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The Changing Epidemiology Of Malnutrition In A Developing Society

The Effect Of Unforeseen Factors

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While much of the improvement in the nutritional status of the population in developing societies may be attributable to the progressive eradication of poverty and removal of socio-economic disabilities, not all changes can be explained on this basis. The changing epidemiology of nutrition-related diseases is sometimes due to fortuitous or unforeseen factors incidental to the developmental process. In this presentation, four classical nutrition-related diseases – namely, pellagra, lathyrism, flourosis and goitre – the epidemiology of which has dramatically changed, have been discussed. The change in respect of each of these diseases has been brought about not necessarily because of steps deliberately designed to remove socio-economic inequalities leading to better nutrition, but due to the intervention of unforeseen factors unleashed by the developmental process.

BENEFICIAL EFFECTS

Experience with the first two of these diseases, that is, pellagra and lathyrism, would exemplify the fact that the epidemiology of nutrition-related diseases can be substantially influenced by changes in pattern of food grain availability following the introduction of new food-production policies. The market forces thus generated could bring about major changes in dietary practices that could dramatically alter the course of nutrition-related diseases. Though the Green Revolution – wherein the emphasis was all on the augmentation of production of wheat and rice – had resulted in substantial increase in the per capita availability of these major cereals, production of pulses and legumes – which contribute to the nutrient quality of cereal-based diets – lagged behind, resulting in a substantial reduction in the per capita availability of these latter food grains. The per capita availability of 'coarse grains' (millets) had also suffered relative neglect (Fig 1, 2). The resulting distortion in the pattern of food grain production was in turn reflected in the relative market prices of these food grains. The market prices of pulses and legumes, which were at one time less expensive than rice and wheat, have now shot up to levels which make it virtually impossible for the poor to achieve adequate access to these foods. The price differential between coarse grains (millets) on the one hand and rice/wheat on the other has also altered to the disadvantage of the former. The near disappearance of pellagra and lathyrism can be attributed to these effects of the Green Revolution.

DISAPPEARANCE OF PELLAGRA

The classical nutritional deficiency disease, pellagra, with a worldwide distribution, has been known since the beginning of this century.

Goldberger's classical work[1] served to demonstrate the association between consumption of maize and pellagra. The low content, in maize, of the essential amino acid tryptophan, the precursor of nicotinic acid, has been held responsible. While the disease has been practically unknown in the rice belt of Asia, in the rural area of the rocky Deccan plateau of India, it was found to be common among the adult population, accounting for 1 per cent of all and hospital admissions in general hospitals of Hyderabad and 8-10 per cent of all admission to mental hospitals in the city in 1960s[2]. But this endemic pellagra, seen in the Deccan plateau of India, occurred in populations subsisting not on maize, but on the millet sorghum (jowar); which is not poor in tryptophan. This observation ran clearly counter to the well accepted view that pellagra was invariably a disease of maize eaters.

A feature common to both maize and sorghum is the high content of the amino acid leucine. Studies carried out at the National Institute of Nutrition, Hyderabad[1], showed that excess leucine in poor sorghum diets could bring about significant changes in key enzymes in the tryptophan-

CONTENTS

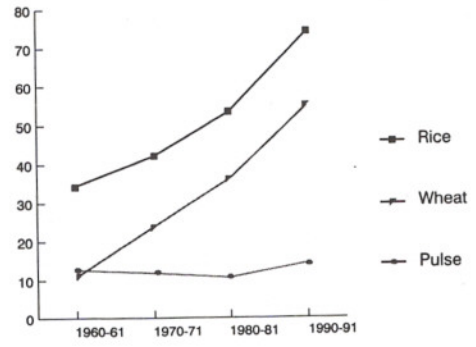
niacin pathway resulting in the inhibition of nicotinamide-nucleotide formation from dietary tryptophan leading to conditioned deficiency of nicotinic acid[3,4,5,6].

Thus, the Indian studies had shown that pellagra was not exclusively confined to maize eaters but could also occur in sorghum eaters among whom excess of leucine and deficiencies of pyridoxine and nicotinic acid may play a part.

These findings regarding the pathogenesis of pellagra among the sorghum eaters of the Deccan plateau of India apart, for the purpose of the present discussion, the important observation is that pellagra, which was once rampant in this part of India, is now extinct from these very areas. This extinction has been brought about not by any specific vertical intervention programme consisting of supplementation of nicotinic acid/pyridoxine, but by unforeseen factors incidental to the development process.

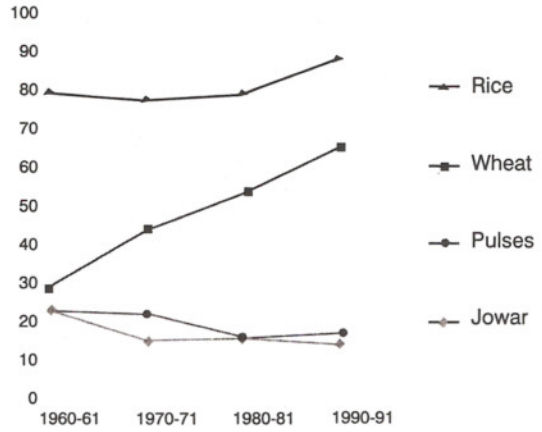
The major factor responsible for this near extinction has been the striking decline in the consumption of jowar in the region even by the poor. Rice and wheat have now displaced jowar as the staple and there has been a marked change in dietary practices. This change has been brought about by the fact that the production of jowar, just as the production of all so-called coarse cereals in the country as a whole, has remained either static or has decreased, while the production of rice and wheat has shown a substantial increase. The per capita availability of jowar, unlike that of rice and wheat, has declined and the striking differences in the price of jowar and rice which prevailed in 1960s has now practically disappeared. Rice and wheat enjoy greater social prestige than jowar (the erstwhile staple of the poor) and are, therefore, preferred even by the poor. Moreover, in recent years, rice is being offered at highly subsidised prices to low income groups, especially in Andhra Pradesh where pellagra was once prevalent. Thus, the extinction of the disease has not been brought about through deliberate efforts to change dietary habits or through specific programmes but through unforeseen factors generated by development, notably, the Green Revolution and consequent changes in the pattern of food production and availability.

FIGURE 1
Production of Rice, Wheat and Pulses from 1960-90 (million tonnes)



Source: Agricultural Statistics at a Glance. Directorate of Economics and Statistics, Ministry of Agriculture, GOI, 1998.

FIGURE 2
Per Capita Availability of Rice, Wheat, Pulses and Jowar from 1960-90 (kg/person/year)



Source: Agricultural Statistics at a Glance. Directorate of Economics and Statistics, Ministry of Agriculture, GOI, 1998.

DISAPPEARANCE OF NEUROLATHYRISM

Neurolathyrism characterised by spastic paraplegia, affecting the lower extremities, has been endemic in parts of Central India in areas where diets are predominantly based on the pulse Lathyrus sativus. The first clinical description of an epidemic of lathyrism in India was given by General Sleaman in 1844[7]. The disease had taken a heavy toll among poor agricultural labourers of Central India for nearly two centuries. The toxic factor in the pulse responsible for the disease was identified as BOAA (B-oxalyl aminoalanine)[8,9]. A simple household method by which the toxins can be removed from the seed by soaking them in hot water for about 15 minutes or by parboiling the seed in a process similar to the parboiling of rice, was also developed. Agricultural scientists in India and Canada had made attempts to identify and selectively propagate genetic strains of Lathyrus sativus low in BOAA.

It was the practice of the rich farmers of the region to pay wages to their bonded labourers in the form of Lathyrus sativus. As early as in the year 1907, the enlightened ruler of Rewa had issued a proclamation banning this practice, but this well-intentioned edict was successfully thwarted by vested interests.

Subsequently, attempts to ban the cultivation of Lathyrus sativus could also not succeed, because Lathyrus is a hardy crop which could be grown easily even on unirrigated land. While the seeds of the plant had become the established staple diet of the poor, the shoots provided fodder for the cattle. Thus, Lathyrus sativus had become strongly entrenched in the agricultural economy of the region, and alternative para-crops which could displace Lathyrus in the region could not be identified and propagated.

On the basis of several studies conducted by us, a four-pronged strategy for the prevention and control of neurolathyrism was suggested:

- Educating the poor community to avoid using Lathyrus sativus as the sole staple diet and to use it only in small quantities, if at all, in admixture with cereals and millets.
- Persuading the community to parboil the seeds before cooking them,
- Dissuading landlords from paying

their labourers' wages in the form of Lathyrus.

- Encouraging agricultural scientists to identify and selectively propagate low BOAA strains of Lathyrus.

Though attempts were made to implement this strategy, the programme could not make much headway in the face of resistance by affluent vested interests on the one hand, and apathy and lack of cooperation on the part of the poor, on the other. The efforts of agricultural scientists to develop low toxin strains did not yield expected results.

Despite this, the gradual decline and the eventual virtual disappearance of the disease by the late 1980s was indeed a surprising and paradoxical development. The striking finding was that the contract agricultural labourers, unlike in the past, were no longer getting Lathyrus sativus in lieu of their wages. Instead, they were getting either money or wheat and other millets. Available figures indicate that the cultivation and total production of Lathyrus sativus in the endemic region had not declined despite an official ban which exists on paper. The nagging questions were: Why was Lathyrus sativus no longer being used to provide wages to the agricultural labourers by the traditionally greedy landlords? If Lathyrus sativus was not being consumed locally by the poor and the affluent, what was really happening to the Lathyrus which was, if anything, being increasingly cultivated? A re-visit to Rewa, the traditional home of the disease, provided the answers.

Lathyrus sativus was the cheapest and the most inexpensive food item in earlier years and was then much less expensive than wheat or rice. But by the 1980s, Lathyrus had become a relatively costly commodity. Its wholesale price, which was just Rs 47 per quintal in 1964-65, had shot up to Rs 270 per quintal – as against Rs 170 per quintal for wheat – even by 1980. Today the price differential between Lathyrus and wheat is even higher. The price of Lathyrus sativus per quintal is even higher than that of wheat. Thus, Lathyrus sativus, far from being a weed growing on the wayside to be freely dispensed to the poor, has now become a precious commodity well beyond the reach of the poor and far more expensive than wheat or rice. It was no longer a profitable proposition for the landlords to pay wages to their labourers in the form of Lathyrus – they were forced to switch over to wheat.

When the wholesale prices of cereals and of pulses are compared for the period 1955-81 (Table), it will be seen that till about 1960, the wholesale price of wheat was higher than that of pulses. However, in the wake of the Green Revolution and with the intensification of cereal cultivation relative to pulses, the per capita availability of pulses declined markedly. Naturally, the prices of pulses soared and since the mid-1960s they have continued to exceed the price of wheat. Adulteration of pulses such as longer Bengal gram with a hardy pulse crop such as Lathyrus sativus, which grows even on unirrigated land has, therefore, become an attractive proposition. Thus, the Green Revolution has had the unforeseen effect of changing the entire course of lathyrism.

TABLE
Wholesale Prices of Wheat and Pulses in India (Rs/quintal)

Year	Wheat	Bengal Gram	Red Gram	Black Gram	Green Gram
1960	41.2	35.7	50.3	48.8	53.1
1981	162.5	351.5	442.5	291.6	384.2

Source: The Lathyrism Problem, Current Status and New Dimensions, NFI Scientific Report 2, 1983.

Evidently, the poor landless labourers were being 'saved' from the poisonous seed not because of the researches and educational programme of the last two decades, but solely due to the intervention of market forces. The very greed and profit motive of the landed gentry, which for centuries was responsible for the perpetuation of neurolathyrism among the poor in Rewa, has apparently helped to redeem the poor by putting Lathyrus sativus out of their economic reach.

DELETERIOUS EFFECTS

The two other classical nutrition-related diseases, that is iodine deficiency and fluorosis, give good examples of how well-intentioned developmental programmes could aggravate and deleteriously alter the course of a disease.

CHANGING COURSE OF IODINE DEFICIENCY DISORDERS

Iodine deficiency disorders in India had been traditionally considered to be a disease state predominantly confined to the sub-Himalayan hilly regions of the country. Huge pendulous goitres and frank cretinism have been reported from the vast sub-Himalayan belt of the country. Goitre has also been reported from the hilly areas of South East Asian countries such as Thailand, Myanmar and Indonesia. With the institution of the programme of iodisation of common salt, the disease had shown signs of substantial regression in these countries since the 1970s.

Since the 1980s, however, a change in the epidemiology of the disease has become noticeable not only in India but in other South Asian countries as well[10]. The iodine deficiency problem in India seems to have now invaded the irrigated plains and is no longer confined to the hilly regions of the sub-Himalayan tract alone. The goitre that is now widely seen in the irrigated plains is certainly not of the huge pendulous variety but often manifests as a low-grade enlargement of the thyroid gland. Using radioimmunoassay techniques, Kochupillai[11] provides evidence of widespread neonatal hypothyroidism in several thousands of new borns in the plains of India.

The important question for our present purpose is: what are the factors that have led to the changing epidemiology of goitre and its emergence in new areas hitherto not known to be goitre endemic.

The possibilities that need to be considered in the context of the emerging evidence are:

- Intensive irrigation involved as part of the agricultural technology following the Green Revolution has resulted in soil alkalinity and depletion of soil micronutrients. Efforts at correcting this through periodic soil testing and soil repletion have been tardy. Depletion of soil iodine is part of this problem

and is reflected in the diminished content of iodine in foods and water. Thus, data from National Institute of Nutrition (NIN), Hyderabad have shown that the average iodine content of water from goitrous areas is 3-16 μg/l as against 5-64 μg/l in non-goitrous areas. Iodine content in foods could be as low as 173-265 μg/day. The extensive loss of iodine from the soil is also attributable to intensive multiple cropping. The intensive cultivation of such crops as sugarcane and the resulting loss of iodine from the soil caused by the considerable biomass generated are factors contributing to this loss.

- Fertilisers, pesticides and food additives now widely used could be expected to inhibit iodine utilisation.

- Increased urinary thiocynate levels in endemic areas, in the face of seemingly adequate levels of urinary iodine excretion have raised the possibility of excessive ingestion of goitrogens which may be expected to interfere with the utilisation of iodine by the thyroid gland. Such goitrogens could either be of dietary origin or could be in the nature of food contaminants in the environment. Goitrogens have been reported from a wide range of plant foods. The question that has to be decided is whether the concentrations of goitrogens in plant foods, which have been known for a long time, have increased in recent years following the institution of modern intensive agricultural technology? Has the heavy use of fertilisers and the new farming procedures now in vogue contributed to the increased uptake and generation of goitrogens in plant foods? Increased urinary thiocynate levels in some endemic areas point to this possibility.

CHANGING COURSE OF FLOUROSIS

Fluorosis was first described in India by Shortt, *et al*[12] more than 60 years ago. The disease had been recognised as an endemic problem in parts of the Punjab, Andhra Pradesh, Karnataka, Rajasthan and Uttar Pradesh. The primary cause of endemic flourosis had been established to be excessive intake of the element fluoride. Since food items do not contribute much fluoride, it is the amount of fluoride ingested through drinking water that determines the risk of flourosis. However, it is known that other factors in the food influence the susceptibility to flourosis. Thus, flourosis is more common among millet (*jowar*) eaters than among rice eaters, and the presence of vitamin C and calcium in the diet also appears to be an important determinant[13].

In children, fluoride toxicity primarily affects the teeth (dental flourosis). In adults, the bony skeleton, ligaments and tendons are affected. The central pathological process is excessive formation of bone and inappropriate calcification of soft tissues. The subjects afflicted with the disease often suffer from spinal deformities and poker backs and are quite often disabled.

While these clinical manifestations were well recognised, a new and serious dimension to the problems of skeletal flourosis suddenly emerged in the mid-1970s. NIN, Hyderabad, then discovered that in parts of Andhra Pradesh, which were long known to be endemic for flourosis, a large number of adolescents and young adults had developed marked degrees of *genu valgum* or 'knock knees' of a form so severe that it incapacitated them. This was an entirely new development seen for the first time in areas where formerly only the classical form of skeletal flourosis was seen in older men[14,15]. In 28 villages belonging to the endemic areas that were surveyed by the NIN team, as many as 600 (2.8 per cent) out of 21,000 subjects surveyed, had this striking deformity. There was also a wide variation between villages with prevalence ranging from as low as 0.2 per cent to 17 per cent. In some villages, almost all the youth were affected.

A series of interesting studies revealed that this new aggravation of an old disease was related to the construction of the large Nagarjunasagar Dam which impounds large amounts of water. The dam had been hailed as a major developmental project which had extended irrigation facilities to a vast, dry and arid area. As part of the developmental effort and in order to mobilise and harness water resources for the increasing population, large dams are being constructed in several developing countries. There is now evidence that in some cases, these well-intentioned efforts could have deleterious consequences. The impounding of water by huge dams could bring about changes in subsoil water levels and in soil chemistry. The sequence of events leading to the new manifestations are stated briefly: Following the construction of the dam and the impounding of large quantities of water, there was an elevation of levels of subsoil water in the dam vicinity and the rise of soil alkalinity which influences the concentration of trace elements in food grains grown in that area. The concentration of molybdenum in food increases and, in view of the well-known antagonistic relationship between molybdenum and copper, leads to copper deficiency and facilitates bone deformities.

Most importantly, fluoride content in subsoil water and in foods grown in the area had also increased. Thus, *genu valgum* afflicting young adults emerged as a new phenomenon, consequent to the construction of the Nagarjunasagar Dam.

Here, then, is an instance of an unforeseen ecological repercussion of a well-intentioned development programme which was envisaged as an unmixed blessing that would help irrigate vast tracts of land and help grow more food.

This experience in Nagarjunasagar has again been repeated in another part of the country, though not because of the construction of a dam but because of another development programme.

The growing population pressure and the resultant scarcity of drinking water in the country has now led to the policy of providing tube-wells, so that a water source is available within a distance of 200 m of any household (100 m in hilly areas). Millions of tube-wells have been thus provided during the last few decades. Tube-wells were also preferred because of the widespread contamination of surface water with water-borne micro-organisms responsible for cholera and hepatitis. Tube-wells have no doubt contributed to the elimination of water-borne diseases in quite a few areas. However, in some areas where the aquifer is surrounded by fluoride-contaminating earth – cryolite, calcite, fluorospar and mica – the water from the tube-well is contaminated with excess fluoride. Thus, all tube-wells are not safe from the point of view of fluorosis in situations where tube-well water is rich in fluoride, it has become necessary to resort to surface-water sources, after proper

treatment of such sources. In areas where excess fluoride has not been detected, an aggravation of fluorosis has been observed.

An epidemiological survey carried out in village Tilaipani, in district Mandla of Madhya Pradesh, has revealed a high prevalence of *genu valgum* (51.1 per cent) and dental fluorosis (74.4 per cent) among children below 20 years, while 16.3 per cent of the children below 10 years were also affected with fluorosis[16]. This is again a relatively new development. While in the Nagarjunasagar area of Andhra Pradesh, the construction of a large dam started the chain of events leading to the aggravation of fluorosis, at Mandla in Madhya Pradesh, fluorosis had become aggravated due to the digging of deep bore-wells (more than 42 m deep), and large-scale consumption of water from such deep bore-wells as against surface wells which were in vogue earlier. The first cases of lower limb deformities were observed two years after the first tube-wells were dug. Thereafter, within a span of three years, the number of cases increased in quick succession to reach the present magnitude of 51.1 per cent for *genu valgum,* and 74.4 per cent for dental fluorosis among children below the age of 20 years.

Incidentally, deep tube-wells have also been found to be responsible for the outbreak of arsenicosis in the Malda district of West Bengal[17].

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Diseases, apparently, have natural histories of their own. Like empires and civilisations, they rise, reign for some time, and then fall or change their course. Scientists can often take credit for the decline of several diseases such as, say, smallpox. In some cases, however, the disappearance or changing course of diseases, once rampant, cannot be attributed to scientific intervention deliberately designed to contain them.

Pellagra and lathyrism, as was pointed out above, had disappeared not because of solutions offered by scientists, but because of unforeseen factors unleashed by the developmental process. Diseases such as goitre and fluorosis have changed their epidemiology again because of unforeseen factors unleashed by developmental programmes.

As we move into the next millennium, new discoveries and initiatives are bound to find application as part of ongoing 'development'. Some of these may have unforeseen effects, sometimes beneficial and sometimes even not. Scientists are not always the masters of human destiny and of the environment. This must be a sobering thought. They must be vigilant to monitor the effects of new interventions in a fast changing world on the health status of populations and on the course of diseases that affect them.

Based on excerpts from the J.C. Bose Memorial Lecture delivered by the author under the auspices of the Royal Society/Indian National Science Academy, in London on November 5, 1998.

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NUTRITION NEWS

• To felicitate Dr C. Gopalan on his 80th Birth Anniversary, the following programmes were held:

At the *Nutrition Society of India,* National Institute of Nutrition, Hyderabad.

Plenary Lecture by Dr M.S. Swaminathan on 'Food Security in India in the 21st Century' on November 26, 1998.

Symposium on 'Frontiers in Nutrition Science' on November 27. Participants included Dr W.P.T. James, Dr P.S. Shetty, Dr Enas E. Enas, Dr Ghafoorunisa, Dr Kraisid Tontisorin, Dr Cecelia Florentio, Dr B. Sivakumar, Dr Kochupillai and Dr Kamala Krishnaswamy.

XXIInd Gopalan Oration by Dr Artemis P. Simopoulos on 'Genetic Variation and Dietary Response'.

At *Nutrition Foundation of India:*

Symposium on 'Science for Human Resource Development', on December 3, 1998. The participants included Dr R.A. Mashelkar, Director General, CSIR and Secretary, Department of Scientific and Industrial Research, Government of India, Dr S. Padmavati, Dr B.N. Tandon, A.S. Paintel, Alan Court and Dr A.K. Susheela.

• The XXVth Kamala Puri Sabarwal Lecture was delivered by Dr Rajammal P. Devadas, Chancellor, Avinashalingam Deemed University, on 'The Role of Women in Preventing Post Harvest Losses'. It was held on December 4, 1998, in Lady Irwin College, New Delhi.