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## *Summary and Conclusion*



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Micronutrient deficiencies are the most common and intractable nutritional problem in the world today. Further, nearly half of all deficient children and women live in Southern Asia (Palmer and West, 2010). In spite of several national nutritional intervention programmes, the prevalence of micronutrient malnutrition continues to be a major public health problem in India. According to the NFHS-3 (2005-06), Indian children have among the highest proportions of malnourishment in the world. Community based approaches have been the mainstay of interventions to address the problem of child malnutrition in developing societies. Proper use of local foods may be met with greater receptivity than other artificial means. By focusing on food groups rather than single nutrients, sufficiency in several micronutrients and macronutrients can be met at once. Food-based dietary guidelines that are based on local foods and scientific rationale are generally challenging and underutilized (Blasbalg, 2011). Hence the need for the present study.

The present study entitled “**Prevalence of Micronutrient Deficiency in Ramanathapuram District and Impact of Interventions**” was conducted with the major objectives of assessing the prevalence of various micronutrient deficiency disorders among the various age groups of Ramanathapuram district, estimating the subclinical levels of micronutrient deficiency through biochemical assessment, developing micronutrient rich products incorporating natural food sources that are cost effective and nutrient dense, developing education module for combating micronutrient deficiency and studying the impact of dietary interventions on micronutrient status of school going children.

A total of 15,400 subjects belonging to the different groups namely infants, preschool children, school going children, adolescents, adults and pregnant women were selected from all the seven taluks of Ramanathapuram district namely Ramanad, Tiruvadana, Rameswaram, Paramakudi, Mudukulathur, Kamuthi and Kadaladi. A total of 200 male and 200 female subjects were selected from each of the age groups to make up to 2200

subjects from each taluk. Background information of the subjects including educational status, occupation, family income, family type and size along with data on the various health problems faced by the subjects and morbidity pattern were collected for each subject using a pretested questionnaire specially designed for the purpose. All the subjects were then clinically examined with the help of a physician for exclusive clinical signs of various micronutrient deficiencies including physical appearance, skin, hair and eyes indicative of various deficiency disorders using a clinical assessment schedule. From each of the seven taluks chosen, 25 per cent of the subjects from each age group excluding the infants were selected in random and assessed for their food and nutrient intake using the 24 hour dietary recall schedule. Anthropometric measurements such as height, weight, body mass index, ponderal index, head circumference, chest circumference, mid upper arm circumference and waist hip ratio were performed for all the subjects chosen for the present study. Five per cent of the subjects from each age group in each of the seven taluks were chosen at random for biochemical assessment namely haemoglobin, vitamin A and urinary iodine levels were assessed for a total of 770 subjects.

The initial dietary assessment revealed that there existed a gap in the diet of the children in terms of micronutrient intake. With an aim of bridging this gap, ready to eat micronutrient food supplements namely biscuits and jam were developed using inexpensive, locally available foods. For the preparation of biscuits, red rice, wheat, rice flakes, jowar, finger millet, pearl millet, roasted Bengal gram dhal, groundnut, ponnanganni greens and lotus stem were selected. For the preparation of the jam, sweet potato, carrot, tomato and beet root were selected. Based on the dietary deficit of the children, it was planned to provide four biscuits weighing 20 g, with 10 g of jam spread between two biscuits. On the whole, 80 g biscuit and 20 g of jam was given to each child which provided 11.5 mg iron, 3201  $\mu\text{g}$   $\beta$  carotene, 0.5 mg folic acid and 1.29 mg iodine. The developed biscuit and jam were assessed for sensory qualities by a panel of 35 judges and categorised using the nine point rating scale. The developed biscuit and jam were also analyzed for different macro and micronutrients using standardised procedures. The

biscuits were stored in sealed polyethylene packs under room temperature in a clean dry atmosphere for a period of six months and analyzed on the first and sixth months for microbial growth.

A nutrition education module containing all the essential aspects of nutrition in general and micronutrients in particular was developed. Several nutrition education materials such as charts, posters, pamphlets, leaflets and calendar were prepared in order to facilitate easy teaching and better understanding of the various concepts of micronutrient nutrition and health.

In order to assess the impact of the intervention programmes, Sourashtra Matriculation Higher Secondary School was chosen from Paramakudi taluk of Ramanathapuram district. A total of 150 children studying in the sixth class in the age group of 11 to 12 years were chosen for the study. In order to facilitate efficient conduct of the study and to avoid differences among the children, all the 50 children belonging to each section were divided into supplementation, nutrition education and control group respectively. The children belonging to the supplementation group were enlightened on the nutritional benefits of the biscuits. All the children were treated for deworming by administering Albendazole tablets. Each child was supplemented with four biscuits weighing 80 g each day in the school premises during the fifteen minute interval period in the mid morning. Just before distribution, 20 g of the jam was spread between two biscuits and distributed to the children. The children were made to consume the biscuits immediately under the supervision of the investigator. Supplementation was carried out for a period of six months. Since parents are seen as nutritional gatekeepers for their children's diets, their views and beliefs are of crucial importance, nutrition education was imparted in the school premises to the parents along with the children. All the teaching aids developed for the purpose were used at appropriate times for nutrition education and take-home handouts were distributed which contained important tips and guidelines that have to be followed by them. The impact of the nutrition interventions was assessed in terms of anthropometric measurements (height, weight, BMI, mid arm circumference and head circumference), clinical profile, morbidity,

biochemical assessment (haemoglobin, serum iron, total protein, vitamin A, zinc, and urine iodine), cognitive test (Malin's Intelligence Scale for Indian Children), physical performance parameters (squat thrust, push up, 50 yard dash and toe touch tests) of the children, and nutritional Knowledge, Attitude, and Practice of the parents. All the parameters were assessed at the beginning and at the end of the intervention.

The salient findings of the study are summarized as follows.

- Majority of the heads of the families of the subjects in Ramanathapuram district were either uneducated or educated only up to secondary level of education.
- Majority of the subjects belonging to the present study had illiterate women in the family. More than 25 per cent of the women in the families of the subjects had studied only up to primary level of education.
- A high percentage of the head of the families (more than 34.4 per cent) were employed in private concerns. Many heads of the families ranging from a minimum of 11.4 per cent to a maximum of 24.4 per cent earned their wages on a daily basis. Rest of the heads of the families were either in government service or in business.
- A high percentage of subjects ranging from 14.6 to 31.5 per cent belonged to low income group. Less than 15 per cent of the subjects belonged to high income group. About 12.1 per cent to 26.8 per cent of the subjects belonged to the economically weaker section.
- More than 70 per cent of the subjects in Ramanathapuram district were non vegetarians. Less than 25 per cent of the subjects belonging to all the age groups were vegetarians. More than 90 per cent of both male and female subjects were seen to be residing in nuclear families.
- Majority of the subjects among all the age groups ranging from 67.5 to 76.9 per cent belonged to families having two to four members. Less than 20 per cent of the subjects had five to seven members in their family and less than 17 per cent of the subjects had more than seven members in their family.

- Diabetes was seen commonly among 21.2 and 23.3 per cent of the male and female adults and 24.6 per cent of the pregnant women. Less than two per cent of the infants preschool children and more than five per cent of adults and pregnant women had heart diseases. Other illnesses such as arthritis, tuberculosis and asthma were seen among less than 1.5 per cent of the subjects.
- Among the 15,400 subjects, infants and preschool children were seen to be more frequently affected by diarrhoea. The overall occurrence of respiratory illnesses was less than six per cent. Worm infestations were seen to be affecting more number of infants (2.4 to 3.1%) and preschoolers (1.1 to 1.6%). Fever, cough and cold were also seen frequently among infants and school going children.
- Around 41.2 and 39.4 per cent of male and female infants were taken to a physician to be treated for common illnesses, many of them were treated with home remedies. Majority of adults neglected their common illnesses and relied on home medication.
- The consumption of iron, calcium and folic acid supplements were most common among infants and pre school children. More than 80 per cent of the pregnant women consumed iron and folic acid supplements.
- Skin problems like rashes and scars were seen to be most common among adults and adolescents. Boils were more commonly seen among school going boys (13 %), preschool girls (11.6 %) and school going girls (11.3 %). Frequent roughness of the skin was reported by less than 40 per cent of subjects among all the age groups. Frequent dryness of skin was reported by 31.4 and 36.6 per cent of male and female infants and 21.1 and 18.9 per cent of male and female preschool children.
- Less than 22 per cent of the subjects in all age groups with a maximum of 21.3 per cent among the preschool boys had poor nutritional status. Less than 23 per cent of the subjects had poor nutritional status with a maximum of 23 per cent among the pregnant women.
- Brittle hair was seen among less than 11 per cent of infants, preschool children, school going children, adolescents and pregnant women. Lustreless hair was most common among the male (35.9%) and female

(37.6%) school going children followed by adolescent and adult subjects. Discoloured hair was the most common among among adults followed by pregnant women.

- Mild angular stomatitis was observed among less than 1.2 per cent of subjects in all the age groups. Less than 0.5 per cent of the adolescents, adults and female preschool children had moderate angular stomatitis. Moderate angular stomatitis was also seen among 0.6 and 0.1 per cent of male and female adults and 0.4 per cent of pregnant women.
- More than half (53.1%) of the pregnant women and more than one fourth of adolescents had pale tongue. Among the other age groups, pale tongue was observed among more than 15 per cent of infants and school going children, and more than eight per cent of preschool children and adults. Redness of tongue was seen most commonly among less than five per cent of infants, less than two per cent of preschool children, adolescents, school going children and pregnant women.
- Night blindness was seen among 0.07 per cent of school going and adult subjects. Conjunctival xerosis was seen among less than two per cent of the subjects with the majority in preschool (1.1%) and school going (1.6%) children. belonged to the male (1.5 %) and female (1.6 %) school going children. Bitot spots was most common among adult male subjects (0.9%). None of the infants and less than 0.7 per cent of subjects in all the other age groups had Bitot spots. Less than 0.7 per cent of the subjects were also seen to be suffering with keratomalacia.
- A total of less than six per cent of the subjects had bleeding gums. Recession of gums was seen among 3.1 and 2.3 per cent of the adolescent, 5.3 and 3.8 per cent of the adult male and female subjects and 2.2 per cent of the pregnant women. Pyorrhoea of the gums was noticed among less than two per cent of the subjects.
- Dental caries was seen among more than two per cent of the school going children and more than five per cent of the adolescents, adults and pregnant women. Discoloured teeth were observed among 12.2 per cent of the male adults and less than eight per cent of the other age groups.

Less than two per cent of adolescents, adults and pregnant women had mottled enamel.

- Lustreless skin was observed among a total of more than eight per cent of infants, preschool and school going children, and more than ten per cent of adolescents, adults and pregnant women. Phrynoderma was seen among less than two per cent of school going children, adolescents and adults.
- Around six per cent of infants, and two per cent of adults and pregnant women had irritable state of mind and one adult male (0.1%) was seen to be suffering with apathy.
- The mean food intake of the preschool children was found to be deficient in all the nutrients. The deficit in the intake of cereals, pulses and milk was less than fifty per cent. Maximum deficit of around eighty per cent was noted in the intake of green leafy vegetables and fruits. There was also a high deficit of more than 60 per cent in the intake of other vegetables.
- The adolescents, adults and pregnant women were not consuming even one fourth of the recommended intakes of green leafy vegetables, other vegetables and fruits. The deficit in cereal intake was the highest among adolescents (up to 49.4%). The diet of the pregnant women was short of the recommended allowances of pulses, leafy vegetables, other vegetables and fruits.
- Nutrient intake assessment revealed that there was a shocking deficit of more than 90 per cent in vitamin A, more than 80 per cent in folic acid and more than 50 per cent in iron intake of preschool children. The deficit in the intake of vitamin A, folic acid and iron in the school going children were more than 80, 50 and 40 per cent respectively among the school going children. The intake of all the other nutrients namely energy, protein, fat, calcium, riboflavin, thiamine and niacin were also less than the recommended allowances.
- The diet of the adolescents, adults and pregnant women were deficit in all the nutrients except fat. The deficit was astonishingly high (90%) in vitamin A and folic acid (75%). The deficit in energy (44.3 and 39.5%),

protein (42.1 and 32.9%) and riboflavin (73.3 and 65%) were higher among the male and female adolescents than the other groups. The pregnant women also had low intake of energy, protein, calcium and vitamin C with a deficit of more than 20 per cent.

- The diet of the subjects in the present study has been very poor with reference to micronutrients. A little more than half of the subjects consumed green leafy vegetables only once in two weeks. Other vegetable sources were consumed once weekly by majority of the subjects. Fruits were also equally neglected with most of the subjects consuming them on a weekly basis. Around 69.9 per cent of the subjects rarely consumed iodised salt either due to lack of awareness or due to its higher cost than non iodised local salt.
- The mean birth weights of the male and female infants were 2.9 and 2.8 kg respectively and the present weights were 8.8 and 7.6 kg respectively. Only 68.4 and 64.7 per cent of the male and female infants respectively had desirable birth weight of more than 2.5 kg. The crown heel length of the male and female infants measured 56.41 and 53.52 cm respectively which were far less than the standards. The head, arm and chest circumference of the male infants were 41.6, 11.52 and 33.51 cm respectively and that of the female infants were 38.51, 10.97 and 34.11 cm respectively.
- About 32.7 per cent of male and 38.1 per cent of female infants were underweight, up to 28.6 and 30.6 per cent respectively were stunted and up to 17.9 and 19.8 per cent respectively were wasted.
- The mean height and weight of the male preschool children were 87.45 cm and 12.61 kg respectively, and that of the female children were 82.51 cm and 12.04 kg respectively. The ponderal indices of the male and female preschool children were 17.92 and 19.49 kg/m<sup>3</sup> respectively. The average chest and mid arm circumference of the male preschool children were 40.52 and 12.64 cm respectively and that of the female preschool children were 40.18 and 12.96 cm respectively.
- Low birth weight was seen among 25.8 and 32.3 per cent of the male and female preschool children. Around 26 per cent of both male and

female preschool children were stunted and more than 18 per cent of the children were wasted.

- The male school going children were taller and heavier than their female counterparts with a height of 129.16 cm and weight of 39.12 kg. However, it has to be noted that both male and female children were shorter and thinner than ICMR (2010) reference values. The body mass indices of the male and female school going children were 15.21 and 14.52 kg/m<sup>2</sup> respectively. The MUAC, chest and head circumferences of the male school going children were 17.51, 56.42 and 49.26 cm respectively and that of female children were 17.82, 58.61 and 49.51 cm respectively.
- The mean height of the male and female adolescents were 155.21 and 147.81 cm respectively. The male and female adolescents weighed 43.12 and 46.87 kg respectively and their respective BMI were 16.56 and 17.98 kg/m<sup>3</sup>. The circumference of the mid upper arm, chest and head of the adolescent male subjects were 24.17, 77.12 and 54.96 cm, respectively and that of the female subjects were 23.52, 78.49 and 53.47 cm respectively.
- The adult male subjects in the present study were taller and heavier than the female adults with a height of 163.52 cm and a weight of 64.93 kg. The respective BMI of the male and female subjects were 24.71 and 21.12 kg/m<sup>2</sup>, both being close to the normal range. The upper arm waist and hip circumference of the adult male subjects were 27.39, 63.54 and 72.54 cm respectively and that of the adult female subjects were 24.96, 56.11 and 68.17 cm respectively. The pregnant women in the present study were 151.74 cm tall and weighed 43.84 kg.
- The mean haemoglobin levels of the subjects ranged from 9.3 to 12 g/dl. These levels were found to be below normal levels among all the groups except infants. More than 25, five and one per cent of the subjects had mild, moderate and severe anaemia respectively.
- The mean serum vitamin A levels were in the range of 19 to 28 µg/dl with the least among adult male subjects and maximum among infants.

Around one to eight per cent and around 35 to 65 per cent of the subjects had deficient and low levels of serum vitamin A respectively.

- The median urinary iodine levels of all the groups were sufficient according to the WHO (2007) cut-off of  $\geq 100$ . However, the median urinary iodine level of pregnant women (136.84  $\mu\text{g/l}$ ) was less than the cut-off ( $\geq 150$   $\mu\text{g/l}$ ). On the whole, more than 40 per cent of the subjects had inadequate iodine status with reference to urinary iodine levels.
- Correlation analysis revealed strong positive correlation between the biochemical parameters and intake of energy, protein, iron, vitamin A, thiamine, riboflavin and folic acid. A strong positive correlation was also identified for blood haemoglobin and vitamin A with body weight.
- The prevalence of Bitot spots which is the manifestation of vitamin A deficiency was obvious in all age groups except infants with a maximum of 0.8 per cent among the adults and 0.6 per cent among preschool children and pregnant women. About 0.07 per cent of preschool children and 0.04 per cent of school going, adolescent and adults were identified with goitre. At the sub clinical level, iron deficiency anaemia was most common among infants (67.1%) and pregnant women (61.4%). Less than eight per cent of the subjects had subclinical vitamin A deficiency with the majority among school going children (6.4%) and pregnant women (7.1%). More than 40 per cent of preschool children, pregnant women and adolescents had subclinical signs of iodine deficiency.
- Nutrient analysis of the developed products revealed that 100 g of the developed biscuits provided 477 kcal energy, 67.34 g carbohydrate, 6.89 g protein, 2412.6  $\mu\text{g}$   $\beta$  carotene, 12.16 mg iron, 1.39 mg iodine and 6.86 mg zinc. Similarly, 100 g of the jam provided 292 kcal energy, 54.5 g carbohydrate, 13.65 g protein, 6352.3  $\mu\text{g}$   $\beta$  carotene, 8.58 mg iron, 2.9 mg iodine and 5.32 mg zinc
- The overall organoleptic evaluation scores of the biscuit and jam were 5.66 and 5.67 respectively. Both the products indicating that the products were well accepted and suitable to be supplemented to children. Shelf life study of the biscuits revealed no detectable microbial

growth. The peroxide value of the biscuits showed a slight increase from 0.26 to 0.37 meq/kg during the six month storage period.

- The mean initial height of the children before intervention ranged from 131.65 to 133.52 cm. After six months intervention period, an increment in height of 4.07 and 3.83 cm in male and female children of experimental group I and an increment of 2.31 and 2.62 cm among the male and female children belonging to the experimental group II were evident. The differences were significant at one per cent level. Supplementation resulted in significantly greater improvement than nutrition education.
- The mean weight of the male children before nutrition intervention ranged from 24.06 kg to 24.43 kg and that of the female children ranged from 23.28 kg to 25.33 kg. The increment in weight after the six month intervention was the maximum among the children belonging to the experimental group I with a mean difference of 1.72 (male) and 1.52 (female) kg. The increment in weight in experimental group II was 1.00 and 0.83 kg among male and female children respectively. Both the differences were significant at one per cent level. The control group registered significantly lower results than the experimental groups.
- The BMI of the children belonging to the present study fell within the range of 13.16 to 14.65. The six month intervention period could make a small but positive impact on the BMI of the children belonging to the experimental group I. These male and female children showed an increment of 0.18 and 0.05 respectively. Comparison between groups revealed a significant difference (1%level) in the changes in BMI among the two experimental groups in comparison to the control group.
- The male and female children belonging to the experimental group I recorded an increase in the MUAC by 0.11 and 0.09 cm respectively. These increments were found to be statistically significant at one and five per cent levels respectively. Among the experimental group II, the increment recorded were 0.04 and 0.02 cm among the male and female children respectively.

- Supplementation resulted in an increase in the head circumference of the male children from 50.13 to 50.46 cm and among female children from 51.35 to 51.72 cm. A likewise increment could also be observed among the children belonging to the experimental group II by 0.21 cm and 0.14 cm among the male and children respectively. Both the increments had a statistical significance at one per cent level. Statistical comparison between the groups indicated significantly greater (1% level) improvements in both the experimental groups than the control group. Further, the children belonging to experimental group I evidenced significantly greater improvements in head circumference than Experimental group II.
- Mean increments in blood haemoglobin status of the children in experimental group I was 1.26 and 1.41 g/dl in male and female children respectively, and 0.64 and 0.70 g/dl respectively in experimental group II. The children belonging to the control group did not show any significant improvement in the haemoglobin levels after the study period. The increment in experimental groups was significantly greater than the control group.
- The children who received supplementation recorded the highest increment in total iron levels of 8.10 and 7.76 µg/dl among the male and female children respectively followed by those whose parents were imparted nutrition education, by 3.70 µg/dl among the male and 3.32 µg/dl among the female children. Both the groups recorded significantly greater increments than the control group.
- The mean increase in the serum protein levels of the experimental group I was 0.93 g/dl among the male and 1.06 g/dl among the female children. The experimental group II recorded a similar increase in the protein levels among both the male and female groups of children by 0.68 g/dl each respectively. Statistical analysis between groups confirmed that both the interventions resulted in significantly (5% level) greater increments in serum protein levels as against the control group though the two experimental groups did not vary significantly.

- A significant increase ( $p < 0.01$ ) could be observed in the serum vitamin A levels of the children belonging to the experimental group I from 28.60 to 32.5  $\mu\text{g}/\text{dl}$  among the male children and from 28.57 to 32.65  $\mu\text{g}/\text{dl}$  among the female children. A similar increase, but to a lesser extent was evident among the children of experimental group II indicating the effectiveness of nutrition education. The children of the control group had almost retained their initial levels of serum vitamin A.
- The urinary iodine levels of the children in supplementation group improved from 104.47 and 107.98  $\mu\text{g}/\text{l}$  to 127.18 to 128.25  $\mu\text{g}/\text{l}$  among the male and female children respectively. A similar improvement was also evidenced among the experimental group II with a mean increase of 12.19  $\mu\text{g}/\text{l}$  and 10.37  $\mu\text{g}/\text{l}$  among the male and female children respectively. Both the groups had significantly better increments than the control group.
- After supplementation, the serum zinc levels of the children belonging to the experimental group I increased immensely by 25.66  $\mu\text{g}/\text{dl}$  among the male and by 77.68  $\mu\text{g}/\text{dl}$  among the female children. There was also an increase in serum zinc levels among the children belonging to the experimental group II by 77.39  $\mu\text{g}/\text{dl}$  among the male children and by 75.30  $\mu\text{g}/\text{dl}$  among the female children. Statistical comparison between groups revealed that both the experimental groups showed significantly (5% level) greater increments in comparison to the control group.
- Cognitive performance of the children assessed in terms of information, performance, arithmetic, vocabulary, digit span and coding tests revealed that the performance of the children belonging to experimental groups I and II increased significantly in all the tests. Improvements were also evident in the control group. However, supplementation and nutrition education yielded significantly better results when compared to the control group. Comparison between the two experimental groups also revealed that supplementation yielded the best results than nutrition education.
- Assessment of the physical performance of the children in terms of squat thrust, 50 yard dash, toe touch and push up tests revealed that there

were significant improvements in the physical performance of the children in both the experimental groups as against the control group. The improved micronutrient status and decreased morbidity of the children could have significantly improved their physical strength and endurance.

- The mean scores of the parents in nutritional test scores improved by 3.17 and 4.15 in knowledge assessment, 3.76 and 4.05 in attitude assessment and 4.03 and 3.76 in practice assessment among male and female children in experimental group II which were significant at one per cent level. Both the other groups evidenced little or no increments indicating that nutrition education had tremendous capabilities of improving the KAP than by any other method.
- The children belonging to the experimental group 1 showed excellent response in terms of clinical signs to the other two groups. Marked reductions in all the clinical signs were evident among the children belonging to the supplementation group. Conjunctival xerosis and Bitot spot completely disappeared among six and two children respectively. Clinical manifestation among the children belonging to experimental group II were also obviously lesser after nutritional education to the parents. Signs of conjunctival xerosis and Bitot's spot decreased from seven to four and from three to two respectively among these children.
- The supplementation of micronutrient rich biscuit resulted in a considerable improvement in the immune status of the children belonging to the experimental group 1 as the incidence of most of the morbidities reduced almost by half considerable reduction in illness was also reported by the children belonging to the experimental group II revealing that the nutrition education has been fruitful. The control group however reflected very mild variations between the initial and final morbidity pattern.

Hence, it can be seen from the findings of the present study that micronutrient deficiency with reference to iron, vitamin A and iodine are still a public health problem in Ramanathapuram district drastically affecting physical, mental and performance parameters of the population at large.

There exists a huge gap in the intake of nutrients and micronutrients in particular among all the age groups, the major reasons for which seems to be negligence and lack of awareness. This situation calls for a multifaceted approach to change the scenario. Supplementation of products developed with local resources has shown to improve the nutritional status of the children in all the parameters evaluated. Nutrition education has also yielded significant improvements next to supplementation. The findings of the present study leads to the conclusion beyond doubt that proper utilization of local resources in a natural way, and generating awareness will be simple but sure measures towards the establishment of a much healthier, disease free community. This study shows that integrating food-assistance programs with routine health care in turn can significantly improve the nutritional status of children. Therefore, it is suggested that the community should be sensitized towards the health benefits of consumption of variety of foods through health and nutrition education which can help decrease the prevalence of undernutrition and multiple micronutrient deficiencies among the community.

It is recommended that future research along the following lines be undertaken to bring out community based strategies on a sustainable basis.

- Supplementation studies for a longer period of time with a larger group of population.
- Explore other underexploited local sources of micronutrients and incorporation into recipes.
- Studies on bioavailability of nutrients from various recipes and means of improving them.
- In depth studies on development of novel food products using micronutrient and phytochemical rich foods for enhancing immunity.
- Development and evaluation of micronutrient rich food formulations introduced in school lunch programmes.
- Imparting an integrated nutrition education programme to school teachers, children and parents to enhance the KAP.