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Micronutrient status of Indian population

Zaozianlungliu Gonmei[1] & G.S. Toteja[1,2]

[1]Centre for Promotion of Nutrition Research and Training with Special Focus on North East, Tribal & Inaccessible Population, Division of Nutrition, Indian Council of Medical Research (Campus II), Tuberculosis Association of India Building, New Delhi & [2]ICMR-Desert Medicine Research Centre, Jodhpur, India

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Micronutrients play an important role in the proper growth and development of the human body and its deficiency affects the health contributing to low productivity and vicious cycle of malnutrition, underdevelopment as well as poverty. Micronutrient deficiency is a public health problem affecting more than one-fourth of the global population. Several programmes have been launched over the years in India to improve nutrition and health status of the population; however, a large portion of the population is still affected by micronutrient deficiency. Anaemia, the most common form of micronutrient deficiency affects almost 50 to 60 per cent preschool children and women, while vitamin A deficiency and iodine-deficiency disorders (IDD) have improved over the years. This review focuses on the current scenario of micronutrient (anaemia, vitamin A, iodine, vitamin B_{12}, folate, ferritin, zinc, copper and vitamin C) status in the country covering national surveys as well as recent studies carried out.

Key words Anaemia - ferritin - folate - iodine - vitamin A - vitamin B_{12}

Introduction

India has made tremendous progress in all fronts since independence including food production. Several programmes or schemes such as Integrated Child Development Services (ICDS) scheme, Mid-Day Meal Programme, National Iron Plus Initiative (NIPI), National Iodine Deficiency Disorders Control Programme (NIDDCP) and National Prophylaxis Programme against Nutritional Blindness due to Vitamin A Deficiency have also been launched over the years to improve the nutrition and health status of the population. However, still a large portion of the population suffers from malnutrition. According to the Food and Agriculture Organization report on State of Food Security and Nutrition in the World[1], it is estimated that 190.7 million (14.5%) people were undernourished in India during 2014-2016.

Micronutrients though required in small amounts, are essential for proper growth and development of the human body[2]. Micronutrient deficiencies also referred to as 'Hidden Hunger' affects the health, learning ability as well as productivity owing to high rates of illness and disability contributing to vicious cycle of malnutrition, underdevelopment and poverty. It is estimated that around two billion people in the world are deficient in one or more micronutrients[3]. Micronutrient deficiencies (such as iodine, iron and vitamin A deficiency) not only affect the health but are

also projected to cost around 0.8-2.5 per cent of the gross domestic product[4]. In India, around 0.5 per cent of total deaths in 2016 were contributed by nutritional deficiencies[5].

National surveys such as National Family Health Survey (NFHS), National Nutrition Monitoring Bureau (NNMB), Annual Health Survey (AHS) and District Level Household Survey (DLHS) have been carried out to assess the health and nutrition status of the population in the country. The national surveys carried out have mainly focused on nutritional status based on anthropometric measurements, dietary intake and anaemia though independent surveys have been carried out to assess micronutrient deficiencies in the country. This review focuses on the current scenario of micronutrient status in the country covering national surveys as well as recent studies carried out. Studies on dietary intake have not been covered.

Iron, vitamin B_{12}, folate and ferritin deficiency

Anaemia is a major public health problem in the country as well as globally affecting nearly a third of the global population[6]. The National Nutritional Anaemia Prophylaxis Programme was launched in 1970 to prevent nutritional anaemia among children, expectant and nursing mothers as well as acceptors of family planning. The programme was later renamed in 1991 as National Nutritional Anaemia Control Programme targeting women in reproductive age group, especially pregnant and lactating women and preschool children[7]. The three strategies of the programme were promotion of regular consumption of foods rich in iron, provisions of iron and folate supplements in the form of tablets (folifer tablets) to the 'high-risk' groups and identification and treatment of severely anaemic cases[8]. In 2013, the Weekly Iron and Folic Acid Supplementation Programme was launched to reduce the prevalence and severity of nutritional anaemia among adolescents. Under this Programme, adolescents studying in class VI to XII from either government or government-aided or municipal schools as well as adolescent girls who are not in school are covered[9]. Subsequently, NIPI was launched in 2013 to prevent and control anaemia covering almost the entire age group, from infants six months onwards to women of reproductive age, providing weekly iron and folic acid (IFA) supplementation and deworming tablets administered twice a year, while daily dose of IFA tablet is being provided for 100 days during pregnancy as well as 100 days after delivery for lactating women[10]. However, more than half of the population still suffers from anaemia. As per the Global Burden of Disease Study 2016[5], iron-deficiency anaemia is among the top 10 causes of disability-adjusted life years for women. The latest National Family Health Survey (NFHS4) carried out by the Ministry of Health and Family Welfare reported the prevalence of anaemia as 58.6, 53.1, 50.4 and 22.7 per cent, respectively, among children aged 6-59 months, women aged 15-49 yr, pregnant women aged 15-49 yr and men aged 15-49 yr[11].

Besides national surveys, various studies carried out in the country have also reported high burden of anaemia. A Task Force Study carried out by the Indian Council of Medical Research (ICMR), New Delhi, across 16 districts of 11 States among 11,260 pregnant women (n=6923) and adolescent girls (n=4337) also reported the prevalence of anaemia as 84.9 and 90.1 per cent, respectively[12]. The NNMB (ICMR) survey carried out in eight States also reported anaemia of around 67 to 78 per cent among preschool children, adolescent girls, pregnant and lactating women residing in the rural areas[13]. A study carried out among a cohort of pregnant women (n=72,750) residing in rural Maharashtra reported the prevalence of anaemia as 91 per cent[14]. A study carried out in rural Telangana among women aged 15-35 yr (n=979) reported lower prevalence of anaemia (28.4%) whereas prevalence of other micronutrient deficiencies such as ferritin (46.3%), folate (56.8%) and vitamin B_{12} (44.4%) was reported to be around 50 per cent[15].

Various initiatives taken by the Government of India have led to reduction in the prevalence of anaemia in the country (Figure). The prevalence of anaemia among preschool children has reduced in the past 16 yr by almost 16 per cent from 74.3 per cent during 1998-1999[16] to 58.5 per cent during 2015-2016[11]. Similarly, DLHS surveys[18,19] have also shown reduction in anaemia among adolescent girls aged 10-19 yr by 41.3 per cent. A slight decrease (1.6%) in the prevalence of anaemia was also observed among men. Among ever married and pregnant women, not much improvement was observed compared to findings of NFHS-2[16]; however, compared to findings of other surveys carried out after 2000, a reduction of 3-7 per cent was observed.

Nutritional anaemia can be caused due to deficiencies of micronutrients such as iron, folic acid and vitamin B_{12}, with iron deficiency being the most common cause of anaemia. There is no nationwide data on status of these micronutrients; however, recent studies have highlighted

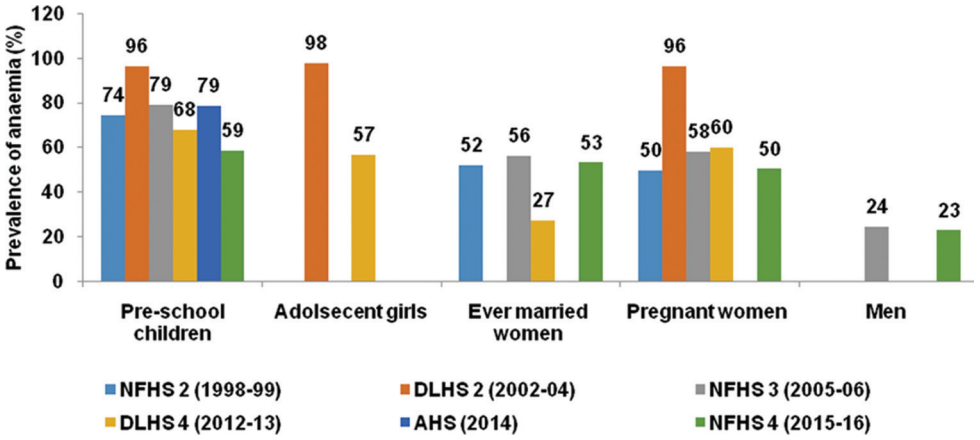

Figure. Trend analysis of the prevalence of anaemia. *Source*: Refs 11, 16-20.

that deficiencies still exist in the Indian population. With respect to vitamin B_{12} deficiency, studies have indicated deficiency as high as 70-100 per cent (Table I). This may also be because about 29 per cent of the Indian population is vegetarian[39]. The prevalence of folate deficiency is not high as compared to vitamin B_{12} deficiency; however, studies carried out in New Delhi and Maharashtra among preschool children and adolescents have indicated deficiency of around 40 to 60 per cent (Table II). Studies have reported the prevalence of low ferritin in almost 60 to 70 per cent of the population (Table III).

Vitamin A deficiency

The Government of India launched the National Prophylaxis Programme against Nutritional Blindness due to vitamin A deficiency in 1970 targeting children aged 1-6 yr with the specific aim of preventing nutritional blindness due to keratomalacia. The programme was modified in 1994, under the National Child Survival and Safe Motherhood Programme where the target group was restricted to 9-36 months children. The age of the target group was later modified as 6 to 59 months in 2006[42]. As per NFHS-4[11], the percentage of children aged 9-59 months who received a vitamin A dose in the past six months has increased from 16.5 (2005-2006) to 60.2 per cent (2015-2016).

The multicentre study carried out by ICMR in 16 districts covering 1.64 lakh preschool children revealed the prevalence of vitamin A deficiency (Bitot's spots) as 0.83 per cent[43]. Another survey carried out by NNMB (ICMR) during 2002-2005 in eight States (Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu and West Bengal) reported similar prevalence of Bitot's spots (0.8%) among 71,591 rural preschool children[44]. Repeat surveys carried out by NNMB in seven States of the country covering rural preschool children have indicated reduction in the prevalence of vitamin A deficiency (Bitot's spots) from 0.7 (1996-1997) to 0.2 per cent (2011-2012)[45]. The Central India Children Eye Study carried out among 11829 schoolchildren of government schools in Nagpur, Maharashtra, reported the prevalence of Bitot's spots as 0.1 per cent[46]. The prevalence of Bitot's spots was also reported as 0.19 per cent among children 0-5 yr in Meghalaya[47].

The prevalence of subclinical vitamin A deficiency (serum retinol <20 µg/dl) among preschool children was reported to be around 62 per cent as revealed by NNMB survey carried out during 2002-2005[48]. A recent carried study carried out in Phek District of Nagaland covering 661 preschool children aged less than five years reported the prevalence of subclinical vitamin A deficiency as 32.6 per cent[49]. The prevalence of subclinical vitamin A deficiency (serum retinol <20 µg/dl) was reported as four per cent among tribal rural women of reproductive age in Central India[38].

Iodine deficiency

The National Goitre Control Programme was launched by the Government of India in 1962 after successful demonstration of salt iodisation to control iodine-deficiency disorders (IDD) in Kangra Valley of Himachal Pradesh. The programme was later renamed as NIDDCP in 1992 focusing on universal salt iodisation. At present, sale of non-iodised salt for direct human consumption is banned under the Food Safety and Standards Act, 2006[50].

The initiatives taken by the Government has resulted in an increase in percentage of households (NFHS-2) using iodised salt, *i.e.*, from 71.6 per cent during

Table I. Some recent surveys carried out in India to assess the prevalence of vitamin B_{12} deficiency

Study	Study area	Study design	Cut-off used for serum vitamin B_{12}	Prevalence (%)
Chakraborty *et al*, 2018[21]	NCR Region and Haryana	Community-based cross-sectional study. School-going adolescents (n=2403) (11-17 yr)	<148 pmol/l	32.4 Rural: 43.9; Urban: 30.1
Gonmei *et al*, 2018[22]	New Delhi	Community-based cross-sectional study. Elderly aged 60 and above (n=77) residing in slums	<203 pg/ml	36.4
Gupta *et al*, 2017[23]	Himachal Pradesh	Community-based cross-sectional study. Schoolchildren (n=215) aged 6-18 yr	<203 pg/ml	7.4
Verma 2017[24]	Maharashtra	School-based cross-sectional study. Adolescents (n=373) aged 11-18 yr	<200 pg/ml	72.7
Mittal *et al*, 2017[25]	New Delhi	Hospital-based cross-sectional study. Term exclusively breastfed infants (n=100) aged 1-6 months	<200 pg/ml	Infants-57.0 Mothers-46.0
Goyal *et al*, 2017[26]	Rajasthan	Hospital-based descriptive study. SAM children (n=80)	<100 pg/ml	37.5
Surana *et al*, 2017[27]	Gujarat	Hospital-based cross-sectional study. Adolescents (n=211) aged 11-18 yr	<160 pg/ml	49.8
Gonmei *et al*, 2017[28]	New Delhi	Community-based cross-sectional study. Women (n=60) aged 60 and above residing in slums	<203 pg/ml	38.0
Sivaprasad *et al*, 2016[29]	Telangana	Community-based cross-sectional study. Adults (n=630) aged 21-85 yr	<203 pg/ml	35.0
Garima *et al*, 2016[30]	-	Pregnant anaemic women (n=257)	<200 pg/ml	67.0
Gupta Bansal *et al*, 2015[31]	New Delhi	Community-based study. Adolescents (n=794) aged 11-18 yr	<203 pg/ml	Anaemia-58.7, 63.3 among anaemic adolescents
Parmar *et al*, 2015[32]	Gujarat	Hospital-based cross-sectional study. Individuals (n=2660) aged 0-96 yr	<200 pg/ml	44.6 <30 yr - 31.5 30 to 60 yr - 39.3 >60 yr - 62.5
Kapil *et al*, 2015[33]	NCT Delhi	Community-based cross-sectional study. Children (n=470) aged 12-59 months	<203 pg/ml	38.4
Chahal *et al*, 2014[34]	Himachal Pradesh	Observational study. Adults (n=153) aged 18-62 yr	<200 pg/ml	43.6
Kapil and Bhadoria 2014[35]	NCT Delhi	School-based cross-sectional study. Adolescents (n=347) aged 11-18 yr	<200 pg/ml	73.5
Bhardwaj *et al*, 2013[36]	Himachal Pradesh	Community-based cross-sectional study. Adolescents (n=885) aged 11-19 yr (n=200 for blood sample)	<200 pg/ml	100.0
Shobha *et al*, 2011[37]	Karnataka	Elderly (n=175) aged 60 and above	-	16.0
Menon *et al*, 2011[38]	Maharashtra	Community-based cross-sectional study. Tribal and rural women of reproductive age (n=109)	<148 pmol/l	34.0

SAM, severe acute malnutrition; NCT, National Capital Territory

Table II. Surveys carried out in India to assess the prevalence of folate deficiency

Study	Study area	Study design	Cut-off used for serum folic acid	Prevalence (%)
Bhide and Kar 2018[40]	Maharashtra	Hospital-based study. Women (n=584) in early pregnancy	<3 ng/ml	24.0
Verma 2017[24]	Maharashtra	School-based cross-sectional study. Adolescents (n=373) aged 11-18 yr	<3 ng/ml	40.2
Goyal *et al*, 2017[26]	Rajasthan	Hospital-based descriptive study. SAM children (n=80)	<3 ng/ml	8.8
Gonmei *et al*, 2017[28]	New Delhi	Community-based cross-sectional study. Women (n=60) aged 60 and above residing in slums	<4 pg/ml	12.0
Gupta *et al*, 2017[23]	Himachal Pradesh	Community-based cross-sectional study. Schoolchildren (n=215) aged 6-18 yr	<4 ng/ml	1.5
Sivaprasad *et al*, 2016[29]	Telangana	Community-based cross-sectional study. Adults (n=630) aged 21-85 yr	<3 ng/ml	12.0
Gupta Bansal *et al*, 2015[31]	New Delhi	Community-based study. Adolescents (n=794) aged 11-18 yr	<4 ng/ml	Anaemia - 58.7 5 among anaemic adolescents
Kapil *et al*, 2015[33]	NCT Delhi	Community-based cross-sectional study. Children (n=470) aged 12-59 months	<4 ng/ml	63.2
Kapil and Bhadoria 2014[35]	NCT Delhi	School-based cross-sectional study. Adolescents (n=347) aged 11-18 yr	<3 ng/ml	39.8
Bhardwaj *et al*, 2013[36]	Himachal Pradesh	Community-based cross-sectional study. Adolescents (n=885) aged 11-19 yr (n=200 for blood sample)	<2.7 ng/ml	0
Menon *et al*, 2011[38]	Maharashtra	Community-based cross-sectional study. Tribal and rural women (n=109) of reproductive age	<6.8 nmol/l	2.0

Table III. Some surveys carried out to assess the prevalence of ferritin deficiency

Study	Study area	Study design	Cut-off used for serum ferritin	Prevalence (%)
Gupta Bansal *et al*, 2015[31]	New Delhi	Community-based study. Adolescents (n=794) aged 11-18 yr	<15 ng/ml	Anaemia - 58.7 41.1 among anaemic adolescents
Bains *et al*, 2015[41]	Punjab	Community-based study. Children (n=312) aged six months to 5 yr	<10 µg/l	71.8
Kapil and Bhadoria 2014[35]	NCT Delhi	School-based cross-sectional study Adolescents (n=347) aged 11-18 yr	<12 ng/ml	59.7
Bhardwaj *et al*, 2013[36]	Himachal Pradesh	Community-based cross-sectional study. Adolescents (n=885) aged 11-19 yr (n=200 for blood sample)	<12 ng/ml	15.0

1998-1999[16] to 93.1 per cent during 2015-2016[11]. The National Iodine and Salt Intake Survey (2014-2015) also reported that 78 per cent of the households were consuming adequate iodised salt[51].

Salt iodine content at the production and packaging site, wholesale and retail levels and in households; urinary iodine levels; thyroid-stimulating hormone (TSH) levels and change in goitre prevalence are indicators for monitoring and evaluating IDD control programmes[52]. In India, of the 414 districts surveyed so far up to the year 2015-2016, 337 districts were found to be endemic for IDD (total goitre rate >5%)[53]. However, NNMB survey carried out during 2002-2005 in eight States, *i.e.*, Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha,

Table IV. Some studies carried out in India to assess the prevalence of iodine-deficiency disorders

Study	Study area	Study design	Total goitre rate (%)	Median urinary iodine concentration (µg/l)	Percentage of iodised salt consumption (≥15 ppm)
Infants					
Amrutha *et al*, 2014[54]	Tamil Nadu	Community-based cross-sectional study (n=2800)	-	Male - 114.7; female - 121.8 (range: 39.9-226.5)	-
Schoolchildren					
Shetty *et al*, 2018[55]	Karnataka	School-based cross-sectional study (aged 6-12 yr) (n=2703) (Goitre); 270 (UIC); 543 (salt)	9.3	202.12	69.8
Bali *et al*, 2018[56]	Madhya Pradesh	School-based cross-sectional study (aged 6-12 yr) (n=2700) (Goitre); 270 (UIC); 540 (salt)	2.08	175	72.4
Sareen *et al*, 2016[57]	Uttarakhand	Community-based cross-sectional study (n=6143)	Udham Singh Nagar-13.2 Nainital-15.9 Pauri Garhwal-16.8	Udham Singh Nagar - 150 Nainital - 125 Pauri Garhwal - 115	-
Gupta *et al*, 2016[58]	Jammu	School-based cross-sectional study (aged 6-12 yr) (n=3955) (Goitre); 400 (salt)	Rajouri- 18.87 Poonch-19.70	-	100
Manjunath *et al*, 2015[59]	Karnataka	Community-based cross-sectional study (aged 6-12 yr) (n=832)	21.9	150	-
Ahmed *et al*, 2014[60]	Karnataka	Community-based cross-sectional study (aged 6-12 yr) (n=10082)	19.01	-	40.1
Kapil *et al*, 2015[61]	Himachal Pradesh	Community-based cross-sectional study (aged 6-12 yr) (n=5748)	Kangra-15.8 Kullu- 23.4 Solan-15.4	Kangra - 200 Kullu - 175 Solan - 62.5	-
Kapil *et al*, 2014[62]	Udham Singh Nagar, Uttarakhand	School-based cross-sectional study (aged 6-12 yr) (n=1807) (TGR); 587 (UIC); 660 (salt)	13.2	150	46.7
Kapil *et al*, 2014[63]	Pauri, Uttarakhand	School-based cross-sectional study (aged 6-12 yr) (n=2067) (TGR); 580 (UIC); 562 (salt)	16.8	115	40.4
Sridhar and Kamala 2014[64]	Karnataka	School-based cross-sectional study (aged 6-15 yr) (n=1600) (goitre); 400 (salt)	0.125	179	90.7
Biswas *et al*, 2014[65]	Darjeeling, West Bengal	School-based cross-sectional study (aged 8-10 yr) (n=2400)	8.67	156	92.6
Kapil *et al*, 2013[66]	Kangra, Himachal Pradesh	School-based cross-sectional study (aged 6-12 yr) (n=1864) (TGR); 463 (UIC); 327 (salt)	15.8	200	82.3

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Study	Study area	Study design	Total goitre rate (%)	Median urinary iodine concentration (µg/l)	Percentage of iodised salt consumption (≥15 ppm)
Kapil *et al*, 2014[67]	Nainital District, Uttarakhand	School-based cross-sectional study (aged 6-12 yr) (n=2269) (TGR); 611 (UIC); 642 (salt)	15.9	125	57.5
Kapil *et al*, 2013[68]	NCT Delhi	School-based cross-sectional study (aged 6-11 yr) (n=1393)	-	200	87.0
Chaudhary *et al*, 2013[69]	Haryana	School-based cross-sectional study (aged 6-12 yr) (n=2700)	12.6	>100	88.0
Zama *et al*, 2013[70]	Karnataka	School-based cross-sectional study (aged 6 to 12 yr) (n=3757)	7.74	-	-
Adolescent girls					
Sareen *et al*, 2016[57]	Uttarakhand	Community-based cross-sectional study (n=5430)	Udham Singh Nagar - 6.8 Nainital - 8.2 Pauri Garhwal - 5.6	Udham Singh Nagar - 250 Nainital - 200 Pauri Garhwal - 183	-
Pregnant women					
Kant *et al*, 2017[71]	Haryana	Community-based cross-sectional study (n=1031)	-	260 (range: 199-333)	90.9
Rao *et al*, 2018[72]	New Delhi	Community-based cross-sectional study	-	147.5	70.6
Sareen *et al*, 2016[57]	Uttarakhand	Community-based cross-sectional study (n=1727)	Udham Singh Nagar - 16.1 Nainital - 20.2 Pauri Garhwal - 24.9	Udham Singh Nagar - 124 Nainital - 117.5 Pauri Garhwal - 110	
Kapil *et al*, 2015[73]	Uttarakhand	Community-based cross-sectional study (n=1727) (TGR); 1040 (UIC) and 1494 (Salt)	Pauri-24.9 Nainital-20.2 Udham Singh Nagar-16.1	Pauri - 110 Nainital - 117.5 Udham Singh Nagar - 124	Pauri - 57.9 Nainital - 67.0 Udham Singh Nagar - 50.3
Kapil *et al*, 2014[74]	Himachal Pradesh	Community-based cross-sectional study (n=1711) (TGR); 1118 (UIC) and 1283 (Salt)	Kangra-42.2 Kullu - 42.0 Solan-19.9	Kangra - 200 Kullu - 149 Solan - 130	Kangra - 68.3 Kullu - 60.3 Solan - 48.6
Joshi *et al*, 2014[75]	Vadodara, Gujarat	Hospital-based cross-sectional study (n=256) (gestational age, 15 wk)	-	297.14	-

TGR, total goitre rate; UIC, urinary iodine concentration

Tamil Nadu and West Bengal, reported total goitre rate of 3.9 per cent among schoolchildren[44]. Some of the recent surveys carried out in the country have reported total goitre rate of more than 5 per cent (Table IV). Further, median urinary iodine concentration, an indicator of current intake indicated adequate iodine intake among schoolchildren aged 6 yr and above (>100 µg/l) and non-pregnant women. A study carried

out in Kangra, Himachal Pradesh, after 60 yr of salt iodisation also reported adequate iodine intake among schoolchildren aged 6-12 yr as indicated by median urinary iodine concentration of 200 µg/l, while total goitre rate was still more than 15 per cent[66]. Around 60 to 80 per cent neonates in Himachal Pradesh were also reported to be deficient in iodine (TSH >5 mUI/l)[76,77].

Insufficient iodine intake among pregnant women has been reported with median urinary iodine concentration of <150 µg/l[57,71-74]. The ongoing Task Force Study on IDD by ICMR at 10 districts of the country would provide a better picture on the current status of iodine status among pregnant women.

Other micronutrient deficiencies

Limited studies have been carried out in the country to assess status of other micronutrients. Studies carried out to assess copper levels have reported deficiency of around 29 to 34 per cent among pregnant women and adult tribal population[78,79]. Available literature on zinc levels has indicated high prevalence of zinc deficiency among children aged 6-60 months (43.8%), adolescents (49.4%) and pregnant women (64.6%)[80-82]. Similarly, the prevalence of zinc deficiency has been reported to be around 52 to 58 per cent among tribal non-pregnant women in Central India[38]. While studies carried out among pregnant women in Assam (12%) and children aged six months to five years in Punjab (18%) reported lower prevalence of zinc deficiency[78,83], a recently published study[84] projected that by 2050, the prevalence of zinc deficiency would increase by 2.9 per cent due to anthropogenic CO_2 emissions. Anthropogenic CO_2 emission disrupts the global climate system affecting food production and altering the nutrient profile of staple food crops and is likely to increase nutrient deficiencies.

Only few studies have also been carried out to assess vitamin C deficiency with plasma vitamin C as an indicator. The India age-related eye disease study carried out among the elderly aged 60 and above in north and south India reported the prevalence of vitamin C deficiency as 73.9 and 45.7 per cent, respectively[85]. Another study carried out among adolescent girls (n=775), residing in slums of New Delhi reported the prevalence of vitamin C deficiency as only 6.3 per cent[86].

Conclusion

Micronutrient deficiency is a major health problem in the country, with anaemia affecting almost 50 to 60 per cent of the population while vitamin A deficiency and IDD have improved over the years. With recent initiatives of the government and strengthening existing health and agriculture systems, micronutrient status of the population is expected to improve in the coming years.

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References

1. FAO, IFAD, UNICEF, WFP and WHO, The State of Food Security and Nutrition in the World. *Building resilience for peace and food security*. Rome: Food and Agricultural Organization of the United Nations; 2017. Available from: *http://www.fao.org/3/a-I7695e.pdf*, accessed on September 10, 2018.
2. World Health Organization. *Micronutrients*. Available from: *http://www.who.int/nutrition/topics/micronutrients/en/*, accessed on September 10, 2018.
3. Thompson B, Amoroso L. *Combating micronutrient deficiencies: Food-based approaches*. Rome: Food and Agriculture Organization of the United Nations and CAB International; 2011.
4. Stein AJ, Qaim M. The human and economic cost of hidden hunger. *Food Nutr Bull* 2007; *28* : 125-34.
5. India State-Level Disease Burden Initiative Collaborators. Nations within a nation: Variations in epidemiological transition across the states of India, 1990-2016 in the Global Burden of Disease Study. *Lancet* 2017; *390* : 2437-60.
6. Lopez A, Cacoub P, Macdougall IC, Peyrin-Biroulet L. Iron deficiency anaemia. *Lancet* 2016; *387* : 907-16.
7. Toteja GS, Singh P. *Micronutrient profile of Indian population*. New Delhi: Indian Council of Medical Research; 2004.
8. Ministry of Health & Family Welfare, Government of India. *Policy on control of nutritional anaemia*. Ministry of Health & Family Welfare Government of India; 1991.
9. National Health Mission. *Weekly Iron and Folic Acid Supplementation (WIFS)*. New Delhi: Ministry of Health & Family Welfare, Government of India; 2015. Available from: *http://www.nhm.gov.in/nrhm-components/rmnch-a/adolescent-health-rksk/weekly-iron-folic-acid-supplementation-wifs/background.html*, accessed on September 10, 2018.
10. Deb S. Implementation of national iron plus initiative for child health: Challenges ahead. *Indian J Public Health* 2015; *59* : 1-2.
11. International Institute for Population Sciences. *National Family Health Survey (NFHS-4), 2015-16*. Mumbai: IIPS. Available from: *http://rchiips.org/nfhs/NFHS-4Reports/India.pdf*, accessed on September 10, 2018.
12. Toteja GS, Singh P, Dhillon BS, Saxena BN, Ahmed FU, Singh RP, *et al.* Prevalence of anemia among pregnant women and adolescent girls in 16 districts of India. *Food Nutr Bull* 2006; *27* : 311-5.

13. National Nutrition Monitoring Bureau. *NNMB Technical report No: 22. Prevalence of micronutrient deficiencies*. New Delhi: Indian Council of Medical Research; 2003. Available from: *http://www.nnmbindia.org/NNMB%20MND%20REPORT%202004-web.pdf*, accessed on September 10, 2018.
14. Patel A, Prakash AA, Das PK, Gupta S, Pusdekar YV, Hibberd PL, *et al.* Maternal anemia and underweight as determinants of pregnancy outcomes: Cohort study in Eastern rural Maharashtra, India. *BMJ Open* 2018; *8* : e021623.
15. Singh S, Geddam JJB, Reddy GB, Pallepogula DR, Pant HR, Neogi SB, *et al*. Folate, vitamin B12, ferritin and haemoglobin levels among women of childbearing age from a rural district in South India. *BMC Nutr* 2017; *3* : 50.
16. International Institute for Population Sciences. *National family health survey (NFHS-2) 1998-99*. Mumbai: IIPS. 2000. Available from: *https://www.dhsprogram.com/pubs/pdf/FRIND2/FRIND2.pdf*, accessed on September 10, 2018.
17. International Institute for Population Sciences. *National Family Health Survey (NFHS-3), 2005-06*. Mumbai: IIPS. Available from: *https://dhsprogram.com/pubs/pdf/frind3/frind3-vol1andvol2.pdf*, accessed on September 10, 2018.
18. International Institute for Population Sciences. District Level Household and Facility Survey (DLHS-2) 2002-04. *Nutritional status of children and prevalence of anaemia among women, adolescent girls and pregnant women*. Mumbai: IIPS; 2006. Available from: *http://rchiips.org/pdf/rch2/National_Nutrition_Report_RCH-II.pdf*, accessed on September 10, 2018.
19. International Institute for Population Sciences. *District Level Household & Facility survey (DLHS-3)*. Mumbai: IIPS; 2007-08.
20. Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India. *Clinical, Anthropometric and Biochemical (CAB) 2014*. Available from: *http://www.censusindia.gov.in/2011census/hh-series/cab.html*, accessed on September 27, 2018.
21. Chakraborty S, Chopra M, Mani K, Giri AK, Banerjee P, Sahni NS, *et al*. Prevalence of Vitamin B12 deficiency in healthy Indian school-going adolescents from rural and urban localities and its relationship with various anthropometric indices: A cross-sectional study. *J Hum Nutr Diet* 2018; *4* : 513-22.
22. Gonmei Z, Dwivedi S, Toteja GS, Singh K, Vikram NK, Bansal PG. Anaemia and Vitamin B12 deficiency in elderly. *Asian J Pharm Clin Res* 2018; *11* : 402-4.
23. Gupta A, Kapil U, Ramakrishnan L, Pandey RM, Yadav CP. Prevalence of Vitamin B12 and folate deficiency in school children residing at high altitude regions in India. *Indian J Pediatr* 2017; *84* : 289-93.
24. Verma S. Incidence of Vitamin B12 and folate deficiency amongst adolescents. *Int J Contemp Med Res* 2017; *4* : 1755-7.
25. Mittal M, Bansal V, Jain R, Dabla PK. Perturbing status of Vitamin B12 in Indian infants and their mothers. *Food Nutr Bull* 2017; *38* : 209-15.
26. Goyal S, Tiwari K, Meena P, Malviya S, Mohd A. Cobalamin and folate status in malnourished children. *Int J Contemp Pediatr* 2017; *4* : 1480-4.
27. Surana A, Tilwani S, Patel S, Prajapati H, Prasad R. Vitamin B12 status among anaemic adolescents. *Int J Community Med Public Health* 2017; *4* : 1780-5.
28. Gonmei Z, Siddhu A, Toteja GS, Dwivedi S, Chand V, Vikram NK, *et al*. Hemoglobin, folate and Vitamin B12 status of economically deprived elderly women. *J Clin Gerontol Geriatr* 2017; *8* : 133-4.
29. Sivaprasad M, Shalini T, Balakrishna N, Sudarshan M, Lopamudra P, Suryanarayana P, *et al.* Status of Vitamin B12 and folate among the urban adult population in South India. *Ann Nutr Metab* 2016; *68* : 94-102.
30. Garima U, Jyala NS, Chaudhary D. A study of Vitamin B12 deficiency in anemia in pregnancy. *Int J Adv Sci Eng Technol* 2016; *4* : 116-9.
31. Gupta Bansal P, Singh Toteja G, Bhatia N, Kishore Vikram N, Siddhu A, Kumar Garg A, *et al.* Deficiencies of serum ferritin and Vitamin B12, but not folate, are common in adolescent girls residing in a slum in Delhi. *Int J Vitam Nutr Res* 2015; *85* : 14-22.
32. Parmar V, Shah P, Khubchandani A, Solanki V, Vaghela V, Jadav J. Vitamin B12 status in different Age Groups. *Int J Res Med* 2015; *4* : 113-5.
33. Kapil U, Toteja GS, Bhadoria AS. Cobalamin and folate deficiencies among children in the age group of 12-59 months in India. *Biomed J* 2015; *38* : 162-6.
34. Chahal JS, Raina SK, Sharma KK, Kaur N. How common is Vitamin B12 deficiency - A report on deficiency among healthy adults from a medical college in rural area of North-West India. *Int J Nutr Pharmacol Neurol Dis* 2014; *4* : 241-5.
35. Kapil U, Bhadoria AS. Prevalence of folate, ferritin and cobalamin deficiencies amongst adolescent in India. *J Family Med Prim Care* 2014; *3* : 247-9.
36. Bhardwaj A, Kumar D, Raina SK, Bansal P, Bhushan S, Chander V, *et al.* Rapid assessment for coexistence of Vitamin B12 and iron deficiency anemia among adolescent males and females in Northern Himalayan state of India. *Anemia* 2013; *2013* : 959605.
37. Shobha V, Tarey SD, Singh RG, Shetty P, Unni US, Srinivasan K, *et al.* Vitamin B_{12} deficiency & levels of metabolites in an apparently normal urban South Indian elderly population. *Indian J Med Res* 2011; *134* : 432-9.
38. Menon KC, Skeaff SA, Thomson CD, Gray AR, Ferguson EL, Zodpey S, *et al.* Concurrent micronutrient deficiencies are prevalent in nonpregnant rural and tribal women from central India. *Nutrition* 2011; *27* : 496-502.
39. Sample Registration System Baseline Survey 2014. Census of India. Available from: *http://www.censusindia.gov.in/vital_statistics/BASELINE%20TABLES08082016.pdf*, accessed on September 4, 2018.
40. Bhide P, Kar A. Prevalence and determinants of folate deficiency among urban Indian women in the periconception period. *Eur J Clin Nutr* 2018; doi:10.1038/s41430-018-0255-2.

41. Bains K, Kaur H, Bajwa N, Kaur G, Kapoor S, Singh A, *et al.* Iron and zinc status of 6-month to 5-year-old children from low-income rural families of Punjab, India. *Food Nutr Bull* 2015; *36* : 254-63.
42. Kapil U, Sachdev HP. Massive dose Vitamin A programme in India - need for a targeted approach. *Indian J Med Res* 2013; *138* : 411-7.
43. Toteja GS, Singh P, Dhillon BS, Saxena BN. Vitamin A deficiency disorders in 16 districts of India. *Indian J Pediatr* 2002; *69* : 603-5.
44. Laxmaiah A, Arlappa N, Balakrishna N, Mallikarjuna Rao K, Galreddy C, Kumar S, *et al.* Prevalence and determinants of micronutrient deficiencies among rural children of eight states in India. *Ann Nutr Metab* 2013; *62* : 231-41.
45. National Nutrition Monitoring Bureau. *Technical report No. 26. Diet and nutritional status of rural population, prevalence of hypertension & diabetes among adults and infant & young child feeding practices: Report of third repeat survey*. Hyderabad: Indian Council of Medical Research; 2012.
46. Sinha A, Jonas JB, Kulkarni M, Nangia V. Vitamin A deficiency in schoolchildren in urban central India: The central India children eye study. *Arch Ophthalmol* 2011; *129* : 1095-6.
47. Nongrum MS, Kharkongor GC. High prevalence of Vitamin A deficiency among children in Meghalaya and the underlying social factors. *Indian J Child Health* 2015; *2* : 59-63.
48. National Nutrition Monitoring Bureau. *Technical report No: 23. Prevalence of Vitamin A deficiency among preschool children in rural areas*. Hyderabad: Indian Council of Medical Research; 2006.
49. Longvah T, Khutsoh B, Meshram II, Krishna S, Kodali V, Roy P, *et al.* Mother and child nutrition among the chakhesang tribe in the state of Nagaland, North-East india. *Matern Child Nutr* 2017; *13* (Suppl 3) : e12558.
50. Pandav CS. Evolution of iodine deficiency disorders control program in India: A Journey of 5,000 years. *Indian J Public Health* 2013; *57* : 126-32.
51. IDD Newsletter. Across India, women are iodine sufficient. India; November, 2015. Available from: *http://www.ign.org/cm_data/IDD_nov15_india.pdf*, accessed on September 10, 2018.
52. World Health Organization. *Assessment of iodine deficiency disorders and monitoring their elimination; a guide for programme managers*, 2nd ed. Geneva: WHO; 2001. Available from: *http://www.who.int/iris/handle/10665/61278*, accessed on September 10, 2018.
53. National Iodine Deficiency Disorders Control Programme (NIDDCP). Available from: *http://www.nhm.gov.in/nrhm-components/national-disease-control-programmes-ndcps/iodine-deficiency-disorders.html*, accessed on August 31, 2018.
54. Amrutha Veena K, Kowsalya S, Kothandapani S. Micronutrient malnutrition profile of infants in South India. *J Hum Nutr Diet* 2014; *27* : 54-7.
55. Shetty A, Rao CR, Kamath A, Vibha SP, Reddy TSK. Goiter prevalence and interrelated components from coastal Karnataka. *Indian J Pediatr* 2018; doi:10-1007/s12098-018-2757-2.
56. Bali S, Singh AR, Nayak PK. Iodine deficiency and toxicity among school children in Damoh district, Madhya Pradesh, India. *Indian Pediatr* 2018; *55* : 579-81.
57. Sareen N, Kapil U, Nambiar V, Pandey RM, Khenduja P. Iodine nutritional status in Uttarakhand state, India. *Indian J Endocrinol Metab* 2016; *20* : 171-6.
58. Gupta RK, Langer B, Raina SK, Kumari R, Jan R, Rani R, *et al.* Goiter prevalence in school-going children: A cross-sectional study in two border districts of sub-Himalayan Jammu and Kashmir. *J Family Med Prim Care* 2016; *5* : 825-8.
59. Manjunath B, Suman G, Hemanth T, Shivaraj NS, Murthy NS. Prevalence and factors associated with goitre among 6-12-year-old children in a rural area of Karnataka in South India. *Biol Trace Elem Res* 2016; *169* : 22-6.
60. Ahmed M, Zama SY, Nagarajarao V, Khan MA. Iodine deficiency in children: A comparative study in two districts of South-interior Karnataka, India. *J Family Community Med* 2014; *21* : 48-52.
61. Kapil U, Pandey RM, Sareen N, Khenduja P, Bhadoria AS. Iodine nutritional status in Himachal Pradesh state, India. *Indian J Endocrinol Metab* 2015; *19* : 602-7.
62. Kapil U, Pandey RM, Jain V, Kabra M, Sareen N, Bhadoria AS, *et al.* Status of iodine deficiency disorder in district Udham Singh Nagar, Uttarakhand state India. *Indian J Endocrinol Metab* 2014; *18* : 419-21.
63. Kapil U, Pandey RM, Prakash S, Sareen N, Bhadoria AS. Iodine deficiency status amongst school children in Pauri, Uttarakhand. *Indian Pediatr* 2014; *51* : 569-70.
64. Sridhar PV, Kamala CS. Iodine status and prevalence of goitre in school going children in rural area. *J Clin Diagn Res* 2014; *8* : PC15-7.
65. Biswas AB, Das DK, Chakraborty I, Biswas AK, Sharma PK, Biswas R, *et al.* Goiter prevalence, urinary iodine, and salt iodization level in sub-Himalayan Darjeeling district of West Bengal, India. *Indian J Public Health* 2014; *58* : 129-33.
66. Kapil U, Pandey RM, Kabra M, Jain V, Sareen N, Bhadoria AS, *et al.* Status of iodine deficiency in district Kangra, Himachal Pradesh after 60 years of salt iodization. *Eur J Clin Nutr* 2013; *67* : 827-8.
67. Kapil U, Pandey RM, Prakash S, Kabra M, Sareen N, Bhadoria AS, *et al.* Assessment of iodine deficiency in school age children in Nainital district, Uttarakhand state. *Asia Pac J Clin Nutr* 2014; *23* : 278-81.
68. Kapil U, Sareen N, Bhadoria AS. Status of iodine deficiency among children in national capital territory of Delhi – A cross-sectional study. *J Trop Pediatr* 2013; *59* : 331-2.
69. Chaudhary C, Pathak R, Ahluwalia SK, Goel RK, Devgan S. Iodine deficiency disorder in children aged 6-12 years of Ambala, Haryana. *Indian Pediatr* 2013; *50* : 587-9.
70. Zama SY, Ahmed M, Vadiraja N. Prevalence of goitre in school children of Chamarajanagar district, Karnataka, India. *J Clin Diagn Res* 2013; *7* : 2807-9.

71. Kant S, Haldar P, Lohiya A, Yadav K, Pandav CS. Status of iodine nutrition among pregnant women attending antenatal clinic of a secondary care hospital: A cross-sectional study from Northern India. *Indian J Community Med* 2017; *42* : 226-9.

72. Rao S, Toteja GS, Bhatia N, Dwivedi S, Gonmei Z, Roy AK. Iodine status of pregnant women residing in urban slums of Delhi. *Asian J Pharm Clin Res* 2018; *11* : 506-8.

73. Kapil U, Sareen N, Nambiar VS, Khenduja P, Pande S. Status of iodine nutrition among pregnant mothers in selected districts of Uttarakhand, India. *Indian J Endocrinol Metab* 2015; *19* : 106-9.

74. Kapil U, Prakash S, Sareen N, Bhadoria AS, Khenduja P, Nigam S, *et al.* Status of iodine deficiency among pregnant mothers in Himachal Pradesh, India. *Public Health Nutr* 2014; *17* : 1971-4.

75. Joshi K, Nair S, Khade C, Rajan MG. Early gestation screening of pregnant women for iodine deficiency disorders and iron deficiency in urban centre in Vadodara, Gujarat, India. *J Dev Orig Health Dis* 2014; *5* : 63-8.

76. Kapil U, Kabra M, Sareen N, Khenduja P, Pande S. Iodine nutrition status amongst neonates in Kangra district, Himachal Pradesh India. *J Trace Elem Med Biol* 2014; *28* : 351-3.

77. Kapil U, Kabra M, Prakash S, Sareen N, Khenduja P. Iodine nutritional status among neonates in the Solan district, Himachal Pradesh, India. *J Community Health* 2014; *39* : 987-9.

78. Mahanta LB, Roy TD, Dutta RG, Devi A. Nutritional status and the impact of socioeconomic factors on pregnant women in Kamrup district of Assam. *Ecol Food Nutr* 2012; *51* : 463-80.

79. Kapil U, Singh P. Serum copper levels among a tribal population in Jharkhand state, India: A pilot survey. *Food Nutr Bull* 2005; *26* : 309-11.

80. Kapil U, Toteja GS, Rao S, Pandey RM. Zinc deficiency amongst adolescents in Delhi. *Indian Pediatr* 2011; *48* : 981-2.

81. Pathak P, Kapil U, Dwivedi SN, Singh R. Serum zinc levels amongst pregnant women in a rural block of Haryana state, India. *Asia Pac J Clin Nutr* 2008; *17* : 276-9.

82. Kapil U, Jain K. Magnitude of zinc deficiency amongst under five children in India. *Indian J Pediatr* 2011; *78* : 1069-72.

83. Herbst CA, Menon KC, Ferguson EL, Thomson CD, Bailey K, Gray AR, *et al.* Dietary and non-dietary factors associated with serum zinc in Indian women. *Biol Trace Elem Res* 2014; *161* : 38-47.

84. Smith MR, Myers SS. Impact of anthropogenic CO_2 emissions on global human nutrition. *Nat Clim Chang* 2018; *8* : 834-9.

85. Ravindran RD, Vashist P, Gupta SK, Young IS, Maraini G, Camparini M, *et al.* Prevalence and risk factors for Vitamin C deficiency in North and South India: A two centre population based study in people aged 60 years and over. *PLoS One* 2011; *6* : e28588.

86. Bansal PG, Toteja GS, Suman R. Plasma Vitamin C status of adolescent girls in a slum of Delhi. *Indian Pediatr* 2014; *51* : 932-3.

For correspondence: Dr G.S. Toteja, Centre for Promotion of Nutrition Research and Training with Special Focus on North East, Tribal and Inaccessible Population, Division of Nutrition, Indian Council of Medical Research (Campus II), Tuberculosis Association of India Building, 3 Red Cross Road, New Delhi 110 001, India
e-mail: gstoteja@gmail.com