	8	3.7	40	240	2.0	400	111
7-9 years	Boys & Girls	500	10	4.9	40	290	2.0	400	142
10-12 years	Boys	650	12	7.0	40	360	2.0	400	180
10-12 years	Girls	650	16	7.1	40	370	2.0	400	186
13-15 years	Boys	800	15	11.9	40	430	2.0	400	238
13-15 years	Girls	800	17	10.7	40	420	2.0	400	204
16 years	Boys	850	18	14.7	40	480	2.0	400	286
16 years	Girls	850	18	11.8	40	400	2.0	400	223

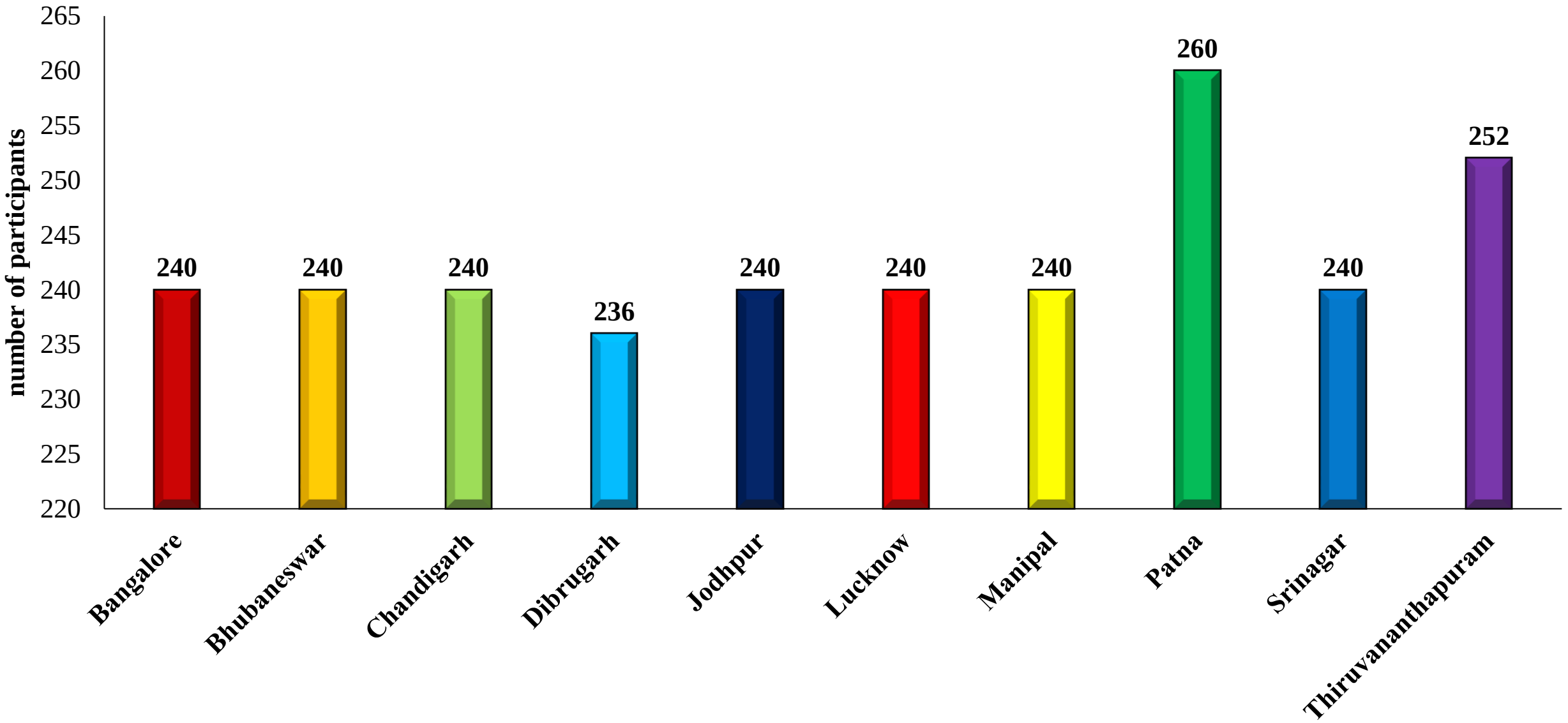
* Reference: Indian Council of Medical Research. ICMR-NIN Expert Group on Nutrient Requirement for Indians, Recommended Dietary Allowances (RDA) and Estimated Average Requirements (EAR). Indian Council of Medical Research; 2020.

Flow diagram of the selection of schools and participants

From April 2019 to February 2020, 2428 participants (49.8% boys) were enrolled from 60 schools.

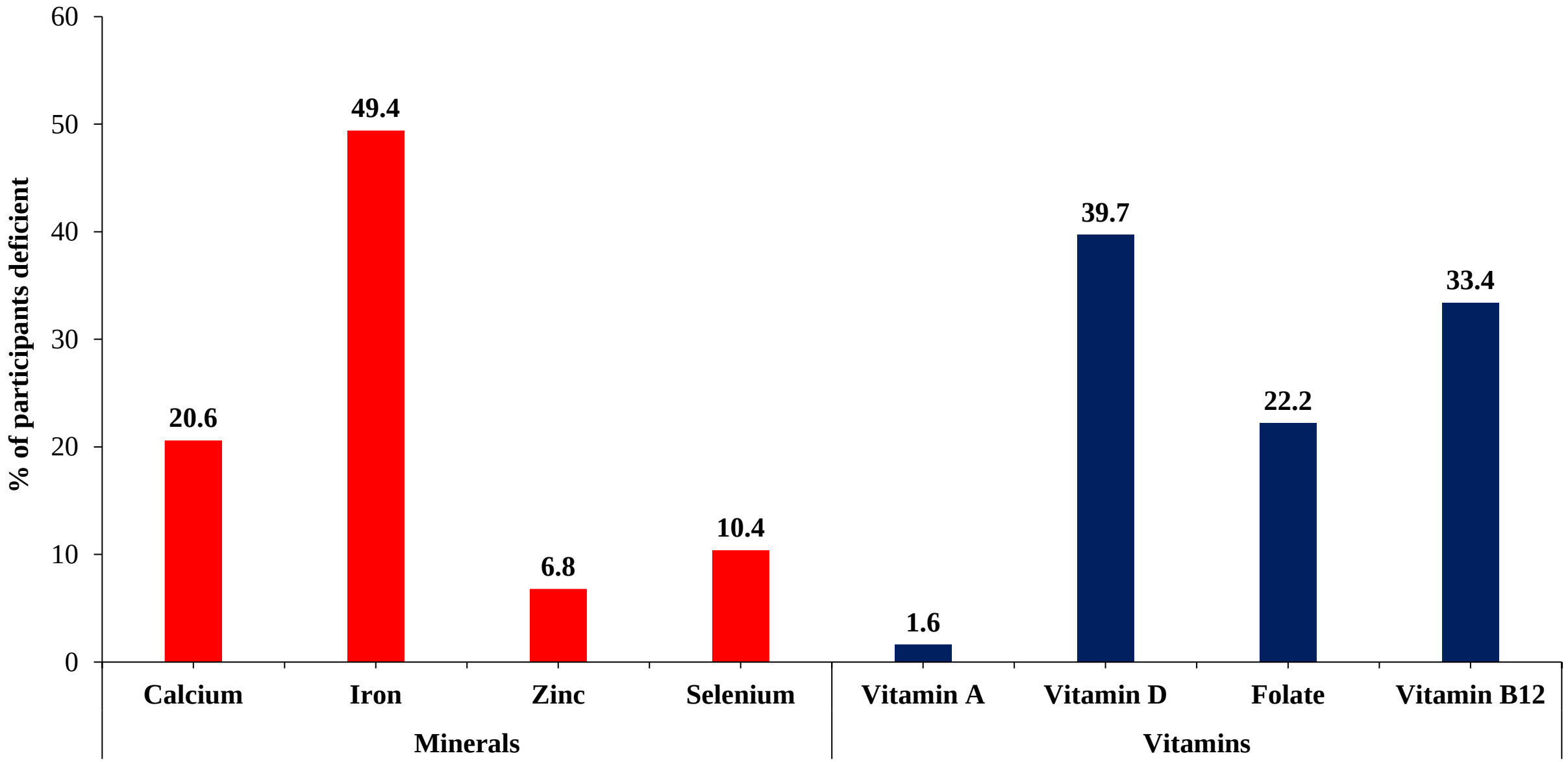


Enrolled participants by sites ~240 (N = 2428)

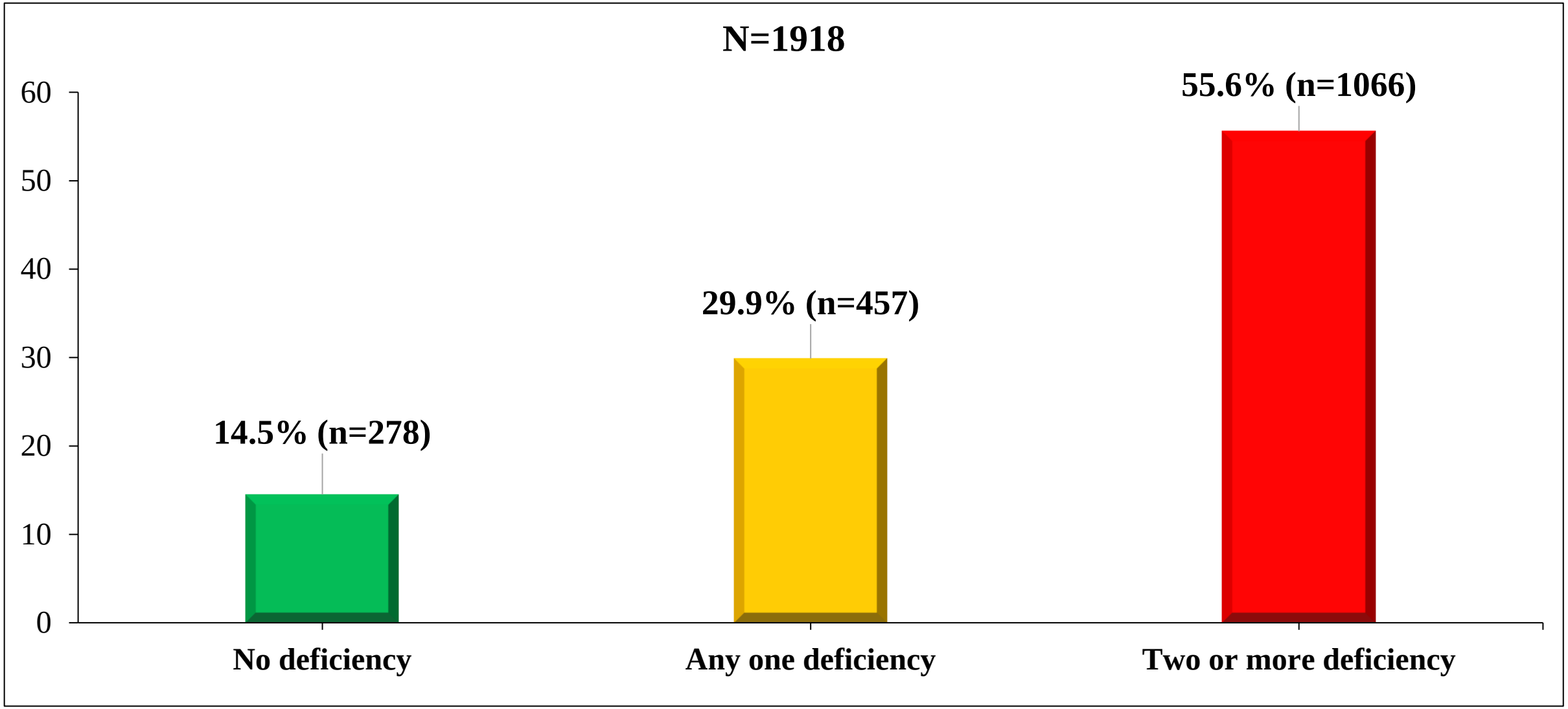


Biochemical MND

Prevalence of micronutrient deficiencies



Distribution of MN deficiency



Comparison of baseline characteristics of participants with no vs any MN deficiency

Characteristics of variable	Levels	No deficiency N = 278	Any deficiency N=1640	p-value
Age (in years)	6-11	172 (61.9)	792 (48.3)	**<0.001**
	12-16	106 (38.1)	848 (51.7)	
Gender	Male	161 (57.9)	795 (48.5)	**0.004**
	Female	117 (42.1)	845 (51.5)	
School type	Government	177 (63.7)	1081 (65.9)	0.47
	Private	101 (36.3)	559 (34.1)	
SES	Upper or upper middle or lower middle	165 (59.4)	927 (56.6)	0.40
	Upper lower or lower	113 (40.6)	710 (43.4)	
Anthropometric indicator	Normal	185 (66.5)	1149 (70.1)	0.06
	Severe thinness or thinness	55 (19.8)	236 (14.4)	
	Overweight or obese or severely obese	38 (13.7)	255 (15.5)	
Member in Family	≤ 5	197 (70.9)	1024 (62.6)	**0.008**
	> 5	81 (29.1)	613 (37.4)	
Birth order	First child	139 (50.0)	686 (41.9)	**<0.001**
	Second child	104 (37.4)	586 (35.8)	
	Three and above	35 (12.6)	365 (22.3)	

Associates of No MND

Participants (n=278) were
Younger age,
living in smaller families and
having none or one sibling and
this was unrelated to BMI category

Cognitive Performance

Logistic regression model: association of Cognitive Impairment with MN deficiency, Gender, SES & BMI

Characteristics of variables	CPM/SPM test	Coding Test	Digit span test	Arithmetic test
	*Adjusted OR	*Adjusted OR	*Adjusted OR	*Adjusted OR
Micronutrient Deficiency				
No deficiency[ref]				
Any one deficiency	**1.84**	1.24	1.28	**1.51**
Two or more deficiency	**2.09**	**1.55**	**1.45**	**1.85**
Gender (female)	**1.26**	**0.62**	0.89	1.17
Socio economic status upper lower or lower)	**2.53**	**2.20**	**3.07**	**1.76**
Anthropometric indicators				
Normal[ref]				
Severe thinness or thinness	**1.43**	1.22	1.07	1.13
Overweight or obese or severely obese	**0.66**	0.86	**0.47**	**0.68**

*Adjusted for gender, socioeconomic status and BMI indicators

Associates of Cognitive Deficiencies

≥2 MND

after controlling for other associates

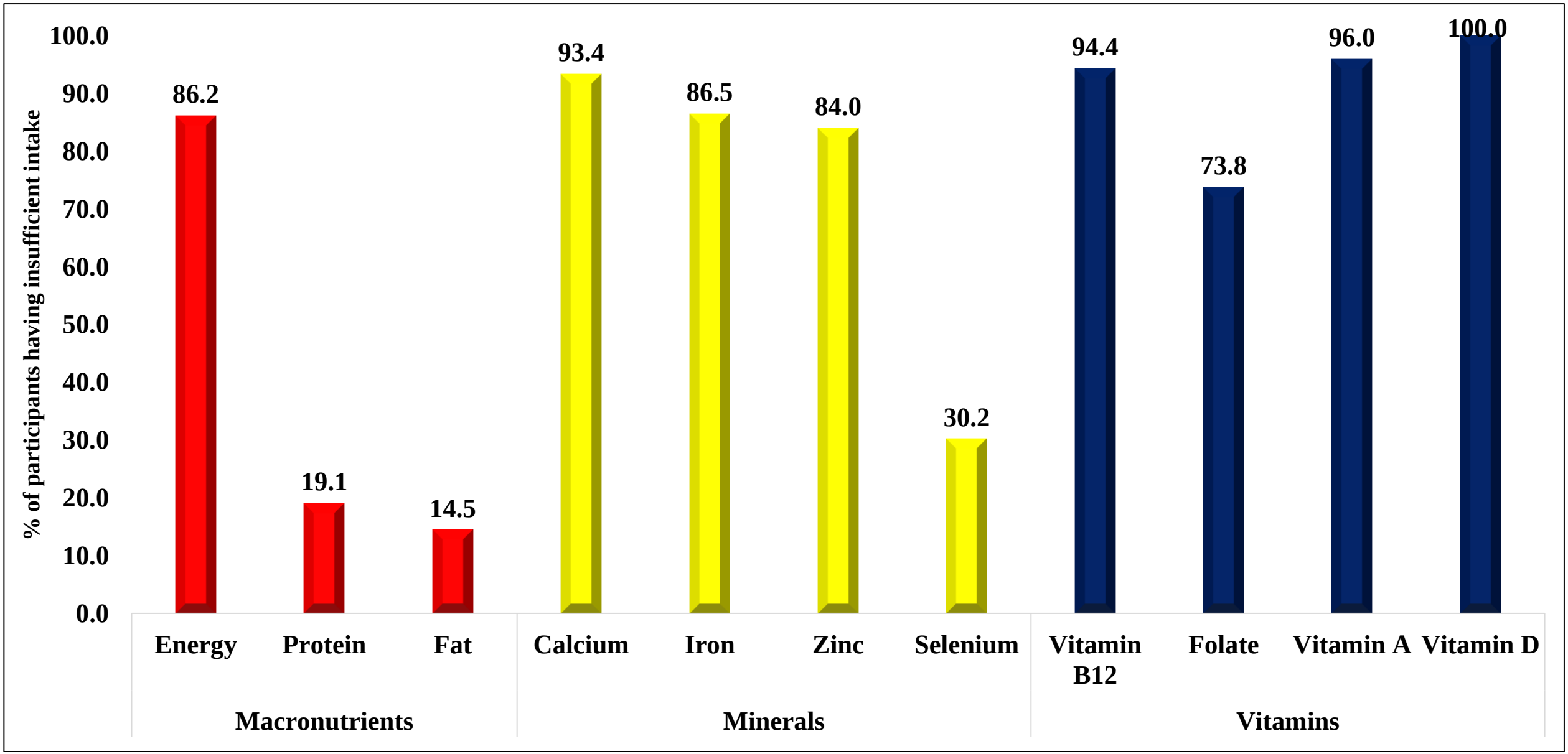
Gender (Girls)

Lower SES

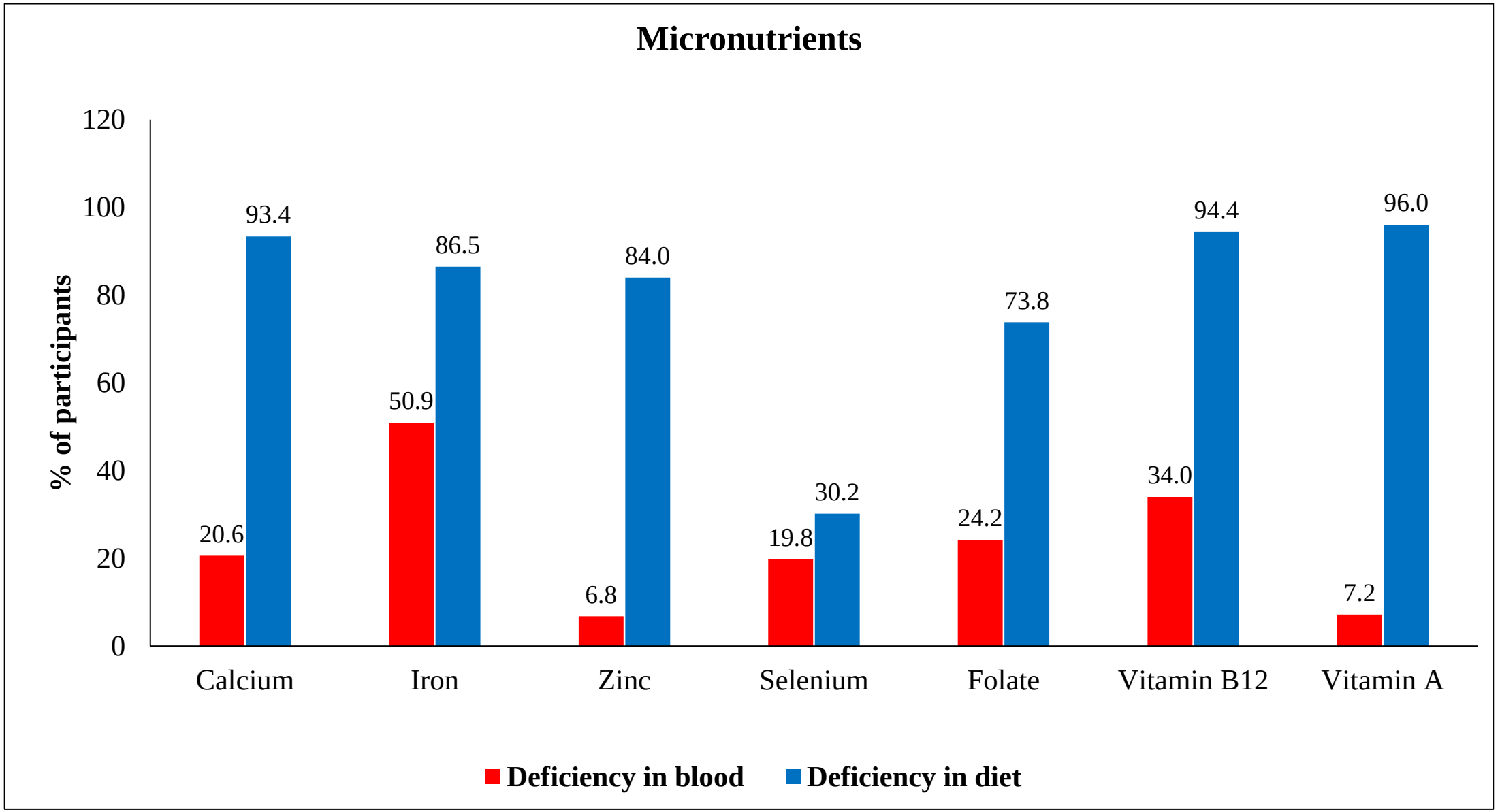
&

BMI – thin/severely thin

Distribution of dietary inadequacy of various macro and micronutrients



Distribution of micronutrient deficiency in blood and diet



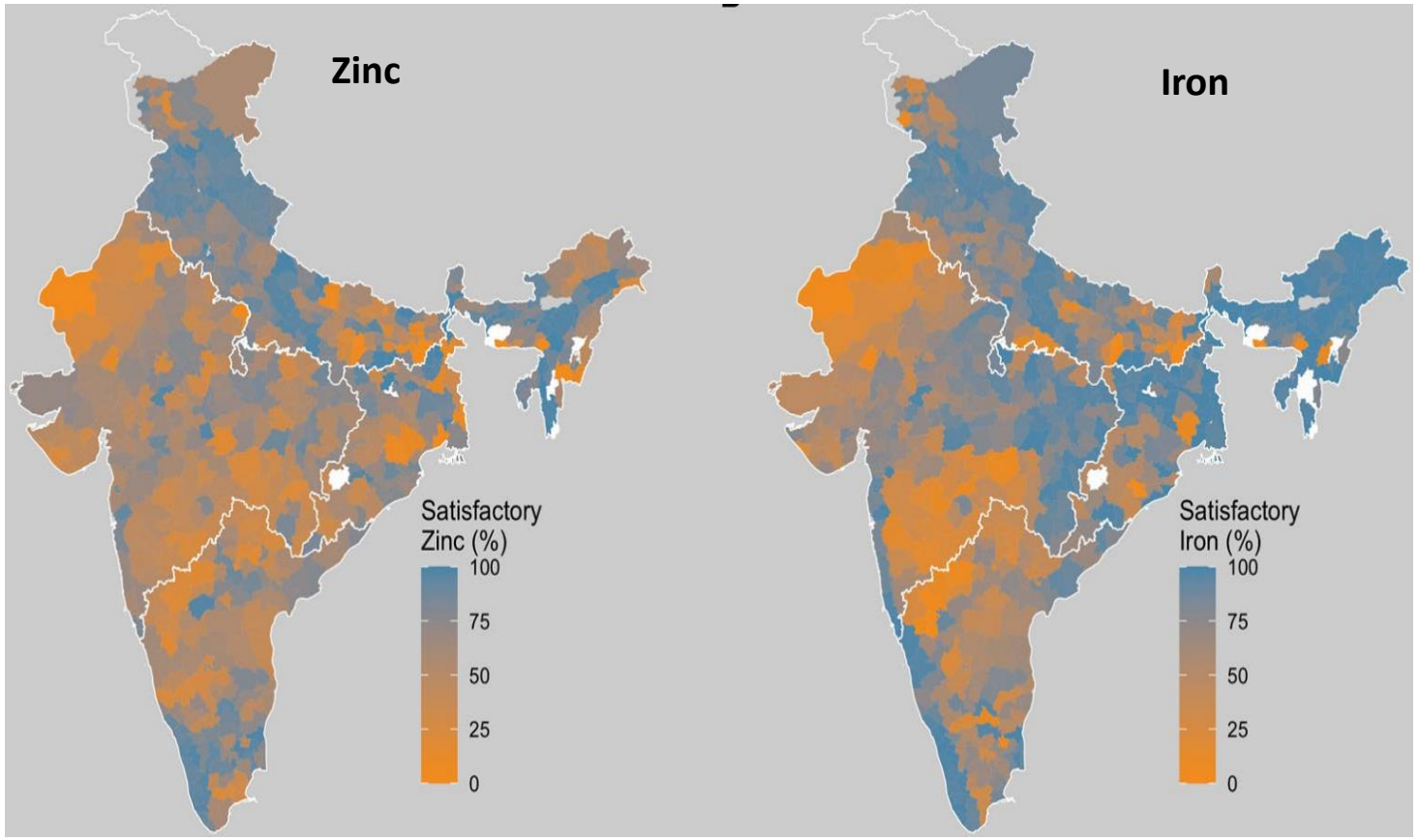
Causes of MN deficiency

Daily recommendation: My Plate for the day

70% Urban children have 2 or more micronutrient deficiency

Possible causes of MNDs

1 **Micronutrient deficient soil & crops**



Nutrient deficient Soil mapping in India

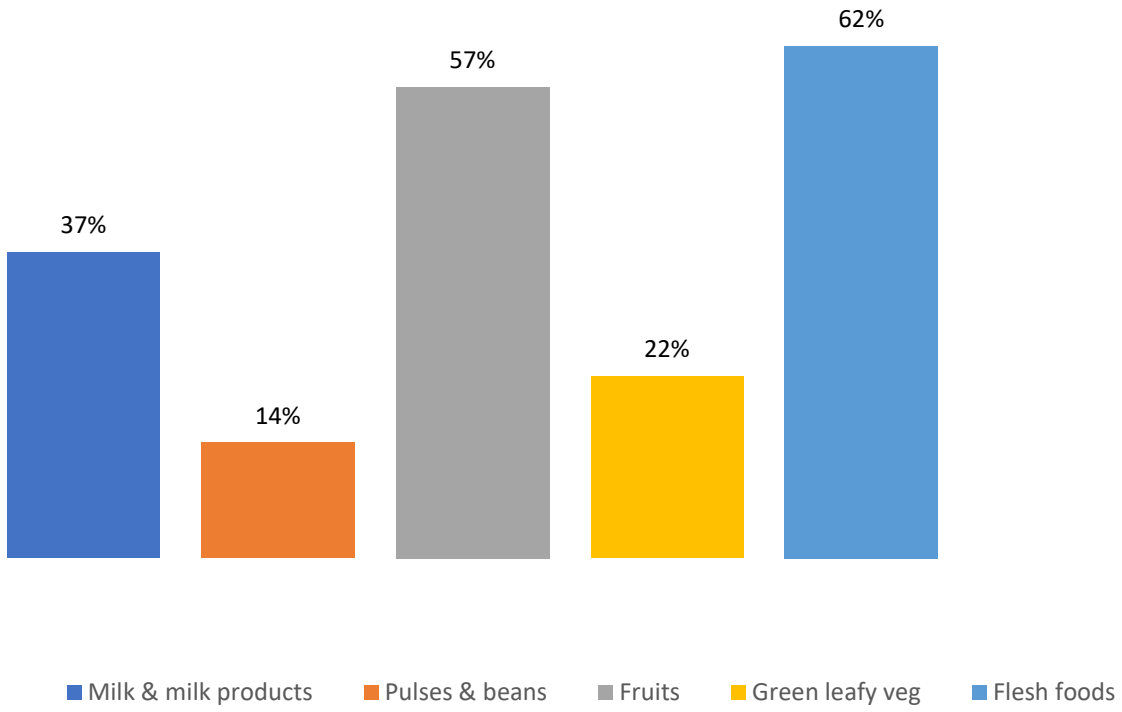
Source: Morton et al, 2023

...contd.

2 Daily Diet Inadequacy

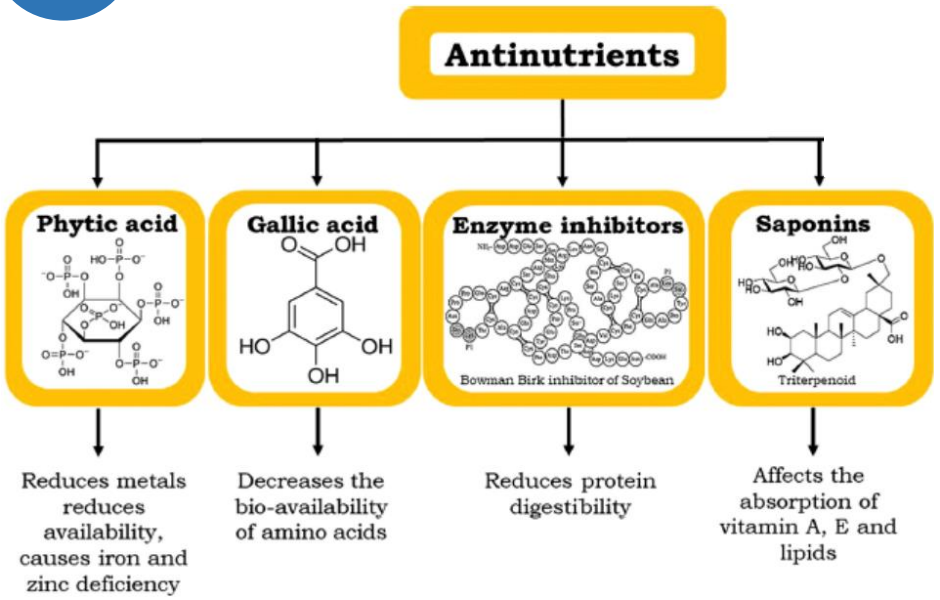
Reduced dietary diversity

Percentage of children (10-19 yrs) not consuming food groups even once in the last week (%)



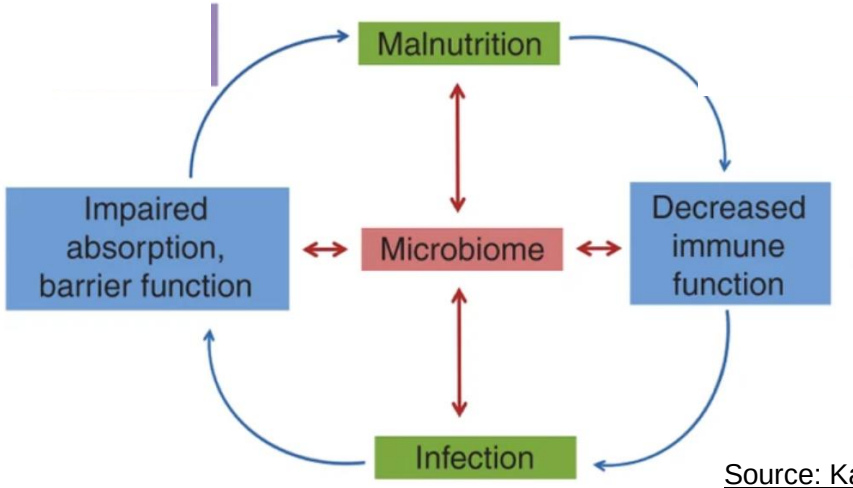
Source: CNNS 2016–18

3 Reduced Bioavailability



Source: Manzoor et al, 2021

4 Malnutrition & Gut microbiome



Source: Kane et al, 2015

What should be done in India?

MMN Supplementations?
Dietary Adequacy?
Further Evidence Needed
Must needs to be understaood

Strengths

- Estimated the prevalence and magnitude of MND (biochemical and dietary) and its association with cognitive impairment at country level.
- Multicentric study with sites being representative of different geo-cultural regions of India..
- Used standardized cognitive assessment tools adapted for Indian children.

Limitations

- Limited to the urban population.
- Cross sectional design
- Due to logistic issues, the total sample size was equally divided across all ten districts, this may have possibly under-represented the districts with higher population densities.
- A selection bias was also possible as the current study included the participants residing within 5 km radius of the school.
- No information about duration of exposure to various levels of micronutrients.
- No information on duration of Breast feeding
- School performance not captured
- Select MN studied

Conclusion

- Two or more MND found in >1/2 participants and was associated with impaired cognitive
- ~ 10%-13% cognitive impairment due to MND
- Attempts must be made to ameliorate MND & anemia on priority in school going children in India.
- Anemia can be used as surrogate marker for multiple MND

Recommendations

- Cognitive abilities contribute to school performance and societal well-being, contributing to attainment of SDG.
- Thus, national programs must effectively work towards elimination of MND and anemia in children to ensure their intellectual well-being and long-term contribution to societal development.

Acknowledgement

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Publications

1. Awasthi S, Kumar D, Mahdi AA, et al. (2022) Prevalence of specific micronutrient deficiencies in urban school going children and adolescence of India: A multicenter cross-sectional study. PLoS ONE 17(5): e0267003. https://doi.org/10.1371/journal.pone.0267003

2. Singh S, Awasthi S, Kumar D, et al. (2023) Micronutrients and cognitive functions among urban school-going children and adolescents: A cross-sectional multicentric study from India. PLoS ONE 18(2): e0281247. https://doi.org/10.1371/journal.pone.0281247

3. Awasthi S, Kumar D, Dixit S, et al. (2023). Association of dietary intake with micronutrient deficiency in Indian school children: a cross-sectional study. Journal of Nutritional Science. 2023;12:e104. https://doi.org/10.1017/jns.2023.83