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Nutritional status and infant mortality rate in Saiha district, Mizoram, India

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This communication examines nutritional status and its impact on infant mortality rate (IMR) in Saiha district, Mizoram, India. 1650 mothers from 17 villages were surveyed using random sampling method. The district has very high IMR (219.6), significantly higher than Mizoram (35). Meanwhile, per day per capita calorie intake is 1703, which is less than the recommended dietary intake (2400 kcal). All food items which people consume daily were collected and nutritional status was assessed. Our result shows that high IMR in the district is due to food insecurity and malnutrition.

Keywords: Food insecurity, infant mortality rate, nutrition status, pregnant mothers.

NUTRITIONAL status has a significant impact on infant mortality rate (IMR) and health of the people, particularly children. It is closely linked with food adequacy and its proper distribution, and is an outcome of complex and interrelated sets of factors[1]. Its deficiency in the body causes several diseases. On the other hand, inadequacy in

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daily food intake may cause several repercussions in the body and mind. Ali[2] observed that inadequate intake of essential nutrients causes several diseases and largely impacts IMR. Lack of nutritious food also results in abnormality in the body system and leads to high mortality rate[3]. Besides inadequate food intake, protein–energy malnutrition also affects millions of people. A study has shown that about 870 million people are undernourished or chronically hungry in the world, out of which 852 million people are from the developing world, 212 million are from Sub-Saharan Africa and 231 million people are from India[4].

Food choice and socio-economic dimensions also influence nutritional status. The nutritional status of a mother has an impact on the health and weight of a baby and thus influences IMR[5,6]. Further, undernourished children are more prone to infections, which results in high mortality rate.

The problems of hunger and malnutrition in developing countries have attracted the attention of scholars worldwide[7], as about 14.9% of the population are undernourished. This figure represents 12.5% of the global population, i.e. one in eight people[4]. Household food security, health services, a healthy environment and proper care of mother and child determine child survival and development[8]. Children from the developing world suffer both from calorie and nutrient deficiencies. In India, most children suffer from iron deficiency[9]. Food insecurity and malnutrition are other factors that cause high IMR[10].

Nutrition includes protein, carbohydrates, fat, vitamins and minerals, essential for a healthy body. Adult mother needs additional nutrients during pregnancy and lactation[11]. India's concern on nutrition is age-old. Although it has achieved a remarkable status in the production of food grains, chronic poverty still exists. In 1960–61, the Nutritional Advisory Committee of India recommended 2250 kcal intake as adequate diet[12], which is now 2400 kcal. The per capita per day calorie intake in India has decreased from 2221 (kcal) in 1983 to 2058 (kcal) in 2012. However, change in per day per capita availability of cereals and pulses has increased to 16.9% and 48.1% respectively[13].

North east India mainly characterizes tribal population, where people living below poverty line are more compared to other states of the country. In terms of nutrition, tribal people receive them from roots of wild plants, tubers, fruits, leafy vegetables, fish and meat[14]. Low income, low production and yield of crops, and low purchasing power cause nutrition deficiency that results in several repercussions in the human body[15]. In the tribal communities, both birth rate and IMR are high. Thus, the number of children reared by a tribal mother is more or less similar to that of mothers from other sections of society[16,17].

Mortality rate can be defined as the number of deaths in a place or group compared with the total number of people, whereas IMR denotes the number of deaths during the first year of life per thousand live births. It is a common experience that health status of tribal people is critically low, mainly due to malnutrition. According to Pant[18], 20 million children are born every year in India; however, only 70% survive up to the age of five years. He further observed that in the Tharu tribes of Uttarakhand, about 81% of the children below five years age died due to early marriage and malnutrition. The last three decades have witnessed considerable gain in child survival worldwide. Global child mortality decreased from 147 per 1000 live births in 1970 to about 80 per 1000 live births in 2002 (ref. 19). Data from the Indian states in 2013 show that Assam and Madhya Pradesh have IMR of 54 each followed by Odisha (51) and Uttar Pradesh (50). Other states such as Rajasthan and Meghalaya have 47 each, Chhattisgarh 46, Bihar 42, Haryana 41, Jharkhand 37 and Mizoram 35 (ref. 20).

Mizoram faces food insecurity because of inadequate production and improper supply. It imports food grains from the neighbouring states. During 2006–2008, the state experienced severe famine due to bamboo flowering that led to food deficiency[21]. Decrease in arable land under shifting cultivation led to decrease in production and accentuated malnutrition; thus IMR is high in Mizoram. According to a report[22], 600 infants and 12 mothers died, during 2012–13. IMR in Mizoram has increased from 16 in 2003 to 35 in 2013 (ref. 23). Saiha district records the highest IMR (219.6), while the national average is 40 (ref. 24).

This communication examines nutritional status and IMR and discusses per day per capita calorie intake by pregnant mothers in Saiha district, Mizoram. We illustrate healthcare facilities, including vaccination for pregnant mothers and children, and explain the other driving forces that affect IMR. We conclude that high IMR is due to low nutritional status in the district.

Saiha district lies in the southern part of Mizoram, and stretches between 21°5′–22°60′N and 92°30′–93°15′E (Figure 1). Myanmar in the east and south, Serchhip district in the north and Lawngtlai district in the west delimit its boundary. Its total area is 1409 km^2 and total population is 56,366 (40 persons living per km^2 in 2011). The rural population constitutes 31,301 (55.5%) and urban population 25,065 (44.46%). Sex ratio is 978 females per thousand males, literacy rate is 88.46%. Saiha district comprises two rural development blocks and 76 villages. The landscape is hilly and mountainous, and agriculture dominates the economic activities. However, output from agricultural fields is inadequate. This has led to food insecurity and malnutrition. Majority of the people live below poverty line. However, the region possesses plenty of natural resources – land, water and forests.

We used both qualitative and quantitative methods, and 1650 mothers from 17 villages were surveyed using random sampling method. Sample size was 40%, depending upon the availability of respondents during the survey period from January to November 2014. A structured questionnaire was constructed and questions were framed on food consumption, nutrient intake, and health and healthcare facilities. Nutrient content of each food item was calculated from food tables and summed up for all food items per gram for the corresponding year. Then, food data were converted into different nutritive values such as energy and vitamins, based on food composite tables and nutritive value of Indian food. We used the method of Gopalan *et al.*[25] to calculate nutrition and calorie values from the gathered data on per day per family food consumption (kg), and then calculated per capita nutrition and calorie values, using the following formula:

1. Per gram houseold food consumption:
   Total food consumption (kg) × 1000/(divided by) No. of family members.

2. Per capita per day food consumption:
   Obtained value from formula 1/No. of days in a month.

3. Nutritional value:
   Obtained value from formula 2/food per 100 g in the food table.

4. IMR:
   No. of infant death/No. of live birth × 1000 population.

Data on socio-economic indicators and IMR were gathered from the study villages. Literacy rate was registered as 68.4%; which is less compared to Mizoram (92%) and India (74%). Per capita income was recorded as Rs 19,280, just half of the national average (Rs 38,169) and the Indian Himalayan Region (Rs 34,029). Average birth rate (total number of births/1000 persons) was 38.95 and normal mortality rate (total number of deaths/1000 persons) was 0.0074. IMR in Saiha district was 219.6, while it is 43.19 for India (2014). In the Himalayan states, Meghalaya has the highest IMR (58) followed by Jammu and Kashmir (49) and Himachal Pradesh (44); while for Mizoram it is 35. We classified the 17 villages under study into three IMR categories and found that four villages have IMR above 200, six in the range 101–200, and the rest of villages have IMR below 100. Table 1 shows the socio-economic indicators and IMR in the study villages.

Per capita per day nutrition and calorie intake value of 1650 pregnant mothers was calculated (Table 2). The main nutrition components comprise moisture, protein, fat, minerals, fibre, carbohydrates, calcium, phosphorus and iron. Mean value of total energy intake was recorded as 1703.5 (kcal).

We correlated nutritional status with IMR and observed that the villages which have low nutritional status have high IMR. Also, IMR was categorized into five groups, i.e. very high (>200), high (101–200), medium (51–100), low (1–50) and nil (Table 3). Four villages fall under very high IMR category and six villages under high IMR category. Rest of villages fall under the other categories (Table 3).

Figure 2 presents correlation between nutrition and IMR. The hypothesis was 'lower the nutritional status, higher is the IMR' and vice versa. The value was found to be significant (0.05).

IMR was correlated with per capita per day calorie intake of pregnant mothers (Table 4). Maximum value was 2131 kcal and minimum was 1294 kcal with a mean value of 1703 kcal. Calorie intake of pregnant mothers was divided into four classes from <1400 to >2001 kcal. IMR was divided into five categories from very high to nil. We noticed that IMR is very high in a number of pregnant mothers (34.57%). Per capita per day calorie intake of 75% mothers is less than 1600 kcal.

Nutritional value of food consumed is another measurement of poverty[26]. Nutrition deficiency of a pregnant mother was analysed in relation with IMR. The main sources of nutrition and their impact on IMR in the study area are discussed below (Table 5):

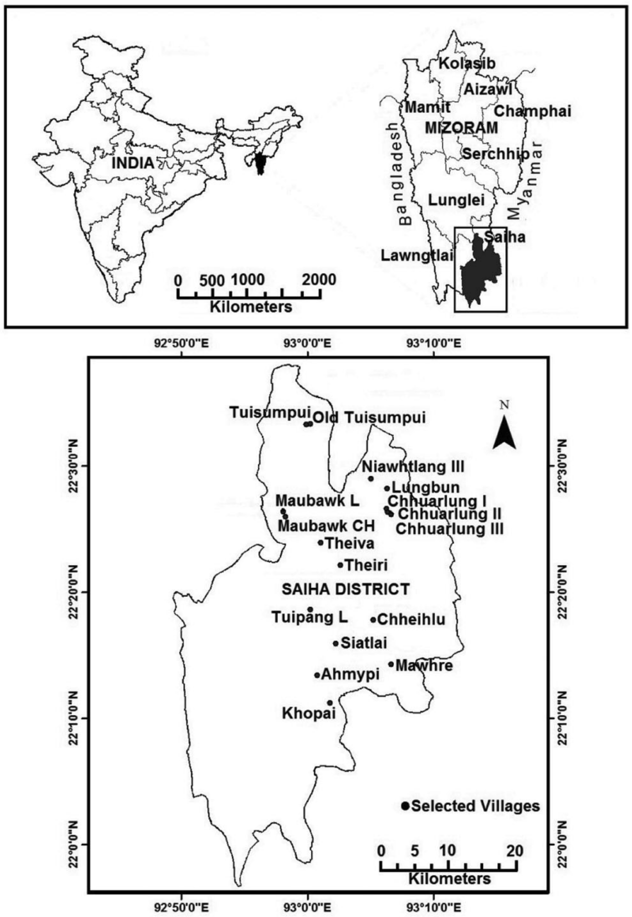

Figure 1. Location map of Saiha district, Mizoram, India, and study villages.

Energy: A large number of pregnant mothers suffer from energy deficiency in quality and quantity in the study villages. Average energy intake was 1703 kcal. A correlation was established between energy intake and IMR. We noticed that IMR was very high among 54.16% pregnant mothers whose energy intake was 1000 kcal. IMR was very low among 14.04% pregnant mothers whose energy intake was 2063 kcal. It indicates that energy deficiency is one of the driving forces of high IMR.

Protein: We calculated protein intake by pregnant mothers to be 54.66 g/day (recommended protein intake is 63.5 g/day). Very high IMR was found in pregnant mothers whose protein intake was 42.34 g/day. Among 82% pregnant mothers, IMR was high, while low IMR was observed among 20% pregnant mothers.

Fat: Average fat intake was 1446 IU (2268 IU is the recommended intake). We correlated fat intake with IMR and found that IMR increases with decrease in fat intake. When the fat intake was 825 IU, IMR was very high; when the fat intake was 1435 IU, IMR was medium and when the fat intake was 2010 IU, IMR was low.

Table 1. Socio-economic indicators and infant mortality rate

Variables	Numbers
Surveyed villages	17
Surveyed pregnant mothers	1650
Literacy rate	68.37%
Per capita income (mean value)	Rs 19,280
Average per capita income in India	Rs 38,169
Average per capita income in the Indian Himalayan Region	Rs 34,029
Nutrients	1703.5 kcal
Average birth rate	0.01 (2014)
Normal mortality rate	0.01 (2014)
Infant mortality rate	219.55 (2014)
Infant mortality rate in India	43.19 (2014)

Source: Data collected by the authors from field survey and secondary source.

Table 2. Per capita per day nutrition and calorie intake value (2013–14)

Variables	Minimum	Maximum	Mean	Standard deviation
Moisture	142	328	204.26	54.8
Protein	20	144	54.66	35.5
Fat	5	213	52.74	61.4
Minerals	3	81	13.13	24.2
Fibre	2	79	10.31	24.2
Carbohydrates	226	784	372.19	157.5
Calcium	140	436	240.77	91.0
Phosphorus	793	1370	998.92	185.2
Iron	15	127	29.20	34.6
Energy (kcal)	1294.9	2131.6	1703.8	285.3

Source: Data collected by the authors from field survey and calculated using SPSS software.

Table 3. IMR, number of villages and average nutrition status ($n = 17$)

Class	IMR	No. of villages	Average nutrition status (kcal)
Very high	>200	4	1175
High	101–200	6	1415
Medium	51–100	2	1761
Low	1–50	1	1962
Nil	0	4	2205
Average	219.6	17	1703.8

Source: Field survey.

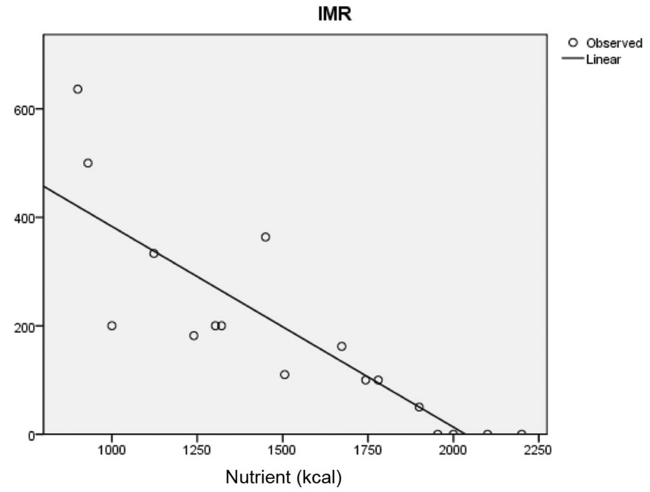

Figure 2. Nutrition intake and infant mortality rate.

Table 4. IMR (%) in relation to nutrition (kcal) of pregnant mothers

IMR calorie intake	<1400	1401–1600	1601–2000	>2001	Total
Very high	5.67	24.9	4	0	34.57
High	3.21	19.57	3.03	0	25.84
Medium	3.39	13.03	1.39	0	17.81
Low	3.21	3.93	4.60	0	11.74
Nil	0.72	0.78	5.27	3.27	10.04
Total	16.1	62.21	18.29	3.4	100

Source: Primary collection of data though household-level survey.

Table 5. IMR in relation to nutrition deficiency of pregnant mothers

Class	Very high	High	Medium	Low	No IMR	Average
Energy	1175	1415	1761	1962	2205	1703.8
Protein	180	280	2100	800	1200	912
Fat	825	1210	1435	1750	2010	1446
Carbohydrates	5670	6850	6210	6870	7560	6632
Vitamin A (carotene)	920	1020	1450	1245	2345	1396
Thiamine (B1)	280	540	678	540	870	581
Riboflavin (B2)	220	335	345	405	510	363
Niacin (B3)	230	440	540	605	680	499
Vitamin C	455	675	680	875	955	728
Folic acid	435	545	450	548	622	520
Calcium	556	652	632	765	880	697
Phosphorus	7300	7350	8500	9450	9805	8481
Iron	455	560	504	645	680	569

Source: Primary collection.

Carbohydrates: Average carbohydrate intake was 372.189 g/day (recommended dietary is 265.16 g/day). Roots and vegetables are sources of carbohydrates and Mizoram produces them in large amounts thus, carbohydrate intake is higher than the recommended intake.

Vitamin A (carotene): A deficiency in daily vitamin A intake was noticed in the study villages. The average intake was 265.16 mcg/day, whereas the recommended dietary is 600 mcg/day. Vitamin A is the most important component of nutrition. When vitamin A intake was less (212.24 mcg/day), IMR was high. Potato and onion, important sources of vitamin A, are the major vegetables in the study villages.

Vitamin B1 (thiamine): Average intake of vitamin B1 was 1 mcg/day, slightly less than the recommended intake (1.2 mcg/day). Milk provides vitamin B1. In the study villages milk production and consumption is very less as pork and beef are the main food of the people.

Vitamin B2 (riboflavin): Consumption of nut fruits and vitamin-rich food is less in the study villages. Here, average daily intake of vitamin B2 was 0.5 mcg/day, while recommended intake is 1.3 mcg/day. Vitamin B2 intake varied from 43% to 75% less than the recommended intake. It is mainly due to less consumption of milk and fresh vegetables.

Vitamin B3 (niacin): Average intake of vitamin B3 was 13.4 mcg/day (recommended intake is 17 mcg/day). In the 'very high' IMR category, vitamin B3 intake by pregnant mothers was 61% less, while it was 45% less in the 'high' IMR category. We noticed that with increase in vitamin B3 intake, there was a decrease in IMR.

Vitamin C: This is obtained from citrus fruits, which Mizoram produces moderately. Thus, average intake of vitamin C was 34.5 mcg/day, close to the recommended intake (42 mcg/day). We found that deficiency of vitamin C resulted in an increase in IMR.

Folic acid: The intake of folic acid was only 96 IU (14,947 IU is recommended). It varied among all IMR classes. Folic acid is obtained from pulses and fruits.

Calcium: This is obtained from milk, vegetables and fruits. Mizoram produces them moderately. Average calcium intake of pregnant mothers was recorded 697 IU (54.7% less than that recommended).

Phosphorus: This is obtained from onion, lady's finger and brinjal. Mizoram grows these crops in large amounts. However, phosphorus intake was only 8481 IU (36,000 IU recommended).

Iron: Green leafy vegetables are rich in iron. Mizoram produces large amounts leafy vegetables. However, we observed 36% iron deficiency among pregnant mothers during the study.

Poor vaccination facilities in the study villages also cause high IMR. Our study shows that only 42.2% pregnant mothers were vaccinated properly during childbirth. Some of the vaccinations such as iron, folic acid and tetanus are unavailable. While interviewing pregnant mothers, we noticed that many children died due to improper vaccination.

Thus nutrition and calorie intake value of pregnant mothers in Saiha district is very low compared to the recommended level; average intake was 1703.8 kcal, while recommended value is 2400 kcal. In comparison to the national average of 2058 kcal, this value is less. Intake of other energy sources by pregnant mothers is also very low. Thus low nutrition intake has led to high IMR. We observed that IMR increases with decrease in nutrition intake.

Our study reveals that Saiha district, which is economically underdeveloped, has low nutritional status, high IMR and less healthcare facilities. Poverty and malnutrition are common and most of the pregnant mothers are undernourished. Inadequacy in nutrition/calorie intake leads to poor health conditions of pregnant mothers. The major driving forces that affect high IMR and low nutritional status are low production and yield of food, fruit and vegetable crops (food insecurity and food unavailability), low educational level, and lack of knowledge regarding food intake and balanced diet. This study shows that IMR is directly affected by nutrition/calorie intake. Higher the nutrition/calorie intake, lower is the IMR and vice-versa. Overall condition of pregnant mothers is unhealthy. Intake of vitamins, iron and calcium by pregnant mothers is poor. Vaccination status is low. The study villages have low infrastructural facilities as they are economically underdeveloped and geographically remote. Healthcare facilities are poor and inadequate at the time of childbirth. Even in the district headquarters, healthcare facilities are not substantial; people have to travel several kilometres to get treatment in Aizawl, the state capital. Carrying capacity of healthcare facilities in Aizawl city is also insufficient; thus people suffer from ill-health.

To improve the health of pregnant mothers, healthcare facilities should be provided at the village level. More employment opportunities should be augmented to enhance income of the families so that adequate food can be consumed. For increasing agricultural production and productivity, modern innovation in the agricultural field is required and public distribution system for proper food grain supply should be properly regularized. Better education facilities should be provided at the village level. Awareness programmes on health and healthcare, better quality of food and education should be launched, and training on improving nutritional status should be imparted to the villagers. Awareness programmes on vaccination to pregnant mothers and newborns should be launched. Proper implementation of all these measures will reduce IMR and increase nutritional status of pregnant mothers.

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Assessment of polycyclic aromatic hydrocarbons and heavy metals pollution in soils of Guwahati city, Assam, India

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Soil pollution in Guwahati city, Assam, India has become a major concern since the last few decades. To study the impact of automobile and industrial emission, distribution patterns of 16 different polycyclic aromatic hydrocarbons (PAHs) and eight heavy metals were investigated in the soil samples collected from 15 different sites. Higher concentration of total PAHs and heavy metals was found in the industrial areas compared to the high traffic areas. Differences in the pollutants observed between the polluted and non-polluted sites, endorse that anthropogenic activities are the major cause of soil contamination.

Keywords: Automobile and industrial emission, heavy metals, polycyclic aromatic hydrocarbons, soil pollution.

PROTECTION of soil is presently a worldwide concern. Urbanization, industrialization and population increase over the last few decades have enhanced the release of toxic organic pollutants, viz. polycyclic aromatic hydrocarbons (PAHs) and heavy metals (HMs) into the environment due to various anthropogenic activities such as fuel burning, industrial emissions, corrosion of metallic particles, etc.[1]. Soil systems are the long-term storehouse of such pollutants and are considered to be a steady index of the state of environmental pollution[2]. The primary input of such organic pollutants into the soil surface is by air-to-surface precipitation[3] and it persists in the toplayer of the soil[4]. Because of the toxicity, exposure to such pollutants in the environment is detrimental to human health and so has become the focus of much attention[5,6].

Many HMs are naturally occurring; however, some are hazardous, particularly in high concentrations in human and plant cells. Sakagami *et al.*[7] have outlined

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