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A Symphonic Approach to Combating Malnutrition

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The problem

Sixtyfive years after Independence, India is a rapidly growing economy with 1.2 billion people. Yet almost one-third of all infants have low birth weight (LBW, <2.5Kg), 50% of the children and 30% of the adults are undernourished as judged by anthropometric indicators, 50-70% of the women and children suffer from iron deficiency anaemia, and there is rampant deficiency of other micronutrients, particularly vitamin A, some B- vitamins (riboflavin, folic acid), and perhaps zinc, vitamin B_{12} and vitamin D. However, we no longer see nutrition deficiency diseases like beri-beri, pellagra and scurvy. Blindness due to vitamin A deficiency (keratomalacia) has become rare. The incidence of severe forms of malnutrition is slowly declining. Yet, there are millions who suffer from sub-clinical deficiency as judged from milder signs and symptoms, biochemical indicators and dietary deficits. The cumulative burden of marginal malnutrition on productivity and medical expenditure can be substantial. The incidence of the iodine deficiency disease – goiter - has declined after the introduction of iodised salt, but has not been eliminated and is not confined to sub-Himalayan regions as earlier thought.

Even as India is grappling with problems associated with the pre-developmental-transition era, like under-nutrition and communicable diseases, there is a growing incidence of post-transition health problems like obesity and associated degenerative diseases like diabetes, hypertension, and cardiovascular diseases. Solutions for the latter problems are being attempted through manipulation of life-style modifications (diet, exercise, etc) in adulthood. Although these can help, the fact that the genesis of these diseases in India can be, intrauterine malnutrition, is often lost sight of. Barker's hypothesis, proposed over 20 years ago, stated that intrauterine malnutrition alters foetal programming, leading to underweight babies with higher fat-to-muscle ratio. This has received independent support even from studies in India[1]. Intra-uterine malnutrition also leads to stunting, and poor cognitive and physical development, which affects national productivity. The window of opportunity for rehabilitation is in the first year of life. The adverse effects are multigenerational.

The question is – where has India gone wrong and how can the problem be approached?

A symphonic approach to the resistant problem of malnutrition

Nutrition security implies, 'physical, economic and social access to age- and physiological status- appropriate balanced diets, clean drinking water, safe environment and primary health care'. Thus, there cannot be a single-bullet approach to shooting down malnutrition. In an orchestra playing a symphony, there has to be a balance between melody and harmony produced by different instruments. In a symphony, though all the instruments and players are important, there is a lead player-violinist, pianist, cellist etc. and a conductor who knows the score well and extracts the best performance. Likewise, for combating malnutrition, there has to be a harmonised approach to ensure awareness and access at affordable cost to balanced diets, disease-free environment, safe drinking water, and primary health care, each of which requires inputs from multiple directions. The Government will have to be the conductor. If a lead instrumentalist has to be identified for achieving health and nutrition goals, the focus should be on female health, nutrition, and education, and not on economic growth (GDP) as is often thought. Economic growth is essential but is not enough, especially if it does not ensure distributive justice to enhance the purchasing power of all individuals.

Nutrition is often subsumed under health, and health often means prevention of communicable diseases through immunization, oral rehydration, treatment of infections, etc, and management of non-communicable diseases through life-style changes and medication in later life. Even though infant and child mortality in India has declined by almost 40% between 1990 and 2008, the incidence of low birth

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weight (LBW) and underweight in under-fives has declined only by about 10-12% during that period, suggesting the need for a specific targeted approach to tackle the problem of under-nutrition in India[2,3].

Why Women?

Successive UNICEF reports show that the degree of malnutrition in children is higher in South Asia of which India is the largest country, than in sub-Saharan Africa and many other least-developed countries. Way back in 1996, Ramalingaswamy, Johnson and Rhohde[4] called it the 'Asian enigma'. Comparisons between the two regions with regard to several putative parameters that would impact on nutrition suggested that the culprit was the high incidence of LBW, which is almost 30% in South Asia, (India) as compared to half that percentage in sub-Saharan Africa. Even 15 years after this observation was made the situation persists (Table 1)[2]. This points to the neglect of women's health in India.

Several other indicators like high maternal mortality, higher incidence of micronutrient deficiencies in women than in men and, most compelling, the low sex ratio, suggest a bias against females. The 2011 census showed a fall in child sex ratio from 927 girls for 1000 boys a decade ago, to 914[5,6,7]. This is despite the official ban on prenatal sex determination and female foeticide. Overall, however, the sex ratio in India has improved marginally from 933 to 940 during the decade, perhaps due to decline in maternal mortality. Female foeticide cannot be attributed to poverty, since it is highest in the relatively affluent states like Haryana, Punjab, Delhi and Chandigarh. It is due to cultural preference for boys for a variety of reasons in a patriarchal society.

According to a recent analysis, the failure of some developing nations (including India) to meet the targets of Millennium Development Goals (MDG) relating to reducing hunger (MDG 1) and child mortality (MDG 4) may be due to the contemporaneous role of intergenerational influences on health[8]. Maternal malnutrition perpetuates such an intergenerational burden.

Besides their roles as mothers and homemakers, women are equal partners in food production in developing countries, where farming is the major occupation. Under-nutrition in women has a ripple effect on national productivity.

A comparison between states in India suggests the complex aetiology of malnutrition[9]. Kerala with lower energy intake than most states in India, and less economic development than many states like Maharashtra and Gujarat, has the lowest degree of malnutrition in preschool children. Gujarat, which is projected as a model state for development fares poorly in many indicators of the Human Development Index, and in nutrition status. Kerala's better performance may be due to overall better human development, including education (particularly of women) and its matriarchal society. It should be pointed out that even in Kerala 35% of the children are underweight and 33% are stunted[9]. In most other states covered under NNMB surveys, the figures for underweight and stunting in preschool children exceed 50%. NNMB surveys unfortunately include only 9 states, most of them in the south.

It is, thus, obvious that if a beginning has to be made, it should be with female health, nutrition, education and empowerment, using a life cycle approach.

Need for nutrition literacy at all levels

For making right choices, awareness regarding problems of malnutrition - causes, consequences and possible remedies - is very important at all levels: policy makers, administrators, professionals (health, agriculture, social science, media, teachers, etc), besides the public at large. Most important is leadership at different levels, which will help to bring about convergence between the efforts of different departments and ministries.

Since malnutrition is a complex and vast subject, further discussion will focus on the dietary aetiology of malnutrition and the approaches to achieve household food security, with emphasis on micronutrients.

Indian diets

Diet surveys done by the NNMB bring out two issues[9]: (I) There is a qualitative deficiency of micronutrients, particularly, iron, vitamin A, riboflavin and folic acid; deficiencies of zinc and vitamins B_{12} and D are also suspected from recent studies. (ii) Within a family, infants and children of 6-36 months age group are most deprived of nutritious diets, primarily because these small children cannot articulate, mothers are ill informed about their nutritional needs, and busy mothers do not find the time to do frequent feeding that is needed for infants. WHO guidelines for infant feeding are: exclusive breast feeding for 6 months, and introduction of complementary feeding after 6 months while continuing breast feeding. Breast feeding is the universal norm in rural India. However, the fault-lines are: discarding colostrum, administration of pre-lacteal foods, and delayed introduction of complementary food. Only about 50% infants in India receive complementary food between 6-9

Table 1 Regional comparison - Sub Saharan Africa Vs South Asia

Parameter	Sub Saharan Africa	South Asia
Infant Mortality Rate (2007)	89	59
Under five mortality	148	78
GNI	965	889
Adult Literacy (%)	62	63
Low Birth Weight (%) 2000-2007	15	27
Malnourished (under 5)	28	45

Source: Reference 2

Table 2 Average intake of foods and nutrients (per Cu) as % RDI, by period of survey

Food	1975-77	2005-06	Nutrient	1975-76	2005-06
Cereals	110	86	**Protein**	103	82
Pulse	85	70	**Energy**	97	76
Milk	77	55	**Calcium**	152	110
Sugar	77	55	**Iron**	62	53
Green leafy vegetables	20	40	**Vitamin A**	41	43
Other vegetables	90	82	**Thiamine**	125	100
Roots and tubers	112	120	**Riboflavin**	57	43
Fats and oils	70	70	**Niacin**	92	92
Sugar and jaggery	77	47	**Vitamin C**	98	110

Source: GNV Brahmam, INSA, 2010, based on NNMB surveys

months of age[2]. Even where complementary food is given, it is inadequate and of poor quality. Correction of these requires behavioural change through appropriate educational strategies using mass media and other methods.

NNMB surveys show that more than 70% of preschool children consume less than 50% of RDA of iron, vitamin A and riboflavin[9]. Thus, the message is: improve access to micronutrient-rich foods at an affordable cost. Alternative strategies for delivering micronutrients - food fortification, bio-fortification, and pharmaceutical supplementation, will also have to be put in place, in a harmonious way.

NNMB diet surveys show a marked decline in consumption of all foods (except green leafy vegetables, and roots and tubers) and corresponding decline in nutrients as a percentage of recommended amounts, over time (Table 2). Apart from in infancy and childhood, food and nutrient deficits tend to be greater during pregnancy and lactation and among adolescents, since their needs are special.

Strategies for increasing access to micronutrients

Basically there are three approaches to increase access to micronutrients: (i) increased production and consumption of traditional micronutrient-rich foods, (ii) food fortification, and (iii) biofortification. Fourth, and perhaps the most important aspect, is prevention of wastage. Almost 40% of farm produce in India is spoilt due to lack of proper storage facilities and cold chain. Traditional methods of village-level storing of foods need a relook since modern silos are very expensive.

Increased production and consumption of micronutrient-rich foods

In vegetarian diets, vegetables, fruits and animal products like milk and eggs are the major sources of micronutrients. India is among the top two countries in the world in the production of vegetables, fruits and milk. Yet, what is produced is insufficient to meet the needs of the growing population and, with the high cost of production, it is beyond the reach of the poor. Among the food grains, rice is a poor source of micronutrients as compared to wheat and other coarse grains (nutri grains) like maize, sorghum and millets. Pulses are also rich in micronutrients such as minerals and B-complex vitamins, besides being important sources of proteins. The Green Revolution has helped to increase the production of rice and wheat through vastly improved productivity. However, since the mid-1990s, “Green Revolution fatigue” has set in and production of these staples is tending to show some decline. However, there is some promise of revival this year. The Food Security Mission, set up in 2007, has helped to increase the production of pulses by a couple of million tonnes, but that is far from adequate to meet the national need. The rising cost of production puts pulses out of the reach of the poor. There has been considerable neglect of millets, which are nutritious, less water-demanding, and more resilient to climate change. They are the grains of tomorrow. (Table 3)[10].

Millets and other coarse grains can be mix-cultivated with pulses and vegetables, and hence a millet farm is a composite, nutrient-packed farm. Future research and extension work will have to focus on enhancing the production of these nutritious grains and promoting their consumption. With some irrigation and fertilizers, their productivity can be increased. The bioavailability of micronutrients from millets needs to be investigated, since the high fibre content of millets would inhibit absorption of micronutrients. Because of the subsidised rice schemes, the preference

Table 3 Area and Production of Millets and Cereals - Time Trends

Area, Lakh Hactares	1955-56	1975-76	1995-96	2005-06	2008-09
Millets	363.42	349.62	240.86	208.48	185.70
Cereals	873.5	1037.24	987.40	992.08	1007.39
Production Lakh tonnes	**1955-56**	**1975-76**	**1995-96**	**2005-06**	**2008-09**
Millets	140.7	199.61	179.88	181.40	186.18
Cereals	695.24	1326.07	2066.96	1952.12	2199.99

Source: Reference 10

for millets has come down and traditional millet growers are turning to paddy and other cash crops. In the past few years, millets have received attention from the National agriculture innovation project, funded by the World Bank through ICAR. Apart from their nutritional properties, their utility as functional foods, due to high content of fibre and other nutraceuticals, is being researched.

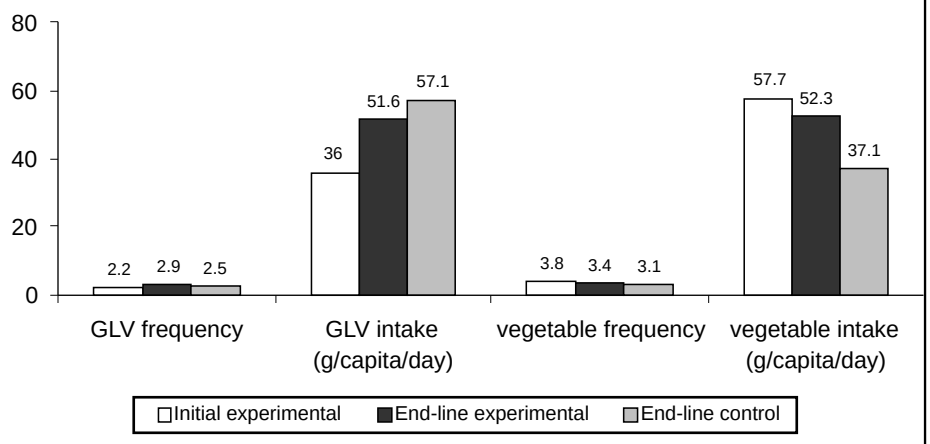
The Horticulture Mission has helped to increase the production of vegetables and fruits, but its main objectives are: income and export. No mention of nutrition. The objective of micronutrient security has to become one of the goals of the Horticulture Mission.

Models for improving household food security: case studies

Hellen Keller International model: Several studies have shown that homestead gardens, and livestock can improve household food security. In a four-nation study in Bangladesh, Cambodia, Nepal and Philippines, supported by Helen Keller International, homestead and community gardens were promoted with technical knowhow and good planting material[11]. Women were the major stakeholders. Apart from increasing the frequency and variety of vegetables consumed by preschool children, there was reduction in the incidence of anaemia in children. The impact on anaemia in women was however, equivocal.

Food security-Cuba: A remarkable model of achieving food and nutrition security has been developed by Cuba[12]. Its food security collapsed after the disintegration of the Soviet Union in 1989, and the continuing US embargo. The National urban agriculture group (in Cuba), established soon thereafter, started promoting the approach of creating "new land" for cultivation by bringing every bit of fertile and infertile, even paved land under cultivation. For the latter, organoponics or raised containers filled with compost and manure-rich soil (often transported from outside) were used. Urban agriculture (the use of patios and yards next to people's homes) became popular. Since petroleum based fertilizers also became scarce, organic farming was promoted with strong R&D backup to develop bio-fertilizers and bio-pesticides. Cuba has now become self sufficient in food and is an exporter. Policies to ensure proper food distribution were also put in place.

Figure: Consumption of GLV and other vegetables (frequency/week and gm/capita/day)



Source: Reference 15

Urban agriculture has been inadequately exploited in India, and offers good scope for improving household food security in urban areas.

Zero hunger project-Brazil: The Zero Hunger Project of Brazil, spearheaded by President Lula da Silva, is a remarkable example of how a large overpopulated country has tackled the problem of hunger[13,14]. Its new economic model included strategies for "income improvement, food cheapening, Increase in basic food supply and emergency actions". Nutrition education using media and cash transfer to women formed part of this model. Brazil has surpassed the MDG targets.

Medak study: In a recent study in villages of Medak district of Andhra Pradesh, an effort was made to promote food, nutrition and environment security through crop diversification using green methods of farming[15]. Traditionally, paddy and sugarcane farmers in a dry-land area with small and marginal land holdings were persuaded to set aside small plots of land (quarter acre to half acre) for orchards with mixed nutrient - rich varieties of vegetables and fruits. Organic fertilizers and pesticides like vermi compost (fertilizer) and neem seed and chilly-garlic decoction (pesticides) were promoted. The judicious use of chemical fertilisers after testing the soil was encouraged. Nutrition and environment education was provided. At the end of 3 years (2010), there was a remarkable improvement in the knowledge of green methods of farming and nutrition among the participating households. There was a significant increase in the consumption of greens over the period of 3 years (2007-2010) but no change in the consumption of other vegetables from the baseline survey. However, as compared to a control group of non-participating households examined in the end-line survey, vegetable consumption was markedly higher in the participating households (Figure). Despite inadequate consumption at home, 25-50% of the produce was sold by the families. During the 3 years (2007-2010) the market price of vegetables went up steeply, and hence it can be concluded that "for poor households, economic compulsion outweighs nutritional wisdom". Simultaneous avenues for poverty alleviation have to be found so that home-grown vegetables and fruits do not act only as replacement for what is purchased from the market. Home grown vegetables offer a shield against price rise.

In some of the villages (Medak study), backyard poultry (BYP) with high egg-yielding varieties of birds was introduced. Acceptance of BYP was good, since it is inexpensive to set up and does not require much land or water. Preliminary findings suggest that the impact of BYP on egg consumption was good, making BYP with high egg-yielding varieties a promising option to increase access to animal foods.

India has a rich biodiversity of plant foods. Systematic programmes of analyzing these local foods, promoting

potentially micronutrient-rich varieties and encouraging their consumption through educational strategies are needed. Some of the micronutrient-rich varieties can be engineered to improve their quality. Plant foods have the added advantage of having health-promoting nutraceuticals and have the potential of serving as functional foods for preventing chronic diseases. This is a promising area of research calling for partnership between agriculture scientists and nutritionists.

Biofortification

Biofortification implies enriching the germ plasm with nutrients through conventional breeding, molecular breeding or genetic engineering. It is a powerful tool that can empower the farmers once access to fortified seeds at affordable cost is ensured without allowing seed companies to exploit the farmers. Conventional breeding and molecular breeding methods are not controversial. They have also been accepted as being compatible with organic farming. On the other hand, environment and health safety issues have been raised as regards genetic engineering, which involves gene transfer from a food or non-food species to food crops.

Biofortified plants thrive better. In India, the potential impact of iron biofortification is promising[16]. India is part of the "Harvest Plus: Bio-fortification Challenge programme which is an interdisciplinary, global alliance of research. It includes: β carotene (pro-vitamin A)-rich sweet potato, and cassava, zinc- and iron-rich rice, wheat, maize, pearl millet, and beans. The DBT network project on bio-fortification of rice, wheat and maize is currently being implemented by ICAR Institutions, state agriculture universities, and the National Institute of Nutrition. Golden rice rich in pro-vitamin A and high-iron rice (high-ferritin gene from mangrove) are examples of transgenic technologies[17,18]. Indian scientists have developed many promising varieties through conventional and molecular breeding. These technologies should be quickly transferred from lab to land.

Food fortification

One of the most successful health interventions in India is the use of iodised salt to combat iodine deficiency (goitre). More recently the National Institute of Nutrition has developed iron-fortified iodised salt (DFS)[19]. The Gazette Notification for its production has been issued. DFS should quickly replace iodised salt to address the dual problems of iron and iodine deficiencies. Fortification can help only in the prevention of deficiency diseases and not in treating severe forms of the diseases. Thus it may take some time to realise the impact of iron fortification of salt in the community at large, since the prevalence of moderate and severe anaemia is widespread, particularly in women and children. Fears expressed in some quarters that DFS will derail the ongoing iodised salt distribution programme are unfounded, since the stability of both the nutrients has been tested. The additional cost is minimal, and DFS should be made available at subsidised cost.

Since wheat and rice are staple grains with bulk consumption, their fortification merits consideration. In many countries cereal products are fortified with iron and other nutrients like folic acid (the latter is to prevent neural tube defects in infants). Folic acid can also reduce serum homocysteine – an independent risk factor for cardiovascular diseases. India needs to examine this strategy in view of the growing incidence of CVD. There are, however, apprehensions that delivering folic acid without vitamin B_{12} may adversely affect the balance between the two vitamins. The bioavailablity of iron from cereals rich in phytates needs to be investigated. Iron salts like Na-Fe-EDTA, have higher bioavailability than ferrous sulphate. The higher cost may get offset by lower dose requirement. The fortification of rice has been attempted by mixing fortified extruded grains from rice flour with rice (ultra rice). This technology has yet to become cost-effective[20].

Fortification of foods with micronutrient sprinklers and spreads for supplementary feeding has been recommended. Well planned studies need to be done to examine the feasibility and cost-effectiveness of such a strategy vis a vis food-based inputs such as vegetables and fruits. The impact of golden rice (rich in vitamin A), ultra rice (rich in iron and other micronutrients) and red palm oil (rich in beta carotene) needs to be investigated in terms of feasibility, and cost-effectiveness.

Gujarat has taken the lead in attempting oil fortification with fat-soluble vitamins, and these efforts are ongoing.

Micronutrient supplementation

The Government of India has two programmes for delivering micronutrients through pharmaceutical preparations: (i) Iron-folate supplementation for pregnant and lactating women and for children and adolescent girls. While the women's programme is going well at least in some states, the other two seem to be on paper only. (ii) Massive-dose vitamin A supplementation for 1-6 year-old children. A detailed discussion of these programmes is beyond the scope of this article, except to say that these programmes have not shown the desired impact. Reasons for failure - scientific, administrative, and cultural, have to be examined.

India has many policies and programmes to help improve nutrition security. What is needed is a symphonic approach with a conductor who knows the score well and brings about harmonious convergence and efficient delivery.

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Action Plan for a Healthy Agriculture, Healthy Nutrition, Healthy People

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Introduction

The Inaugural Conference on 'Healthy Agriculture, Healthy Nutrition, Healthy People' of the World Council on Genetics, Nutrition and Fitness for Health was held at Ancient Olympia, Greece on October 5-8, 2010. The focus of the Conference was on the evolutionary aspects of diet throughout the life cycle in terms of genetic predisposition, health, disease prevention and sedentary lifestyles; the dietary changes brought about by modern agriculture, agribusiness, food production systems, changes in climate and the need for urban agriculture and architecture, all of which are influenced by governments, national and international policies. Therefore the role of governments and international organizations was extensively discussed during the last session of the Conference by the participants from 20 countries representing six continents.

General conclusions and recommendations

Today we live in a nutritional environment that is very different from the environments to which we are genetically adapted. Major changes in our food supply accompanied the domestication of animals and the agricultural revolution about 10,000 years ago.

Later, the industrial revolution and developments in food technology brought about further major changes in the composition of foods, one of the most important of which was a change in the quantity and quality of the various fatty acids.The content of saturated fat and omega-6 essential fatty acids increased, whereas the content of omega-3 fatty acids decreased. A development related directly to industrialisation was the intentional increase in the content of trans-fatty acids produced by the hydrogenation of polyunsaturated and monounsatured fatty acids. Furthermore, a 30% decrease in the content of essential vitamins and minerals in fruits and vegetables has accompanied the use of chemical fertilizers, which are produced by processes requiring large amounts of energy and, perhaps most serious of all, resulting in dangerous disruption of the phosphorus cycle. In spite of these and many other close relationships between agriculture and food production on the one hand and nutritional and ecological problems on the other, policies for agriculture, for the environment and for human nutrition and health are largely disconnected. In our analyses, priorities and policies, we quite obviously need to take a broader view, one that at the very least recognizes the complex relationships between farming, human health, and the ecological systems on which life on earth depends.

The presentations at the conference noted that the human genome has not changed very much during the relatively short period (10,000 years) of these major changes in diet. It is likely, therefore, that chronic diseases such as certain forms of cardiovascular disease, obesity, diabetes, cancer, arthritis, mental illness and neurodegenerative diseases are due, at least in part, to an environment of food and other elements of modern life to which we are genetically not well adapted. An analysis of epidemiological studies of dietary fatty acids and coronary heart disease (CHD) indicated that, in contrast to almost all current recommendations, high amounts of dietary linoleic acid (the major omega-6 fatty acid) from vegetable oils actually increase the risk of CHD.

The production of vegetable oils such as corn oil is a major element of modern food production systems. It may therefore be very unfortunate that foods with a high ratio of linoleic acid (omega-6) to alpha-linolenic acid (omega-3) of about 15/1, common in developed countries, are now spreading to developing countries adopting the agricultural and dietary practices of the so-called developed world. Studies of transgenic animals (the FAT-1 mouse) provided further support for the concept