Diet & Anemia in India

Experience from the Nutrition Surveys in India

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Dietary intakes of rural women & children in India: low Diet Diversity (NNMB 2012)

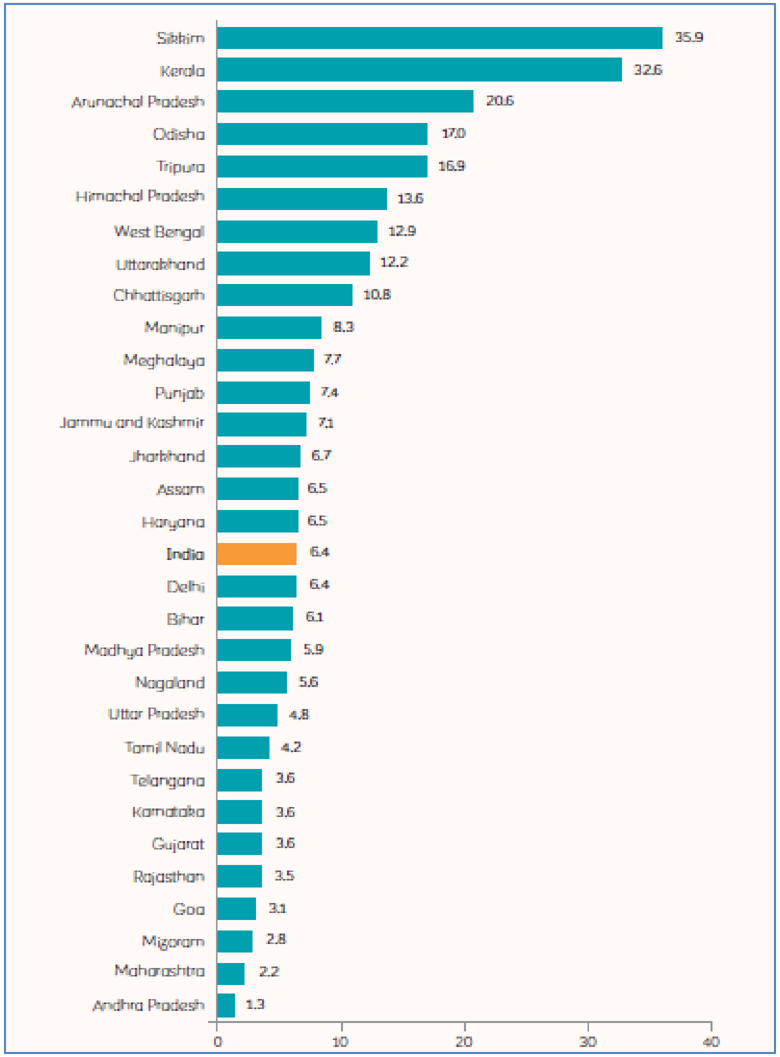
	Cereals Millets	Legumes	Green leafy veg.	Other veg	Roots Tubers	Nuts Oil seeds	Fruits	Meat poultry	Milk Milk products	Fats Oils
NPNL women (n=9519)	341	28	19	49	70	8	24	21	82	15
Pregnant (n=322)	354	34	18	47	60	7	32	21	79	16
Lactating (n=693)	395	34	19	48	70	6	24	16	66	17
1-3 y children (n=2895)	131	15	7	13	21	2	12	6	86	6
Urban (per CU, median)	347	31	18	47	65	6	24	18	80	15

Children (6-23 mo) receiving minimum adequate diet (NFHS 4)

Breastfeeding children : 9%

Non- Breastfeeding children : 14%

6-23 mo children receiving minimum acceptable diet (%)
(CNNS 2016-18)



Minimum Acceptable Diet = Minimum meal frequency + minimum diet diversity

Children (6-23 mo) receiving MAD (NFHS 4)
Breastfeeding children : 9%
Non- Breastfeeding children : 14%

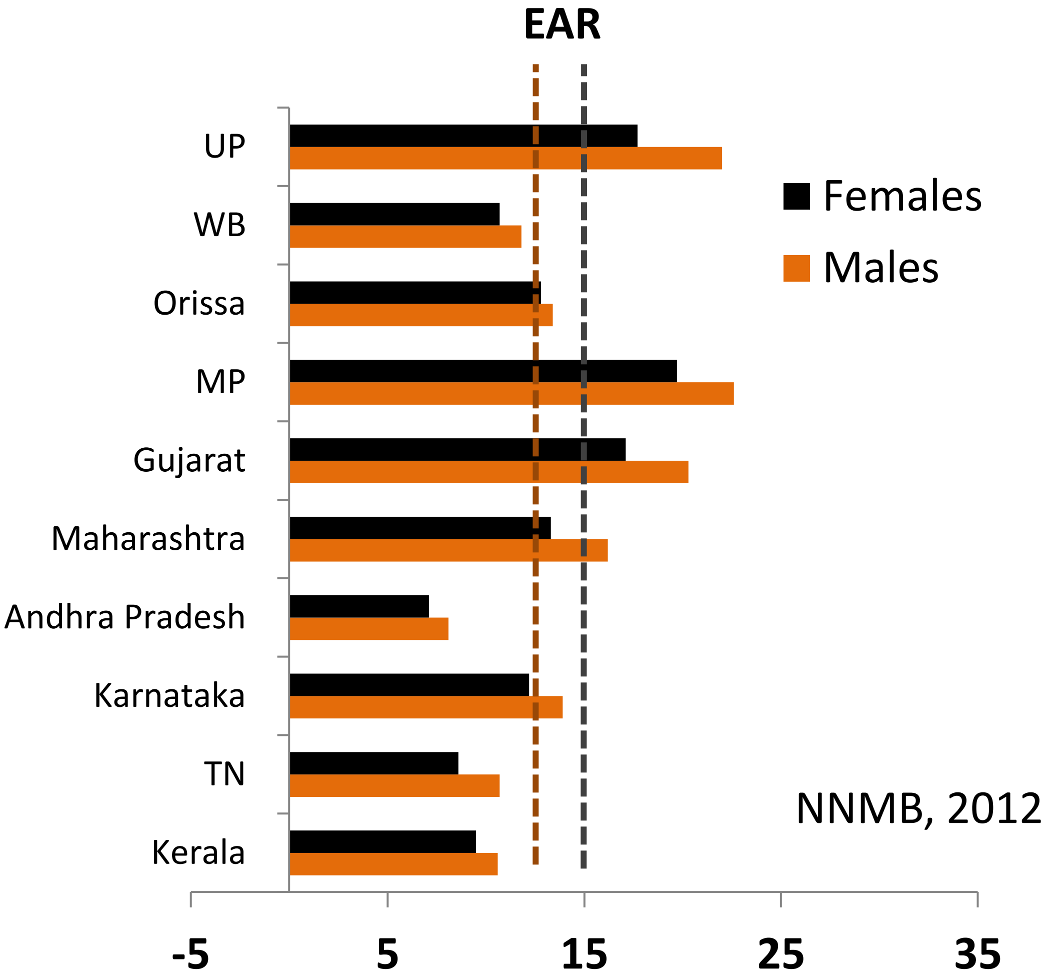
Nutrient intakes of adults (Men & women)

		Protein (g)	Total fat (g)	Energy (Kcal)	Calcium (mg)	Iron (mg)	Vit-A (µg)	Thiamin (mg)	Ribofla(mg)	Niacin (mg)	Vit-C (mg)	Folate (µg)
MEN (Sedentary)	MED	49.4	27	1846	370	13	132	1.2	0.8	14.6	33	121.6
	EAR	42.9	25	2110	800	11	460	1.18	1.64	16	65	250
	Deficit	**-6.5**	**-2**	**264**	**430**	**-2**	**328**	**-0**	**0.84**	**1.4**	**32**	**128**
MEN (Moderate)	MED	53.4	25.1	2020	335	14.2	123	1.4	0.8	15.9	28	134.1
	EAR	42.9	30	2710	800	11	460	1.18	1.64	16	65	250
	Deficit	**-11**	**4.9**	**690**	**465**	**-3.2**	**337**	**-0.2**	**0.84**	**0.1**	**37**	**116**
WOMEN (NPNL Sedentary)	MED	43.8	23.4	1664	328	11.5	119	1.1	0.7	13.1	30	106
	EAR	36.3	20	1660	800	15	390	1.14	1.56	12	55	180
	Deficit	**-7.5**	**-3.4**	**-4**	**472**	**3.5**	**271**	**0.04**	**0.86**	**-1.1**	**25**	**74**
WOMEN (NPNL Moderate)	MED	47	22.9	1786	292	11.8	112	1.2	0.7	13.1	24	116.7
	EAR	36.3	25	2130	800	15	390	1.14	1.56	12	55	180
	Deficit	**-11**	**2.1**	**344**	**508**	**3.2**	**278**	**-0.1**	**0.86**	**-1.1**	**31**	**63.3**
URBAN (per CU)	MED	53.9	50.7	1931	402	13.2	136.5	1.0	0.7	9.8	51.3	202.1
	SD	22.9	27.0	692	360	7.9	462.6	0.7	0.4	4.6	52.2	441.2

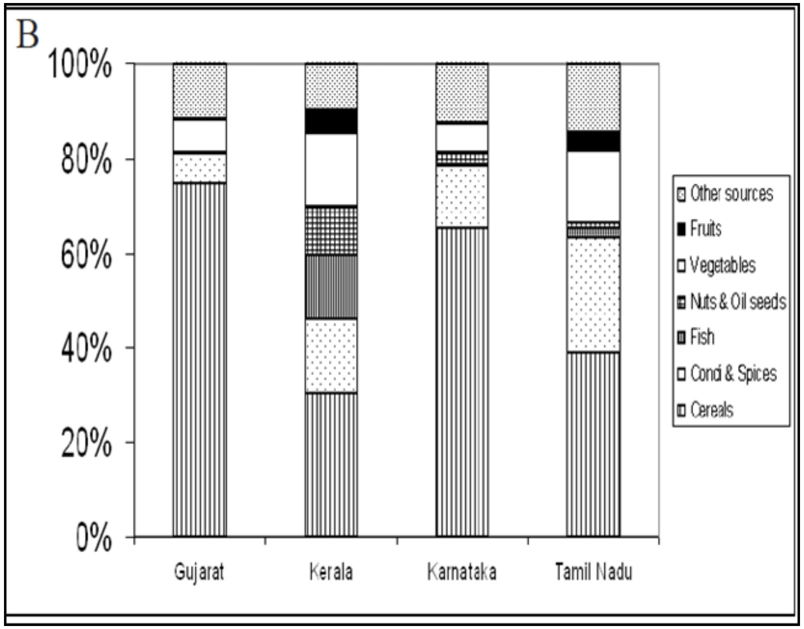
Nutrient intakes of children & adolescents

		Protein (g)	Total fat (g)	Energy (Kcal)	Calcium (mg)	Iron (mg)	Vit-A (µg)	Thiamin (mg)	Ribofl (mg)	Niacin (mg)	Vit-C (mg)	Folate (µg)
1-3 Y (n=2895)	**Med**	**19.7**	**11.8**	**733**	**166**	**4.7**	**61**	**0.5**	**0.3**	**4.8**	**9**	**48.1**
	EAR	**9.2**	**25**	**1010**	**400**	**6**	**180**	**0.56**	**0.78**	**8**	**23**	**90**
	Deficit	-11	13.2	277	234	1.3	119	0.06	0.48	3.2	14	41.9
4-6 Y (N=2915)	**Med**	**27.9**	**15.0**	**1033**	**198**	**7.2**	**74**	**0.7**	**0.4**	**7.6**	**15**	**71.9**
	EAR	**12.8**	**25**	**1360**	**450**	**8**	**240**	**0.76**	**1.06**	**11**	**29**	**111**
	Deficit	-15	10	327	252	0.8	166	0.06	0.66	3.4	14	39.1
16-17 Y BOYS (N=898)	**MED**	**46.4**	**22.7**	**1785**	**299**	**11.9**	**112**	**1.2**	**0.7**	**13.7**	**25**	**117.4**
	EAR	**45.1**	**40**	**3320**	**850**	**18**	**480**	**1.83**	**2.54**	**14**	**83**	**286**
	Deficit	-1.3	17.3	1535	551	6.1	368	0.63	1.84	0.3	58	169
16-17 Y GIRLS (N=991)	**MED**	**42.2**	**20.7**	**1588**	**270**	**11**	**104**	**1.1**	**0.7**	**12.1**	**25**	**108.2**
	EAR	**37.3**	**35**	**2500**	**850**	**18**	**400**	**1.39**	**1.93**	**14**	**63**	**223**
	Deficit	-4.9	14.3	912	580	7	296	0.29	1.23	1.9	38	114.8

Dietary Intake of Iron among rural men & women (NNMB 2012)



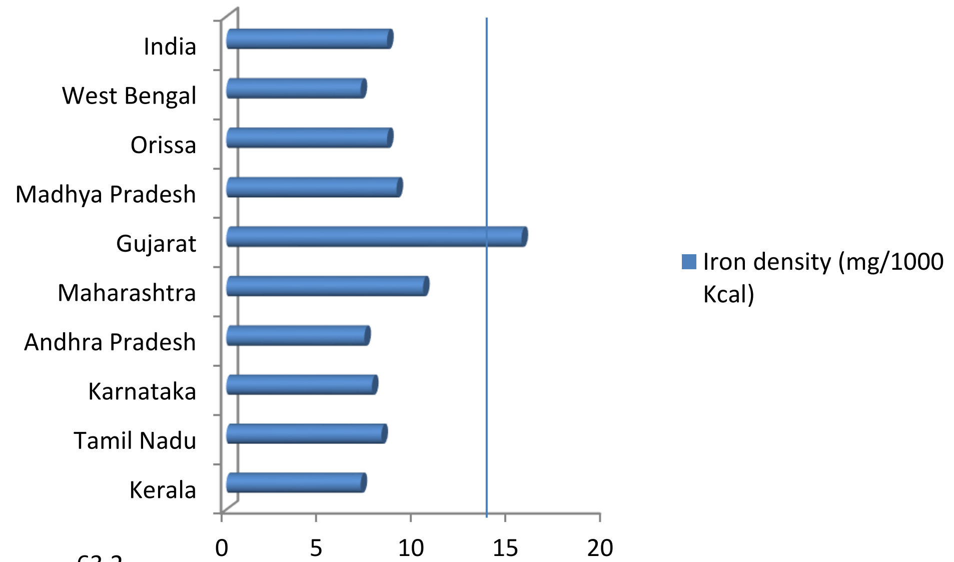
Food sources contributing to iron intake

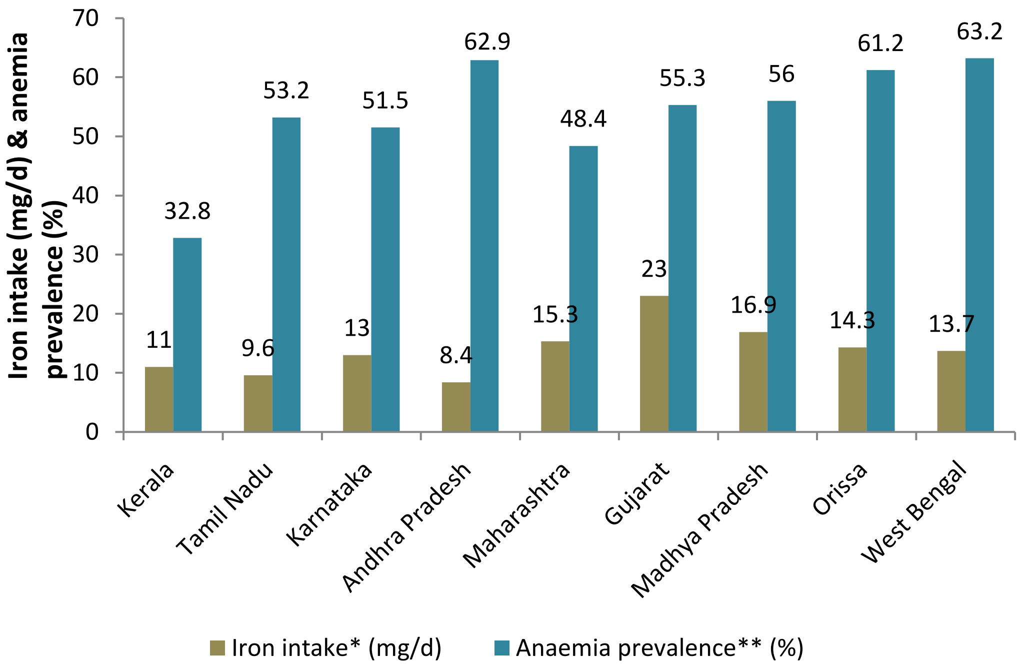


Nair and Iyengar, IJMR ,2009

Median Intake is 12.8 mg/d (N=18365)
Median iron intake of US WRA 12 mg /d

Iron density & intake *vs* Anemia Prevalence in women of reproductive age





Recommended adequate dietary iron density 14.2 mg/ 1000 KCal

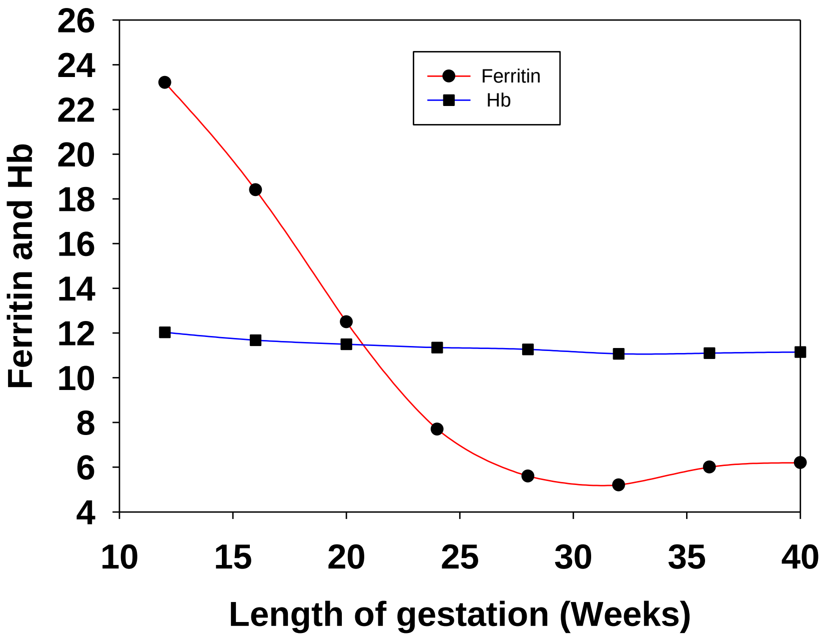
(Nair & Iyengar, IJMR ,2009)

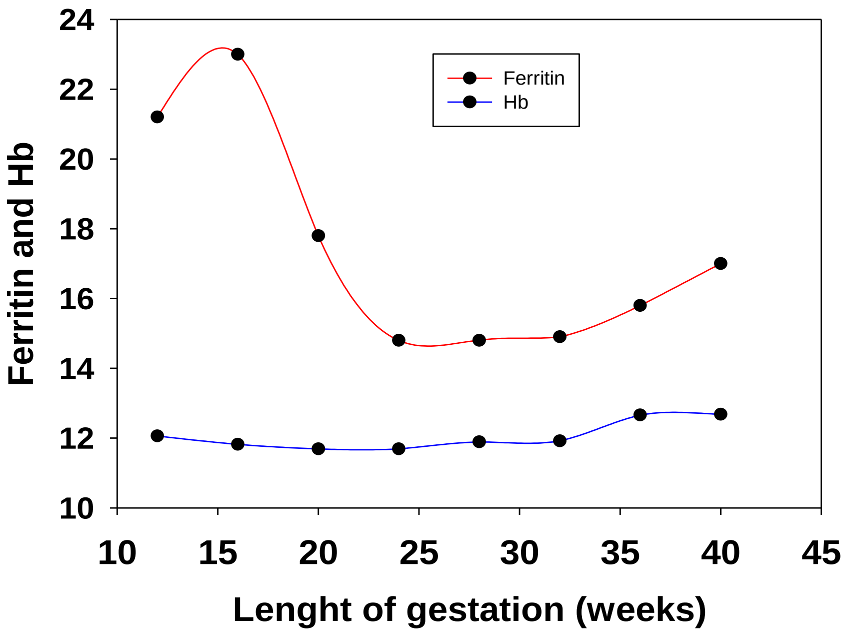
ANEMIA *VS* IRON DEFICIENCY

Effect of iron supplementation on serum ferritin levels during & after pregnancy

Taylor DJ. Brit J Obstetrics Gynaecology, 1982, 89: 1011-1017

Serum ferritin, total plasma ferritin and haematological indices were determined during and for 6 months after normal pregnancy in 45 healthy women, 21 of whom took oral iron supplements.

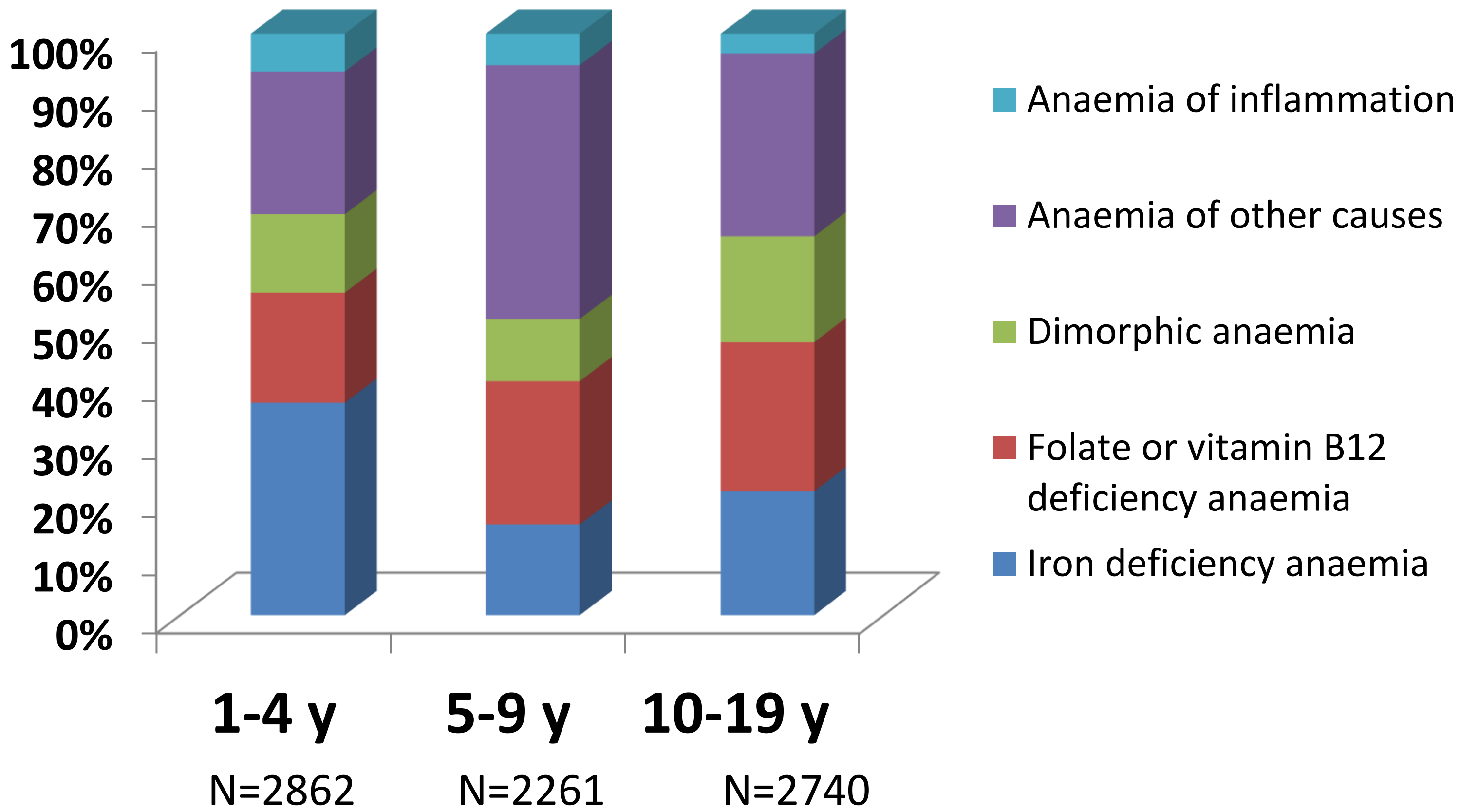




Iron: Type 1 nutrient

Ferritin comes down first followed by Hb: We expect more ID than anemia

Types of anemia in Indian children & adolescents CNNS, 2016-18

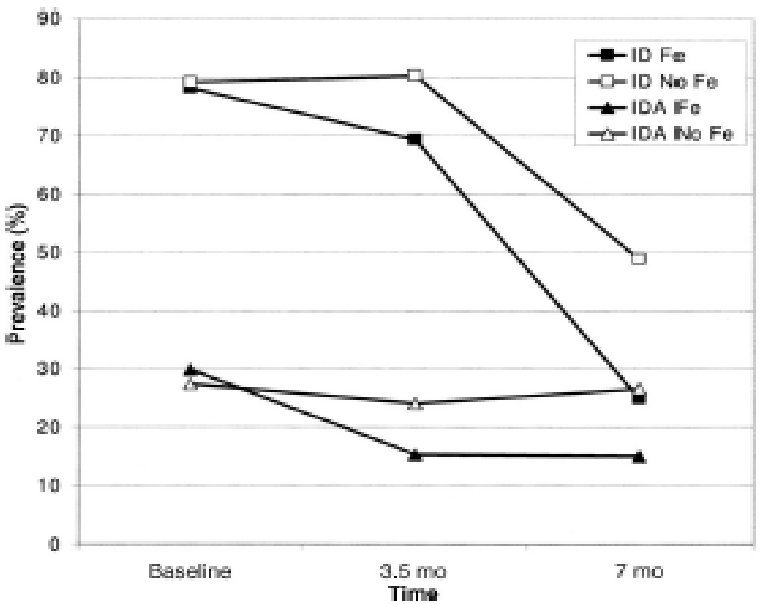


Source: *Sarna A et al. Lancet Child Adolesc Health. 2020;4:515-525*

Indian studies on iron suppl^{n} through fortified rice – Limited impact on anemia reduction

Morretti et al. Am J Clin Nutr 2006; 84:822-9

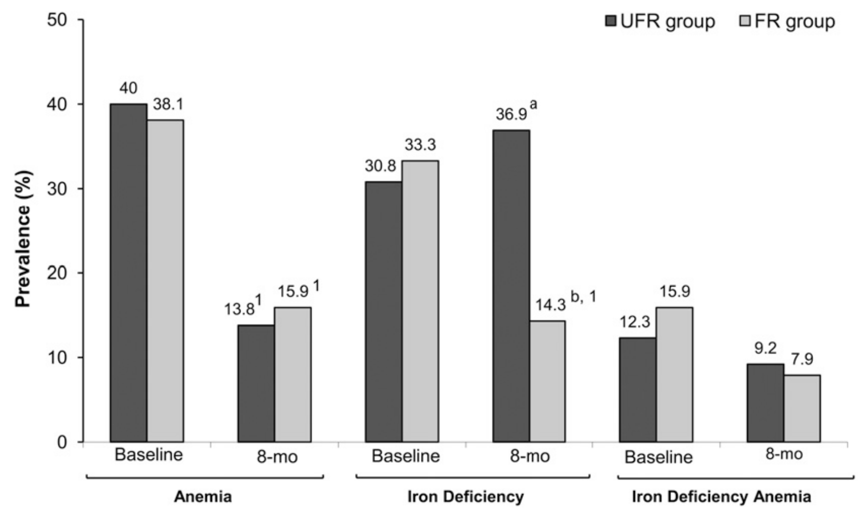
Iron (MGFP) 20 mg/day X 7 mo
6-13 y children (n=184)



Iron fortification reduced ID but no significant change in Hb & IDA

Radhika M et al. Am J Clin Nutr 2011; 94: 1202-10.

Iron (MGFP) 19 mg/day X 8 mo
5-11 y children (n=140)



Both I &C groups – significant reduction in anemia De-worming & supervised MDM increased Hb; Fortification increased Ferritin

Reported iron absorption among WRA & adolescent girls in India

(Ghosh et al., *J Nutr*, 2019, 149:366–371)

Study	Age (y)	N	Anemia status	Cereal source	Meal iron (mg)	Isotope iron (mg)	Absorption (%) Mean ±SD
Thankachan et al.	18-35	20	Anemic	Rice	1.3	3.0	17.5 ± 11.4
	18-35	20	Normal	Rice	1.3	3.0	7.3 ± 5.9
Kalasuramath et al.	18-35	15	Anemic	Rice	2.5	3.0	8.3 ± 2.2
	18-35	15	Anemic	Wheat	3.4	3.0	11.2 ± 1.6
	18-35	15	Anemic	Ragi (millet)	2.7	3.0	4.6 ± 1.9
	18-35	15	Normal	Rice	2.5	3.0	2.7 ± 1.7
Herter-Aeberli et al.	18-35	16	Normal	Rice	1.3	5.0	10.0 ± 6.5
	18-35	13	Normal	Rice	1.3	5.0	16.7 ± 4.6
Nair et al. (2013)	18-35	16	Normal	Rice	10.8	3.4	9.7 ± 6.5

Inclusion of guava increased non-heme iron bioavailability from rice-based meal in adolescents

(Nair, K M, et al. *The Journal of nutrition* 143, (2013): 852-58)

TABLE 4 Percentage of iron bioavailability and fractional zinc absorption from rice-based meals without (regular) and with (modified) guava in girls and boys[1]

	Girls		Boys		*P* value[2]		
Mineral	Regular	Modified	Regular	Modified	Diet	Sex	Diet × sex
Iron	9.7 ± 6.5	23.9 ± 11.2	8.6 ± 4.1	19.2 ± 8.4	0.0001	0.125	0.459
Difference		14.2 ± 14.5*		10.6 ± 10.4*			
Zinc	26.9 ± 6.4	27.3 ± 7.4	32.5 ± 16.6	37.1 ± 3.0	0.122	0.054	0.208
Difference[3]		0.5 ± 6.3		4.6 ± 10.9			
Reference dose: ^{58}Fe[4]	58.2 ± 22.2		48.9 ± 16.0				

[1] Values are means ± SDs, n = 15 for girls and 14 for boys. *$P < 0.05$ (paired t test).

[2] Derived by 2-way repeated-measures ANOVA. The effect of diet on iron bioavailability was significant and showed a trend of higher fractional zinc absorption in boys.

[3] No significant difference in fractional zinc absorption between regular and modified diets.

[4] No significant difference in percentage bioavailability of iron.

Influence of tea & ascorbic acid on iron absorption in young women

Thankachan P, Walczyk T, Muthayya S, Kurpad AV, Hurrell RF. The American journal of clinical nutrition. 2008; 87(4):881-6.

Fractional iron absorption from the reference meal with or without tea and ascorbic acid (AA)[1]

Study and test meal	IDA group: Fractional iron absorption	IDA group: Iron absorption ratio	IDA group: P	Control group: Fractional iron absorption	Control group: Iron absorption ratio	Control group: P
	%			%		
Tea study						
Meal						
A: reference meal	18.2 (12.6; 26.4)[2]	0.41 ± 0.15[3]	<0.001	7.5 (4.0; 14.2)	0.51 ± 0.22	<0.05
B: reference meal + 150 mL black tea	7.1 (4.3; 11.7)			3.5 (2.1; 5.9)		
A: reference meal	19.7 (13.5; 29.0)	0.33 ± 0.17	<0.001	5.2 (2.6; 10.8)	0.34 ± 0.18	<0.01
C: reference meal + 300 mL black tea	5.6 (3.1; 10.1)			1.6 (0.7; 3.8)		
AA study						
Meal						
A: reference meal	15.6 (8.5; 28.6)	2.91 ± 0.99	<0.001	7.1 (4.5; 11.4)	2.70 ± 1.35	<0.001
B: reference meal + AA (2:1 molar ratio)	42.8 (22.4; 81.8)			16.8 (8.5; 33.6)		
A: reference meal	16.5 (8.7; 31.5)	3.50 ± 0.77	<0.001	9.4 (5.4; 16.3)	3.43 ± 1.29	<0.001
C: reference meal + AA (4:1 molar ratio)	56.8 (35.0; 92.3)			30.8 (22.7; 41.8)		

[1] $n = 10$ in both iron-deficient anemia (IDA) and control groups in each study. Absorption values within each study interval (B/A or C/A) are compared as absorption ratios normalized to iron absorption from the reference meal. An absorption ratio <1 indicates an inhibiting effect of tea; an absorption ratio >1 indicates an enhancing effect of ascorbic acid.

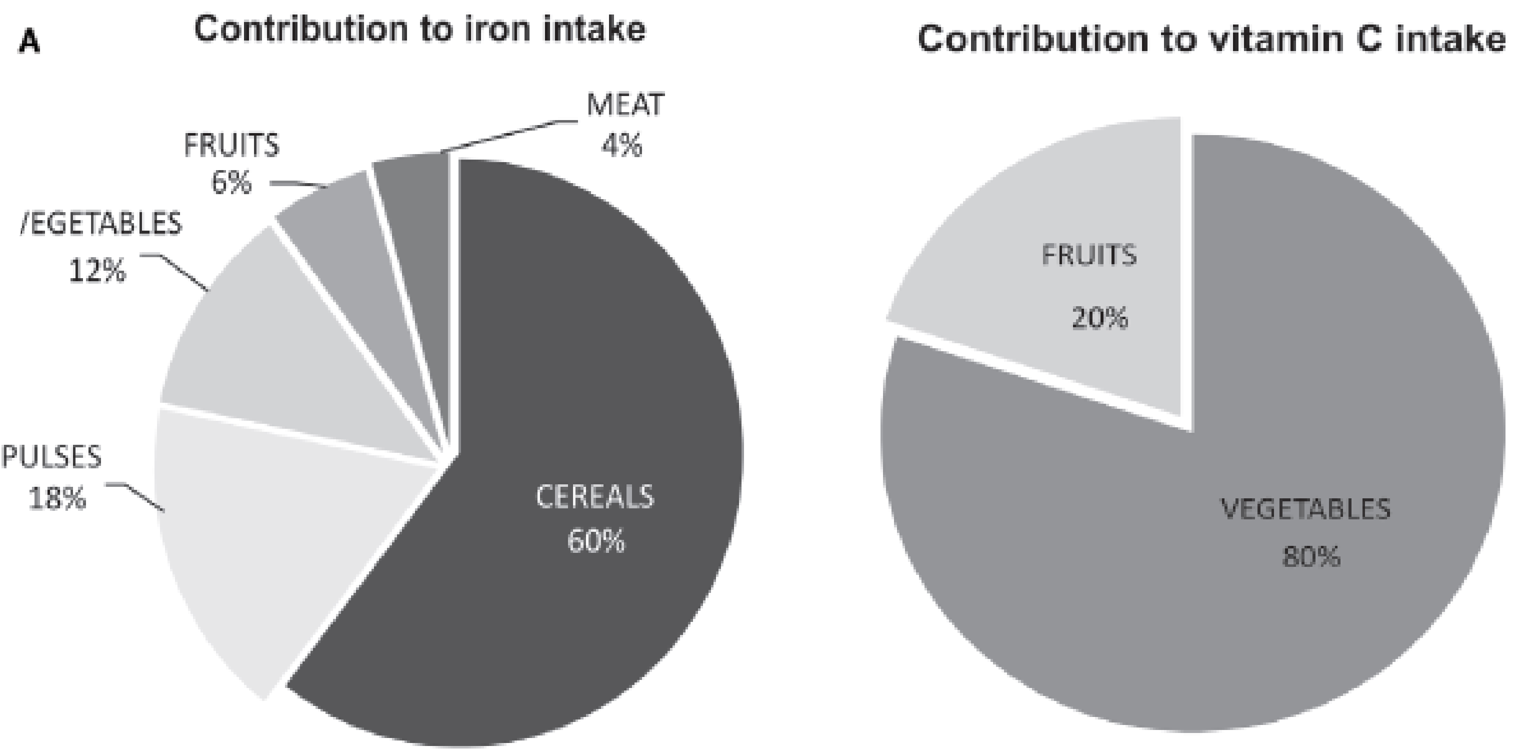
[2] $\bar{x} - SD$ and $\bar{x} + SD$ in parentheses (all such values).

[3] $\bar{x} \pm SD$ (all such values).

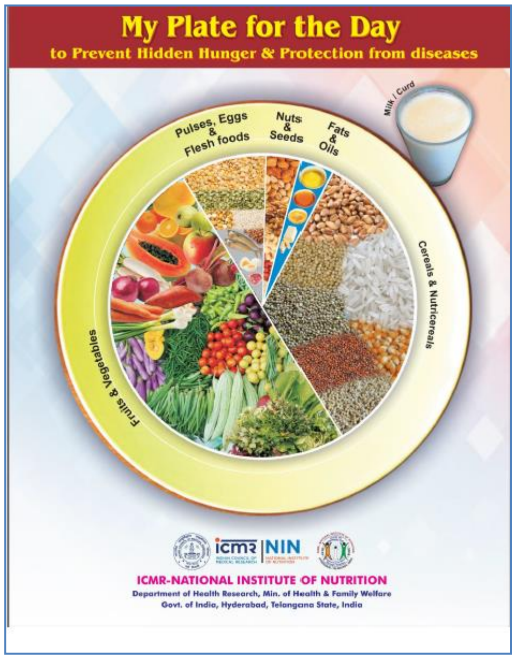
Iron absorption was higher with ascorbic acid & lower with tea among iron deficient & non-iron deficient participants

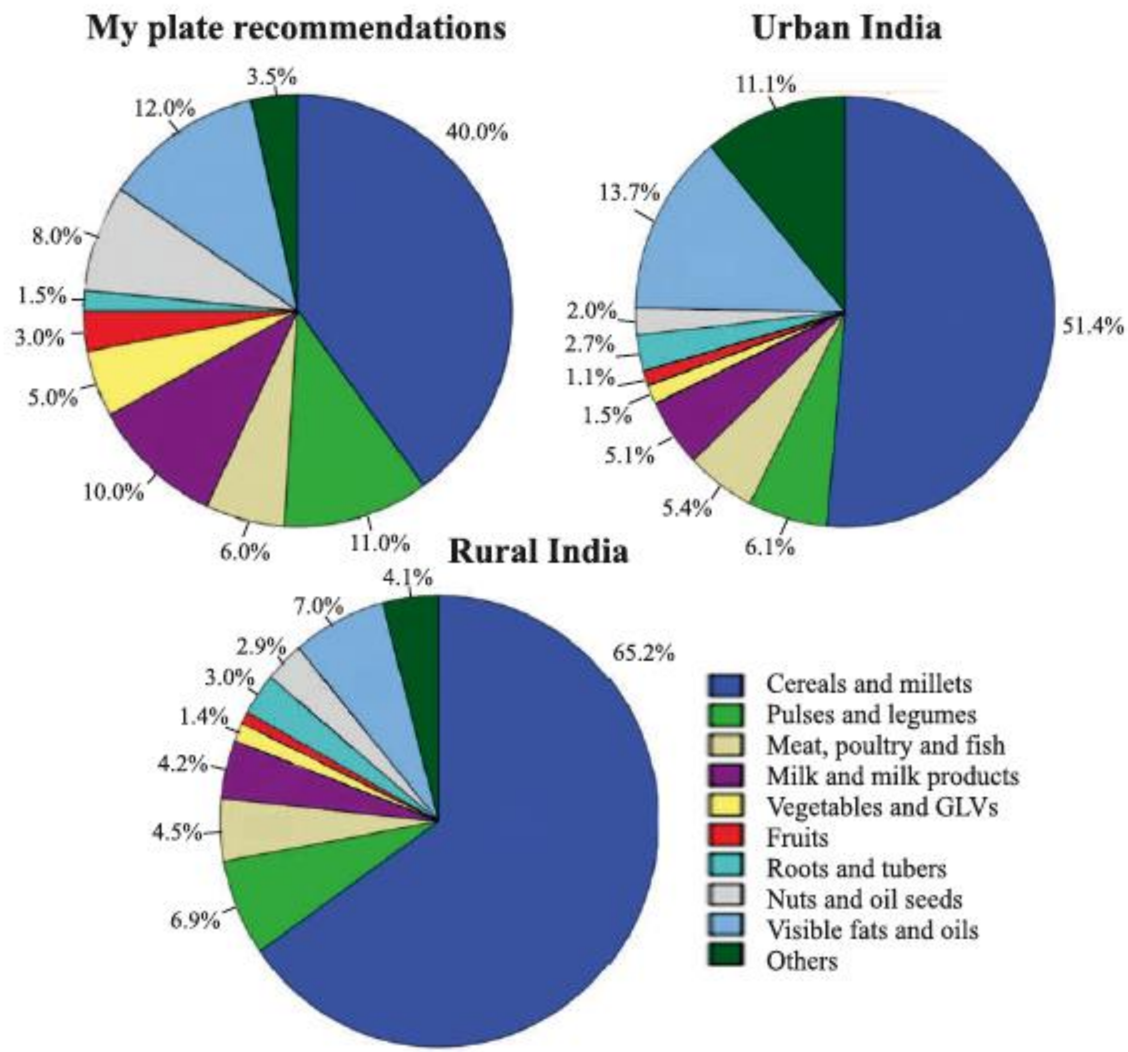
Food –based interventions to modify diet quality & diversity to address multiple micronutrient deficiencies

Nair KM, Augustine LF, Archana K, Frontiers in public health, 2016



Contribution of different food groups in meeting the daily requirement of iron and vitamin C: calculated using a model diet &Indian food composition database





Note: Other foods include chips, biscuits, chocolates, sweets and juices

Risk of inadequate / excess iron intake in different states

Santu Ghosh et al. *Nutr*, 2019, 149,:366–371; NSSO 68th round

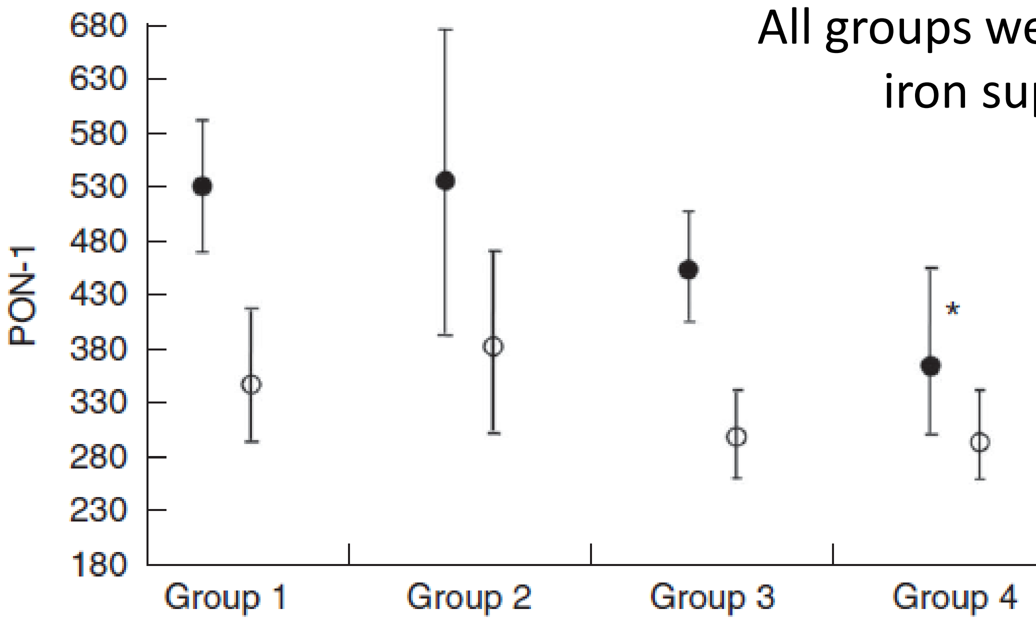
State	Risk of inadequate Fe intake in habitual diets	Risk of inadequate intake after fortification & supplementation		Risk of excess intake after iron fortification & supplementation	
		10 mg/d[4]	24 mg/d[5]	10 mg/d[6]	24 mg/d[7]
Assam	83	33	5	0	0
Bihar	49	13	2	0	7
Delhi	49	13	2	0	8
Goa	72	28	4	0	1
Gujarat	45	13	2	0	16
Haryana	33	8	1	0	27
Jharkhand	65	20	3	0	4
Karnataka	60	17	2	0	3
Kerala	70	22	3	0	1
Madhya Pradesh	36	9	1	1	29
Maharashtra	48	11	1	0	12
Manipur	93	37	5	0	0
Punjab	34	8	1	0	25
Rajasthan	25	6	1	1	54
Tamil Nadu	79	26	3	0	1
Uttar Pradesh	42	11	1	0	15
West Bengal	68	26	4	0	2

Iron supplementation in pregnant women with high Hb is associated with oxidative stress

Shastri L, Rajkumar SP, Mani I, Tinku Thomas T & Kurpad AV, Pub Health Nutr. 2016, 19,3210-15

Mean paraoxonase-1 (PON-1) in the trimester 1 blood of mothers & cord blood

All groups were given the routine iron supplementation



NBW LBW NBW LBW

Low/Normal Hb1 High Hb1

*P =0·004 for Group 4 vs Group 1.

Solid circles : blood of mothers ; Hollow circles: cord blood of babies

SUMMARY

- Nutrition surveys show overall low diet quality
- Weak association between dietary iron intake & anemia
- Inadequacy of dietary iron intake based on EAR 2020– lower than previously estimated
- Poor bioavailability of dietary iron- a larger problem
- Iron interventions alone would have limited value
- Food synergy approaches with enhanced diet diversity would be more helpful

THANK YOU