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Hidden Hunger (Micro Nutrient Deficiencies - MNDs) Among Pregnant Women and Pregnancy Outcomes. - A Hospital Based Study in Chennai.

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Abstract

Introduction. It is estimated that India suffers a 1% GDP loss due to MNDs. Most studies on MNDs among pregnant women in India have focussed on one / two MNs. Studies on multiple MNDs and pregnancy outcomes in India are rare. Global Hidden Hunger Index scores have been computed using child related data. None have been computed for pregnant women. We conducted a study to: (i) estimate the prevalence of multiple MNDs among pregnant women (ii) describe pregnancy outcomes for women with MNDs and (iii) compute Hidden Hunger Index Scores for pregnant women. **Methods:** Adopting a cross sectional study design we surveyed pregnant women 48-72 hours before delivery attending a tertiary care hospital in Chennai city. We interviewed women to get information on identification, socio economic, past and current pregnancy particulars. We abstracted information on weight, height, Blood pressure, blood sugar, etc. from the case records. We carried out serological and blood tests to assess MND and haemoglobin status for Vitamins: A, B6 and B12 and minerals: zinc, calcium, magnesium, copper, ferritin. We estimated the prevalence of deficiencies for each of these MNs. We used Fisher Exact Chi Square and students T test to test the significance of the difference between two proportions and means. A p value < 0.05 was considered significant. **Results:** We recruited 304 pregnant women – of whom > 99% had one or more MNDs**.** The mean number of MNDs per woman was 3.75 (SD: 1.50). The prevalence of individual MNDs was: Vitamin A (69%), B12 (76%), Zinc (57%), Calcium, (43%), Magnesium (39%) Copper (2%) and haemoglobin deficits / Anaemia (42%). Nearly 23% of women experienced adverse pregnancy outcomes - maternal and/or foetal. Hidden Hunger Index scores for these women was 45. **Conclusion:** The high prevalence of multiple MNDs, high HHI score and high level of adverse pregnancy outcomes among pregnant women in our study suggests the need to provide multiple micronutrient supplementations rather than single preparations during pregnancy to ensure smooth and successful pregnancy outcomes.

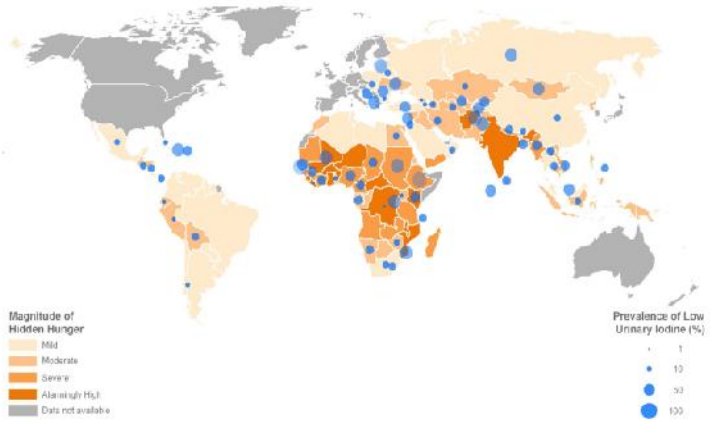
Keywords: pregnancy, micronutrients, maternal / foetal outcomes, Hidden Hunger Index.

Introduction

Impressive gains have been accrued with respect to the number of persons suffering from hunger globally with the Global Hunger Index (GHI) scores falling from 20.6 in 1990 to 12.5 in 2014 in developing countries – suggesting a 39% reduction. In spite of this between 2012-2014, about 805 million people continue to be chronically undernourished**. (1)**. South Asia, and Sub Saharan report the highest 2014 GHI scores at 18.1 and 18.2 respectively. The declines of >5 points in South Asia have been largely attributed to declines in child under nutrition. India recorded a 26% decline with GHI scores falling to 17.8 in 2014 from 31.2 in 1990. Between 2005 (24.2) and 2014 (17.8) the reduction has been 6.4 points in GHI scores. This decline has been attributed to declines in national underweight estimates during the last eight years – from 43.5 % in 2005 to 30.7% in 2014**.(2)**

Globally, approximately one in three persons i.e. an estimated 2 billion, suffer from multiple micronutrients deficiencies (MNDs) - collectively termed as "Hidden Hunger" (HH), accounting for about 7% of global disease burden. Sub Saharan Africa, India and Afghanistan had very high Hidden Hunger Index scores**.(3)** (Fig. 1 & Tab. 1) which was also associated with high prevalence of stunting, iron deficiency anaemia and vitamin A deficiency among preschool children.

Figure 1: Magnitude of Hidden Hunger



Magnitude of Hidden Hunger (Zinc, Iron and Vitamin A Deficiencies), Prevalence of Iodine Deficiency

Table 1 : Top 20 countries affected by multiple Micronutrient deficiencies

Top 20 Countries Affected by Multiple Micronutrient Deficiencies

Rank	Country	Hidden Hunger Index Score	Deficiency Prevalence (%)		
			Zinc (Stunting as Proxy for Zinc)	Iron (Anemia Due to Iron Deficiency)	Vitamin A (Low Serum Retinol) (<0.7 µmol/L)
1	Niger	52.0	47.0	41.8	67.0
2	Kenya	51.7	35.8	34.5	84.4
3	Benin	51.3	44.7	39.1	70.7
4	Central African Republic	51.0	43.0	42.1	68.2
5	Mozambique	51.0	47.0	37.4	68.8
6	Sierra Leone	50.0	37.4	37.9	74.8
7	Malawi	49.7	53.2	36.6	59.2
8	India	48.3	47.9	34.7	62.0
9	Burkina Faso	48.3	44.5	45.8	54.3
10	Ghana	47.7	28.6	39.0	75.8
11	São Tomé and Príncipe	47.7	29.3	18.4	95.6
12	Afghanistan	47.7	59.3	19.0	64.5
13	Democratic Republic of the Congo	47.7	45.8	35.7	61.1
14	Mali	46.0	38.5	40.7	58.6
15	Liberia	45.3	39.4	43.4	52.9
16	Côte d'Ivoire	44.0	40.1	34.5	57.3
17	Gambia	43.7	27.6	39.7	64.0
18	Chad	43.3	44.8	35.6	50.1
19	Madagascar	43.0	52.8	34.2	42.1
20	Zambia	42.0	45.8	26.5	54.1

In 36 countries housing 90% of the world's stunted children, micronutrients deficiencies – particularly vitamin A and zinc- accounted for around 12% of total number of lives lost (DALYs) due to ill health, disability and premature deaths. In 20 countries with the highest Hidden Hunger Index Scores, it was estimated that 40% of preschool children were stunted, > 30% suffered from iron deficiency anaemia and >50% had Vitamin A deficiency**.(3)**

Countries with High Human Development Index (HDI) scores had low Hidden Hunger Index scores and vice versa. Of the 149 countries with HDI scores < 0.9, Niger had the highest Hidden Hunger score and Hungary the lowest. Even mild to moderate deficiencies in micronutrients appeared to exert adverse impacts on human growth and development, functionality and productivity. Women in the reproductive age and young children from low income countries seem to be most vulnerable to Hidden Hunger.

Globally the most prevalent micronutrient deficiencies include iron, zinc, Vitamins A, B12 and other B vitamins.(3) Although the developing world is home to a larger proportion of the population with MNDs, iron and iodine deficiencies are widely prevalent in the developed world.(GH 2014). Of the 3.1 million child deaths that occur annually due to under nutrition, 1.1 million are caused by MNDs **(4, 5)**

The nutritional status of women during conception and pregnancy has long term impacts for foetal growth and development. Annually about 18 million babies suffer from brain damage due to iodine deficiency and nearly 50,000 women die in childbirth due to severe anaemia. Iron deficiency anaemia is reported to sap the energy of nearly 40% of women in the developing world **(6, 7).** It is further estimated that 190 million school children and 19 million pregnant women suffer from Vitamin A deficiency (8). The most commonly occurring MNDs across all ages include: iodine, iron, zinc, calcium, vitamin D and B vitamins.

It is well known that pregnancy is associated with increased nutritional needs (both macro and micro nutrients) to meet the demands of a growing foetus. Nutritional adequacy is thus an important prerequisite to ensure optimal health status of the mother and the baby. Nutritional deficiencies of any magnitude are likely to be associated with adverse pregnancy outcomes such as : gestational hypertension, eclampsia, preterm birth, low birth weight, intra uterine growth restriction, congenital anomalies and maternal and infant mortality **(9,10)**. In addition, gestational nutritional inadequacies have also been linked to chronic diseases such as Diabetes Mellitus, CVD, etc. in adulthood**. (11,12).** It has further been observed that multiple micronutrient deficiencies co-exist in pregnant women – particularly in developing countries **(13).**

Hidden hunger may be due to several factors such as low intake due to low awareness, availability, affordability, access and acceptability of MN rich foods. Poor / low absorption of intakes due to infections may further aggravate the deficiency state.

The economic cost of all MNDs is considerable and reduces the GDP by 0.7 – 2 % in most developing countries. It is estimated that India suffers a 1% GDP loss and Afghanistan 2.3% GDP loss due to MNDs **(14,).** Global losses in economic productivity due to macro and micro nutrient deficiencies amount to 2-3% of GDP **(15)** accounting for US$ 1.4-2.1 trillion per year **(16).**

It is thus amply clear that MNDs play an important role not only in the growth and development of individuals but also adversely impacts on the economic growth and productivity of nations. While reducing the problem of MNDs assumes priority, inherent barriers to reddressal exist. For many MNDs prevalence data are unavailable. For still others there is little consensus on the standard recommended intakes. For many MNs the relationship between intake and utilisation is not fully understood.

In India most studies have focussed on MNDs among children. There are very few studies on pregnant women and these have mostly focussed on one or two MNs. One study by Pathak P et al (2004**) (17)** among pregnant women in rural Haryana reported the prevalence of several MNDs ranging from 73.5% for zinc, 2.7% copper, 43.6% magnesium, 73.6% iron, 26.3% folic acid and 6.4% iodine. Studies on the impact of multiple MNDs on pregnancy outcomes particularly in the Indian context are rare.

Furthermore, while Global Hidden Hunger Index scores have been computed using child related data, no such scores have been computed using data for pregnant women. There is thus an urgent need to: (i) estimate the prevalence of multiple MNDs among pregnant women simultaneously (ii) assess their effects on pregnancy outcomes and (iii) compute

Hidden Hunger Index Scores for pregnant women. The present study is one such an effort.

Methods

Study setting

Over 98% of deliveries in Chennai city are hospital based and since most of the pregnant women go to a government hospital, we conducted this study at the Institute of Social Obstetrics and Kasturba Gandhi Government Hospital for women, Triplicane, Chennai. Nearly 12,000 deliveries take place in this hospital annually accounting for over 40% of total deliveries in the city. Since this is a tertiary care center, many complicated pregnancies are referred to this hospital.

We conducted a cross sectional study and surveyed pregnant women attending this hospital around 48 – 72 hours before delivery. With a reported prevalence of iron deficiency anaemia among pregnant women = 58%,**(18)** absolute precision of 6%, 95% Confidence Interval, 15% non response rate, we estimated a sample size of 299 women, rounded to 300. We visited the labor ward of the hospital and randomly recruited pregnant women 48-72 hours before delivery.

Data Collection

Using an interview schedule consisting of semi structured questions, we collected information from the pregnant women on: identification particulars, socio-demographic-cultural factors, obstetric history, current pregnancy details, and pregnancy/delivery outcomes. We physically examined all the pregnant women to: measure fundal height, estimate foetal heart rate, assess clinical signs and symptoms of micronutrients deficiencies. We carried out anthropometric (height and weight) measurements on the pregnant women.

We conducted laboratory tests to assess micronutrient deficiencies serologically. We included the following micronutrients for assessment: Vitamins A, B6 and B12; Minerals: calcium, magnesium, zinc, ferritin, transferrin, transferrin receptor, and copper. Normal ranges and deficiency cut offs used for this study are detailed in Table 2. Using cyanmethemoglobin method, we estimated the haemoglobin level for all pregnant women.

Table 2 : Micronutrients Normal ranges and deficiency cut-off in third trimester.

Micro nutrient	Normal Range	Deficient value
Copper	130 – 240 **µg/dl**	< 130 **µg/dl**
Iron	30 – 193 **µg/dl**	< 60 **µg/dl**
Haemoglobin	9.5 – 15.0 **g/dl**	< 11 **g/dl**
Ferritin	0 – 116 **µg/L**	< 15 **µg/L**
Transferrin	51.6 – 94.9 **nmol/L**	> 94.9 **nmol/L**
Transferrin Receptor	1.9 – 4.4 **mg/L**	> 4.4 **mg/L**
Magnesium	1.1 – 2.2 **mg/dl**	< 1.8 **mg/dl**
Calcium	8.2 - 9.7 **mg/dl**	< 8.2 **mg/dl**
Zinc	50 – 77 **µg/dl**	< 70 **µg/dl**
Vitamin B6	0.48 – 17.7 **µg/dl**	< 0.49 **µg/dl**
Vitamin B12	9.9 – 52.6 **ng/dl**	< 20.33 **ng/dl**
Retinol	29 – 42 **µg/dl**	< 20.057 **µg/dl**

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Data Analysis

For each of the micronutrients included for study we estimated the proportion of pregnant women who were deficient. We further calculated the proportion of pregnant women who were anaemic and classified their anaemia status using WHO classification. We compared the mean serum values for each micronutrient for pregnant women with and without deficiencies and tested the significance of the difference using Students t - test. A p value < 0.05 was considered significant. We calculated the percent of pregnant women with micronutrient deficiencies and experience of adverse pregnancy outcomes e.g. pregnancy induced hypertension (PIH), Premature rupture of membranes (PROM) pre - eclampsia, still birth, preterm births, low birth weight (weight <2500gms at birth), and congenital anomalies.

We computed the Hidden Hunger Index for pregnant women by including all the micronutrients in our study and giving equal weight for each micronutrient and haemoglobin values and dividing the same by the total number of micronutrients and haemoglobin values - similar to the procedure adopted to compute Hidden Hunger Index scores for children **(3) .**

Human Subject Protection:

This study was approved by the Technical and Ethics Committees of the National Institute of Epidemiology and the Ethics Committee of Kasturba Hospital for Women. Formal permission was obtained from the Directorate of Medical Education, Government of Tamil Nadu, to conduct this study. Voluntary, written informed consent was obtained from all the pregnant women who were also assured of confidentiality and the right to withdraw from the study at any time without any repercussions for their right to receive all required care in the hospital.

Limitations of the Study

Since the study subjects were recruited 48 hrs -72 hrs prior to delivery, information on the effects of MNDs on early pregnancy outcomes were not recordable. Although 10ml. of venous blood were drawn from each pregnant woman, for some women all MNs were not tested due to inadequacy of serum harvested, thus resulting in different denominators for some of the MNs.

Results

Profile of study subjects

We recruited a total of 304 pregnant women as against an estimated sample size of 300. Of these 304 pregnant women, 35% (105/304) were diagnosed as “High Risk”. This high proportion of High Risk women could be because as mentioned earlier, the selected hospital is a tertiary care teaching hospital to which many complicated pregnancies are referred. The various high risk conditions experienced by these women are presented in Table 3.

Table 3 : Percent distribution of ‘High Risk’ pregnant women according to High Risk conditions.

High Risk Conditions	High Risk Women (105)	Percent
Oligohydramnios	11	10.5
Age > 30 years	1	1.0
Foetal Heart sounds absent	3	2.9
Cephalo Pelvic Disproportion	7	6.7
Previous Lower segment Cesearean Section	23	21.9
Pregnancy Induced Hypertension	20	19.0
Gestational Diabetes Mellitus	4	3.8
Congenital Anomaly	3	2.9
Mal presentation (Foetal/Placental)	4	3.8
Rhesus Negative	8	7.6
Systemic Diseases	8	7.6
Imminent Eclampsia	1	1.0
Anemia (Mild/ Moderate)	2	1.9
Long term Infertility	2	1.9
Premature Rupture Of Membranes	1	1.0
BOH	2	1.9
Twins	3	2.9
Intra uterine Death/Intra uterine growth retardation	2	1.9
Total	105	100.0

Approximately 82% of pregnant women were Hindus, 12% Muslims and 6% Christians. Among Hindus, 57% were from Backward class (BC), and 24% belonged to Scheduled caste and scheduled tribe. Less than 5% were illiterates, 42% educated up to middle school and 44% up to and beyond secondary school. About 97% were homemakers, 97% non vegetarians and 55% hailed from joint families. The mean age of the women was 24years (SD 3.59 yrs) and mean family size was 4.21 (SD 2.10) members. The mean monthly family income was Rs.5512 (SD 2994.84).

The mean age at menarche was 13.63 years (SD 1.25), mean age at marriage = 20.96 (SD 2.97) years, mean age at first conception = 21.82 (SD 2.96) years and mean number of pregnancies per mother = 1.72 (SD 0.96). During the current pregnancy the mean number of antenatal checks undergone per woman =6.34(SD 2.00). The mean height of the women =154.72cms (SD 5.74cms) and at the time of registration the mean weight = 53.09kgs (SD 8.9). However the mean weight of the women at the time of survey (i.e. 48-72 hours prior to delivery) was 61.85kgs (SD 9.54), suggesting an average weight gain of 8.76 kgs. across pregnancy.

About 99% women were prescribed iron tablets, 88% folic acid, 94% calcium, and 32 % multivitamins. Only 57% reported taking the medicines regularly, nearly 29% missed one or two doses and 12 % missed several doses. With regard to pregnancy outcomes: nearly 97% were cephalic presentations, 3% breech; about 97% were live births, 3% still births, 6.3% pre term births, 2% congenital defects; about 47% were vaginal deliveries, and 52% LSCS.

With respect to minor problems related to current pregnancy, 11% women experienced nausea, 3% stomach ailments, 81% morning sickness, 22% loss of appetite, 2% bleeding gums, 16% abdominal pain, and 57% giddiness. About 5% had Grade I Goiter and another 5% had Grade II Goiter. None had bitots spots, keratomalacia and night blindness. About 2% had glossitis, 3% tingling sensation, 15% facial pallor, 10% pale conjunctiva, 9% puffiness of face, 17 % general weakness, 23% pedal oedema and 47% muscle cramps.

Prevalence of Micronutrient Deficiencies

Of the 304 pregnant women included in our study, only 2 women were not deficient in any of the MNs that we tested. About 99.3% (302/304) women were found to be suffering from deficiency of one or more MNs. Table 4 provides details of the frequency distribution of the number of MNs that these pregnant women are deficient in. It was observed that only 3% of women are deficient in one MN. Nearly 54% of pregnant women suffer from deficiencies of 4 or more MNs. The mean number of MNDs per pregnant women is 3.75 (SD : 1.50).

Table 4 : Distribution of pregnant women according to Risk Status and number of MNDs

Total Deficiency	Normal Women		High Risk Women		Total Women	
	N	%	N	%	N	%
0	2	1.0%	0	.0%	2	.7%
1	6	3.0%	3	2.9%	9	3.0%
2	38	19.1%	13	12.4%	51	16.8%
3	57	28.6%	22	21.0%	79	26.0%
4	54	27.1%	26	24.8%	80	26.3%
5	20	10.1%	21	20.0%	41	13.5%
6	14	7.0%	17	16.2%	31	10.2%
7	6	3.0%	1	1.0%	7	2.3%
8	2	1.0%	1	1.0%	3	1.0%
9	0	.0%	1	1.0%	1	.3%
Total	199	100.0%	105	100.0%	304	100.0%

When we compared the number of MNDs among normal v/s high risk women we observed that while all high risk women were deficient in one or more MNs, 2 of the normal women were free of any of the MNDs included for assessment in our study. The mean number of MNDs per woman for high risk women was 4.10 (SD: 1.52) whereas that for normal women was 3.57(SD: 1.46). We further observed that a significantly ($p = 0.009$) higher proportion (64%)of high risk women suffered from 4 or more MNDs compared to normal women (48%).

The prevalence of MNDs among our study subjects as a whole ranges fro a low of 2% for copper to a high of 76% for Vitamin B12. Nearly 69% of women are deficient in Vitamin A, 57% deficient in Zinc, 43% deficient in Calcium, 42% have haemoglobin (Hb.) levels <11gm% and 39% deficient in Magnesium. Interestingly none of the women were found to be deficient in Vitamin B6**.** (Table 5).

Of those who were Vitamin A Deficient, 65% (198/304) were mildly deficient and 4% (11/304) were severely deficient. With regard to haemoglobin levels, 29% had mild anaemia, 11% moderate and 2% severe anaemia. The mean Hb value for the non anaemic women (total, high risk and normal) was 12.5gm% (SD:1.1- 1.3). For women with mild anaemia the mean Hb was around 9 gm% (SD: 0.6) and for those with severe anaemia the mean Hb was 6.4 gm% (SD: 0.4).

When we compared the prevalence of MNDs among normal and high risk women we observed that higher proportion of the latter had deficiency of zinc (78%), calcium (49%) and magnesium (46%) compared to normal mothers (zinc: 46%; calcium: 40%; magnesium: 35%).

We compared the mean serum values for each MN among women who were deficient with those who were not deficient and found that for all the MNs included for assessment, the mean values of women who were deficient were significantly (p = 0.000) lower compared to their non deficient counterparts. (Table 6)

We further compared the mean serum values for women with deficiencies for high risk and normal women and observed that for magnesium, calcium and zinc, the high risk women had significantly (p = 0.000) lower serum values compared to normal women. Only for vitamin B12 normal women had significantly (p=0.000) lower mean serum values compared to high risk women. For all other MNs no significant difference was observed in the mean serum values between the two groups.

Micronutrient Deficiencies and Pregnancy outcomes

Based on a review of literature, we considered the following the spectrum of pregnancy outcomes that could be associated with MNDs: (a) For the mother: (i) normal uneventful course of pregnancy without any associated maternal complications, (ii) Pregnancy Induced Hypertension (PIH) and (iii) Premature Rupture of the Membranes (PROM) and (iv) Pre - eclampsia. (b) For the foetus: (i) normal full term baby, (ii) Preterm / premature baby, (iii) Low birth weight baby, (iv) congenital anomalies and (v) still born baby.

Of the 304 women**,** 71 (23%) experienced adverse maternal and foetal outcomes. The frequency distribution of women with adverse outcomes is profiled in Table 7. Adverse outcomes were observed to be significantly (p = 0.0000) higher (47/71) among high risk women compared to normal women (24/71).

When we examined maternal outcomes we found that 182/304 women had normal uneventful course of pregnancy, 22 /304 women experienced adverse outcomes such as PIH (20), PROM (1) and Pre - ecclampsia (1). With respect to foetal outcomes, 55/304 mothers experienced adverse outcomes .e.g. Still births (10), Preterm births (20), Low Birth weight (22), and congenital anomalies (3).

Details of each of the adverse maternal and foetal outcomes and the MNDs experienced by the mother, are provided in Tables 8 & 9**.** From these tables it is very evident that large numbers of women with adverse outcomes suffer from Vitamins B12 and A , zinc, calcium magnesium, and haemoglobin deficiencies.

Hidden Hunger Index (HHI) score for this group of pregnant women

To compute HHI scores we included the prevalence of deficiencies of 8 MNs. Giving equal weightage to all MNs, we added the prevalence values for each of the MNs and divided the total by 8 to yield the HHI score for these women. We observed that the HHI scores were highest (48.75) for high risk women and lowest (43.0) for normal women. The combined HHI score for both groups was 45.12. (Table 10).

Discussion

In this study we estimated the prevalence of MNDs among pregnant women, described pregnancy outcomes among women with MNDs and computed HHI scores for pregnant women. With only 2 out of 304 women being free of MNDs in our study we observed that overall prevalence of MNDs is very high.

Table 5: Prevalence of MNDs among pregnant women in 3rd trimester (48-72 hours before delivery) – Overall, High risk and Normal women

Micronutrients	High Risk women(105)				Normal women (199)				Total women (304)			
	N	Deficient	%	95% CI	N	Deficient	%	95% CI	N	Deficient	%	95% CI
Copper	105	5	4.8%	1.56 – 10.76	199	1	.5%	0.01 – 2.77	304	6	2.0%	0.80 – 4.60
Iron	64	8	12.5%	5.55 – 23.15	96	19	19.8%	12.36 – 29.17	160	27	16.9%	11.43 - 23.59
Ferritin	102	35	34.3%	25.19 – 44.37	172	59	34.3%	27.24 – 41.91	274	94	34.3%	28.70 – 40.26
Haemoglobin	105	46	43.8%	34.14 – 53.83	199	83	41.7%	34.78 – 48.89	304	129	42.4%	36.85 – 48.22
Magnesium	105	48	45.7%	35.96 – 55.72	199	69	34.7%	28.08 – 41.73	304	117	38.5%	33.04 – 44.23
Retinol	105	66	62.9%	52.88 – 72.09	199	143	71.9%	65.06 – 77.99	304	209	68.8%	63.16 – 73.85
Transferrin	104	1	1.0%	0.02 – 5.24	198	3	1.5%	0.31 – 4.36	302	4	1.3%	0.43 – 3.59
VitaminB12	104	81	77.1%	67.93 – 84.77	199	149	74.9%	68.25 – 80.74	304	230	75.7%	70.36 – 80.29
VitaminB6	104	0	.0%	-	199	0	.0%	-	304	0	.0%	-
Zinc	104	82	78.1%	68.97 – 85.58	199	91	45.7%	38.67 – 52.92	304	173	56.9%	51.12 – 62.51
Calcium	104	51	48.6%	38.70 – 58.53	199	79	39.7%	32.85 – 46.86	304	130	42.8%	37.17 – 48.55
Transferrin Receptor	104	7	6.7%	2.75 – 13.38	197	15	7.6%	4.32 – 12.25	301	22	7.3%	4.74 – 11.01

Table 6 : Mean serum values for MNDs and blood values for Hb for pregnant women in 3rd trimester (48-72 hours before delivery) - Overall, High risk and Normal women

	High Risk Women						Normal Women						Total Women*					
	Not Deficient			Deficient			Not Deficient			Deficient			Not Deficient			Deficient		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Copper	100	221.8	45.8	5	109.1	9.1	198	222.0	38.3	1	110.0	.	298	221.9	40.9	6	109.3	8.2
Iron	56	306.9	404.1	8	42.2	12.6	77	304.3	295.5	19	37.6	13.9	133	305.4	344.0	27	39.0	13.5
Magnesium	57	2.5	0.7	48	1.4	0.3	130	2.1	0.2	69	1.6	0.2	187	2.2	0.5	117	1.5	0.3
Calcium	54	9.2	0.8	51	7.2	1.0	120	8.9	0.8	79	7.7	0.5	174	9.0	0.8	130	7.5	0.8
Zinc	23	80.2	9.1	82	54.4	11.9	108	79.7	6.7	91	60.5	7.8	131	79.7	7.1	173	57.6	10.3
Vitamin_B6	105	4.0	3.1	0	.	.	199	3.1	2.1	0	.	.	304	3.4	2.5	0	.	.
Vitamin_B12	24	27.0	7.3	81	14.1	2.9	50	32.4	12.8	149	12.5	3.2	74	30.6	11.6	230	13.0	3.2
Haemoglobinb	59	12.5	1.3	46	9.2	1.3	116	12.5	1.1	83	9.4	1.2	175	12.5	1.2	129	9.3	1.2
Ferritin	67	32.5	14.9	35	11.2	2.2	113	35.7	21.1	59	10.6	2.9	180	34.5	19.0	94	10.8	2.7
Transferrin	103	33.2	17.1	1	101.0	.	195	27.6	17.0	3	108.3	2.9	298	29.5	17.2	4	106.5	4.4
Transferrin Receptor	97	2.2	0.9	7	5.8	0.9	182	1.8	0.9	15	5.7	1.2	279	1.9	0.9	22	5.7	1.1
Retinol	39	28.3	6.4	66	15.0	3.3	56	26.8	5.4	143	15.1	3.1	95	27.4	5.9	209	15.1	3.1

***** All Mean Micronutrient values of deficient Women are significantly lower than non-deficient Women.

Table 7 : Distribution of pregnant women according to Pregnancy Outcome – Maternal & Foetal - Overall, High risk and Normal women

	High Risk Women	Normal Women	Total
Adverse Pregnancy (Maternal / foetal)	47	24	71
Normal Pregnancy	58	175	233
Total	105	199	304

Table 8 : Distribution of Adverse **Maternal** outcome according to MNDs experienced by pregnant women

		Maternal Adverse Outcome					
		Women	**PIH**	**Pre Eclampsia**	**PROM**	**Other HR Conditions**	**Non HR Women**
High Risk Women	Copper Deficiency	5	2	0	0	3	0
	Haemoglobin Deficiency	46	4	1	1	40	0
	Ferritin Deficiency	35	5	0	1	29	0
	Magnesium Deficiency	48	10	0	1	37	0
	Calcium Deficiency	51	9	0	1	41	0
	Zinc Deficiency	82	14	1	0	67	0
	VitaminB12 Deficiency	81	18	1	1	61	0
	Retinol Deficiency	66	11	1	1	53	0
	Total HR Women	**105**	**20**	**1**	**1**	**83**	**0**

Table 9 : Distribution of Adverse **Foetal** outcome according to MNDs - Total, High Risk and Normal women.

		Foetal Adverse Outcome					
		Total	**Normal Delivery**	**Still Birth**	**Pre Term**	**Congenital Defects**	**Low Birth Weight**
High Risk Women	Cu Deficiency	5	4	1	0	0	0
	Hb Deficiency	46	30	7	2	1	6
	Ferritin Deficiency	35	25	6	1	0	3
	Mg Deficiency	48	33	4	3	1	7
	Ca Deficiency	51	34	7	3	1	6
	Zn Deficiency	82	59	8	6	2	7
	VitaminB12 Deficiency	81	55	7	8	2	9
	Retinol Deficiency	66	47	7	4	1	7
	Total HR Women	**105**	**74**	**10**	**8**	**2**	**11**
Normal Women	Cu Deficiency	1	1	0	0	0	0
	Hb Deficiency	83	72	0	4	0	7
	Ferritin Deficiency	59	54	0	3	0	2
	Mg Deficiency	69	62	0	2	0	5
	Ca Deficiency	79	69	0	4	0	6
	Zn Deficiency	91	79	0	5	1	6
	VitaminB12	149	130	0	10	1	8

	Deficiency						
	Retinol Deficiency	143	122	0	10	1	10
	Total Normal Women	**199**	**175**	**0**	**12**	**1**	**11**
Total Women	Cu Deficiency	6	5	1	0	0	0
	Hb Deficiency	129	102	7	6	1	13
	Ferritin Deficiency	94	79	6	4	0	5
	Mg Deficiency	117	95	4	5	1	12
	Ca Deficiency	130	103	7	7	1	12
	Zn Deficiency	173	138	8	11	3	13
	VitaminB12 Deficiency	230	185	7	18	3	17
	Retinol Deficiency	209	169	7	14	2	17
	All Women	**304**	**249**	**10**	**20**	**3**	**22**

Table 10 : Hidden Hunger Index Score estimated for study subjects i.e. Pregnant women in 3rd trimester

Micronutrients	**Prevalence Percentage**		
	Overall %	High Risk %	Normal %
Copper	2	5	1
Ferritin	34	34	34
Hemoglobin	42	44	41
Magnesium	38	46	35
Retinol	69	63	72
B12	76	77	75
Zinc	57	78	46
Calcium	43	49	40
Total	361	390	344
HHI score	**45.12**	**48.75**	**43.00**

With respect to Vitamins, though none of the women were deficient in Vitamin B6, the prevalence of both Vitamins A and B12 deficiencies were very high. In a cross sectional study of 366 urban south Indian pregnant women of < 14 weeks gestation conducted by Samuel et al in 2013**(19),** 51% had low plasma (<150 pmols/L) Vitamin B12 levels and 42% had impaired (200mg/ml) vitamin B12 levels. A review of 40 research studies on B12 deficiency among those consuming vegetarian diets by Pawalak R. Et al in 2014,(20) reported a prevalence range of 17-39% among pregnant women dependent on the trimester.

The prevalence of B12 deficiency is much higher in our study compared to the above two reports. This could be because of differences in the trimester of study. In our study nearly 99% of women are non vegetarians. Despite this, the reason for the high prevalence of B12 deficiency could be because in the Indian context, for the most part non vegetarian foods are consumed only once a week or even less frequently because of factors such as higher cost and relatively longer preparation time.

According to WHO's Global prevalence of Vitamin A Deficiency in Populations at risk- global data base (1995-2005**),(8)** among pregnant women the global prevalence of night blindness was 7.8% and the global prevalence of serum retinol concentrations <0.70umol/L was 15.3%. In South East Asia the prevalence of night blindness among pregnant women was 9.9% and the proportion of pregnant women with serum retinol levels < 0.70umol/L was 17.3%. In India among pregnant women the prevalence of night blindness was 12.1% and prevalence of serum retinol levels < 0.70umol/L was 17.1%. With a prevalence of serum retinol concentrations < 0.70umol/L reaching 69% it is amply clear that Vitamin A deficiency in our study population is more than four times higher than the national figure. However none of these women suffered from night blindness. **(8)**

With regard to minerals, the prevalence of zinc, calcium and magnesium deficiencies is also high in our study. With respect to zinc deficiency although the prevalence is high (57%) in our study population it women in Harayana state. Interestingly the prevalence of magnesium deficiency (39%) in our study is slightly lower than that reported by Pathak et al in 2004 (43.6%) among pregnant women of 28 weeks gestation in Harayana state. Again compared to the prevalence of copper deficiency reported by Pathak et al (2.7%) the prevalence is only marginally lower (2.0%) in our study.

With regard to adverse pregnancy outcomes, nearly 23% of our study women have experienced adverse maternal and / or foetal outcomes. In all these women with adverse outcomes, we observed that high numbers suffered from Vitamins A, and B12, and calcium, magnesium and zinc deficiencies. We also observed the concurrent occurrence of other biological conditions that are not reported to be associated with MNDs co existing to complicate pregnancy and delivery outcomes**.** (Table 11) So it is likely that both MNDs and other pregnancy related complications could both independently contribute to adverse pregnancy outcomes.

We observe that the HHI scores for pregnant women are very high and similar to that observed for children for India. The lack of availability of such computations for pregnant women in other settings renders comparisons difficult but also stresses the urgent need to carry out such an exercise on a global scale to facilitate appropriate intervention that would ultimately enable achievement of MDGs 4 & 5 - of reducing maternal and child mortality. Our study results also emphasize the need for providing multiple micronutrient supplementations to women during pregnancy rather than single preparations to ensure smooth and successful pregnancy outcomes.

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Competing interests

All the authors declare that there are no competing interests.

nevertheless appears to be lower than the figures reported by Saeed Aktar in 2013(21) (64.6%) and Pathak et al in 2004 (17) (73.5%), both for pregnant

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