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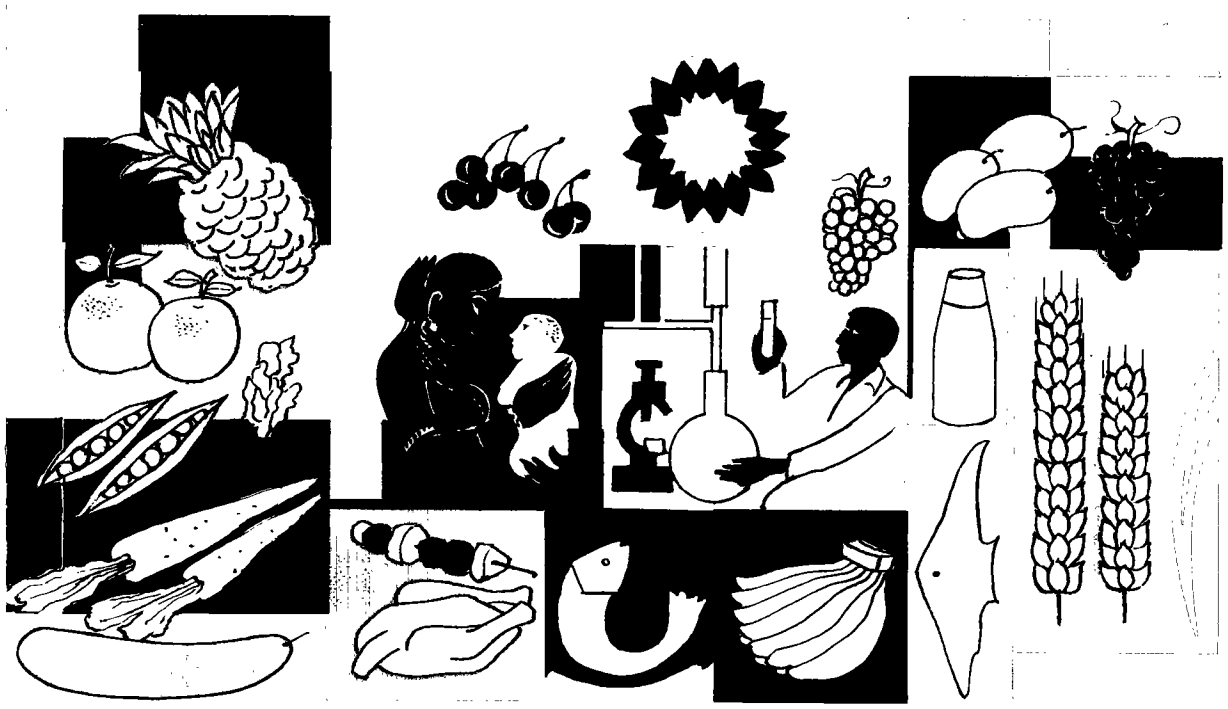
NUTRITION RESEARCH IN SOUTH-EAST ASIA

The Emerging Agenda of the Future

Dr C. Gopalan



World Health Organization
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New Delhi, 1994

About the Author

Dr C. Gopalan, the author of this publication, has been engaged in the study of nutritional problems among the poor communities for over four decades. After graduating in medicine and acquiring the M.D. degree in General Medicine from the Madras University, he obtained Ph.D. and D.Sc. degrees from London University, and fellowships of the Royal Colleges of Physicians, London and Edinburgh. He was Deputy Director, National Institute of Nutrition (then Nutrition Research Laboratories, located in Coonoor) from 1950 to 1960, and Director, National Institute of Nutrition, Hyderabad, from 1960 to 1974. Under his directorship, the Institute witnessed considerable expansion and came to be recognized as a leading centre of nutritional research and training not only in India but also in the world.

From 1974 to 1979, Dr Gopalan was Director-General, Indian Council of Medical Research, in which capacity he was responsible for the direction and management of medical research in the country.

Dr Gopalan has been on the WHO Expert Panel on Nutrition almost continuously for over 30 years. He was the President of the International Union of Nutritional Sciences and the first Chairman of the WHO South-East Asia Regional Advisory Committee on Health Research, for five years, and Member of the Global Advisory Committee on Health Research of WHO. He was Chairman of the Technical Discussions on Nutrition of World Health Assembly in 1977.

Dr Gopalan founded the Asian Congress of Nutrition series and was the President of the first Asian Congress, held in Hyderabad in 1970. He is the founder of the Nutrition Society of India.

He is a Fellow of the Royal Society of London and a Fellow of all the leading Science Academies in India.

He is the author of over 200 papers on nutrition, published in journals in India and abroad, and the recipient of a number of awards and prizes.

Dr Gopalan is currently the President of the Nutrition Foundation of India.

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The Emerging Agenda of the Future

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Foreword

THIS IS the third book that the WHO Regional Office for South-East Asia has been publishing with technical contributions of Dr C. Gopalan in the last decade. The three can be considered as a trilogy providing an intellectual and scientific basis to nutrition planning in South-East Asia.

The first book, Nutrition Problems and Programmes in South-East Asia (Regional Health Paper, SEARO, No. 15), reviews experiences, country by country, draws general lessons and makes recommendations in the context of overall development.

The second book is entitled Nutrition in Developmental Transition in South-East Asia (Regional Health Paper, SEARO, No. 21). It carries the analysis further and examines the impact of the developmental transition that is occurring in nutritional status – present and projected – in all regional countries. It proposes strategies for an effective response to what is seen as a combination of old and new nutrition problems in South-East Asian countries arising from continuing and accelerating changes in economies, population distribution and structure, environmental conditions and cultural influences.

The present book – the third in the series – carries the analysis of needs into the domain of research. It argues, rightly, that research performed by regional scientists and carried out in the Region must include contributions to the growth of scientific understanding of nutrition as well as research on the best means to apply knowledge in programmes. To limit regional research to the latter would be counter-productive, both for programmes and for development itself in the Region and the world at large.

WHO gives priority to research of relevance to primary health care and focuses on the support of health systems research. However, the range of nutrition is broad and covers many aspects of life while its focus is deep

and encompasses many disciplines. The need for good, relevant research in nutrition is great; so I hope and trust that this publication will lead to research support for nutrition from a comprehensive partnership.

Over the decades, institutions in the Region have assembled an impressive array of skills and experience in nutrition research and implementation. In the past few years, mechanisms of collaboration in sharing solutions to our problems have developed – the South-East Asia Nutrition Research-cum-Action Network is a good example. I hope and expect that this book will be a major contribution to relevant and comprehensive research that will lead to an amelioration of our existing nutrition problems and the prevention of those that may arise from the demographic, environmental and human changes that are already upon us.

Dr U Ko Ko
Regional Director

Preface

IN THIS publication, an attempt has been made to present, in broad outline, a possible agenda for nutrition research in the countries of South-East Asia for the turn of the century. The countries considered here are Bangladesh, India, Indonesia, Maldives, Myanmar, Nepal and Thailand. All of them fall in the South-East Asia Region (SEAR) of the World Health Organization (WHO). I am most grateful to Dr U Ko Ko, Regional Director, WHO South-East Asia Region, for entrusting me with this assignment.

This publication is the third in the series of publications on nutrition prepared by me for WHO (SEAR) during the last six years. The first of these was a critical review of the "Nutritional Problems and Programmes of the Region"; the second a consideration of "Nutrition in Developmental Transition in South-East Asia".

The present publication deals with some of the major nutrition and nutrition-related research issues that may need special attention in the coming decades. This is by no means an exhaustive list of all items of a future nutrition research agenda. It would have been presumptuous to have even attempted to draw up such an exhaustive list. What is presented here is an illustrative list of major items that may need attention.

The two major considerations in the choice of subject areas for research have been: (1) that the subject is of major public health importance, and (2) that it presents some unresolved or newly-emerging issues that require elucidation.

The book has been organized under three sections. The first section, which sets out the "General Considerations", provides, as it were, the backdrop to this publication. It sets out the considerations which influenced the choice of items of a future nutrition research agenda for the Region.

Section II, which is the main body of the book, presents examples of major scientific areas that could form the subjects of research in the coming decades. In each chapter of this section, the available scientific information with respect to the area under discussion has been briefly reviewed and the unanswered questions that appear to await elucidation have been highlighted. Each chapter ends with a short note mentioning the specific issues for research.

Chapters in this section fall into two broad categories. The first five chapters deal with problems of undernutrition that are already receiving attention. With respect to these, the new dimensions that merit research are discussed. The latter chapters deal largely with areas of emerging importance which have not as yet received adequate attention from nutrition research scientists of the Region.

Section III, the final chapter, discusses issues related to the organization, management and implementation of a meaningful programme of nutrition research in the Region. It seeks to refer to some basic ingredients of the infrastructure that would be needed for future nutrition research.

I wish to thank Dr U Ko Ko for giving me this opportunity and for the courtesy that he extended to me. Dr Aung Than Batu, Director, Research and Human Resources, SEARO, gave me all the support and help I needed for this task and I am grateful to him as also to Dr J.M. Gurney, Regional Adviser in Nutrition, SEARO.

As part of this assignment, I visited major institutes in Thailand and Indonesia, and the National Institute of Nutrition Hyderabad, India. I greatly benefited by the extensive discussion with scientists of these institutions and I am deeply grateful to all of them. I am specially thankful to Dr Darwin Kariyadi, Dr Krasid Tontisirin and Dr Vinodini Reddy, Directors of the three major nutrition research institutes, for all the help that they and their staff extended to me.

C. Gopalan

CONTENTS

List of Tables

List of Figures

Section I

GENERAL CONSIDERATIONS

1. THE CHANGING NUTRITION SCENE IN SOUTH-EAST ASIA

THERE have been remarkable changes in the nutrition scene in the countries of South-East Asia – Bangladesh, India, Indonesia, Maldives, Myanmar, Nepal and Thailand (referred to as SEAR in this book) during the last few decades. These changes will necessarily have a bearing on the pattern of future nutrition research in the Region. In this chapter, these changes and their possible impact on future nutrition research in the Region will be briefly considered.

Historical Aspects

The end of the Second World War was, in many ways, a watershed in the history of the countries of SEAR – not just in the narrow political sense, but also from the point of view of their socioeconomic development. With the attainment of political freedom, the countries of the Region embarked on ambitious programmes of socioeconomic development. Despite resource constraints and competing sectoral claims for priority, programmes for the promotion of the health and nutritional statuses of the populations did find considerable support. This has been reflected in the steady decline in mortality rates and in the progressive increase in life-expectancy – more striking in some countries than in others.

Investments in nutrition action programmes and in nutrition research have been quite impressive. While basic research on human nutrition and on nutrition-related health problems has been steadily promoted through well-equipped national institutes of nutrition, agricultural research designed to augment food production has also received generous support. The National Institute of Nutrition, Hyderabad, India, with a long history and tradition of nutrition research, the Nutrition Research Institute at Bogor, Indonesia, and the Institute of Nutrition at Mahidol University, Bangkok, are examples of leading nutrition research

centres of the Region with outstanding contributions to their credit. Active research on nutrition has also been undertaken in Bangladesh, Myanmar, Sri Lanka and Nepal.

Agricultural research scientists of the Region have also helped to make the Green Revolution the success it has been. Food technology institutes and the chain of home science colleges have contributed their share towards the promotion of better food conservation and consumption practices.

More than four decades have now elapsed since the countries of the Region embarked on this developmental journey. Though the problems of ill-health and undernutrition in these countries have by no means been completely overcome, there can be no doubt that substantial progress has been achieved.

Elimination of famine

The prophets of gloom of the 1960s and the early 1970s, who predicted large-scale famines and pestilence, have been proved wrong. Despite phenomenal population growth, food grain production, by and large, has more than kept pace with population growth, thanks to the Green Revolution, and there has at least been no decline in the per caput food grain availability – by no means a small achievement. Large-scale famines of the type that used to decimate vast sections of populations with distressing periodicity have been eliminated. Buffer stocks of food grains are now available in most countries, and, with improved early-warning systems, food can now be rushed to areas of anticipated scarcity. This is not to deny that there are still pockets of chronic hunger, aggravated by natural disasters such as floods and droughts. But large-scale famines have been eliminated in SEAR. In this respect, the Region is in a more fortunate position than some of the Sub-Saharan countries of Africa.

Decline in florid nutritional deficiency diseases

Several major nutritional deficiency diseases, which were once public health problems, have been either totally eliminated or considerably reduced. Thus beriberi of the cardiac and dry types, and pellagra have been almost totally eradicated. Keratomalacia, which was a major cause of nutritional blindness in some countries of SEAR over 40 years ago, has reached vanishing point, and although cases do still occur in extremely deprived pockets, the disease is no longer the public health problem that it once was. In the hierarchy of major nutritional problems currently besetting SEAR, vitamin A deficiency perhaps stands fourth in the order, with anaemia, protein-energy malnutrition (PEM), and

goitre being far more widespread. Kwashiorkor of the classical blubbery type has become rare, and the incidence of cases of "severe" PEM has been halved.

When this scenario of today is compared with the vastly different one observed over 40 years ago, the magnitude of the success on the "nutrition front" will be obvious. It is important to emphasize this point because this is not often recognized.

Contribution of nutrition research

Nutrition research in the Region has made valuable contributions not only towards the elucidation of the pathogenesis of major nutritional diseases of the Region but also towards identifying practical ways by which these can be eliminated. This became possible because nutrition researchers of the Region have, by and large, addressed problems right at their own doorsteps, without being unduly swayed and swept away by the "fashions of the moment" elsewhere; and they have tried to identify sustainable solutions to their problems in consonance with their respective national needs and resources. In this process they have also succeeded in making significant contributions to the growth and development of nutrition science. The South-East Asia Regional Office of the World Health Organization (WHO/SEARO) has made notable contributions towards strengthening institutional capabilities and towards the promotion of nutrition education training and research in the Region.

In its publication "Health Research Strategies of the South-East Asia Region", 1993, WHO/SEARO emphasized that the overall objectives of health research are to generate and apply knowledge that will contribute towards the attainment of the goal of Health for All through Primary Health Care. The four broad strategies that were enunciated for this purpose in the publication were as follows:

- Research should be related to the eight elements of primary health care and researchable areas should be identified and prioritized within the framework of the eight elements of primary health care;
- The types of research should be given differential emphasis with the main emphasis being on health systems research;
- The health research system should be developed as a whole and linked to the health care system; and
- Intersectoral research and research beyond the health domain in matters affecting health is to be promoted.

Nutrition research efforts in the Region have generally conformed to this approach.

It is not necessary for our purpose here to review the successes and achievements of nutrition research in the Region but some outstanding contributions which have had profound practical significance may be briefly mentioned. What is particularly noteworthy and creditable is that some of these contributions, at the time they were originally made, ran counter to the then prevailing opinion. The fact that they had to sail against the prevailing current did not deter the scientists of the Region from persisting with their efforts. Thus, for example, at the height of the "protein controversy", when special protein-rich concentrates, such as fish-protein concentrate, were being promoted as the right solution to the PEM problem, scientists of the Region argued that the problem of PEM, at least in SEAR countries, was largely and primarily a problem of calorie deficiency. They also argued that, if conventional habitual cereal-legume-based diets of the Region could be provided in amounts adequate to meet the energy needs of the populations, the protein needs would also be largely met. This approach has had far-reaching practical significance. With respect to other major nutritional problems, such as vitamin A deficiency, anaemia (iron fortification of common salt), goitre (neonatal hypothyroidism) and lathyrism (discovery of the toxic alkaloid β-N-oxalyl amino alanine (BOAA)) and fluorosis, scientists of the Region have also made pioneering contributions.

Lessons for the future

The decline of major nutritional deficiency diseases in the Region during the last four decades has some major lessons for the future – for public health administrators and nutrition scientists all over the world.

One thing that can be stated with certainty is that the decline of these diseases did *not* come about because of specific (vertical) isolated "intervention programmes". Thus, beriberi and peripheral neuritis, which were once rampant in India, were not contained and overcome because of any programme of large-scale public distribution of synthetic vitamin B_1 to populations in endemic areas. Similarly, pellagra was not overcome through a programme of nicotinic acid (or tryptophan) distribution. Nor can the steep decline of keratomalacia be attributed to a programme of distribution of massive oral doses of synthetic vitamin A. Though such a programme did exist in some parts of India, it was later proved to have been too poorly implemented to have made any significant impact, and, in any case, the programme did not reach more than 15 per cent of the target groups in any state. Likewise, the decline of kwashiorkor cannot be attributed to the distribution of fish-protein concentrates, then promoted by some groups, or to lysine fortification of wheat, strongly advocated by some experts. Indeed, there is no evidence anywhere in global literature that any major nutritional

deficiency disease, barring iodine deficiency goitre, has been eliminated by the distribution of just a single nutrient to the afflicted population.

The near total disappearance, within the last four decades, of florid nutritional deficiency diseases which were once major public health problems in the Region, is a remarkable experience which carries important messages to health/nutrition scientists and administrators of all developing countries. These results are a strong vindication of the validity of the concept of the *integrated* rather than the *isolated* (vertical) approach towards combating undernutrition. It is to the credit of nutrition scientists of the Region that they recognized that improvement in the nutritional status of the people could not be achieved through isolated vertical programmes but only as part of overall improvement in health status. Thus "nutrition" was rightly viewed as just one component of an integrated primary health care package.

Emerging Challenges

The gratifying success with respect to the elimination of famines and reduction in the incidence of florid nutritional deficiency diseases during the last four decades, however, will by no means justify relaxation of vigilance on the nutritional front or diminished emphasis on nutrition research in the Region in the future. Indeed, the challenges that lie ahead will, if anything, prove more demanding.

The decline of florid nutritional deficiency diseases represents no more than the disappearance of the tip of the iceberg. The inputs that will be needed to achieve better "survival" and freedom from florid diseases are far less than those that will be needed to promote better health and better nutrition in the survivors. Countries of SEAR cannot afford to linger too long in this transitional phase of their journeys towards better health/nutrition for their populations. The challenge posed by a rising pool of sub-standard survivors (with impaired stamina, poor productivity and increased susceptibility to infections) has to be met through vigorous programmes for improving the quality of human resources in which nutritional improvement must necessarily be the central focus. Nutrition research of high quality will be needed in order to provide the necessary scientific underpinning for this effort.

The change in the profile of undernutrition described earlier, and the process of developmental transition with such attendant sequels as urbanization, industrialization, population growth and ageing, will naturally call for consequential changes in priorities and strategies with respect to nutrition research. If nutrition research in the future has to retain its relevance and importance, the nutrition research agenda of the future must fully reflect the changing needs. There will also be a need for changes with respect to management of nutrition research.

These emerging challenges which nutrition research of the future has to address will be briefly considered.

Factors of Change

The major factors that have contributed to the changed nutrition scenario during the last four decades will continue to operate with as much, if not increased, intensity in the next few decades as well. These will be briefly recapitulated.

- ***Modern intensive agricultural technology.*** This has contributed to profound changes in soil chemistry, which are beginning to be reflected in the trace element composition of soils and foods. The importance of trace elements in human nutrition, especially in populations such as those of SEAR, which are heavily dependent on plant foods, is now being increasingly appreciated. Zinc deficiency could emerge as a major factor to contend with, and the bioavailability from food of several other micronutrients, including iodine and iron, may be compromised. The trace element composition of foods in general may undergo significant changes, which could call for a review of current recommendations regarding the composition of balanced diets.

- ***Industrialization and urbanization.*** The increasing use of street foods, ready-to-eat foods and processed foods, together with the population explosion, could contribute to increased environmental degradation. Problems of increased food contamination with microbiological and chemical contaminants (some of them carcinogenic) could gain importance. At least some of the contaminants could also aggravate the cancer problem.

- ***Rising affluence.*** The rapid emergence of a newly affluent middle class (prone to dietary excesses and errors) could lead to a further escalation of diet-related degenerative diseases such as obesity, diabetes, coronary heart diseases and hypertension.

- ***Changes in lifestyle and occupation pattern.*** These could bring about further changes in dietary practices and eating patterns of populations. The break-up of joint families and changes in occupation patterns (especially of women) could contribute to changes with respect to child-rearing practices and breast-feeding, which will need to be carefully monitored.

- ***Ageing.*** The changing age structure of populations will bring the nutritional problems of the aged increasingly to the fore.

- ***Biotechnology.*** In addition to the above, new technological advances, especially in the area of biotechnology and genetic engineering, could result in

the development of new foods and food products. While agricultural production could be considerably expanded through achieving enhanced efficiency of photosynthesis, accelerated plant breeding through tissue culture techniques, embryo rescue, protoplast fusion and the use of DNA vectors also holds out immense possibilities. The availability of new foods and food products achieved through genetic engineering could bring about changes in dietary patterns. Some of these may not be beneficial, and all of them will need to be carefully investigated and monitored with respect to their nutritional implications and potential toxicity.

Nutrition Research in the Future

In this chapter, the possible scope and range of future nutrition research is considered in broad outline. In subsequent chapters some specific areas of future nutrition research will be discussed in greater detail.

Problems related to undernutrition

Nutrition research in the past four decades has largely been influenced by the concern to eliminate florid nutritional deficiency diseases, which were of such dimension as to be public health hazards.

As pointed out earlier, several of these problems have now been either totally eliminated or considerably mitigated. Apart from diseases such as beriberi, pellagra and scurvy, which have ceased to be public health problems, significant headway has also been made in tackling the problems of vitamin A deficiency and protein-energy malnutrition.

There are however a few problems, such as iron-deficiency anaemia and goitre and iodine deficiency-related disorders, in which adequate progress has not yet been made in many countries. With regard to the problem of high incidence of low birth weight in infants, the records of the countries of the Region have been mixed – some countries registering significant declines and some not having had much success. Growth retardation in children, a manifestation of general undernutrition in children and in communities in general, is still widespread. Only a minority of children in SEAR can really be considered to have experienced normal growth. This situation therefore calls for a rethinking of research strategies with respect to the problems of undernutrition. With respect to vitamin A deficiency, for example, the old strategy of relying on periodic massive doses of synthetic vitamin A, which was quite appropriate over two decades ago when keratomalacia was a major public health emergency, is no longer valid in the present situation when keratomalacia has ceased to be a public health problem, and when we have instead to deal with milder forms of vitamin A deficiency

affecting not just pre-school children but older groups and women in reproductive ages as well. Our future efforts must be directed towards facilitating and promoting a strategy which will address this changed need.

With respect to growth retardation, research strategies must be directed towards achieving a beneficial secular trend in child growth reflecting progressive elimination of dietary and environmental constraints which are currently inhibiting the growth and development of children. The major bottleneck with respect to growth that was operative earlier, viz., calorie-protein deficiency, may no longer be of major importance. The possible role of deficiency of micronutrients, especially that of zinc (and possibly calcium, especially in the adolescent group), may have to be considered.

Also, attention may need to be devoted not just to physical growth and development but also to psychomotor development, mental development, physical stamina and work performance – aspects that have been relatively neglected in the past.

The subject of growth during adolescence will need special attention in view of the striking differences seen between the patterns of growth in adolescence in countries of SEAR on the one hand, and in industrialized developed countries on the other. Changing trends with rising affluence, such as age at menarche, and changing lifestyles and occupation patterns merit further study. The effect of intensive nutritional supplementation in undernourished children on growth and on the age of onset of menarche also needs investigation.

The persistent high incidence of low birth weight (LBW) in infants of South Asian countries, despite impressive declines in infant and child mortality during the last two decades, is a subject which calls for intensive research. The differences between countries with respect to LBW incidence provide unique opportunities for coordinated research programmes in this direction.

Iron-deficiency anaemia is still widespread. While folate deficiency is an added factor in some countries, it appears that this is not so in Thailand. Since iron-deficiency anaemia is widespread even in children, and since girls who become pregnant are often anaemic to start with, it seems doubtful that the present strategy of supplementation of iron/folate tablets during the last 100 days of pregnancy is the right answer. The development of an alternative strategy calls for appropriate research.

Regarding goitre, there are still practical problems with respect to iodation, such as the stability of iodine in fortified salt, which call for research. Apart from iodation of common salt, which is the preferred strategy, iodation of drinking

water and oral iodinated oil administration have also been suggested for use in selected areas. The validity of these approaches will need to be investigated. The emergence of new areas of goitre endemicity raises important issues. The suggested possible role of goitrogens in foods and the environment in this endemicity, and the poor bioavailability of iodine in foods, also need to be researched.

Research related to emerging problems

The major problems emerging as a result of the ongoing transition are: (1) escalation of chronic degenerative diseases and diseases associated with rising affluence; (2) food contamination arising from increasing environmental degradation, and increasing use of processed foods subjected to unhygienic food processing; (3) nutritional problems related to distortion in trace element composition of foods, and (4) nutritional problems related to ageing.

Cancer, obesity, diabetes and coronary heart diseases have already emerged as important public health problems related partly to dietary factors. Considerable research on these problems is currently being undertaken in developed countries. However, these problems present some special features in SEAR, and they call for special research efforts in the countries of the Region. The profile of cancers in the countries of SEAR is somewhat different. Also, coronary heart diseases and diabetes seem to be less related to a high fat (saturated) diet than to high carbohydrate intake and insulin resistance (syndrome X).

Food contamination attributable to microbial and fungal organisms is a major problem in the countries of SEAR because of lack of sanitation and poor storage conditions. Food contamination attributable to chemicals is now likely to acquire increasing importance because of industrialization, increased use of processed foods and general environmental degradation attributable to population pressure. Research designed to identify potential contaminants and to determine safety limits based on risk analysis will become increasingly important. An effective programme for ensuring food safety/quality must rest on solid data and on a sound research base.

Trace element deficiencies (and excesses) are likely to play increasing roles in nutritional problems of the future. The trace element composition of foods is being steadily distorted because of changes in soil chemistry induced by modern intensive agricultural technology. Feasible methods for the estimation of trace elements need to be developed and propagated. Epidemiological studies on the possible role of trace element malnutrition in major diseases will need to be supported by authentic laboratory data on trace element composition of foods and body fluids and tissues.

Urbanization, which is gathering momentum, will have deleterious repercussions on nutrition; and street-foods and ready-to-eat foods, not always hygienically prepared, will enter into the dietaries of populations, including children. The practice of breast-feeding may be eroded because of changing occupational patterns of women, with consequent deleterious effects on infant nutrition. The study of these problems and the identification of effective strategies to counter them calls for intensive research.

The proportion of the aged in the population will rise in the coming decades, and nutritional problems of the aged will demand increasing attention. Geriatrics is currently a totally neglected field in most of the SEAR countries and needs to be developed. Research on optimal ways of feeding the aged and on ensuring optimal nutrition and productivity for them will gain increasing importance.

Basic research

Hard and fast divisions of research into "basic" and "applied" categories often turn out to be arbitrary. There are some who would argue that poor, developing countries must opt for "applied" rather than "basic" nutrition research, leaving the latter for the more prosperous industrialized countries of the West. This is a wholly counter-productive approach. If the nutrition research laboratories of countries of SEAR neglect basic research, they will be progressively reduced to the status of "field stations" for the testing out of hypotheses and concepts developed elsewhere. Even epidemiological research and field studies directly related to the problems of the Region will require strong scientific underpinning. Such underpinning can only be provided by high-quality basic work in the fields of biochemistry, microbiology, immunology, biotechnology and endocrinology within the Region. High-quality nutrition research has to rest on this strong scientific foundation.

If good quality research is to be fostered, the practice of sending data and tissue samples gathered through field work to foreign laboratories for analysis must stop. Facilities and expertise must be developed locally for such analyses. Even worse is the practice of sending raw data collected through laborious field research to foreign stations for statistical analysis. This practice, which is unfortunately still widely prevalent, must be discouraged in the interests of nutrition research in the Region. This is not to deny the need for collaboration; but for collaboration to be fruitful and meaningful it must be a partnership of equals, sometimes with complementary skills.

The need to nurture local expertise and to promote self-reliance has become all the greater in the context of the growth towards privatization and

commercialization of research, especially in such key areas as biotechnology and genetic engineering, which are of vital importance to the Region's future. In this publication the emphasis is largely on practical public health problems, but good research on these problems necessarily involves a great deal of *basic* research, and this must be supported.

Open-ended research

In the foregoing paragraphs, some major nutritional problems which merit priority in the research agenda have been mentioned. However, perceptions with respect to priorities can vary with time, and research into subjects which currently appear to be of no practical importance could yield information which may be of importance in the future. Truly great discoveries are rarely made through so-called "project-oriented" research where objectives are pre-determined and protocols are rigidly drawn. Excessive regimentation often kills individual initiative and destroys the chances of real discoveries.

It is therefore good policy not to shut out what may be called "open-ended" research, which may not have obvious pre-determined goals that fit in with present-day perceptions. Indeed it may prove rewarding to set apart about 10 to 20 per cent of the available nutrition research budget for such open-ended research. This does not imply that research that is not backed by well-argued research proposals will be supported, but that even research proposals falling outside the priority category could find support provided the proposals are well reasoned and the scientists wishing to undertake the research are well trained and qualified. This is a policy which could enrich nutrition research. Countries of SEAR are certainly not flush with research funds, but even so, national nutrition research policies should provide some room for individual initiatives and for testing out seemingly unconventional approaches and ideas.

* * *

The general considerations that may determine the pattern of nutrition research in the future have been discussed above. In subsequent chapters, examples of major subject areas which could find a place in a future research agenda will be presented.

Section II

NUTRITION RESEARCH AGENDA FOR THE FUTURE

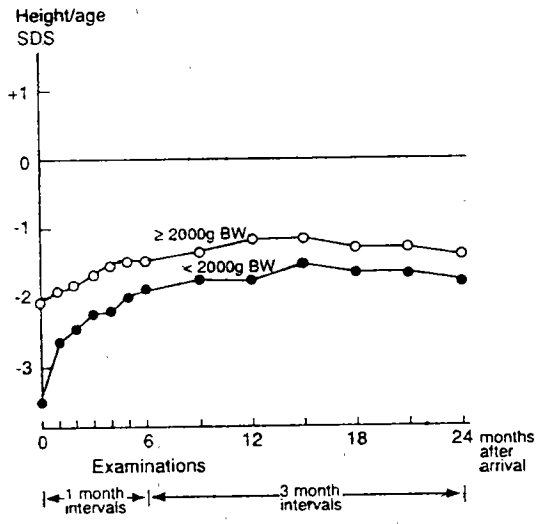
2. LOW BIRTH WEIGHT

THE weight of an infant at birth broadly reflects the quality of its intra-uterine development. Birth weight is an important parameter which could be indicative of: (1) the immediate viability of the neonate, and (2) the state of maternal health/nutrition during pregnancy. From the public health point of view, the mean birth weight in a community may provide a broad indication of the quality of maternal health/nutrition care that is available to it. In monitoring trends with respect to improvements in the quality of antenatal care, birth weights could be a useful criterion.

Low birth weight (LBW) in full-term infants apparently has a significance which extends well beyond the neonatal period. Ghosh's pioneering longitudinal studies[1] have shown that infants with LBW continue to grow in a sub-standard growth trajectory, being worse off from this point of view than infants who start with better birth weights. The weight difference observed at birth between infants with low and with normal birth weight continues right through infancy and early childhood. This pioneering observation has been repeatedly confirmed. Perhaps the most convincing confirmation comes from studies on growth and development of Indian children adopted in Sweden[2]. These studies have shown that, despite the fact that poor Indian children adopted by Swedish parents enjoy the benefits of a good diet and environment after their adoption, there is still a significant difference in height/age at the end of two years between infants who start with birth weights >2000 g and those who start with birth weights of <2000 g (Figure 1). This clearly shows that intra-uterine retardation, as reflected in LBW, has a lasting, deleterious impact on growth, which even good diet and environment cannot entirely reverse.

The recently reported findings of Barker *et al*[3] from England are suggestive of an even more ominous significance of low birth weight. In a remarkable study, which involved 5654 men born in Hertfordshire, England, between 1911 and

Figure 1. Growth curves of infants with birth weights of < 2000 g and those with > 2000 g



SDS = Standard Deviation Scores
Source: Proos, L.A.: Growth and development of Indian children adopted in Sweden. Uppsala University, 1992.

1930, these authors found that the standardized mortality ratio for cardiovascular diseases fell from 125 for men who had weighed 2.5 kg or less at birth to 68 for men who had weighed more than 3.8 kg at birth. Their studies in Preston[4] also showed that subjects who had had low birth weights in relation to the period of gestation were significantly more prone to develop, in later life, "syndrome X" – a combination of hypertension, impaired glucose tolerance, non-insulin-dependent diabetes, low high-density lipoprotein (HDL) levels, hyperinsulinaemia, increased plasma fibrinogen and factor VII concentrations, and abdominal obesity leading to cardiovascular disease. The authors postulate that maternal undernutrition and consequent intra-uterine growth retardation could programme body structure, physiology and metabolism in a manner that increases the individual's susceptibility to degenerative cardiovascular disease in later life.

Whatever the explanation, these observations must be considered to be of great significance in the context of the high incidence of low birth weight in some countries of the Region (e.g. India, Bangladesh and Nepal) on the one hand, and the disturbing evidence for greater proneness of South-East Asians, especially Indians, to diabetes and cardiovascular disease on the other. These observations

indicate that environmental factors (namely maternal under-nutrition and the consequent unfavourable intra-uterine environment) rather than genetic predisposition (as is generally believed) may account for the suspected greater proneness of Indians to diabetes and cardiovascular disease.

Under the circumstances, research designed to identify (1) the factors currently contributing to the high incidence of LBW now prevailing in several countries of SEAR, and (2) the ways by which such high incidence can be reduced, must obviously command high priority. Such research will serve two major objectives of any meaningful national health/nutrition policy, viz, (1) achieving optimal maternal nutritional status during pregnancy in the context of current constraints, and (2) providing a start in life devoid of irreversible handicaps for new generations of infants. There can be no better practical contribution towards ensuring the quality of our future human resources.

Mean birth weight

Data provided by the World Health Organization (WHO)5 show significant differences in mean birth weights of babies in different parts of the world (Table 1).

Table 1. *Mean birth weights in different parts of the world*

Region	Mean birth weight (kg)
North America, Western Europe and Australia	3.5 – 3.6
Eastern Europe	3.1 – 3.3
Africa and East Asia	2.9 – 3.1
South Asia	2.7

Source: Low birth weight: A tabulation of available information, WHO/MCH/92.2, Geneva, 1992.

South Asian countries have the unfortunate "distinction" of being those with the lowest mean birth weight. Also, one-third of neonates in many South Asian countries (Figure 1) are of low birth weight and less than 2500 g at birth.

Low birth weight

Birth weights of less than 2.5 kg are considered as belonging to the low category of LBW. This is currently the generally accepted international criterion[6]. The overall incidence of low birth weight in North America and Europe is far less than in Asia and Africa (Table 2).

Table 2. *Time trends in the prevalence of low birth weight*

Region	Percentage prevalence of LBW	
	1979	1990
Asia	22	21
Africa	15	15
Latin America	13	11
North America	7	7
Europe	7	6
Oceania (excluding, Japan, Australia, New Zealand)	20	20
USSR	8	7
Developing countries	20	19
Developed countries	7	7
Global	18	17

Source: Low birth weight: A tabulation of available information, WHO/MCH/92.2, Geneva, 1992.

Data with respect to LBW incidence in the countries of SEAR are shown in Table 3.

Table 3. *Mean birth weight and LBW in SEAR*

Country	N	LBW (<2500g) Percentages	Birth weight (g) (mean ± SD)
India (1990)	4307	28.2	2633 ± 417
Indonesia (1987)	1647	10.5	2936 ± 415
Myanmar (1981-82)	3582	17.8	2852 ± 469
Nepal (1990)			
Rural	2529	14.3	2787 ± 416
Urban	3629	22.3	2760 ± 498
Sri Lanka (1990)	1851	18.4	2841 ± 458
Thailand	4124	9.6	3004 ± 462

Source: Report of the WHO Expert Committee on the use of anthropometry for women during the reproductive cycle and the newborn infant, 1993.

Some inherent inaccuracies in birth weight data from different countries must be recognized. It is difficult under field conditions, and indeed sometimes even in hospital situations, to record birth weights under optimal conditions. Birth weights may not be recorded till several hours after birth and the recording may not always be accurate. These practical problems may account for discrepancies in available data. There are even greater discrepancies in assessments of the

relative proportions of pre-term and full-term LBW deliveries, because here, apart from inaccuracies pertaining to birth weight recordings, inaccuracies with respect to assessment of gestational age come into the picture. In the interpretation of available data on LBW incidence, these practical problems have to be borne in mind and minor differences have to be interpreted with caution. The data are useful to the extent that they indicate prevailing trends.

Inter-regional differences

There are obvious factors which may explain inter-regional differences in birth weight. North American and European women are taller, heavier, have better weight gain during pregnancy because of better diet, and enjoy the benefits of excellent antenatal and obstetric care as compared to the majority of women of Asia. The only factors that contribute to low birth weight in affluent populations of North America and Europe are pre-term birth, tobacco smoking, drug abuse and genital tract infection[7]. While this general assessment is largely true, there are several other aspects related to inter- and intra-regional differences in the incidence of low birth weight that still await elucidation.

The Indian scene

India is a vast country and the quality of health care, the female literacy rate and the acceptance of family planning vary widely between different states – with Kerala in the south being at one end of the spectrum and Uttar Pradesh in the north generally being at the other end. With respect to maternal and child health care and acceptance of family planning, Tamil Nadu in the south comes next to Kerala.

Available data on mean birth weights and LBW incidence in different states of India are shown in Table 4. A note of caution is necessary in the interpretation of these data – they are hospital-based data and mostly drawn from a single major hospital in each State. The data from Jameshedpur (Bihar) should not be taken to reflect the overall situation in that backward State. Jameshedpur is the 'steel city' of India where excellent health care facilities have been set up by an enlightened industrial house (Tata), and must therefore be considered to represent an exceptional situation in that State. Subject to these limitations, the data provide interesting pointers. Mean birth weight is highest in Kerala, Tamil Nadu and Delhi, and LBW incidence is lowest in Kerala, being half that in Uttar Pradesh and one-third of that in Gujarat. These data, like those from Sri Lanka, show that, with good antenatal care and a motivated community with a high level of female literacy, the problem can be successfully handled even in the present context of socioeconomic constraints. Data would of course be far better if the

diets of mothers could be improved; poverty however continues to be the main bottleneck in this regard, even in Kerala.

Table 4. *Mean birth weight of infants in different regions of India*

Study centre	Mean birth weight (g)	Percentage below 2500g
Delhi	2764 ± 545	25.1
Varanasi (Uttar Pradesh)	2628 ± 504	30.6
Madras (Tamil Nadu)	2710 ± 536	23.0
Trivandrum (Kerala)	2881 ± 533	15.3
Calcutta (W.Bengal)	2673 ± 394	20.1
Jameshedpur (Bihar)	2693 ± 437	19.0
Baroda (Gujarat)	2449 ± 520	46.4
Bombay (Maharashtra)	2597 ± 441	34.9

Source: Collaborative study on high-risk pregnancies and maternal mortality. ICMR Task Force Study, ICMR, 1990 (Unpublished data).

The Need for Disaggregated Data

Gestational age

For a proper understanding of the present situation and of emerging trends with regard to LBW, it is important to obtain and assemble disaggregated data on low birth weight. Low birth weight infants may belong to different categories, and not all categories carry the same significance as indicators of either maternal health/nutrition or the viability and prospects of future growth and development of the infant. Thus, the gestational age of neonates could be: 'term' (37-41 weeks), 'pre-term' (<37 weeks) or 'post-term' (>41 weeks); and in each of these gestational age-groups, there could be neonates who have weights appropriate for age, low for age or high for age. Much higher proportions of LBW in North American whites and Europeans are attributable to pre-term deliveries than in North American blacks and Asians; for this reason, American white neonates with birth weights <2.5 kg have poorer survival rates than American black neonates with similar low birth weights[8]. While pre-term infants with low birth weights are at higher risk with respect to immediate survival as compared to LBW term infants with similar low weights, their subsequent growth and development in the event of survival is superior.

Symmetric and asymmetric LBW

It may also be important to distinguish between 'symmetric' (low birth weight associated with corresponding low birth length) and 'asymmetric' (low birth weight with near normal length) LBWs. Broadly speaking, the former usually

indicates maternal nutritional deprivation right from conception, while the latter points to such deprivation especially in the last trimester. The subsequent growth performance of these two categories is different. One of the very few attempts to disaggregate data on LBW into symmetric and asymmetric categories was the study of Leela Raman[9] of the National Institute of Nutrition, Hyderabad, India. In an analysis of data on 2000 full-term deliveries from poor and upper socioeconomic groups in Hyderabad, symmetric growth retardation was seen in 45.5 per cent of infants of <2 kg weight, all of whom belonged to poor-income groups. With increasing birth weight (2.0 – 2.25 kg and 2.26 – 2.5 kg), only 8.5 per cent and 9.8 per cent respectively showed symmetric LBW, while the majority were of the asymmetric category and these were also drawn from poor-income groups. In the high-income class, irrespective of weight, none of the infants had symmetric LBW.

Sub-categories of LBW

For practical purposes of monitoring changing trends, it is useful to classify LBW in three sub-categories – 2.25 kg to 2.5 kg, 2.0 kg to 2.25 kg and 2 kg. Initial efforts in countries with high incidences of LBW must be directed towards ensuring that birth weight moves nearer the limit of 2.5 kg and that the proportion of cases of very low birth weight diminishes progressively. Failure to categorize LBW into such sub-groups may mask initial improvements. In Table 5, data assembled by Leela Raman have been presented. These reveal the socioeconomic gradients, both with respect to absolute figures and with respect to their distribution in different sub-categories of LBW10. Studies of this kind would be extremely useful in monitoring changes with respect to levels of poverty as well.

Table 5. *Disaggregated data on birth weight distribution (Percentages)*

Birth weight categories (kg)	Low income	Middle income	Upper income
≤2.25	9.9	7.4	3.8
2.26 – 2.50	28.8	21.5	7.6
2.51 – 2.75	20.2	23.5	18.3
2.76 – 3.00	24.3	26.6	23.0
≥3.01	16.2	21.0	47.3
Total	100.0	100.0	100.0

Source: Raman, L.: Maternal risk factors in intra-uterine malnutrition. *Indian Journal of Paediatrics,* 1987, 54: 503-510. **Data base** – 3777 singleton uncomplicated deliveries.

Because of the present paucity of disaggregated data on LBW, it is difficult to explain intercountry or intracountry differences and the changing trends. Thus,

in the last two decades, there has been a significant reduction in the incidence of LBW in such countries as Sri Lanka and Thailand. The reported incidence of LBW in Myanmar is also less than in countries of the Indian sub-continent. Previously, over two decades ago, the incidence of LBW in Sri Lanka was nearly similar to the average levels now observed in India. It is now reported that the incidence of LBW in Sri Lanka has declined to 20 per cent[11] and in Thailand to 9 per cent from 11 per cent[12]. It is also reported that pre-term births account for nearly 50 per cent of all low birth weights in Sri Lanka[11] – a proportion much higher than in India (17 per cent) – suggesting that the decline in LBW in Sri Lanka in recent years has largely been due to a decline in low birth weight of term infants.

The latest Situation Analysis Report[13] from Indonesia indicates that low birth weight is still an important problem in Indonesia although its importance is obscured by the lack of information. Table 6 shows the current wide regional differences in LBW incidence in that country.

Table 6. *Incidence of low birth weight in selected areas of Indonesia*

Location	LBW (Percentages)	Note
North Sumatera	9.9	Hospital
Bandung, West Java	8.9	Maternity clinics
(Unung Berung)	14.7	(Semi urban area)
	17.5	Hasan Sadikin Hospital
Sukabumi, West Java	10.7	Rural areas
Bogor, West Java	10.4	Rural areas
Sampang, Madura, East Java	9.0	Rural areas
Pacitan, East Java	20.2	Health centres
Jakarta	9.4	16 Maternity clinics
Jakarta	10.9	5 Hospitals
Bogor, West Java	10.2	Hospitals, maternity clinics, TBAs
West Sumatera	11.3	Hospitals and maternity clinics
Central Jakarta	9.3	Hospitals and maternity clinics
East Nusa Tenggara	13.3	4 villages of Central Kupang sub-district

Source: Situation analysis of children and women in Indonesia. Prepared by BAPPENAS and UNICEF, April 1993.

Within India, as pointed out earlier, in Kerala, which has as good a record with respect to female literacy, outreach and quality of health care and family planning as Sri Lanka, the incidence of low birth weight is the lowest in the country (15.3 per cent). In Punjab, where diets of women during pregnancy are apparently better than in Kerala, the incidence of LBW is still 23 to 25 per cent or more, showing that improved health care has to go hand in hand with improved

maternal diet for maximal results. It also appears that maternal diets in Punjab are still inadequate with respect to folic acid.

Maternal anthropometric status

A recent WHO secondary data analysis[14] of the influence of maternal anthropometric status on LBW has clearly brought out the effects of maternal height and weight gain on the incidence of low birth weight.

Mean weights and heights of mothers (post partum) from some SEAR countries are given in Table 7. It will be noted that, with respect to both weight and height, mothers of South Asia are worse off than those of Thailand and Myanmar.

Table 7. *Mean weights and heights of mothers (post partum)*

Country		Weight (kg)	Height (cm)
India		42.1 ± 4	150 ± 5
Indonesia		46.0 ± 6	149 ± 4
Myanmar		46.9 ± 8	151 ± 5
Nepal	(Rural)	43.0 ± 5	150 ± 5
	(Urban)	44.6 ± 6	150 ± 5
Sri Lanka		43.5 ± 7	150 ± 5
Thailand		49.9 ± 7	153 ± 5

Source: Report of the WHO Expert Committee on the use of anthropometry for women during the reproductive cycle and the newborn infant, 1993.

Effects of Dietary Supplementation during Pregnancy on Birth Weights of Infants

There have been notable studies from SEAR countries on the effects of dietary supplementation during pregnancy on the birth weight of infants. In their detailed reports on nutrition in pregnancy and lactation, over 30 years ago, Venkatachalam[15] and Gopalan[16] presented evidence that the birth weights of infants belonging to poor socioeconomic groups subsisting on diets providing around 1400 – 1500 kcal were almost 300g less (3.0 to 2.7 kg) than those of infants born to mothers of the same ethnic group but from a higher socioeconomic group. Venkatachalam[15] also showed that when poor pregnant women, whose home diets provided 1400-1500 kcal, were admitted to hospital during the last four weeks of pregnancy and provided with a diet of nearly 2500 kcal, they delivered babies with a mean birth weight of about 3 kg. This birth weight was about 200 g more than that of infants born to mothers of the same economic group who had entered the hospital only at the time of delivery and who therefore did not have the benefit of either bed rest or better diet during the last four weeks of pregnancy.

Venkatachalam was careful to point out that it was "not possible to dissociate the effects on birth weight brought about by physical rest during the last few weeks of pregnancy from those resulting from improved diet".

Srikantia and Leela Iyengar[17] showed over 20 years ago that, in women of poor income groups subsisting on diets providing about 1500 kcal and 40 g protein daily during pregnancy, dietary supplementation during the last four to six weeks of pregnancy (resulting in an overall daily calorie intake of 2400 kcal and including 60-80 g protein plus supplements of iron and a multivitamin preparation) brought about a significant increase of over 300 g in the birth weights of infants. Even here, the possible contribution of bed rest due to hospitalization must be taken into account.

The role of folic acid

Leela Iyengar *et al*[18] showed that, while iron supplements during pregnancy did not result in significant improvement in the birth weight of infants, iron and folate supplementation did bring about a significant increase, of about 200g. A recent study[19] in a slum community substantiated these earlier observations. The authors attributed the beneficial effect of folic acid to increase in weight, DNA and protein content of the placenta in the folic acid supplemented group. They argued that, since food supplementation as such would be expensive and difficult to implement, iron folate supplementation alone would contribute to a lowering of LBW incidence. These were pioneering studies of considerable practical importance.

Recent studies in SEAR

Recent studies in South-East Asian countries on the effects of food supplementation in the last trimester of pregnancy on birth weights of infants have yielded contradictory results. Bhatnagar *et al*[20] found that, in women receiving a supplement providing an additional 300 calories and 16 g protein daily during the last trimester of pregnancy, the mean birth weight of infants was significantly higher and the incidence of LBW lower (21.7 per cent compared to 34.7 per cent in the non-supplemented group). Krasid Tontisirin *et al*[21] also found significant increases in the birth weights of infants whose mothers were on 1500 kcal daily home diets and had received additional dietary supplementation providing 300 kcal daily during the last trimester of pregnancy. On the other hand, Kardjati *et al*[22] in Indonesia found that, in mothers whose home diets provided 1540-1720 kcal daily, the differences in birth weights between infants of mothers who received additional energy supplements at high and low levels were insignificant. They argued that energy supplementation could have a positive effect only when habitual home diets were poor. However, the home dietary intake level of 1540-1720 kcal

in their subjects cannot be considered adequate on the basis of currently-recommended dietary allowances. Blackwell *et al*[23] in Taiwan, Adams *et al*[24, 25] and Rush *et al*[26] also found that high energy supplements in the groups they investigated did not bring about better weight gain in mothers or improvement in birth weight of infants. It is possible that home diets in these groups were not very poor.

A recent study[27] carried out under the auspices of the Nutrition Foundation of India among mothers in Punjab on a daily calorie intake of around 2000 kcal, showed that supplements which provided 450 kcal daily during the last 12 weeks of pregnancy brought about significant improvement in birth weights of infants when the supplements had been provided regularly for at least 60 days in the last trimester. Supplementation over shorter periods was not associated with significant improvement in the birth weight of infants. Differences in maternal weight gain in pregnancy between supplemented and unsupplemented groups however did not reach the level of statistical significance.

The major points of interest that emerge from these studies are:

(1) Where diets are either poor or marginally adequate, dietary supplementation in the last few weeks of pregnancy can yield significant measurable benefits in the form of increased weight gain in pregnancy and higher birth weight of infants.

(2) Leela Iyengar *et al*'s[18] study showed a significant effect of folate supplementation in pregnancy on the birth weight of infants. This observation may well provide the answer to the finding that, while the incidence of LBW is relatively low in some countries of the South-East Asia Region, such as Thailand, Indonesia and Myanmar, where the incidence is around 12 per cent, in India the incidence ranges from 25 per cent to 35 per cent. These striking differences may well be attributable to differences in folate nutritional status during pregnancy. In Thailand, for example, folate deficiency is no longer considered a major problem as diets provide adequate folic acid. Apart from fish sauce, green leafy vegetables – a rich source of folic acid – figure prominently in the diets (including those of the poor) of pregnant women in Thailand, Myanmar and Indonesia, but not in those of India.

It would appear that the one major contribution towards improving the nutritional status of pregnant women and the conditions of their neonates in SEAR in general and in the Indian subcontinent in particular, could come through better dietary intake by pregnant women of green leafy vegetables, which are not

only a good source of carotene, but also of folic acid, iron and vitamin C. Unfortunately, not much attention has been directed towards this logical approach. Indeed, improved intake of green leafy vegetables by pregnant women could make a far better (and more physiological) contribution to the elimination of the problems of vitamin A deficiency than the currently propagated pharmaceutical approach of synthetic vitamin A distribution to infants and children. South-East Asian countries will do well to expend the meagre material and manpower resources available to them for research on identifying practical ways for promoting the intake of green leafy vegetables and on quantifying the impact of such increased intakes on the problems of vitamin A deficiency, anaemia and LBW. This will prove far more rewarding in the long run to these countries than the misguided approach of large-scale field trials with synthetic vitamin A.

Influence of age at marriage

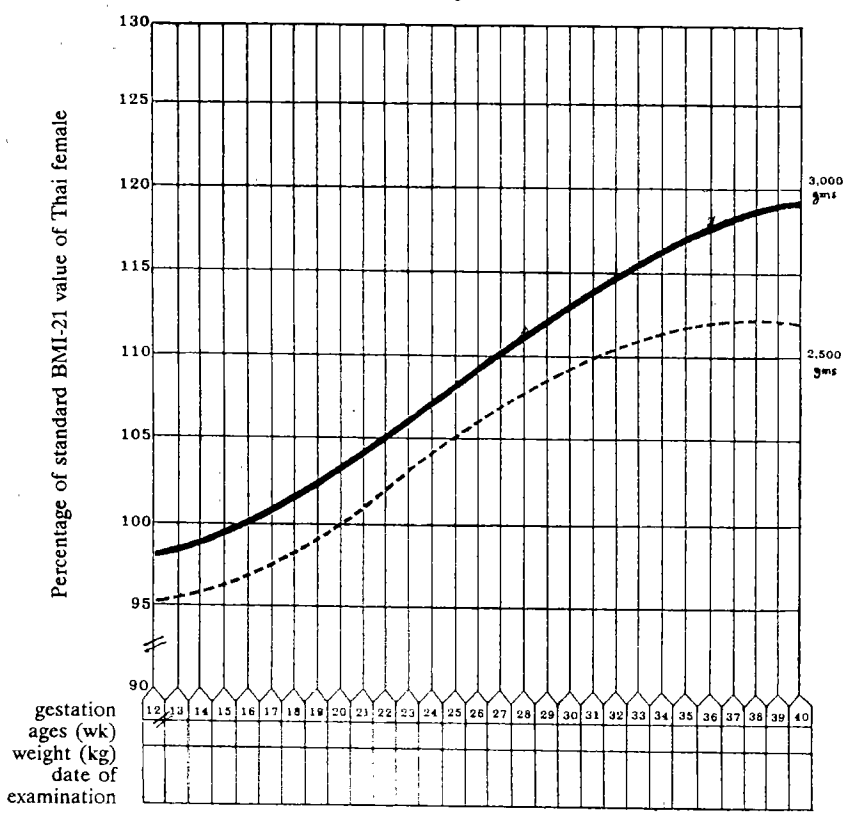
The average age of girls at marriage in India, according to the latest data, is 16.7 years. In parts of India belonging to the "Hindi belt", the average age has been found to be as low as 13.8 years, with consummation of marriage taking place at 15.3 years[28]. The average age at marriage in countries such as Thailand, Sri Lanka and Indonesia is much higher.

There is a significant increase in body weight and height during adolescence. It has been suggested that the relatively higher incidence of LBW in India, as compared to some other countries of SEAR, could be partly attributed to the lower average age at marriage. It is noteworthy that the State in India which records the highest mean birth weight and the lowest LBW incidence, namely Kerala, is also the State where the mean age of girls at marriage is the highest.

Body mass index

The use of body mass index (BMI) as a method of detecting mothers who are possibly at risk of delivering babies of LBW has been suggested by investigators in SEAR as being a convenient index independent of age, parity and height[29] (Figure 2 and Table 8). Monitoring increases in weight gain, which is the most logical approach, would involve serial measurements. The merit of BMI lies in the fact that, at a given point of time, it could help in providing a broad indication of risk of LBW. However, the use of BMI implies that maternal height is not a factor of major significance from the point of view of LBW risk. There are observations in the literature[30,31] which show that this may be a wrong assumption, and that a stunted mother is at greater risk of producing a LBW infant.

Figure 2. Pregnant nutrition chart (Vallop Curve) for the prevention of low-birth-weight infants



Source: Thaineua V *et al. Study to formulate suitable and effective pregnant nutrition chart.* Department of Health, Ministry of Public Health, Bangkok, Thailand, June 1993

Table 8. *Maternal BMI and LBW*

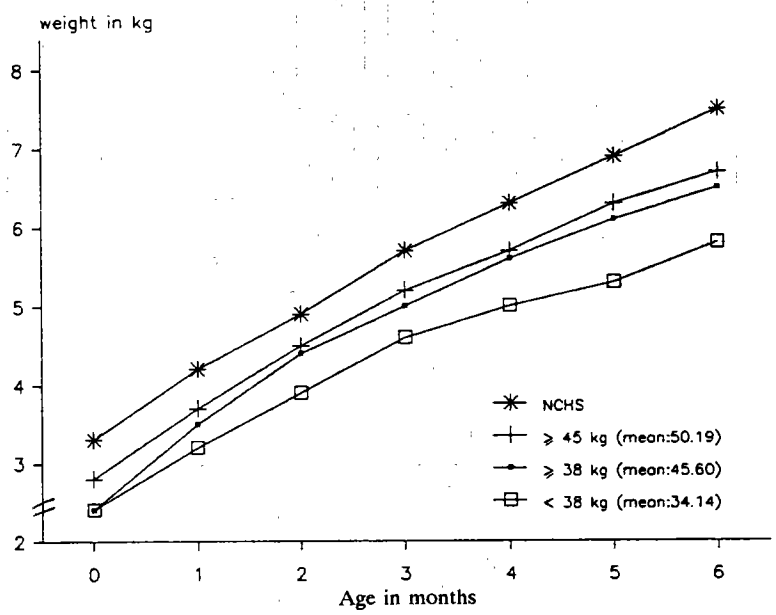
BMI	LBW (Percentage)
< 16	53.1
16 – 17	41.4
17 – 18.5	35.9
18.5 – 20	27.7
20 – 25	26.4
25 – 30	14.7
> 30	20

Source: *Nutrition News*, 12(2), National Institute of Nutrition, Hyderabad, 1991.

A study carried out under the auspices of the Nutrition Foundation of India (NFI)[32], however, showed that maternal weight rather than maternal height is the major determinant of the infant's birth weight. This study showed that, against an incidence of about 30-33 per cent low-birth-weight deliveries in poor communities in general, the incidence among mothers with pre-pregnancy weights of over 45 kg was likely to be no more than 17 per cent. It may therefore be argued that, if women in poor communities can be helped to achieve a body weight of about 50 kg at the height of their pregnancy (assuming a modest gain during pregnancy), substantial reductions in the incidence of low-birth-weight deliveries in poor communities could be brought about.

Even more heartening is the indication that infants of mothers who achieve a body weight of around 50 kg at the height of their pregnancy grow satisfactorily for four months, achieving body weights exceeding 90 per cent and body lengths exceeding 98 per cent of the World Health Organization/National Centre for Health Statistics (WHO/NCHS) standards. The advantage of the initial good start is apparently maintained right through infancy despite general evidence of growth retardation after the fourth month (Figure 3). The study also showed

Figure 3. Average weights of infants in different maternal weight categories



Source: Maternal nutrition, lactation and infant growth in urban slums. *Scientific Report 9,* Nutrition Foundation of India, 1988

that, even in the case of mothers who are significantly stunted, achieving a body weight of around 50 kg by the end of pregnancy can result in a substantial reduction in the incidence of low-birth-weight delivery. This conclusion is of considerable practical significance. Stunting in the present generation of mothers cannot be corrected through nutrition intervention, but augmentation of maternal weight gain during pregnancy can be achieved through nutrition intervention, improvement in diet, rest and restriction of energy expenditure during the last weeks of pregnancy. Fortunately, it may not be necessary to wait for a future generation of mothers of good height to solve the present problems of intra-uterine growth retardation.

The NFI study also provided suggestive evidence that a major contribution to the "smallness" of the low-birth-weight baby may be taking place in the third trimester. While the low-birth-weight infants of the poor communities studied were about 88 per cent of the NCHS standard with respect to their body weights, they were above 92 per cent of the NCHS standard with respect to their lengths, indicating that poor fat deposition in the third trimester may be the major factor. The practical importance of this finding is that, where resources are limited, even nutrition supplementation during the third trimester only could prove significantly beneficial.

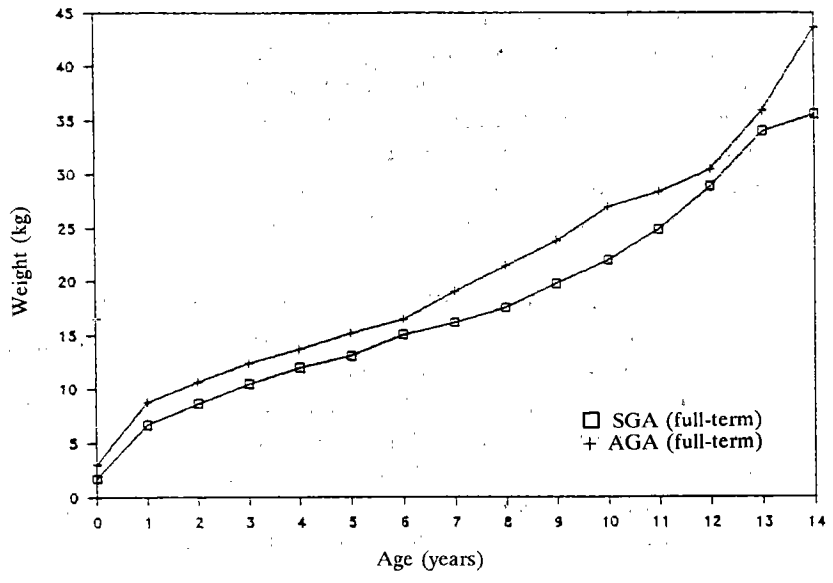
Maternal working conditions

Apart from mothers' anthropometric statuses, their occupational and working conditions may also be related to the problem of LBW. It has been reported that reduced placental blood flow in women working in a standing position in tropical temperatures could be an important factor contributing to the incidence of LBW in poor communities in the tropics[33]. The fact that the average gestational age at delivery is shifted to the left by about a week in poor Indian communities could be attributable to this.

Effect of LBW on Subsequent Growth Performance of the Infant

The studies of Ghosh *et al*[1] showed that intra-uterine growth retardation as reflected in LBW has a lasting effect, evident in the subsequent growth performance of the infant (Figure 4). Should this be the case, then the deleterious implications of LBW would be irreversible. Ghosh *et al's* subjects belonged to poor groups, and the infants with LBW continued to live in poor conditions and to subsist on poor diets during their infancy.

Figure 4. Growth pattern of children



SGA = Small for gestational age
AGA = Appropriate for gestational age
Source: Ghosh S *et al. (Unpublished observations)*

A recent longitudinal study carried out in the slums of Hyderabad has shown that infants born with low birth weight and birth length (<90 per cent) and with poor BMI and weight for height, have poor velocity of growth in terms of both weight and height. It is of interest to assess whether the growth status differs between infants with symmetric and asymmetric growth retardation[34].

A recent study in Punjab, under the auspices of the Nutrition Foundation of India, also showed that, while there was no significant difference in the absolute weight gain during the first four months of extra-uterine life between infants with LBW and normal infants, the former continued to grow more slowly and did not catch up despite the fact that the diets during lactation of the Punjabi women, who were exclusively breastfeeding their infants for the entire four month period, were quite adequate. This seems to confirm Ghosh's observation that intra-uterine retardation, as reflected in LBW, has a lasting impact which is reflected in the subsequent growth performance of the infant. This observation indicates that programmes for combating the problem of LBW should be directed to improving the maternal health/nutrition state rather than to repairing the handicap of LBW

through better infant feeding. The Swedish experience with adopted Indian orphans referred to earlier is also a pointer in this regard.

Areas of Research

The following are possible fruitful areas of research which emerge from these considerations:

- Elucidation of the reasons underlying the striking intercountry differences in the incidence of LBW in the Region. Could differences in folate nutritional status explain this?
- If maternal anaemia and folate deficiency are contributing factors, would it be a wise policy to limit iron/folate distribution to the last 100 days of pregnancy? (This issue will be returned to a later chapter).
- Since maternal dietary supplementation as a public health policy may not be feasible, would a programme for significantly increasing the intake of green leafy vegetables (GLV) (which would also incidentally bring about increased intake of folic acid and iron, vitamin C, zinc and calcium) help to overcome the problem? Is the relatively lower incidence of LBW in Thailand, Myanmar and Indonesia (as compared to countries of the Indian subcontinent) attributable to differences in the intake of GLV?
- What would be the appropriate strategies for achieving a convergence of the following three interventions: (a) dietary improvement; (b) better implementation of antenatal care and iron-folate distribution, and (c) promotion of programmes for increasing the age of girls at marriage?
- What is the place of supplementary feeding programmes directed at mothers during the last trimester of pregnancy?
- How could an optimal mix of interventions for reducing the incidence of low birth weight in infants actually be implemented under the prevailing conditions?

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3. GROWTH AND DEVELOPMENT

MEASUREMENT of growth has always been an important tool for assessing the nutritional status of children. Anthropometry has enjoyed an important place among procedures for nutrition surveys of populations and for assessment of the magnitude of undernutrition in individuals and communities.

Perhaps the most widespread clinical manifestation of undernutrition in all developing countries, including those of SEAR, is the retardation of growth of children. The hallmark of "successful" national development in any developing society is the progressive elimination of growth retardation in successive generations of children, resulting in a situation where the anthropometric attributes of children reflect the full expression of their genetic potential for growth and development. The most striking success story of this type, in recent times, has been that of post-second World War Japan. Growth measurements of large numbers of Japanese children have been accurately and regularly recorded over the last forty years, and have highlighted the close association between economic prosperity and environmental improvement as well as the progressive elimination of growth retardation in children in that country.

Secular trend

The progressive increase in anthropometric measurements in successive generations, brought about by the removal of dietary and environmental constraints on growth, constitutes the so-called "secular trend" in growth. In countries of North America and Europe, "secular trends" were evident for nearly four to five decades before a "plateau phase", representing the maximum attainable height, was reached. Japan is also almost reaching this phase now, after more than 40 years of successful development. A secular trend is evident among affluent sections of populations in SEAR countries; but among the poorest sections this trend is not striking and indeed is absent in at least some countries.

In recent years, the slogan "better child survival" has replaced the older objective of "better maternal and child health". This is unfortunate, since child survival is not necessarily the same thing as child health/nutrition. The inputs needed for the former are of a far lower order than those needed for the latter. The absence of a convincing secular trend in child growth among the poorer sections of the populations of SEAR is evidence that the success of countries of the Region with respect to "better child survival" has not yet been matched by similar success with respect to "better child health/nutrition".

Wrong leads

There have been some wrong leads with respect to child growth in recent times. It has been suggested that "smallness" reflecting retarded growth need not be harmful[1] and can be viewed as a form of "cultural adaptation"[2] . There have also been suggestions that retarded linear growth may not matter and that what is important is a significant weight/height ratio. There is absolutely no valid scientific basis for these false leads, which can only result in perpetuation of undernutrition, and these postulates need to be firmly rejected by the policy-makers of the South-East Asia Region. There should be no doubt or hesitation about accepting the position that national nutrition policies of countries of SEAR must aim at achieving the maximum possible level of (linear) growth for the children of these countries. It is of course not height *per se*, but what good height signifies in terms of the child's overall development that is the underlying consideration.

Monitoring growth trends

Countries of SEAR are now in varying stages of developmental transition. Assessments of growth of children – cross sectional and longitudinal – will become more important than ever before in nutritional investigations. Now that impressive success with respect to child survival has been achieved in SEAR, vigorous attempts to promote the nutritional status of survivors cannot be delayed if the quality of the human resources of these countries is not to be compromised by an expanding pool of sub-standard survivors. Measurements of growth must find an important place in evaluating and monitoring the success of these attempts. The objective must be to achieve for the children of these countries a significant beneficial secular trend with respect to their patterns of growth, reflecting their progressive ascent to a state of "normalcy" and optimal health/nutrition that will permit the full expression of their genetic potential. In short, the objective of any meaningful national nutrition policy must be the liberation of children from prevailing dietary and environmental constraints which are currently inhibiting and retarding their physical growth and mental development. Research efforts of the Region must be directed towards the achievement of this objective.

Periodic measurements of levels of growth in cross-sections of population groups will reveal the extent of improvement between two points in time and also the differences in improvement between population groups. It is important that such measurements of carefully chosen representative samples of the country's children are carried out and that the results are published so as to provide direction to national planners and policy-makers.

The National Nutrition Monitoring Bureau in India, located at the National Institute of Nutrition, Hyderabad, has been carrying out such surveys. However, these surveys do not cover the entire country; Punjab, a state believed to be the most prosperous, for example, is not included. Also, it is not enough to publish data on anthropometric measurements periodically, and the major messages that emanate must be highlighted. It is possible that the data may stimulate secondary research directed towards the clarification of some issues. National Nutrition Monitoring Bureaus could thus be a most valuable component of the overall nutrition research infrastructure of any country.

Growth standards

There have been suggestions that the International Growth Standard, proposed by WHO[3], may not be applicable to children of SEAR and that these countries should settle for separate growth standards reflecting a lower order of growth suited to their current states of socioeconomic underdevelopment.

Separate growth standards would be justified only if it is clear that the present lower anthropometric measurements of children of SEAR are of truly genetic origin. This has not been demonstrated. On the contrary, the Japanese experience as well as the experience with the children of affluent sections of SEAR's populations, go to show that genetic differences with respect to growth performance, as between American children on whom NCHS standards are based on the one hand, and affluent SEAR children on the other, are relatively insignificant, at least as far as the pre-adolescent phase of growth is concerned. There are apparently some differences with respect to growth during adolescence, and this is an area which calls for future research. But at least as far as the pre-adolescent growth phase is concerned, the International Growth Standard, proposed by WHO, would seem quite applicable. Indeed, the adoption of the international WHO Standard would have the practical advantages of facilitating intercountry comparisons. Studies carried out under the auspices of the Nutrition Foundation of India[4,5] have provided strong evidence in support of this viewpoint.

It is important for the countries of the Region to determine periodically the growth patterns of the most affluent sections of their populations in order to determine if the gap between these and the NCHS standards are narrowing.

Growth retardation as an indicator of nutrient deficiency

Growth retardation is a "non-specific" indicator of undernutrition, "non-specific" in the sense that it does not by itself indicate the precise nature of the nutrient deficiency or mix of nutrient deficiencies. It is likely that the mix of nutrient deficiencies currently inhibiting growth in a given situation varies from location to location or from one point in time to another. Though all nutrient deficiencies inhibiting growth may act through a common pathway at the cellular level, the nutrient deficiencies that are primarily involved can vary. The dietary deficiencies responsible for growth retardation in a given situation therefore need to be identified in order to provide direction to programmes for dietary improvement. This will become increasingly necessary in view of changing agricultural production policies and changing dietary patterns incidental to development.

Thus, with rising incomes and lessening poverty, calorie-protein deficiency may become progressively less important as the major inhibitor of growth. On the other hand, modern intensive agricultural technology, not adequately supported by programmes of soil testing and soil replenishment, has resulted in salination and increased alkalinity of soils and depletion of essential soil micronutrients (especially zinc). This is reflected in a lower content of micronutrients (especially zinc) in the foods grown on such soils. Under the circumstances, zinc deficiency could emerge as an important factor contributing to growth retardation. This implies that future programmes of nutritional anthropometry must be supported by detailed analyses of prevailing diets of children, especially with respect to micronutrient composition.

Growth as an index of overall child development

It must be remembered that our primary concern with growth retardation is that it is often an indicator of sub-standard psychomotor and mental development and functional impairment. Studies on Indian children adopted in Sweden have shown that the high incidence of retardation of psychomotor development observed in undernourished infants on arrival in Sweden from India is substantially reduced after two years on good diets, even though some deficiency in height/age persists[6]. This suggests that psychomotor underdevelopment associated with low birth weight is reversible with good diet during infancy and early childhood. The Swedish studies did not apparently include other tests of mental development. The Swedish situation with respect to adopted Indian orphans is of course different from the real life situation in poor communities in SEAR, in the sense that the latter children continue to live in poor environments and to subsist on poor diets.

It is important to monitor psychomotor development and mental development in samples of growth-retarded children at different stages of growth. This is

necessary in order to assess what growth retardation actually means in terms of mental and learning ability. Is it possible that high-school drop-out rates among poor children are the result of such poor learning ability? Growth studies will acquire far greater significance if they are supported by studies on mental development on the one hand and by studies on physical stamina and work efficiency on the other.

Unfortunately, not much effort has been directed towards developing an appropriate battery of simple and reliable indicators for the easy detection of developmental disabilities in pre-school children. Shahnaz *et al*[7] at the National Institute of Nutrition have recently completed a multicentric collaborative study and have come up with a simple, low-cost, culture-appropriate, psychological development battery of tests which, according to them, can be used with ease by trained public health grassroots functionaries. This instrument was standardized on a large rural, tribal and urban sample comprising more than 13 000 children drawn from three regions of India. Centile age reference values were constructed based on the performance of the study children with respect to 66 "milestones". Quality control of data was ensured through inter-rater and test-retest measures of reliability. There is a need for similar studies in other locations and for the wider use of tests of psychomotor and mental development and of work performance in growth-retarded children and for investigations of correlation between mental under-development and physical growth-retardation.

Catch-up growth

In real life situations in poor communities, it is difficult to investigate the possibilities of catch-up growth since sustained improvement in diet and environment over prolonged periods, which is necessary for facilitating such catch-up, is difficult to achieve. Here again, the Swedish studies on adopted Indian children provide some interesting pointers[6]. These studies have shown that substantial catch-up in linear growth is possible with the good diet that these children receive but an interesting finding was that catch-up growth during the childhood phase was, in many cases, cut short because of the early onset of menarche (even earlier than in affluent native Swedish children). Though the duration and magnitude of the subsequent growth was of a normal order, the final height attained was less because of the early curtailment of the childhood phase of growth consequent on the earlier onset of menarche.

Thus it would appear that an intensive nutrition rehabilitation programme designed to promote catch-up growth in early childhood could prove somewhat counter-productive from the point of view of attainment of maximal final height. This is not to argue against dietary improvement in childhood but to argue for even greater attention to the promotion of good optimal growth in the intra-uterine

phase of development. It is important to identify the most rewarding mix of nutritional interventions in childhood and adolescence which will result in optimal growth and development of children who start with the initial disadvantages of low birth weight and intra-uterine retardation.

Growth in adolescence

The WHO expert group, constituted in late 1975 to advise on the use of anthropometric indicators of nutritional status, recommended that the data assembled by the National Centre for Health Statistics (NCHS) of the USA be used as an international reference up to the age of ten years[3]. The use of the NCHS standard beyond the tenth year as a universal international standard was not recommended by this expert group because of differences in the pattern of adolescent growth between different populations. Unfortunately, there has not been much work in this area in SEAR countries. Most growth studies in the Region have concentrated on the pre-school phase (under fives). It is now important to collect data on patterns of adolescent growth among different socioeconomic groups in the Region.

A study carried out under the auspices of the Nutrition Foundation of India[4] has shown that, while girls from the most affluent sections of the community have a growth pattern similar to the NCHS standard till the twelfth year, beyond this age there is a divergence in the growth curve, with the Indian girls growing slower. This finding is similar to the reported Japanese experience[8] (Figures 5 and 6). The important question that arises is: is this difference genetic, or is it attributable to dietary and nutritional factors? It has been argued that calcium deficiency or zinc deficiency could underlie the differences with respect to adolescent growth of Indian and American girls. In order to test this hypothesis, the Nutrition Foundation of India is undertaking a study on the effect of calcium supplementation in adolescence on growth performance[9]. The results of the study may throw some light on this question. It is known that there are differences with respect to the attainment of peak bone mass between black and white girls in the USA; the former achieve more bone mass during adolescence[10]. It has been claimed that there is no difference with respect to the accretion of bone mass between white Americans and Asian Caucasians. However, it is possible that the calcium supply available in predominantly cereal-based Asian dietaries is not adequate to sustain peak bone growth during adolescence.

The Nutrition Foundation of India study mentioned above may provide the answer, but studies of this kind in other countries will also be necessary. Growth in the period between the twelfth and the eighteenth years – the pre-pubertal and pubertal growth spurt – represents an important phase of growth. Differences in height between a 14-year old and an 18-year old Asian girl are substantial,

Figure 5. Mean height of girls – Delhi, Japan and NCHS

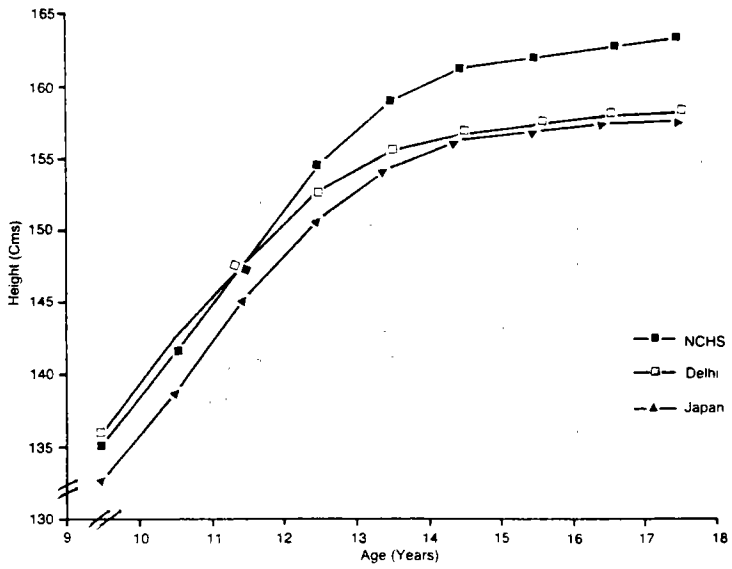
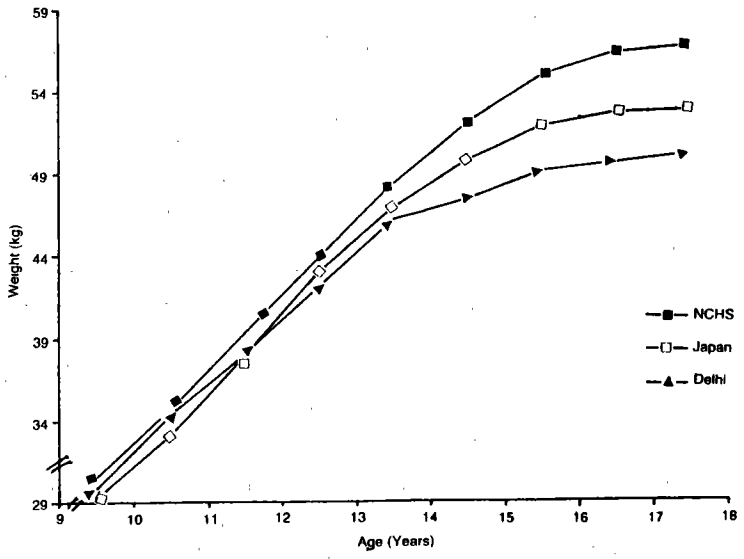


Figure 6. Mean weight of girls – Delhi, Japan and NCHS



Source: Growth of affluent Indian girls during adolescence, *Scientific Report 10*, Nutrition Foundation of India, 1989.

and this may have a bearing on such things as obstetric performance and birth weight of infants.

Studies on patterns of adolescent growth, and on the effects of dietary factors thereon, must receive greater attention in the countries of SEAR.

Areas of Research

The questions that arise from the foregoing considerations may be briefly highlighted:

- Has a significant secular trend with respect to growth become discernible among the poorest sections of the child populations of SEAR?
- What are the nutrient bottlenecks that inhibit growth? Are these now changing?
- Is the NCHS standard applicable to under-fives in SEAR countries? Is there any special advantage or scientific justification for separate growth standards for different countries of the Region? Is there evidence of true genetic difference with respect to growth potential?
- How far do physical growth measurements correspond to levels of psychomotor and mental development? For this purpose the countries of SEAR need to develop an appropriate battery of tests to measure levels of mental development in these children.
- What is the pattern of adolescent growth? Is it being influenced by genetic or dietary factors?
- What is the optimal mix of nutritional interventions for ensuring optimal growth in infants who start their developmental journey with the initial disadvantage of low birth weight?
- What is the optimal mix of interventions that will promote maximal linear growth in children who start with the initial disadvantage of low birth weight?
- How could such a mix of interventions be actually implemented?

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4. IRON/FOLATE DEFICIENCY ANAEMIA

IRON deficiency anaemia is perhaps the most widespread clinical nutrition deficiency disorder in SEAR today. Over four decades ago, "primary" iron deficiency was heavily compounded by "secondary" iron deficiency induced by chronic malaria and hookworm infestation. It is not that the two latter conditions have now been totally eliminated, but they have been considerably mitigated. Gone, fortunately, are the days when pot-bellied children with huge splenomegalies were a common sight in the countryside and when "splenic index" was the widely used measure of a community's health status. Gone too is the picture of severe hookworm anaemia with general anasarca. The current practice of using footwear by even the poorest sections of the population – which was not much in evidence in earlier years – partially accounts for most of the mitigation of hookworm disease, but the problem has by no means been totally solved.

However, despite a seemingly satisfactory overall intake of iron in diets (satisfactory on the basis of currently recommend allowances), iron-deficiency anaemia is widespread – not just among pregnant women but also among children and men in SEAR countries. The poor bio-availability of iron in cereal-based diets appears to be the major factor responsible. A high proportion of adolescent girls are anaemic, and the majority of poor women are anaemic even at the time of commencement of pregnancy. The conventional practice of administering iron/folate tablets (60 mg elemental iron and 500 μg folic acid) during the last 100 days of pregnancy has, under the circumstances, apparently not been an adequate answer to the problem of anaemia of pregnancy.

Anaemia is an important "risk factor" in pregnancy. There is believed to be a two- to three-fold increase in the perinatal mortality rate when maternal haemoglobin levels fall below eight gm/dl[1]. That maternal anaemia also contributes to an increase in perinatal mortality and to intra-uterine growth retardation[1] is

also generally accepted. Maternal immune depression and increase in morbidity has also been reported among anaemic pregnant women[2]. In children, anaemia not only compromises immunocompetence but also learning ability[3]; and in adults, impaired work performance is to be expected[4].

The direct clinical manifestations of anaemia are not spectacular and, for this reason, the far-reaching public health implications of anaemia are not appreciated. Indeed, there was a time when even experts naively argued (in the same vein as "small is healthy") that "moderate" reductions in haemoglobin levels, not being associated with serious functional disabilities, may not matter. Fortunately, with more evidence of the effects of anaemia, this view has now receded into the background.

Current Status of Anaemia Control Programmes

Countries of SEAR are all implementing programmes for the control of anaemia of pregnancy. These programmes have largely consisted of the administration of iron/folate tablets (60 to 120 mg iron/500 μg folate) in the last 100 days of pregnancy as part of antenatal care. No serious efforts towards education to improve the diets of pregnant women have been attempted, and some illiterate poor communities are still under the wrong impression that a good diet in pregnancy may result in bigger babies, which pose greater obstetric risks! It is now clear that the strategies employed for combating the problem of anaemia in SEAR countries have been largely inadequate, as some of the data presented below show.

India. The data on haemoglobin levels in the latter half of pregnancy in urban and rural populations are shown in Table 9. An "unsupervised" multicentric trial of the effect of administration of iron supplements (as tablets) at 60 mg, 120 mg and 180 mg dose levels with a fixed dose of 500 μg of folic acid was carried out among pregnant women of 20 to 24 weeks gestation for a period of 100 days[5]. The baseline data showed that 17 per cent of women had haemoglobin levels of less than 9 g/dl to start with when all centres were considered together. Indeed, the percentage of women with such low levels was as high as 48.7 per cent in Rajasthan. Only 53 per cent of the subjects complied and took the tablets for more than 90 days, while 23 per cent totally dropped out. The mean haemoglobin levels were 11.5 g/dl in those women who complied. The high number of drop-outs and the high degree of non-compliance were the major reasons for the inadequate overall response. What was also a matter of concern was that a significant proportion (37.8 per cent) of pregnant women who had consumed the tablets for more than 90 days had haemoglobin levels of less than 10 g/dl, and as many as 19.4 per cent had haemoglobin concentrations of less than 9 g/dl.

Table 9. *Haemoglobin levels in different periods of gestation in India*

Gestational age (Weeks)	Haemoglobin levels (g/dl)	
	Urban	Rural
21 – 24	10.6 ± 1.76	9.3 ± 1.65
25 – 28	10.4 ± 1.82	9.0 ± 1.71
29 – 32	10.3 ± 1.92	9.0 ± 1.72
33 – 36	10.5 ± 1.84	9.4 ± 1.75
37 – 40	10.7 ± 1.96	9.6 ± 1.81

Source: Prema K *et al.* Changes in haemoglobin levels during different periods of gestation, *Nutrition Reports International*, 1981, 23: 634.

Thailand. Surveys in 1980-88 indicated a prevalence rate of 30-43.3 per cent anaemia in the south[6,7,8], 20.4 per cent in the north[9], and 35.9 per cent in the east of the country[9]. Over 15 per cent of under-fives in 1991 and over 18 per cent of school children in 1990[10] were found to be anaemic. Unlike other countries of SEAR, folate is not included along with iron in the supplementation programme in pregnancy as part of antenatal care. It is believed that folate deficiency is not a major public health problem in the country. Apart from iron supplementation from mid-pregnancy till delivery (using a daily dose of 120 mg elemental iron[11], food (fish sauce) fortification with iron, and dietary diversification are also being attempted[12]. But apparently the impact has not yet been striking since the logistic problems have not been overcome.

Indonesia. Though there has been no national survey in recent years, data gathered in the 1980s showed that 50 to 70 per cent of pregnant women, 20 to 30 per cent males and 25 to 35 per cent of school-going children were anaemic[13]. It is believed that there has been no significant impact on the problem of iron deficiency anaemia during the last few decades.

Lessons from Past Experience

The message that stand out from the depressing experience so far is that overcoming anaemia in the cereal-eating populations of SEAR will need an effective convergence of three major approaches. Firstly, diets, especially of pregnant women and children, will need to be improved. The bio-availability of iron in cereal-based diets can be improved by ascorbic acid. A food source that supplies not only iron but also vitamin C and folic acid is green leafy vegetables. The major thrust in the control of anaemia must be in promoting the intake of green leafy vegetables, a measure which also holds the key to the control of vitamin A deficiency and other micronutrient deficiencies. Despite an abundance of vegetables and fruits rich in iron, vitamin C, folic acid and β-carotene, most countries of SEAR have failed thus far to optimally utilize this valuable source

of food. While half of the populations are anaemic, nearly one-third of fruits and vegetables grown in these countries perish annually because of lack of proper preservation and storage.

Secondly, iron or iron folate supplements confined to the last 100 days of pregnancy can only confer limited benefit, for a number of reasons. One reason is that antenatal services reach only a part of the population at risk; and, even with respect to the subjects who are reached, it is difficult under practical field conditions to ensure regular, continuous daily administration for 100 days at a stretch. Another reason is that a high proportion of the population fails to comply for the reason that they do not perceive the supplement as being related to the disability which they recognize, and as well the supplement often induces mild alimentary upset. Yet another reason is that those administrating the programme are not always specifically trained and motivated to secure the compliance of the populations in their charge through a programme of education. Under the circumstances, and considering that a majority of girls are anaemic even at the time of conception, it has been suggested[14] that, instead of limiting iron tablet distribution to the last 100 days of pregnancy, it may be a good policy to start supplements for adolescent girls and, especially, for all girls immediately after marriage. If, in such a programme, iron tablets are not taken every day but only periodically, even then such an approach could yield better results than the present one wherein iron supplementation is limited to the last 100 days of pregnancy. It is also possible that, if girls get accustomed to taking iron tablets while they are still young and non-pregnant, there may be better compliance and better acceptance of iron tablets during the last 100 days of pregnancy.

It has also been claimed that damage to the foetal brain which arises from maternal anaemia takes place early in pregnancy[15]. Should this be the case, iron supplementation during the last trimester of pregnancy will not be the answer. Since it is as important to protect the foetus from neural underdevelopment as to protect the mother from obstetric risks, iron supplementation, to be meaningful, may have to start early. This is yet another powerful argument in favour of adopting the policy of not waiting for pregnancy to advance to the last trimester before undertaking iron supplementation, but to start early with the adolescent girl, even before she conceives.

The third major approach stems from the claim that folic acid deficiency – another factor involved in pregnancy anaemia – may cause neural tube defects in the foetus in the first four weeks of pregnancy[16]. This is yet another issue that points to the need for a revision of the present strategy of iron and folate supplementation limited to the last 100 days of pregnancy. A new strategy of iron/folate supplementation starting with adolescence needs to be evaluated, both from the feasibility point of view and from the efficacy point of view.

Commenting on the suggestion[14] that iron-folate supplementation should start in adolescence, Hallberg (personal communication) considers that the suggestion to give iron before pregnancy to young women who are expected to have poor iron stores is very wise. The fact that many girls become pregnant during adolescence, even before their own growth is complete, implies that their iron requirement will be very marked, and it will be difficult to meet this requirement within the time available during pregnancy. However, it is important to recognize that the dosage of iron appropriate to Western women with body weights of 55 to 60 kg may not be necessary for girls with body weights around 40 kg. Holberg supports the idea of giving iron to "mothers-to-be" as probably the only rational way to combat anaemia in populations with a high prevalence of severe iron deficiency.

Viteri *et al*[17] suggested that, with continued daily administration, iron absorption could decrease and that intermittent administration may ensure better absorption. However, the view that continued supply of iron will reduce iron absorption because of "tiredness" of the intestinal mucosa, has been refuted by Hallberg. In the strategy for administration of iron starting in adolescence, iron intake is bound to be intermittent, given the ground realities, and if Viteri *et al* are right, this would then prove to even be an advantage.

Another approach that is worth propagating is that of fortification of suitable food items with iron. Fortification of common salt with iron in India, and of fish sauce with iron in Thailand, have been tried. It is important to identify factors that have stood in the way of wide adoption of this approach. Recently, an American group has suggested iron EDTA for food fortification[18].

What is now needed is a programme which attempts a convergence of the three major approaches discussed above. The operational problems involved, which may vary from country to country, need to be identified and combated. The technologies needed are fairly clear but research at the grassroots level is necessary to identify how the current hurdles to the effective application of each of these approaches and to their overall convergence can be overcome.

Folate Deficiency

Apart from iron deficiency, folic acid deficiency is believed to be an important factor in the causation of anaemia of pregnancy in countries of SEAR. It is for this reason that folate is included along with iron in supplementation programmes for pregnant women and children. It has also been shown that, where combined deficiency of iron and folate is involved, giving iron alone unmasks folic acid deficiency.

Apart from its importance in haemopoiesis, recent studies have shown that folic acid deficiency may also be involved in neural tube defects (spina bifida

and anencephaly)[19,20]. As mentioned earlier, the deleterious effect of folic acid deficiency on neural tube development occurs within the first four weeks of pregnancy. The dose of folic acid needed for the prevention of neural tube defects is still being debated, but the daily dosage of 500 μg, which is contained in the iron/folate tablets now in use in some SEAR countries, should be considered adequate until there is clear evidence to the contrary.

Studies in SEAR

A WHO collaborative study in Burma and Thailand[11] indicated the occurrence of neural tube defects, especially encephalocoele, possibly attributable to folic acid deficiency. A randomized double blind trial was undertaken under the auspices of the Indian Council of Medical Research (ICMR) in order to investigate if administration of folic acid and other vitamins before and after conception could reduce the risk of neural tube defects. The study, which began in 1990, was terminated in October 1991 on unethical grounds following publication of the results of the UK MRC trials[21], which indicated definite beneficial effects of vitamin therapy in reducing neural tube defects.

Areas of Research

The questions that seem to need answers are:

- What, precisely, is the nature of dietary improvement needed to combat anaemia in cereal-eating populations, and how is this improvement to be achieved? If green leafy vegetables can augment iron intake, how can their increased intake be ensured?
- Is it necessary to review the present policy of iron/folate distribution in the last 100 days of pregnancy as the answer to the problem of pregnancy anaemia? If so, what is the alternative approach?
- If defects of brain development due to iron deficiency, and neural tube defects due to folic acid deficiency, occur early in pregnancy, would a programme of iron/folate supplementation confined to the last 100 days of pregnancy be meaningful?
- What are the current bottlenecks in the implementation of a programme of fortification of suitable food items with iron, and how can they be overcome?

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5. GOITRE AND IODINE DEFICIENCY RELATED DISORDERS

GOITRE and related disorders attributable to iodine deficiency affect several countries of the Region. Programmes for the control of this problem have been continuing in all these countries with varying degrees of success.

In Thailand, in 1992, as many as 39 provinces were identified as being goitre endemic, with a prevalence rate of 12.24 per cent[1]. It has been claimed that the goitre rate declined from 19.31 per cent in 1989 to 15.11 per cent in 1991, in Loei province, and from 30.51 per cent in 1990 to 16.11 per cent in 1992 in 16 north-eastern provinces, Uttaithani province and 7 provinces of central Thailand[2]. According to the report of a UNICEF/WHO study, Bhutan had a total goitre rate of 60 (goitre rate as a weighted percentage for age and sex) in 1983; cretinism was also reported to be widely prevalent[3]. Kochupillai in India reported, in 1989, a goitre prevalence rate of 80 per cent in Deoria and 70 per cent in Gorakhpur in Uttar Pradesh, of 60 per cent in Gonda in Madhya Pradesh, 29 per cent in Delhi and 1.3 per cent in Kerala[4]. Goitre is reported to be prevalent in the larger islands of Indonesia, including Sumatera, Kalimantan, Java, Sulawesi, and Irian Jaya. The total goitre rate of 37.2 per cent in 1982 had declined to 27.7 per cent in 1990, and the visible goitre rate declined from 9.3 to 6.8 per cent during the same period[5].

There can thus be no doubt that goitre is still endemic in many countries of SEAR, and considerable research on this problem has been carried out in the countries of SEAR, specially during the last two decades. However, there are still quite a few aspects of the problem which call for research. Some of these are briefly highlighted below.

Stability of iodine in fortified common salt

Fortification of common salt with iodine is the time-honoured and time-tested approach for combating the problem of goitre. However, there are still some operational issues that need to be settled in order to ensure effective implementation of the programme under the conditions prevailing in SEAR countries. Salt that is often used for iodation is not of the best quality; and the stability of iodine in the salt has posed problems and has partly contributed to the poor implementation of the programme.

Research on methods of improving the stability of iodine in common salt needs to be promoted. Work at the National Institute of Nutrition, Hyderabad, has shown that by using stabilizers, such as calcium carbonate, the shelf life of the iodated salt can be enhanced[6]. The usefulness of sodium carbonate, a water-soluble stabilizer, in enhancing the shelf life of iodated salt has also been demonstrated[7]. This technique has been found applicable to powdered salt as well as to crystal salt. The merit here is that, since sodium carbonate is easily available and is inexpensive, this technique may not add significantly to the cost of the final product. In fact, with such a stabilizer, the level of iodation can be brought down from the present 30 ppm to 20 ppm.

Apart from identifying procedures for increasing the stability of iodine in salt, it is also important to study the effect of different culinary practices on iodine retention in the final cooked product. At present there is very little work in this area. Cooking practices vary widely and it may be important to propagate the practices which result in minimal loss of iodine. Ultimately, what is important is the iodine content in the cooked food.

Also, the countries of SEAR must develop the technology and the means to manufacture potassium iodate of a grade that can be used for salt fortification. Potassium iodate now has to be imported. Thus, for example, because of the fact that its State Pharmaceutical Company has stopped production, Indonesia currently has to import potassium iodate, and this has added significantly to the cost of fortified salt since no subsidy is offered to the salt manufacturer. The salt iodation programme in Indonesia has thus suffered. Since goitre is a major public health problem common to the countries of SEAR, these countries could pool their resources to achieve regional self-reliance in this regard.

Neonatal hypothyroidism

Using radio-immunoassay techniques, Kochupillai[8] in India showed that the incidence of neonatal hypothyroidism in endemic goitre regions is more than a hundredfold higher than in non-endemic regions. This finding has given the

much-needed momentum to the goitre prophylaxis programme by revealing a dimension of the problem hitherto not well appreciated. In highly endemic areas of the country, with the introduction of the salt iodation programme, the incidence of neonatal hypothyroidism was found to have declined impressively[8] (Table 10).

Table 10. *Incidence of neonatal hypothyroidism in three endemic goitre districts of Uttar Pradesh State, India, before and after successful salt iodation*[a]

District	Incidence per 1000 births	
	Pre-iodation	Post-iodation
Deoria	133	16
Gonda	75	9
Gorakhpur	85	17

[a]Data on the basis of 5500 newborns in the three districts screened so far (studies are continuing).

Source: Kochupillai N. Neonatal hypothyroidism in India. *Mount Sinai Journal of Medicine.* 1992. 59(2): 111-115, 1992

It is important that a few reference laboratories in the countries of SEAR are equipped to monitor the efficacy of implementation of salt iodation programmes by screening urine samples for iodine and by assessing declines in the incidence of neonatal hypothyroidism. This facility must become available to a number of laboratories in SEAR and necessary training for this purpose should be organized on a national or regional basis.

Emergence of new goitre-endemic areas

There is evidence that goitre endemicity is currently emerging in some new areas, e.g., the irrigated plains of Central India and Bali. Studies from Myanmar have indicated that pockets of endemic goitre exist in low-lying areas of the country where hitherto the problem was not considered to be important, being believed to be confined to hilly regions. An overall goitre rate as high as 67 per cent has now been reported from some of the low-lying areas of the country[9].

The precise factors underlying the emergence of new goitre endemic areas have not yet been identified, and may be related to modern practices of intensive agricultural technology and soil management, resulting in diminished bio-availability of soil iodine reflected in diminished content of iodine in foods and in water. The emergence could also be related to excessive use of fertilizers, and it is also possible that pesticides and some food additives may be involved. These are questions that need to be answered through research that could be jointly carried out by health scientists and agricultural scientists.

Goitrogens in foods and environment

Studies in India by Kochupillai[8] have shown that, in certain regions where salt iodation has been efficiently implemented, as reflected by urinary iodine excretion in populations, declines in the prevalence of iodine deficiency disorders are not impressive, e.g., in the Harakh area of Barabanki district of the Terai region of India. In this area, the incidence of neonatal hypothyroidism continues to be as high as six per cent even though the level of salt iodation has been found to be satisfactory and urinary iodine excretion reflects adequate iodine intake. Because of this finding, Kochupillai and his group have estimated urinary thiocyanate levels as an initial indicator for goitrogen ingestion in some of the districts of Uttar Pradesh, and have found high levels of excretion of thiocyanate in a significant proportion of subjects in this area (Table 11). Peroxidase-inhibiting goitrogens have been suspected of interfering with the effective utilization of iodine by the thyroid gland. Such goitrogens could either be of dietary origin or they could be food contaminants.

Table 11. *Excretion of urinary thiocyanate in Uttar Pradesh, India*

District	No. of samples	Thiocyanate mg/dl	Subjects with >1.6 mg/dl[a] (percentages)
Aligarh	99	1.12 ± 0.47	7
Agra	96	1.05 ± 0.41	15
Bulandshahar	90	1.77 ± 0.74	58
Mathura	94	1.17 ± 0.42	17

[a]Value shown to be goitrogenic in the Zarian endemic area.
Source: Kochupillai N. (unpublished data).

Intensive studies on possible goitrogens are necessary, especially in new, emerging goitre-endemic areas and in those areas in which goitre persists despite well-implemented salt iodation programmes. Goitrogens have been reported from a whole range of plant foods, including vegetables such as knohl kohl, radish and lady's finger[10,11]. The question that has to be decided is whether the concentrations of goitrogens in plant foods, which have been recognized for a long time, have increased in recent years following the introduction of modern intensive agricultural technology. Have the heavy use of fertilizers and the irrigation and farming practices now in vogue contributed to increased uptake and generation of goitrogens in plant foods? Could this explain the emergence of new goitre endemic areas in the irrigated plains?

Identification of alternative approaches

Apart from iodation of common salt, which is clearly the method of choice, special circumstances may demand alternative strategies. Injections of iodised oil

were suggested, but the demerits of this approach have been now recognized[12] and it would be unwise to resort to this strategy. On the other hand, other approaches such as iodation of drinking water[2] and periodic oral administration of iodinated oil [2] could be investigated. However, as far as the latter is concerned, it is important to be sure that massive oral iodine dosage does not suffer from the same demerits as the parenteral approach with respect to neonatal hypothyroidism.

In the northern villages of Thailand with high rates of goitre, an in-house water iodator was tested and found to be effective and appropriate[13]. A programme of fortification of salt by a self-help method met with great success in a district in Loie province in north-east Thailand. Using low-cost technology and locally-available materials, public health officials educated the villagers in endemic goitre and endemic cretinism and taught them to iodate their own water[13]. In some highly endemic areas of Thailand, oral capsules of iodine supplement containing 200 mg/per capsule have been used as a temporary measure[14]. Another procedure that is being attempted is to add iodine to fish sauce, which is widely used in the country (6 drops per 750 ml of sauce)[2].

The efficiency of these alternative strategies in comparison with the conventional, time-tested and widely-used approach of salt fortification has, however, not yet been adequately evaluated.

The strategy for "double" fortification of common salt with iron and iodine has been developed in India and has been demonstrated to be feasible for implementation[15]. However, considering that even the current programme of fortification of salt with iodine seems to be posing difficulties with respect to implementation, this new technology, though highly desirable, has not yet found wide application. Now that India has adopted the policy of universal salt iodation, adding iron along with iodine to salt could be the ideal solution for combating the two widely prevalent problems of anaemia and goitre. But it appears that this approach is not likely to find wide application in the countries of the Region in the immediate future.

There has been an attempt on the part of some agencies to vigorously promote the use of injections of iodinated oil. This approach has been attempted in Nepal. The possible deleterious repercussions of this procedure, apart from its expense and the fact that it would entail continued reliance of countries of SEAR on external sources for their goitre control, have been pointed out[12,16]. A major additional objection to this procedure is the prospect that the use of so-called "disposable" syringes (not actually disposed of in practice) that this procedure involves could cause the spread of AIDS and drug addiction, which are already serious problems in some goitre-endemic areas bordering the Himalayas.

Identification of suitable indicators of goitre prevalence

For the evaluation of the different strategies of goitre control, apart from the crude indicator of total goitre rate (over ten per cent believed to indicate IDD endemicity), there is also a need for more accurate and sensitive indicators such as urine iodine and hormone estimation in sub-samples. Technology such as ultrasonography, which is now available at lower cost, can also be used. Soil iodine levels, and iodine levels in water and agricultural products can also provide supporting evidence. It is important for SEAR countries to collaborate in developing feasible indicators that can be used at different levels for evaluating the efficacy of control strategies.

Areas of Research

The major questions that need answers and the major areas in need of research are:

- What are the factors underlying the emergence of goitre in irrigated plains of the Region? Is this related to modern agricultural practices? What is the role of goitrogens in foods? Is it the case that the presence of such naturally occurring goitrogens in food has been increased by modern agricultural practices?

- Alternative strategies (alternative to salt iodation) such as iodine in drinking water, in common use, and new oral dosages need to be evaluated using sensitive indictors.

- Technology for improving the stability of iodine in fortified salt needs to be developed and evaluated.

- The use of suitable indicators of iodine deficiency, such as urinary iodine estimation and hormone assays, must be developed for use by research laboratories in the Region.

- Countries of SEAR should pool their resources to develop technologies for manufacturing the potassium iodate needed for salt iodation programmes.

- How can the current specific practical hurdles to effective supplementation of salt iodation programmes be overcome?

There is considerable scope for intercountry cooperation in all the above areas of research.

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6. VITAMIN A DEFICIENCY

THE severe manifestation of vitamin A deficiency, namely keratomalacia, was an important public health problem in some countries of SEAR over three decades ago. However, there has been a remarkable change in the incidence and profile of vitamin A deficiency in the Region during the last two or three decades. As a result of these striking changes, vitamin A deficiency today stands far below protein-energy malnutrition (PEM), anaemia and goitre in the hierarchy of nutritional deficiencies in the Region. In deciding on the strategy for the control of vitamin A deficiency, and on the priorities for future research in this area, it is important to recognize this cardinal fact.

The two outstanding clinical manifestations of vitamin A deficiency are: (1) corneal xerosis (and keratomalacia) leading to nutritional blindness, and (2) conjunctival xerosis (and Bitot's spots). Corneal xerosis leading to keratomalacia is generally seen in children under two years of age and is attributable not just to vitamin A deficiency alone but to coexistent protein-energy malnutrition, zinc deficiency and superadded infections as well. The evolution of the disease is so rapid that the interval between detection of the disease and loss of vision can be a matter of a few hours. Keratomalacia is thus a medical emergency that can lead to permanent disability. Conjunctival xerosis, on the other hand, is a relatively chronic and much milder, though more widespread, form of xerosis seen in pre-school and older children. The strategies needed for the control of these two problems are obviously different.

Incidence of Keratomalacia – The Present Status

Keratomalacia leading to nutritional blindness *was* a major public health problem in parts of India, Bangladesh, Nepal and Indonesia till about the 1960s and the early 1970s. However, during the last 20 years there has been a steep and

significant decline in the incidence of the disease, with the result that today keratomalacia (nutritional blindness) is no longer the public health problem it once was. Cases of keratomalacia do still occur, but from such evidence as we have, their numbers today are very small. In ophthalmic and paediatric teaching centres where, at one time, scores of keratomalacia cases used to be seen every year, over 20 years ago, ophthalmologists report that cases are now hard to find, even for purposes of demonstration and training.

The statement still frequently made that "millions of children are turning blind every year because of vitamin A deficiency" is most certainly not true of SEAR any more. Also, extrapolation of data from limited field studies in isolated, extremely poverty-stricken endemic pockets, can lead to inflated and exaggerated estimates of "national" incidence. Thus, among extremely poor (Muslim) population groups who do not breast-feed their infants in a few hamlets in the southern part of Thailand, isolated cases of keratomalacia have been reported[1], but it would be misleading to extrapolate these data to "national" incidence for the whole of Thailand, where keratomalacia is by no means a public health problem. Also, it must be remembered that corneal scars detected in a field survey do not necessarily always imply past keratomalacia. Indeed, the commonest cause of corneal scars in poor population groups is injury of the cornea.

A review of the latest available data on the prevalence of keratomalacia in India, Indonesia and Thailand will highlight the above points.

India. The most recent national survey of blindness, carried out under the auspices of the Government of India and WHO[2] showed that no more than 0.04 per cent of all cases of blindness in the country could be attributed to vitamin A deficiency. Cases of blindness (visual acuity of the better eye 3/60) from all causes in this national survey together accounted for 1.07 per cent of the population (thus indicating that keratomalacia could have accounted for blindness in just 0.0004 per cent of the population). Even if we allow for the high mortality among victims of keratomalacia, these survey data would indicate that keratomalacia is currently a relatively insignificant factor in the causation of blindness in India.

Data from the School of Tropical Medicine, Calcutta, once the hot-bed of keratomalacia, and from the Christian Medical College, Vellore, a leading centre reputed for its studies on problems of vitamin A deficiency and undernutrition in children, are also suggestive of a sharp reduction in the incidence of keratomalacia (Table 12). A careful scrutiny of hospital data from Calcutta in fact suggests that the decline in the incidence of keratomalacia had started even before the massive dosage prophylaxis programme had been instituted.

Table 12. *Annual incidence of keratomalacia cases in leading Indian hospitals (percentages in parentheses)*

Hospital	Year	All cases	Cases of keratomalacia
Tropical Paediatrics Clinic	1964-72[a]	1070	8.5 (average)
School of Tropical Medicine, Calcutta	1974-85[a]	995	1.3 (average)
	1987[b]	1160	0
	1988[c]	1120	0
Christian Medical College, Vellore	1960	13 641	5 (0.37)
	1970	21 844	6 (.028)
	1981	28 931	5 (.017
	1984	31 137	3 (.009)
	1987	35 377	0
	1989	37 219	3 (.008)

[a]Bhattacharyya AK and Chatopadhyaya.PS. *Bulletin of the Calcutta School of Tropical Medicine*, 1986, 34: 44-47.
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[c]Sunder Rao PS. Christian Medical College, Vellore, Hospital Records.

Indonesia. The results of the 1992 national survey for the 15 problem provinces (Table 13) have been summed up as follows in an official Indonesian publication:

Table 13. *Prevalence of xerophthalmia in pre-school children in 15 provinces of Indonesia, 1978 and 1992*

Province	Bitot's spot		Corneal xerosis/ Corneal ulceration/ keratomelacia		Corneal scar	
	1978	1992	1978	1992	1978	1992
DI Aceh	2.4	0.0	0.5	0.0	0.2	0.0
North Sumatera	0.4	0.2	0.0	0.0	0.2	0.0
West Sumatera	1.3	0.0	0.2	0.0	0.2	0.0
South Sumatera	0.3	0.1	0.2	0.0	0.5	0.0
Bengkulu	0.7	0.0	0.2	0.0	0.2	0.0
West Java (rural)	1.5	0.1	0.1	0.0	0.2	0.0
Central Java (rural)	1.0	0.3	0.0	0.0	0.2	0.0
Bali	0.8	0.1	0.1	0.0	0.2	0.0
Lombok	1.6	0.1	0.2	0.0	0.2	0.0
West Kalimantan	0.4	0.2	0.0	0.0	0.2	0.0
Central Kalimantan	0.7	0.1	0.2	0.0	0.0	0.0
South Kalimantan	1.5	0.0	0.0	0.0	0.2	0.0
South Sulawesi	0.4	2.9	0.1	0.0	0.1	0.0
North Sulawesi	0.6	0.6	0.0	0.0	0.0	0.0
Ambon	2.0	1.0	0.0	0.0	0.2	0.0
Total	1.3	0.4	0.1	0.0	0.2	0.0

Source: GOI (1992). Nutrition Research Development Board. Ministry of Health (LITBANG GIZI) – (Muhilal personal communication).

"Keratomalacia no longer exists in any province and the prevalence of Bitot's spots has decreased by 73 per cent in the period. The decrease observed in all of the major problem provinces suggests that in Indonesia as a whole xerophthalmia is no longer a public health problem. This progress ensures that both Repelita V and WSC goals for vitamin A deficiency have already been reached in as far as the eye-related consequences of vitamin A deficiency are concerned"[3].

Thailand. An official report from Thailand[4] states that "no signs of Bitot's spot or keratomalacia were observed and only two to three per cent reported night blindness ...". WHO has classified Thailand to be a country where xerophthalmia and vitamin A deficiency are *not* public health problems, but where their prevalence should be closely monitored[5].

Periodic Administration of Massive Oral Doses of Vitamin A

The present strategy for the control of vitamin A deficiency in many SEAR countries largely consists of the administration, at periodic intervals of six months, of a massive oral dose of 200 000 I.U. of vitamin A to children under three years of age in endemic areas. This strategy was primarily designed for the control of keratomalacia and not for the more pervasive, though milder, problem of conjunctival xerosis, which affects a much wider age spectrum. This strategy was developed and introduced by the National Institute of Nutrition, Hyderabad, in the late 1960s[6,7,8,9], after elaborate field studies, at a time when nutritional blindness (keratomalacia) was perceived as the most important manifestation of vitamin A deficiency and a major problem of public health scale. This approach, despite its suspected limitations, was resorted to, because it was felt that keratomalacia, then a widely prevalent acute medical emergency, called for an approach which would be more *immediate* in its action than dietary improvement. Even so, this approach was envisaged purely as an *interim* measure and as a temporary adjunct to dietary improvement, till such time as the obvious natural approach of dietary improvement and promotion of increased intake of β-carotene-rich foods by the population at risk could be satisfactorily ensured.

Though dietary improvement and promotion of increased intake of β-carotene-rich foods have frequently been mentioned as the final objectives in the intervening 20 years, in actual fact no concrete steps in these directions have been taken. Indeed, research and action in these areas had almost come to a halt till very recently. As a result, what was originally envisaged as an adjunct has now become an expanding central piece with unhealthy commercial overtones.

The time has now arrived for a careful review of the present strategy which is nearly (almost solely) dependent on synthetic vitamin A. Such a review is called for not just because of the decline of keratomalacia, but, even more importantly, because of our present better appreciation of the limitations of the present strategy, arising from our experience with its implementation during the last two decades. These limitations have been discussed at length in an earlier publication[10]. Briefly, they are as follows:

- In a proportion of cases, even among pre-school children, the approach proves ineffective in correcting vitamin A deficiency, for a variety of reasons.
- Because of limited shelf life and because of logistic problems of ensuring regular supply, practical implementation is often difficult.
- Most importantly, this approach does not help to prevent and control vitamin A deficiency in school children and pregnant women, among whom milder signs of vitamin A deficiency are widespread in endemic areas.

Without doubt we cannot give massive oral doses of vitamin A periodically to half the populations. The massive dosage approach was mostly a blunderbuss operation, which might have been justifiable as a "fire-fighting" measure in the emergency situation in which keratomalacia was a widespread public health problem. It certainly cannot qualify as the permanent answer to the vitamin A deficiency problem after the emergency has disappeared.

Fortunately, the pressure of the keratomalacia emergency, which conditioned the earlier approach, is not now operative, and we are better able to adopt a strategy that will address the root causes of the problem. The need for a change-over at this stage to a more durable strategy consistent with the present status of the problem and national interests has to be recognized.

Current attempts to widen the market for synthetic vitamin A

It is important in the changed context to resist the current ill-conceived attempts to further expand the use of synthetic vitamin A, and the advisability of the proposed administration of the first massive dose of vitamin A at the time of vaccination against measles (at nine months of age) should be questioned.

There is a need to investigate serum vitamin A levels following simultaneous measles vaccination and vitamin A administration, and to compare them with both basal levels and with the levels which follow vitamin A administration alone (when they remain high for months). This is because urinary loss of vitamin A

may be high when administration of vitamin A takes place along with measles vaccination since vitamin A is not absorbed during infections and measles vaccination induces a mild infection. It is possible that serum levels are much lower when administration of the vitamin follows measles vaccination than when it is administered alone because the uptake of the vitamin may be less.

We do not know enough about the metabolic and hormonal side-effects (apart from the immediate toxic effects) of periodic doses of synthetic vitamin A on growth and development in general, and on growth and development of the brain in particular, especially when such doses are administered at frequent intervals to very young infants in poor health and of substandard body weight. It should not be forgotten that nearly one-third of poor infants in India, Nepal and Bangladesh are of low birth weight. John and Sivakumar[11], for example, found a significant increase in serum amino nitrogen levels in children following a massive oral dose of vitamin A. This observation needs to be confirmed and its significance and implications need careful examination, especially since it is now being suggested that each child could receive as many as nine to ten massive oral doses of vitamin A, starting from early infancy! Ten per cent of young infants in a recent Bangladesh study, who were given massive oral doses of vitamin A, are reported to have developed fontanelle bulging, an indication of increased intra-cranial pressure.

We cannot dismiss this finding as being of little significance. What is the effect of periodic increase in intra-cranial tension on the growth and development of the brain during early infancy, especially where a high proportion of children are already showing psychomotor deficit as a result of intra-uterine growth retardation? This is a critical issue which cannot be brushed aside.

Vitamin A and Child Mortality

There have been five major field studies on the effects of vitamin A administration on child mortality in SEAR: (1) Sommer *et al* in Indonesia[12], (2) Rahmathullah *et al* in India[13], (3) Vijayaraghavan *et al*[14] in India, (4) Keith West *et al*[15] in Nepal, and (5) Agarwal *et al*[16] in India. Two of these studies (by Vijayaraghavan *et al* at the National Institute of Nutrition and by Agarwal *et al*[16]) showed that there was no significant reduction in child mortality as a result of vitamin A administration. Sommer *et al*[12] and Rahmathullah *et al*[13], on the other hand, have claimed significant reduction in child mortality following administration of vitamin A, the former with massive doses at six-monthly intervals and the latter with smaller doses at weekly intervals. Keith West *et al*[15] found that vitamin A reduced the mortality risk from diarrhoeal diseases but increased the mortality

risk from respiratory diseases, and that the overall "average" effect was a significant reduction in mortality. These studies, which were expensive exercises, generated controversy and confusion. The drawbacks of the studies which showed reductions in mortality, and the reasons why the conclusions are untenable, have been discussed in several earlier publications[17,18,19,20,21] and need not be elaborated here.

The meta analysis exercise

Because the reported studies on the effects of vitamin A on child mortality yielded conflicting results, some North American scientists undertook a meta analysis of published data. On the basis of this exercise, they arrived at the conclusion that there was a significant "average" reduction in child mortality but no effect on morbidity following administration of vitamin A. The "average" here is no more than a statistical fiction. Indeed, after this "average" was arrived at, a study from India[16] showed a negative effect. This, and the possible negative results of a similar kind from other studies, could depress the "average" to the level of insignificance.

This meta analysis exercise and its conclusions are questionable for the following reasons:

- The studies that were analysed, were not originally planned and designed to cover populations which were truly representative of the populations of the Third World beset with the problem of vitamin A deficiency.
- Practically all the studies which produced positive results, were carried out by the same school, while those producing negative results were reported by three separate groups from three entirely different institutions. Thus the meta analysis exercise was heavily biased towards positive results even at the start.
- Apart from the question of the validity of the meta analysis exercise itself, there is a basic consideration which throws doubt on the practical value of the studies. The study designs adopted in all the reported studies represent an artificial, unreal situation which bears no relation to present models of primary health care.

The important question that SEAR countries should consider is "where does administration of synthetic vitamin A as a procedure for reduction in child mortality stand when considered in the *total context of primary health care?"* The studies reported so far were not designed to answer this issue. These studies show, at best, that in a situation where there are no effective primary health care interventions, vitamin A medication may bring about marginal reductions in child mortality in some locations, although even this is of a far lesser order than that which can be achieved without deliberate specific interventions but with repeated

visits by health workers alone (the control placebo group). A population in which such a reduction in mortality has been achieved with synthetic vitamin A will still need primary health care and better diets.

Nobody expects health visitors to visit deprived areas just to distribute synthetic vitamin A and not to carry out any other interventions. Indeed, health workers in developing countries are always required to carry out a multiplicity of tasks which together constitute the primary health care package. Under the circumstances, a sensible study design would have been one in which both groups (experimental and control) received the basic primary health care package, while the experimental group received synthetic vitamin A in addition. It is extremely unlikely that, with such a design, even the marginal differences in mortality now being claimed between experimental and control groups would have been seen.

Vitamin A deficiency a part of multiple nutritional deficiencies

Unlike iodine deficiency (goitre), it is almost never the case that children suffer from isolated, vitamin A deficiency. Vitamin A deficiency is invariably associated with PEM and frequently with anaemia and vitamin B complex deficiency. Vitamin A deficiency is just *one* component (and currently a minor component) of the syndrome of undernutrition. In this context of multiple nutrient deficiencies and in the light of emerging knowledge of the inter-relationships of nutrients (specially that of vitamin A with such nutrients as protein and zinc), a strategy which seeks to combat vitamin A deficiency on the public health scale using a single synthetic drug does not make sense. Dietary improvement is obviously the sensible approach.

Logical Approach for the Future

Future research efforts must be clearly directed not towards examining the scope for continued use and further expansion of the pharmaceutical approach of synthetic vitamin A distribution, which is clearly unnecessary now, but towards progressively phasing it out altogether, and towards improving the intake of carotene-rich foods which are available in abundance within the Region.

The origins of vitamin A deficiency in childhood can be traced to: (1) poor vitamin A nutrition status of the mother during pregnancy and lactation, resulting in poor liver reserves of vitamin A in the neonate and poor levels of vitamin A in breast milk; and (2) poor intake of foods rich in either preformed vitamin A or in provitamin A carotenoids by the infant after weaning and thereafter. A logical approach to the prevention of vitamin A deficiency in the community must seek to address these basic causes.

The most logical way of combating vitamin A deficiency would be to improve the vitamin A nutritional status of women during pregnancy. Maternal transfer of vitamin A to the foetus takes place in the latter part of pregnancy[23,24]. Maternal vitamin A nutritional status may also be expected to condition breast milk vitamin A concentration[24]. Massive doses of synthetic vitamin A are precluded in pregnancy because of the known teratogenic effects of synthetic vitamin A. Dietary improvement consisting of increased intake of carotene-rich foods is the only logical approach, and research efforts should be directed towards this central objective.

Carotene-rich foods

SEAR countries in which milder forms of vitamin A deficiency still exist are fortunately blessed with a wide array of inexpensive foods rich in provitamin A carotenoids. Apart from the well-known conventional green leafy vegetables (GLV), recent studies at the National Institute of Nutrition, Hyderabad, have shown that the leaves of a surprisingly large number of plants growing wild in the countryside (and which do not need specially-tended kitchen gardens for their cultivation) are also good sources of beta-carotene. Studies at the same Institute have also recently highlighted the enormous, as yet untapped, potential that exists for the effective utilization of a whole range of inexpensive, locally-available fruits, specially mangoes, for combating vitamin A deficiency in poor, tribal populations[25].

Several green leafy vegetables are not only good sources of carotenoids, but they contain other nutrients as well, which can also contribute, in some measure, to better nutrition. The nutrient composition of some common green leafy vegetables indicated in Table 14 highlight this point.

Table 14. *Vitamin and mineral content of some commonly-used green leafy vegetables (Values per 100g of edible portion)*

Leafy vegetables	Carotene (μg)	Folic Acid (μg) (Total)	Vitamin C (mg)	Iron (mg)	Calcium (mg)
Spinach	5580	123	28	1.14	73
Amaranth (*A. gangeticus*) (tender)	5520	149	99	3.49	397
Bathua leaves	1740	–	35	4.2	150
Drumstick leaves	6780	–	220	0.85	440
Fenugreek leaves	2340	–	52	1.93	395
Agathi	5400	–	169	3.90	1130
Radish leaves	5295	–	81	0.09	265

Source: Gopalan C *et al.* 1989, *Nutritive value of Indian Foods*, NIN (ICMR) Revised and updated by Narasinga Rao BS *et al.*

Children and women of poor communities suffer not from vitamin A deficiency alone but from other nutrient deficiencies as well, including those of iron and folate (and possibly calcium). Present knowledge regarding vitamin A metabolism also indicates that, in the pathogenesis of xerophthalmia, apart from vitamin A and energy-protein, zinc nutrition may also be important[26,27,28]. It must therefore be made clear that in the ultimate analysis, it is through all-round improvement of poor dietaries rather than through the intake of an isolated nutrient that the nutritional status of populations can be ensured. Fortunately, the heritage of abundance of natural foods in developing countries should enable them to achieve such dietary improvements. Green leafy vegetables, because of their nutrient composition, can contribute significantly to such improvements.

Spirulina

Pioneering work leading to the development of spirulina, a rich source of pro-vitamin A carotenoids from the blue-green alga *Spirulina fusiformis*, has been carried out by Seshadri of the Murugappa Chettiar Research Centre in Madras. The product has been intensively investigated by scientists of the National Institute of Nutrition[29]. With further research and improved technology it should be possible to identify ways by which spirulina can be widely harvested and incorporated in a potent, inexpensive and acceptable form in the dietaries of the people of developing countries.

Red palm oil

There are also bright prospects for augmenting the cultivation of red palm in India, Indonesia and Bangladesh. With further research designed to identify ways by which the provitamin A fraction of red palm oil can be utilized (instead of being discarded, as is unfortunately happening with the palmolein product being currently produced in Malaysia), red palm oil could be a powerful tool for combating vitamin A deficiency. The studies of Manorama and Rukmini[30] indicate the possibilities of wide use of crude palm oil in habitual dietaries.

It is thus clear that developing countries already have an abundant and relatively inexpensive supply of foods which bountiful nature has provided for them right at their own doorsteps. There is also a vast, as yet untapped, potential for further augmenting the production of such foods in these countries. It would be extremely short-sighted and imprudent not to put these valuable, indigenous, inexpensive resources to proper use, and, instead, to continue to rely on extraneous support.

The superiority of β-carotene

There is enough evidence to show that provitamin A carotenoids are at least as effective as (if not more so than) synthetic vitamin A in combating vitamin A

deficiency. A historic example is that of Britain, which successfully ensured the adequate vitamin A nutritional status of her population during the second World War through judicious use of provitamin A carotene-rich foods at a time when the availability of preformed vitamin A (from Danish butter) was severely curtailed because of the German blockade.

Work now being carried out in many SEAR countries, including India, Indonesia and Thailand, demonstrates the scope for the successful use of beta-carotene-rich foods in combating vitamin A deficiencies. Suttilak Smitasiri *et al*[31], for example, in their study on ways of promoting ivy gourd consumption, found a significant decrease of night blindness in the project area compared to an increase in the control area. Considerable work on the carotene profile of commonly-available vegetables and fruits is now being carried out at the National Institute of Nutrition, Hyderabad. The Nutrition Foundation of India has undertaken a major multicentric study designed to construct seasonal and regional calendars of carotene-rich foods which could be used in educational programmes. Programmes for the distribution of seeds of carotene-rich vegetables and fruits to rural communities are being undertaken in Bangladesh. It is not beta-carotene alone that is of good nutritive value. Other carotenoids also have nutritive values of different orders and, in addition, have the ability to quench singlet oxygen and free radicals, a property that could play a cancer-preventive role.

Areas of Research

There is a great need to intensify research directed towards achieving augmented production and consumption of carotene-rich foods. Horticultural research has, in general, not received as much encouragement and support as research in other fields. This imbalance in agricultural and food research must now be corrected considering the very rich biodiversity and the wide range of fruits and vegetables currently available in the Region which are not being optimally and judiciously used. The answer to the problem of micronutrient deficiency – not just vitamin A deficiency alone – could result from these efforts. Some specific suggestions are listed below:

- The emphasis in research on augmented production and nutritive value of horticultural products must be directed not only to fruits and vegetables meant for export and for consumption by the affluent, but also to green leafy vegetables which can find a place in the poor man's dietary and which currently do not enjoy much social prestige. This is the most neglected area today.

- The new biotechnology tools of genetic engineering must be used to develop varieties of green leafy vegetables which possess the optimal mix of high carotene, vitamin C, folate, calcium and iron content on the one hand, and low fibre and oxalate on the other, along with better acceptability, palatability and cooking qualities. The objective must be to facilitate the incorporation of green leafy vegetables in adequate amounts and in acceptable forms into infant weaning diets. There are currently striking locational and varietal differences with respect to these attributes of GLV, and through research it should be possible to develop at least a few varieties which can find a place in public health programmes.

- Intensive research designed to develop acceptable recipes based on foods rich in provitamin A carotenoids, and education programmes designed to ensure their incorporation in habitual dietaries, must now receive high priority. With the better analytical procedures now available, it is necessary to update information regarding the carotene content of foods. Detailed inventories of β-carotene-rich foods, their regional and seasonal availability, and information as to how acceptable recipes based on them can be propagated, must be made widely available to health workers. Indeed, this must become an important part of the training of all health workers.

- Seeds of good varieties of green leafy vegetables and plants currently available, or those that may become available through future research, should be made available to the public through fair price shops or through welfare centres. Programmes of this kind are already proceeding under the auspices of the Grameen Bank in Bangladesh, and must now be widely adopted in other SEAR countries as well.

- There is a need to intensify research designed to identify appropriate technology by which spirulina can be presented in potent, inexpensive and acceptable forms. Spirulina could then be made available (freely or at subsidized cost) to pregnant women, nursing mothers and children through welfare centres and maternal and child health centres, with advice as to how it can be incorporated in their daily dietaries. Pregnant women and nursing mothers will need special attention in this regard.

- Agricultural research scientists should pay great attention to the augmentation of red palm cultivation, for which good scope exists in a number of countries in Asia. Research designed to identify ways by which red palm oil can be presented in an acceptable form must receive priority.

- Antenatal programmes must give almost as much attention to improving the vitamin A nutritional status of pregnant women as to the correction of anaemia. Advice to mothers as to how their diets can be improved for this

purpose at minimal cost, using resources often available on their own door-step, must become an integral part of nutrition education and antenatal care.

- A top item on the agenda of home science colleges in developing countries must be the development of acceptable and palatable recipes based on locally-available green leafy vegetables, spirulina, and red palm oil that could find an important place in the dietaries of pregnant and lactating women and children. There will be practical problems in ensuring the intake of green leafy vegetables, or fruits in season, in quantities adequate enough to meet the daily vitamin A requirements in infancy and early childhood. It is in this area that considerable research by home science colleges is necessary.

However, spirulina and red palm oil, being richer sources of beta-carotene, need be incorporated in dietaries of young children in much smaller amounts than green leafy vegetables. For example, about 1g daily of spirulina powder and one teaspoonful of red palm oil, in the forms in which these are currently available in India, are adequate to meet the vitamin A requirements of pre-school children. But before these latter products (spirulina and red palm oil) can be used on a wide public health scale, considerable improvements in technology are necessary and their production must be greatly augmented so that the cost of the final product is considerably reduced.

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7. NUTRITION AND CANCER

STUDIES on the possible role of dietary factors in the development of cancer have not thus far attracted much attention from nutrition scientists in the countries of SEAR. This is understandable. In the prevailing context of poverty, undernutrition and lack of sanitation, nutritional deficiency diseases and communicable diseases have had to command greater attention. However, this situation has to change.

Cancers are already emerging as important causes of death in these countries and have now to be viewed as one of the major public health problems. The continuing presence of undernutrition on the one hand, and the introduction of potential carcinogens into the environment as part of the ongoing process of development on the other, clearly portend escalation of the cancer problem in the years ahead. In the context of their double burden, developing countries of SEAR may be in a worse state than developed countries, which need not contend with the problems of poverty and undernutrition.

Current Status in SEAR

Unfortunately, authentic data on the incidence of cancer in SEAR countries are as yet meagre. Indeed, serious attempts to set up institutional arrangements for gathering such data and for monitoring changing trends have yet to take effective shape. However, the need for action in this area is now being widely recognized by health administrators of these countries. Nutrition scientists of these countries are also beginning to take increasing interest in investigations into the possible role of dietary factors in the pathogenesis of cancer. Research in the area of nutrition and cancer interrelationships will need to be greatly stepped up in the years ahead.

Official data of the Ministry of Public health, Thailand, show that malignant neoplasms – of all forms – have now emerged as the third leading cause of death in that country (36.8 per 100 000), after accidents (51.4) and diseases of the heart (49.5)[1]. Data on cancer obtained from hospital records in Indonesia, by the Non-communicable Diseases Research Centre of the Ministry of Health, also reflect a rising trend in incidence[2]. Part of the increase in reported incidence may possibly be due to improvements in the reporting system.

Population-based cancer registries in India, which cover 3.5 per cent of the population, indicate a crude cancer incidence rate of 66 per 100 000[3], while the crude mortality rate from cancer is estimated to be 38 per 100 000[3], somewhat similar to that reported from Thailand. Age-adjusted incidence rates of cancers in India for the period 1980 to 1987 are indicated in Table 15. It is to be noted that cancers of the alimentary system (the oral cavity, pharynx and oesophagus) and of the trachea and bronchus are common in males, while cancers of the genital tract (especially cervix) and of the breast are important in females. It is estimated that the annual incidence of cancer cases by 2000 A.D. will be over 700 000[4].

Table 15. *Age-adjusted incidence of cancer in the Indian population (per 100 000) 1982-87*

Type of cancer		Bangalore	Bombay	Madras
Oral cavity and pharynx	Male	16.1	27.2	19.7
	Female	12.9	10.4	13.0
Oesophagus	Male	7.6	8.7	7.2
	Female	7.9	7.9	5.5
Stomach	Male	9.8	6.9	14.2
	Female	5.3	4.2	6.3
Rectum	Female	2.5	–	1.8
Total genital	Female	37.3	29.1	54.5
Cervix		29.3	18.1	44.4
Ovary		4.5	6.1	5.2
Breast		16.7	22.8	18.9
Prostate		4.3	6.3	–
Larynx	Male	4.0	8.2	4.3
	Female	0.7	1.4	0.5
Trachea, bronchus and lungs	Male	10.8	13.3	7.7
	Female	1.7	2.9	1.3

Source: Annual Report, National Cancer Registry, New Delhi, Indian Council of Medical Research. 1987

The fact that, in SEAR countries, the overall incidence of cancers of all sites currently appears to be somewhat lower than rates reported from other parts of the world, must not justify continued complacence. Firstly, a major factor to be considered is that low life expectancy, which could be contributing to the current seemingly low incidence, is now being progressively eliminated. Secondly,

disaggregation of the available data on cancer incidence reveals the disturbing finding that even now the incidence of cancers in such sites as the oral cavity, pharynx and larynx is high in India in comparison with other parts of the world. Cancers in the above sites, together with lung cancers, account for 40 to 50 per cent of all cancers in males and 20 per cent in females in India[5].

The Role of Nutritional Factors

Cancer is a disease of multiple etiology. There are agents in the host and environment which may promote or inhibit carcinogenesis. Under the circumstances, it is difficult to quantify with precision the role of nutritional factors. Even in the USA, where undernutrition is not a major problem, 35 per cent of all cancers have been estimated to be diet-related[6].

There are however some conclusions which can be drawn from the currently available evidence. Epidemiological studies strongly implicate tobacco[7], with or without betelnut, and alcohol[8], in the causation of oral, head and neck cancers. A number of experimental studies substantiate the view that nutrition has a modulating role in epithelial cancers. Indeed, as early as 1933, Orr[9] implicated low vitamin A intake in the causation of epithelial metaplasia. Notani and Jayant[10] claimed a protective effect of vegetables and fish on cancers. Kamala Krishnaswamy[11] documented the association of cancers with poor dietary intake of several nutrients (also reflected in lowered blood levels), such as vitamins A and E, zinc and selenium. Low intake of vegetables, green or otherwise, was found to be particularly associated with significantly higher risk of cancers[10]. A case control study of oesophageal cancer[12] showed low mean blood levels of retinol, zinc ($p < .001$), and folic acid ($p < 0.01$). The relative risk was significantly higher with low levels of zinc.

In Krishnaswamy *et al*'s[13] study, which points among other things to the possible role of selenium deficiency in cancer, significantly lower levels of selenium in oral cancer and oesophageal cancer patients than in matched controls were found. While selenium deficiency has been suggested as a possible factor in carcinogenesis, it has been suggested that selenium toxicity is involved in diseases in cattle[14,15]. Paddy straw, on which cattle are fed in parts of north India and Pakistan, has been claimed to contain toxic levels of selenium because of increased uptake of selenium by the plants from the alkaline soils of the region. Sulphur has been shown to have a detoxifying role in situations of selenium toxicity[16]. In a review of the role of selenium in human health[17], Krishnaswamy has pleaded for more intensive research in this area.

Recent studies on cervical dysplasia suggest correlations with poor intake of vitamins A and C, β-carotene and selenium[18]. Poor pyridoxine nutritional status has been documented in cervical cancer patients[19].

A remarkable current study on the potential role of nutritional factors in carcinogenesis is being carried out by Krishnaswamy *et al*[20] in India in the Srikakulam district of Andhra Pradesh, where oral cancers attributable to the prevailing habit of "reverse smoking of tobacco" (with the burning end inside the oral cavity) is in vogue among certain sections of the population. In more than 30 per cent of such "reverse" smokers, pre-cancerous oral lesions are encountered which eventually lead to the development of oral cancers in a good proportion.

Krishnaswamy *et al* used the opportunity provided by this situation to undertake a dietary prevention trial designed to assess the impact of a "cocktail of micronutrients, viz., vitamin A, riboflavin, zinc and selenium". After one year of such supplementation, it became evident that subjects with pre-cancerous lesions receiving nutrient supplement exhibited a much higher regression of lesions (57 per cent) than the control unsupplemented group (8 per cent). Biomarkers, namely micronuclei, and DNA adducts, which were monitored both in the supplemented and unsupplemented group, showed a significant fall in the former (60-95 per cent) and no fall in the latter. These observations are in line with earlier observations on tobacco chewers in southern India, in whom supplements of vitamin A and carotene, singly or in combination, were shown to have a significant beneficial effect[21,22].

Epidemiological data from affluent countries indicate an association between high intake of total and saturated fats and breast cancer[23]. An analysis of risk factors in breast cancer in Indonesia[24] showed the increased risk of breast cancers in subjects on high fat diets. Dietary fat intakes in SEAR are generally low. On the other hand, increased risk of cancer of the colon and lungs in males, of cancer of the cervix and breast in females, and of leukaemia in both sexes has been reported in conjunction with low serum cholesterol associated with central distribution of body fat (abdominal obesity)[25]. Since South Asians appear more prone to central obesity, this observation may merit concern.

Apart from nutrients, the role of toxic contaminants in foods, such as mycotoxins and nitrosamines, in carcinogenesis in SEAR countries[26] has also received attention.

Protective Role of Dietary Factors

There is evidence that some dietary factors play protective roles in cancer.

Firstly, the high fibre content of Asian dietaries, may, on the basis of current epidemiological evidence, exert a protective effect in colon cancers.

But perhaps the strongest evidence for the protective effect of dietary factors on cancers is the one relating to dietary carotenoids. Foods rich in carotenoids appear to be protective against a range of cancers – of lungs, larynx, pharynx, oral cavity, oesophagus and stomach. Further, deficiencies of certain dietary factors such as iron, folic acid and zinc, have been associated with increased rates of upper alimentary tract cancers; and since iron/folate deficiency is widespread in the populations of SEAR countries, this is cause for concern. Since these cancers currently account for a major part of cancers in males in SEAR, the importance of high intake of vegetables and fruits rich in carotenoids and of correction of iron deficiency anaemia is therefore obvious. Apparently, the high concentration of fat-soluble anti-oxidants present in foods of plant origin (vegetables and fruits) accounts for the protective effect.

Recent studies also indicate that dietary flavones, phenols, and isothiocyanates[27] inhibit cancers. Asian dietaries include several spices which contain these substances. The antimutagenic properties of spices have been studied in detail in India and the spice *Curcuma longa* (turmeric) has received special attention[28,29,30]. In addition to turmeric, several spices, such as garlic, ginger and mustard, seem to have protective effects.

To sum up then, there are currently both negative and positive aspects of Asian dietaries with respect to carcinogenesis. Deficiencies of such micronutrients as carotenoids, zinc, iron and selenium are among the major negative factors. The presence of fibre and of a number of inhibitors in traditional Asian dietaries is a plus point, as is also the low intake of dietary fat, particularly of saturated fat. However, under the impact of development, some of the latter factors may progressively diminish. Improvement of diets with respect to micronutrients must, on the basis of current evidence, make the most significant beneficial contribution to protection from cancer. The one most important message that stands out from the plethora of literature on the subject is the need to vigorously promote the intake of green leafy vegetables in Asian dietaries. This may be of central importance.

Areas of Research

- Multicentric epidemiological studies for the elucidation of the possible role of dietary factors in different types of cancers will have to be undertaken in SEAR. Appropriate study populations will need to be identified based on considerations of compliance, feasibility of follow-up,

data on overall incidence rates, and the prevalence of contrasting dietary exposure.

- Long-term cohort studies at the population level are necessary. Methods of dietary assessment, to quantify chronic exposure to different nutrients and non-nutrients, will need to be developed and validated. This must be backed by reliable data with respect to food composition – especially with respect to micronutrient composition – both in raw and cooked foods. Food storage and cooking practices among consumers will need careful study.

- Intervention studies following stipulated changes in diet can be undertaken provided reliable methods exist to register cases of cancer. Such intervention studies with specific nutrients and varying dosage schedules, in order to evaluate the responses of high-risk groups with identified pre-cancerous events, may prove rewarding. Krishnaswamy *et al*'s ongoing study on communities with pre-cancerous lesions related to the practice of reverse smoking referred to earlier in this chapter is an example.

- Studies on the role of food contaminants, especially mycotoxins, in cancer – both experimental and community studies – will continue to be important as newer mycotoxins come to light, as also studies on nitrates and nitrosamines (preformed) and *in vivo* nitrosation reactions in deficiency states.

- Where potential carcinogens have been suggested or actually identified, practical ways by which these carcinogens can be eliminated from, or reduced in, the food chain will also need to be determined.

All this may seem a tall order in the conditions now obtaining in SEAR, and epidemiological skills of a high order will need to be built up. These efforts should, at least, be undertaken by leading nutrition centres and leading cancer research centres working in concert. Fortunately, there are quite a few such centres in SEAR.

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8. NUTRITION AND DEGENERATIVE DISEASES – OBESITY, CORONARY HEART DISEASE AND DIABETES

WITH increasing affluence, and changing lifestyles and occupational patterns, the problems of obesity, diabetes and coronary heart disease are likely to be numbered among the leading public health problems of SEAR countries within the next two decades. Though these problems are common to all affluent societies, both in the developed and developing countries, some factors of them may need special attention in SEAR countries. The present indications are that, in population groups emerging from poverty into relative affluence, these diseases may present grave dimensions.

An exhaustive review of the available literature on these problems from SEAR countries will not be attempted here. However, some major aspects of the problems, which seem to merit special attention in the SEAR countries, will be briefly discussed.

Obesity

A convenient measure of body fat is the body mass index (BMI = body mass in kg/(height in m)^2). A BMI of 20-25 has been proposed as a normal range for adults of developed countries. It has been suggested that a BMI of 18.5 to 20 or 20–22 may be more appropriate for developing countries, although these cut-off points are arbitrary approximations which may help to monitor changing trends with respect to obesity.

Chronic calorie deficiency is still widespread in some countries of SEAR. Thus it has been estimated that nearly one-third of the population of India lives

below the poverty line, subsisting on diets which fail to meet nutrient requirements. Even so, the annual data provided by India's National Nutrition Monitoring Bureau (NNMB) show that 3.6 per cent of the rural population have a BMI exceeding 25[1]. In another study of high-income groups, 9.5 per cent of males and 28 per cent of females had BMI levels exceeding 25 per cent[2]. Considering that the populations covered by the NNMB surveys are predominantly low-income groups, these figures must be considered significant. A survey in the mid-1980s in Thailand showed that, among officers of the State Electricity Generating Authority, 23.3 per cent of males and 18.8 per cent of females were obese[3]. There has been a rapid increase in the numbers of people in middle-income groups in recent years (and most of the "new recruits" to this group fall in the neo-rich category). The incidence of obesity in these sections is believed to be particularly high. These are the potential candidates for diabetes and coronary heart diseases.

Abdominal obesity

There is growing evidence that obesity of the type in which fat is deposited centrally (abdominal obesity), in contrast to obesity of the type where fat deposition occurs predominantly in the hips and gluteal region, is associated with greater hazards[4]. A waist-to-hip ratio of more than 0.85 is considered to indicate abdominal obesity[5]. There are differences in the metabolism of adipocytes of the abdomen and of the gluteal region[6]. It seems possible that the actual dietary composition of high-calorie diets may play a role in determining the site of predominant deposition of fat, though there is, as yet, no documented evidence to this effect. It is also likely that hormonal factors that may be genetically determined, may also play a role in this regard.

There is an impression that South Asians are more prone to abdominal obesity than Europeans or North Americans, but this needs to be substantiated through well-controlled studies. Recent epidemiological evidence points to the conclusion that abdominal obesity is definitely associated with hypertension, heart diseases and diabetes[7]. For this reason, the condition has to be viewed as an important risk factor. The higher vulnerability of Asian migrants to coronary heart diseases, reported from the UK, could be related to this factor[8].

There has not been much interest in SEAR countries in monitoring the changing trends in the incidence of obesity and the types of obesity. In view of the mounting evidence that abdominal obesity is an important risk factor, this problem must now receive far greater attention. The question that needs to be addressed is: what are the dietary and hormonal factors that underlie preferential deposition of fat in the abdomen in obesity?

Coronary Heart Diseases

In Table 16, data on the prevalence of coronary artery disease in Delhi, India, are presented. A study in 1962[9] (based on autopsy) showed a prevalence of 98/1000. A recent community-based study[10] on a large sample of the urban population of Delhi showed a prevalence rate of 32/1000 (when based on clinical history) and 97/1000 (when based on ECG changes). The results of autopsy-based and community-based studies may not be comparable. Obesity and diabetes were found to be strongly correlated with coronary heart disease. The prevalence was three times higher in the high socioeconomic group compared to the poor group; and the prevalence in urban Delhi was over four times that in rural Delhi. These observations provide disturbing evidence that, with increasing urbanization and affluence, the problem will assume serious dimensions in the years ahead.

Table 16. *Prevalence of coronary artery disease in the Indian population*

Location	Year	Prevalence
Delhi[a] (urban)	1962	98/1000 (autopsy)
Delhi[b] (urban)	1990	32/1000 (clinical history) 97/1000 (ECG changes)

[a]Padmavati S. Epidemiology of cardiovascular disease in India. II. Iscahemic heart disease. *Circulation* 1962. 25: 711-717

[b]Chadha SL, *et al.* Epidemiological study of coronary heart disease in the urban population of Delhi. *Indian Journal of Medical Research*. 1990. 92: 424-430.

The community-based study in urban Delhi in 1990 revealed a prevalence rate of 44-48 per cent hypertension in coronary heart disease patients (CHD), indicating hypertension to be an important risk factor in CHD. Diseases of the heart have emerged as the leading cause of death in Thailand, the death rate being 49.5 per 100 000[11]. A study of risk factors in coronary heart diseases in Jakarta, Indonesia, showed prevalence rates in the population of 14.9 per cent for hypertension, of 2.7 per cent for old myocardial infarcts, and of 0.5 per cent for strokes[12].

There can thus be no doubt that coronary heart diseases have already emerged as a problem of importance in SEAR.

The precise factors that underlie the escalation in the incidence of coronary heart disease, especially in urban populations of SEAR countries and among Asian immigrants to industrialized countries of Europe, are still not clear. The greater proneness to coronary heart disease of immigrants from the Indian subcontinent in the UK has been attributed, among other factors, to the predominance of

ghee (clarified butter) in their diets[13]. It is suggested that peroxides in ghee may be atherogenic and may contribute to high blood cholesterol. However, the incidence of coronary heart diseases among the urban middle class in Delhi has apparently not shown any striking association with excessive ghee consumption.

Profile of fats and fatty acids in Asian diets

While animal foods, such as meat, milk, ghee, butter and cheese, contain saturated fats, plant foods, such as cereals, pulses, spices and vegetable oils (except coconut), which most vegetarian Asians consume, contain polyunsaturated and monounsaturated fatty acids and no cholesterol. Vegetable oils and plant foods contain more linolenic acid (n-6) than alpha-linolenic acid (n-3)[14]. Great interest in the beneficial effect of fish oil was sparked off by the pioneering study of Bang *et al*[15]. Recent studies have shown that, since the body can synthesize long chain n-3 polyunsaturated fatty acids (PUFA) (the beneficial component of fish oil) from alpha-linolenic acid present in plant foods and vegetable oils (especially rape seed and mustard oils), these latter can substitute for fish[14].

Another important finding is that green leafy vegetables provide about seven times more alpha-linolenic acid than fresh beans and other vegetables[16]. In cereal-pulse based lacto-vegetarian diets, inclusion of green leafy vegetables will ensure adequate intake of n-3 fatty acid[16]. Thus, green leafy vegetables are important not only for infants and women in the reproductive age but for adult men as well.

Research on the fatty acid profiles of inexpensive plant foods available in the Region must find an important place in the future nutrition research agenda. Since green leafy vegetables (GLV) are an important source of carotene, vitamin C, folic acid, iron, calcium, and n-3 fatty acids, it is important to carry out detailed analysis of GLVs available in the Region in order to identify varieties which have the optimal mix of desirable nutritional properties.

Diabetes

Diabetes is closely linked to diet and nutrition, both with respect to its causation and management. There appear to be some differences in the pathogenesis and course of diabetes between people in tropical developing countries and those in developed countries.

A multicentric study carried out by the Indian Council of Medical Research (ICMR), which covered six regions of India, showed that the prevalence rate of diabetes in urban areas was 2.5 per cent against 1.5 per cent in rural areas[17].

Recent epidemiological studies[17,18,19,20] document a prevalence rate of 3 to 5 per cent. The reported prevalence of diabetes in migrant Indians is indicated in Table 17.

Table 17. *Age-adjusted prevalence of non-insulin-dependent diabetes mellitus (NIDDM) in migrant Indian populations (Percentages)*

	Urban		Rural	
	Men	Women	Men	Women
Fiji Indians[a]	14.4	12.6	13.7	13.2
Mauritian Hindus[b]	11.9	9.0	–	–
Southall Asians[c]	8.9 (Total)	–	–	–

[a]Zimmet P *et al.* Prevalence of diabetes and impaired glucose tolerance in the biracial Melanesian and Indian Population of Fiji : A rural-urban comparison. *American Journal of epidemiology*. 1983. 118: 673-88
[b]Ohlson LO, et al. The influence of body fat distribution on the incidence of diabetes mellitus. 13.5 years of follow-up of the participants in the study of men born in 1913. *Diabetes*. 1985. 34: 1055-58
[c]Mather HM and Keen H. The Southall diabetes survey: Prevalence of known diabetes in Asians and Europeans. *British Medical Journal*. 1985. 291: 1081-84.

In a series of papers on diabetes in the Bulletin of the Nutrition Foundation of India, several aspects of the diabetes problem have been discussed and the points that require elucidation have been highlighted [21,22,23]. Harsha Rao[24] has argued that early undernutrition plays a role in the pathogenesis of diabetes mellitus in later life.

Types of diabetes in undernutrition

Three types of "atypical" diabetes have been reported in undernourished populations: (1) ketosis-resistant insulin-requiring diabetes, called type I, originally described by Hugh Jones[25] in Jamaica and later by Ahuja[26] and Vaishnava[27] in India; (2) Tropical malnutrition diabetes with pancreatic calcification requiring high doses of insulin for its control, and (3) NIDDM seen in the undernourished and obese in developing countries – characterized by moderate hyperglycaemia, insulin resistance, and proneness to ketosis. Much of the high incidence of diabetes in urban populations is accounted for by NIDDM of this type associated with abdominal obesity.

A striking finding in a recent study[28] was the significant association between abnormal, impaired glucose tolerance, insulin resistance, increased BMI and increased waist-hip ratio (abdominal obesity) – again highlighting the fact that abdominal obesity is a central factor common to the problem of hypertension, diabetes and coronary heart disease. The constellation of insulin resistance, impaired glucose tolerance, high blood pressure, hypertriglyceridaemia, and low high-density lipoprotein (HDL) levels commonly encountered in Asia has been designated "syndrome X".

The role of chromium in syndrome X'[29] needs to be investigated. Evidence that chromium deficiency results in insulin resistance and that insulin resistance can be ameliorated by chromium supplementation has been produced[30]. Chromium has been shown to potentiate the action of insulin *in vivo* and *in vitro*. The potentiation of *in vitro* activity has been attributed to a special chemical form, termed Glucose Tolerance Factor, tentatively identified as a chromium-nicotinic acid complex.

Chromium deficiency has also been implicated as a risk factor for cardiovascular disease[31]. If chromium deficiency is a contributing factor, what are the factors in the diet and environment that can explain such deficiency? The major dietary source of chromium is sugar. On the other hand, the hazards of chromium toxicity due to uncontrolled discharge of effluents from tanneries into ponds and streams, and consequent high concentrations of chromium in riverine and marine food, must also be guarded against.

The prevalence of diabetes in Asian countries is much higher in urban populations than in rural populations. Data from India in this regard have been referred to in this chapter. Urban migration results in changes in lifestyle, occupational pattern, exercise level and diet. The major dietary changes are substitution of unrefined wheat or rice or millets by highly polished wheat or rice; increased intake of sugar; and possibly increased intake of fat in some income groups.

Table 18. *Chromium content of some common foods*

Food	Chromium mg/100g
Bajra *(Pennisetum typhoideum)*	0.023
Jowar *(Sorghum vulgare)*	0.008
Ragi *(Eleusine coracana)*	0.028
Rice, parboiled, hand pounded *(Oryza sativa)*	0.009
Rice, milled 10%	0.003
Wheat whole *(Triticum aestivum)*	0.012
Wheat flour (whole)	0.006
Wheat flour (refined)	0.001

Source: *Nutritive value of Indian foods*. Gopalan C *et al.* (Revised and updated by Narasinga Rao BS *et al.*) Indian Council of Medical Research, 1991.

Data on the chromium content of unrefined and refined cereals, presented in Table 18, show that the overall chromium level in the urban diet, based on highly refined and polished cereals, is likely to be lower than that in the rural diet based on undermilled cereals and millets. Apart from chromium, another trace element present in undermilled cereals which is lost as a result of refining, is zinc (Table 19). Thus, highly refined and polished wheat and rice are not only deficient in chromium but also in zinc. What role, if any, these factors play in

the escalation of diabetes in urban populations can, in the present state of our knowledge, only be speculated upon. Further research is necessary in this respect, as also on the significance of other aspects of dietary change following urban migration.

Table 19. *Zinc content of wheat flour*

Wheat flour	Zinc content (μg/g)
Whole wheat	37.7
Biaozhun (partially refined)	20.8
Fuqiang (highly refined)	12.5 (67% loss)

Source: Jiang Z and Li T. Prevalent nutritional problems among infants in China. *International Child Health*. 1993. 4(3): 55-68.

Some Unanswered Questions

Some of the major unanswered questions that seem to need investigation, in the light of available literature, may be broadly highlighted. While high intakes of fat, especially saturated fat, are associated with coronary heart diseases in Europe and the USA, as far as Asian countries are concerned, high dietary fat intake, while it may be important, does not seem to be the major causative factor[32] of coronary heart disease. Cholesterol levels in coronary heart diseases in Asian subjects are rarely as high as those reported in Europe and the USA. A relatively low cholesterol level (with low HDL cholesterol) is the general feature[33]. However, there appears to be a strong association between 'abdominal obesity' on the one hand, and hypertension, diabetes and coronary heart disease on the other. Relatively high carbohydrate and high calorie Asian diets associated with insulin resistance seem to favour abdominal obesity.

NIDDM in SEAR countries is associated with carbohydrate intolerance and insulin resistance. Asian dietaries are predominantly cereal-based. Millets, once the staple of poor rural groups, are now being steadily replaced by wheat and rice, especially the highly milled varieties. This change implies a marked reduction in dietary fibre content and chromium. Studies have shown that post-prandial blood glucose levels after millet diets are lower than those achieved after wheat or rice diets[34]. High calorie intake in Asian high-income groups is largely achieved through high intake of refined cereals and carbohydrates, rather than through fats and meat, as in Europe and North America. Can this account for a greater susceptibility to abdominal obesity; or are there genetically determined hormonal factors that favour deposition of fat preferentially in the abdominal region? Available data favour the hypothesis that insulin resistance, and the metabolic pattern associated with it, underlies the high risk for affluent South Asian people

of coronary heart disease[35]. The relationship of insulin resistance to increased proneness to hypertension and coronary heart disease has to be elucidated.

In summary therefore, the combination of central obesity (abdominal) with high triglyceride, HDL and high low-density lipoprotein (LDL) levels is documented as the X syndrome, and is associated with high prevalence in Asians of morbidity and mortality due to cardiovascular disease and diabetes[29].

Thrombotic and fibrinolytic factors

In studies on cardiovascular diseases in SEAR, not much attention has been devoted to thrombotic and fibrinolytic factors. Lipoprotein (a) {Lp(a)} levels are known to alter the balance between coagulant and fibrinolytic activities as Lp(a) competes with plasminogen binding sites[36]. High Lp(a) levels could inactivate plasminogen and decrease its production, which is necessary for fibrinolysis. High fibrinogen levels have been identified as a risk factor favouring platelet aggregation and thrombotic episodes[37]. At present, we have no data on the effect of dietary factors, particularly high carbohydrate diets of the type prevailing among affluent Asian populations, on blood coagulation/anti-coagulation factors.

In the context of rapid urbanization in SEAR, the reasons for the remarkable escalation in the incidence of coronary heart diseases and diabetes in the urban setting, as compared to the rural setting, need investigation. Is this difference attributable to changes in dietary habits and work patterns? Is the unchecked intensive air pollution now prevailing in the mega-cities of SEAR also a contributing factor? The intensity of the prevailing air pollution in such cities may be expected to be as deleterious with respect to the cardiovascular system as is excessive smoking. We have no studies or data related to these possibilities. The victims of coronary heart disease are largely drawn from the middle-income groups and are relatively young.

The long-term objective must be to develop strategies for the prevention and control of these diseases. The strategies that are being promoted in Europe and North America may not necessarily be appropriate for the populations of SEAR.

Areas of Research

The broad areas of research with respect to obesity, diabetes and coronary heart disease that must receive special attention in SEAR countries will be briefly recapitulated:

- What are the factors – dietary and hormonal – contributing to central (abdominal) obesity?

- What are the factors – dietary and environmental – underlying the escalation of diabetes and coronary heart diseases in the urban population?
- What is the role of chromium deficiency in the observed insulin resistance in Asians with diabetes? Is it possible that the highly refined sugar used by urban populations in place of the less refined varieties in use among rural populations could account for the high incidence of diabetes in the urban setting?
- What is the influence of diet on the profile of factors related to thrombosis or fibrinolysis? What is the contributory role of deleterious changes in these factors in increasing the incidence of coronary heart disease in the urban setting?
- What are the dietary items in the habitual Asian dietaries that are "protective" from the point of view of proneness to coronary heart disease? In particular, detailed information on the fatty acid profile of green leafy vegetables available in the Region needs to be provided.

Clearly, studies of the kind that will be needed in these areas will call for close collaboration between epidemiologists, cardiologists, nutrition scientists, haematologists, diabetologists and biochemists. The forging of such inter-disciplinary research teams is the real challenge. These studies will need laboratory support of a high order, especially where estimation of trace elements and fatty acids is involved.

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9. OSTEOPOROTIC FRACTURE

An Emerging Public Health Problem in Asia?

Osteoporosis is currently a public health problem of major concern in the countries of North America and Europe. The condition clinically manifests itself in the form of fractures of the neck of the femur or compression fractures of the vertebrae. According to one estimate, by the age of 70 years, at least 40 per cent of American women will experience at least one osteoporotic fracture[1], and in 12 to 20 per cent of them the fracture and its complications will prove fatal while in the majority of the rest, prolonged supportive care will be necessary. The incidence among women is nearly double that among men.

In contrast to the above experience, osteoporosis is generally viewed as a problem of minor public health importance in countries of the Third World. For this reason, studies on osteoporosis and its clinical and public health implications have not figured prominently in medical research in developing countries, including those of South and South-East Asia. Studies on bone which have generally attracted attention in India are those related to the problem of fluorosis; and fluorosis has been largely looked upon (till lately) as a disease characterized by osteosclerosis rather than osteoporosis.

While it is true that, on the basis of available evidence, the incidence of osteoporotic fractures is presently far less in the countries of Africa and Asia than in the USA and Europe, there is emerging evidence to suggest that the problem may demand increasing attention in the years ahead, at least in Asian countries. The considerations which point to such an assessment are, briefly, the following:

- The apparently low incidence of osteoporotic fractures in populations of Asian countries so far could be partly attributable to the relatively low life expectancy. Peak bone mass is achieved by early adulthood and thereafter there is progressive loss of bone density, estimated to be around

one per cent per year. It may therefore be expected that, for the reduction in bone density to reach the point where osteoporotic fracture can occur, a time-span of around 20 years may be required, even in populations with a relatively low peak bone mass. With increasing life expectancy, and with the sex ratio favouring the female after 40 years of age, it may be predicted that there will be a significant expansion in the pool of potential candidates for osteoporotic fracture in the years ahead and that this therefore could emerge as an important health problem. Should this happen, health/nutrition care of the aged could become a far more formidable problem than it would otherwise be; and there is no doubt that the proportion of the elderly among Asian populations will progressively increase in the years ahead.

- It is possible that the marked growth retardation and consequent overall reduced skeletal mass of large sections of Asian populations might have partially mitigated the depletion in bone density attributable to low calcium intake in childhood and adolescence. Also, diets very high in protein, of the type that are usually consumed in the USA and Europe, are known to promote increased loss of calcium in the urine. Low protein diets generally in vogue in developing countries could have contributed to better calcium economy. With the progressive removal of constraints on overall growth and with improved diets and incidental increase in dietary protein, these "protective" factors may not be operative in future years.

- There is convincing evidence that Africans and blacks in the USA are relatively immune to vertebral and hip fractures related to osteoporosis because of racial and genetic factors[2,3,4]. A comparative study of changes in vertebral bone density in black girls and white girls during childhood and puberty shows that vertebral bone density is substantially greater in black female subjects in late puberty, and that this difference eventually results in increased peak bone mass in black girls, largely accruing during the 4th and 5th Tanner stages of sexual development[5]. Bone density in black adults, both female and male, has been found to be 10 to 20 per cent greater than in white adults[4]. The metabolic factors underlying this racial difference have yet to be satisfactorily elucidated. Hormonal factors, such as growth hormone, gonadotropins and sex steroid hormones, and calcium-regulating hormones, such as parathyroid, may play a role. Asians, however, do not apparently enjoy the genetic advantage which confers on black Americans relative freedom from the risk of osteoporosis.

In the development of osteoporosis, not only the peak bone mass that is attained in early adulthood but also the rate of subsequent bone loss – especially in the post-menopausal period – is important. There are currently no studies on

the rates and patterns of bone loss in the post-menopausal period which compare American white subjects with American blacks and Asians. It is possible that the extent and pattern of decline in oestrogen levels may be important in determining the loss of bone mass in the post-menopausal period; and there could be racial differences in this regard between Asian and American women but we have no evidence yet.

On the basis of such data as are presently available, it has to be concluded that Asian populations are as vulnerable and prone to osteoporotic fractures as American whites, and that, if other factors contributing to osteoporosis, such as longevity and sedentary lifestyle, also come into play, osteoporotic fractures could emerge as important public health problems in Asian countries. The few research centres in the South-East Asia Region where technical facilities and expertise for studies on bone currently exist, are now reporting a significant incidence of osteoporotic fracture (e.g. Department of Medicine, Ramathibodi Hospital under Dr. Rajatanavin, Bangkok, Thailand, and the National Institute of Nutrition, Hyderabad, India).

Research on the problem of osteoporotic fracture is currently greatly handicapped in countries of SEAR by the lack of adequate sophisticated equipment. Some of the techniques that were earlier in use for the assessment of bone density have now become obsolete because of inadequate sensitivity. Modern techniques for determining bone density, such as the one based on quantitative computer tomography (which measures only trabecular bone, metabolically more active than cortical bone and likely to respond more rapidly to hormonal changes) and another using dual photon absorptiometry or dual energy X-ray absorptiometry, call for expensive equipment. In addition, expertise in hormonal assays and their interpretation is necessary for comprehensive studies on the problem. The current paucity of data from SEAR on this problem may be related to these constraints. It is, however, gratifying that at least two leading centres in the Region are currently engaged in pertinent studies. These centres must be encouraged and supported to undertake collaborative work in this area of emerging importance. Some of the issues that may need to be addressed will be briefly discussed below.

Possible Factors that Need Consideration

The role of calcium deficiency

The present picture regarding the epidemiology of osteoporosis would suggest a minimal role for calcium deficiency in its pathogenesis. Thus, the countries where osteoporosis and fractures of the hip are common are precisely those in

which the intake of milk and dairy products in particular, and the overall intake of dietary calcium in general, is high. This contrasts with developing countries, where osteoporosis is not at present a major health problem, and where there is a low dietary calcium intake. Available excellent reviews of literature on the preventive role of calcium in osteoporosis present contradictory conclusions. There are multiple factors that affect bone loss. While several factors, genetic and environmental, could possibly influence the attainment of peak bone mass, there are others which could influence the subsequent rate of bone mass loss. Elucidation of the precise role of calcium deficiency in osteoporosis, a disease of apparently multifactorial origin, will be a difficult undertaking.

There is evidence supporting the view that increased dietary calcium intake can reduce the risk of osteoporosis[6,7]. It is claimed that calcium deficiency during skeletal formation can decrease peak bone mass and thereby increase the risk of fractures in later life. The skeleton reaches maturity in late adolescence, and it is estimated that 37 per cent of the total skeletal mass of adults is accumulated during the few years of adolescence. It is reasonable to argue, therefore, that adequate supply of dietary calcium, in order to ensure optimal calcium balance during the active phase of adolescent growth, is essential for the attainment of peak bone mass. Dietary calcium is apparently absorbed more efficiently during adolescence than in adulthood and while the level of dietary calcium may determine the pattern of skeletal growth and peak bone mass, it is also possible that the momentum of growth may decide the pattern of metabolic handling of dietary calcium. The subject of dietary calcium requirement in different stages of growth and development is therefore still an unsettled issue.

The dietaries of poor Asian communities provide around 300 mg of calcium, well below the recommended levels. Asian dietaries are predominantly cereal-based, and the phytin content of such dietaries may contribute to the poor bio-availability of calcium. Major sources of calcium, such as milk and dairy products, are generally beyond the reach of the poor. Green leafy vegetables are a good source, but, unfortunately, their intake is low. Spices such as mustard, cumin seeds, curry leaves and coriander, which often figure in Asian dietaries, are good sources of calcium[8] but they are generally taken in relatively small quantities.

Betel leaves and lime may provide some calcium, especially for the adult women who have the habit of chewing them[8]. Millets such as Ragi, which are good sources of calcium, are progressively being given up[9]. On the whole, the dietary calcium intake in Asians of all age-groups, including childhood and adolescence, are well below recommended levels. If low dietary calcium intake is an important determinant of low peak bone mass, and of the risk of osteoporotic

fractures in old age, then Asians in general must be vulnerable. The paradox, however, as was pointed earlier, is that currently the incidence of osteoporotic fractures in these populations is less than in populations subsisting on daily diets which provide at least double the level of calcium contained in poor Asian diets.

This is obviously an area which calls for intensive research.

Adolescent growth

The Nutrition Foundation of India undertook a multicentric study on the pattern of growth of adolescent girls drawn from the most affluent sections of the Indian population[10]. The study showed that the growth performance of these Indian girls conformed to the 50th percentile of the National Centre for Health Statistics (NCHS) standards till the 12th year, and that thereafter (between the 12th and the 18th years) increments in heights of Indian girls were significantly less than those of American girls, as represented by NCHS standards. The difference between the adult heights of American girls on the one hand, and (affluent) Indian girls on the other, developed almost entirely during adolescence (12 to 18 years). The authors of the study argued that, while the level of dietary calcium intake in the predominantly cereal-based Indian diet was perhaps adequate to sustain optimal growth during childhood, it was not sufficient during adolescence, when the demand for calcium for skeletal growth is much higher (since nearly 40 per cent of the overall skeletal growth is compressed within a short time-span of just six years). The growth pattern of Indian girls during adolescence was nearly similar to that reported for Japanese girls.

If reduced dietary calcium intake results in reduced overall skeletal mass, then the effect of low calcium intake on bone density may be minimal. The "wisdom of the body" may dictate that only such skeletal growth as is commensurate with the available dietary calcium is permitted, so as to maintain "bone quality" (an adaptation). This might explain the poorer growth performance of Indian and Japanese girls during their adolescence as compared to American girls. It could be argued that growth retardation might serve to offset the possible deleterious effect of low dietary calcium intake with respect to risk of osteoporotic fracture.

The Nutrition Foundation of India has launched a study to determine the effect of calcium supplementation on the growth performance of Indian girls during adolescence. The results of this study, which is nearing completion, may throw some significant light on this issue.

In a three-year, double blind, placebo-controlled trial of the effect of calcium supplementation (1000 mg of calcium citrate malate per day) on bone mineral

density in 70 pairs of identical twins, it was found that, in pre-pubertal children whose average dietary intake of calcium approximated the recommended dietary allowance, calcium supplementation enhanced the rate of increase in bone mineral density[11]. This effect was, however, not observed in post-pubertal subjects. It was concluded from this study that calcium supplementation, especially during the period of pre-pubertal adolescent growth, can contribute to enhanced peak bone mass, and it was conjectured that this could in turn contribute towards decreased risk of osteoporotic fracture in later years.

In the post-menopausal period, the evidence for a preventive role of calcium supplementation on bone mass reduction is not convincing[12,13,14,15]. Maintenance of bone mass during pre-menopausal years seems to be primarily dependent on the integrity of ovarian function rather than on the level of dietary calcium. On the whole, oestrogen deficiency rather than dietary calcium deficiency seems to emerge as the major cause of post-menopausal osteoporosis.

Most of the studies on the effects of calcium supplementation on bone mass have been carried out on populations with adequate levels of calcium intake. The effects of such supplementation in populations, such as those in Asia which subsist on substantially lower levels of calcium, could be different. This is an area which calls for painstaking, rigorously-controlled epidemiological studies of fairly long duration, with laboratory and technical support of a high order.

Indian Studies on Osteoporotic Fracture

Veena Shatrugana *et al*[16] carried out a retrospective study of osteoporotic fracture at the National Institute of Nutrition in Hyderabad, India. They came up with the remarkable finding that the general impression of osteoporotic fracture, being rare in India, may not be justified. The records of cases admitted to a single hospital in Hyderabad during a ten-month period (January to October 1987), which they analysed, showed that there were as many as 396 cases of fracture. While fractures in female subjects under 40 years of age were mostly work/accident-related, those in subjects above 40 years of age were mostly osteoporotic fractures. Indeed, practically all fractures in subjects of more than 60 years of age were osteoporotic in nature. There were as many as 176 cases of osteoporotic fracture in women above 40 years of age in their sample (Tables 20 and 21). The authors indicated that this number could be an underestimate since quite a few records could not be traced. The data show that osteoporotic fracture in women over 40 years of age in the southern part of India is by no means uncommon.

Table 20. *Distribution of cases of fracture in one hospital in Hyderabad, India, during January–October 1987 (Percentages in parentheses)*

Age (years)	Cases of fracture	
	Women	Men
Under 40	80 (27.7)	61 (57)
40 and above	209 (72.3)	46 (43)
Total	289	107

Table 21. *Types of fracture in women over the age of 40 in one hospital in Hyderabad, India, during January–October 1987*

Type of fracture	Cases	Per cent
Osteoporotic		
Neck of femur	145	69.3
Shaft of humerus	18	8.6
Radius (Colle's)	8	3.8
Pelvis	5	2.4
Others	33	15.9
Total	209	100

These data therefore raise some important and interesting issues which call for further research. Evidence for such a high incidence of fracture of the hip is not available from hospitals in other parts of the country. It is noteworthy that compression fractures of the vertebrae do not figure in Veena Shatrugana *et al*'s sample. This point is returned to below.

Fluorosis

Unlike perhaps in the USA and Europe, an important factor that has to be taken into account in the interpretation of data on osteoporosis and osteoporotic fracture in India and possibly some other countries of Asia, is the problem of fluorosis. As in India, in parts of China, the Arusha region of Tanzania and South Africa also, diets low in calcium, together with a high fluoride intake, produce a metabolic bone disease characterized by osteosclerosis in some parts of the skeleton and by osteoporosis and possibly osteomalacia in other parts. A syndrome of endemic genu valgum in fluorosis endemic areas, characterized by osteoporosis, osteomalacia and osteosclerosis, has been described in adolescents and young adults in India[17]. There have been attempts to treat type I osteoporotic vertebral fractures through fluoride administration[18] although a history of femoral neck fracture is a specific contraindication for such treatment. Increased incidence of hip fracture in osteoporotic patients following fluoride therapy has been reported[19,20], though there appears to

be some controversy about the significance of the painful "lower extremity syndrome" that develops as a side-effect of fluoride therapy.

Fluorides apparently have the property of inducing osteosclerosis preferentially in the vertebral bones, and in the presence of a low calcium diet this is associated with depletion of minerals from limb bones, leading to their osteoporosis. It may be important to review Veena Shatrugana *et al*'s interesting data in the light of this. It is noteworthy that their sample included several subjects who were a little over 40 years of age – not really in the extreme "geriatric" category. Secondly, and more importantly, while fractures of the neck of the femur predominated in their series of cases, vertebral fractures were virtually absent. It is possible that there were vertebral fractures in the series, but in the absence of specific investigation directed to this, they may have been missed. Hyderabad is not exactly a fluorosis-endemic area but the possibility of the major hospital there having attracted patients from nearby fluorosis-endemic areas cannot be ruled out. Increased fluoride retention in subjects subsisting on sorghum (jowar) diets, as compared to those subsisting on rice-based diets, has been reported[21]; and jowar does figure prominently as a staple in the diets of some of the poor-income groups in the area. Therefore, what may be being dealt with here is not the geriatric osteoporotic fractures of the USA and Europe but a syndrome of osteoporotic fracture of the neck of the femur incidental to fluorosis, in which high fluoride intake, low calcium dietaries and post-menopausal loss of bone density (in the case of women past 40 years of age) may all be contributing factors. Studies currently in progress at the National Institute of Nutrition by Veena Shatrugana *et al* may throw light on this interesting possibility.

The foregoing account shows that studies on osteoporosis in the context of generally low dietary calcium intake (and high fluoride content in water in some pockets) must find a place in the future nutrition research agenda of South-East Asian countries. Such studies will not only present interesting academic challenges but may also be of practical value. They may throw light on the unsettled issue of optimal dietary calcium requirement and may possibly contribute towards the prevention of osteoporotic fracture in the elderly and towards better management of the problems of the aged.

Areas of Research

The above considerations raise the following questions:

- What is the incidence of osteoporotic fracture in the countries of the Region? Is the impression that osteoporotic fracture is rare in Asians justified? Is there reason to think that the incidence is rising?

- Does the reported increased incidence of osteoporotic fracture in the Hyderabad area relate to a fluorosis problem?
- Does low calcium intake in Asian dietaries contribute to osteoporotic fracture in old age? Is there a need for calcium supplementation during adolescence in order to improve the peak bone mass attained in early adulthood?

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10. NUTRITION OF THE AGED

BY THE year 2025, the proportion of the populations above 60 years of age in the different countries of SEAR will range from 6.4 to 16.9 per cent[1]. Since the sex ratio favours females after the age of 60 years, the majority of this population will be women. A considerable proportion may be poor and, because of the steady break-up of the joint family culture, they may be living alone. Since the productivity of this group is expected to be impaired, employment opportunities for them will be poor. The aged will add significantly to the overall "dependency ratio", with the added disadvantage that investments for their support will have to be largely based on humanitarian rather than cold economic considerations. Also, the diseases they suffer from will be of the chronic kind involving prolonged medical care. There can therefore be no doubt that the care of the aged will be an important challenge for the countries of SEAR in the next century.

The strategy must be to ensure that at least the "young old", i.e. the age-group between 60 and 70 years of age, live in a reasonably healthy state and remain productive to the extent that they can support themselves, without being too heavy a burden on their families and the State. A health/nutrition policy for the aged directed to this purpose, taking into account the available resources and prevailing cultural values of SEAR countries, will need to be evolved.

In earlier chapters, some specific problems largely pertaining to the elderly were considered, e.g. osteoporosis and degenerative diseases. Here we will consider the general nutrition problems of ageing.

Recent publications have provided valuable information on currently available data with respect to ageing[2,3]. Unfortunately, there has not been much interest in the subject of nutrition in ageing in SEAR countries, for obvious reasons. The Indian Council of Medical Research recently organized a conference on ageing[4] wherein different aspects of the problem, including nutrition, were discussed.

This is an indication of the growing interest in the problem in the countries of the Region. Unfortunately, geriatrics finds no important place in the medical curriculum, and geriatrics as a speciality has attracted very few medical scientists. Attention to geriatric nutrition is also inadequate in the training of dietitians.

The ageing process

Chronological and biological ageing fortunately do not always run parallel. Through judicious health and dietary practices it should be possible to retard biological ageing. The major objective of research must be to identify such judicious practices.

There has been little research on the biology of ageing in SEAR countries. Ageing impairs the immune system and the functioning of the digestive system, reduces muscle and bone mass and is often associated with degenerative changes in cardiovascular and central nervous systems. It is important to identify dietary practices which will retard each of these processes in order to evolve the most appropriate dietary management procedures.

The most striking feature of ageing is the decline in lean body mass[5,6,7], and it is now known that exercise regimens can help to retard this decline[8]. This is important because the loss of lean muscle mass is often accompanied by parallel changes in insulin sensitivity, basal metabolism and morbidity[9]. There is also redistribution of body fat centrally and intra-abdominally in old age. A good proportion of aged in countries of SEAR may belong to poor-income groups, and chronic calorie deficiency in such subjects may be expected to accelerate and aggravate the loss of lean body mass.

Ageing also involves a decline in critical human functions, and it is important to identify the nutrition management procedures that will help to retard such a decline. For example, it has been claimed that decline in immunocompetence in ageing can be retarded by vitamin E[10], and zinc[11]. Ageing also impairs digestive secretions and induces hypochlorohydria that can inhibit vitamin B_{12} and folate absorption[9].

Mental function

Decline in mental function in ageing and confusional states may be partly amenable to amelioration through appropriate dietary practices. The possible role of precursors of neurotransmitters may merit special attention in this regard. Tryptophan is the dietary precursor of serotonin; and it has been shown that tryptophan supplementation can increase brain serotonin levels and induce consequent beneficial changes such as alterations in sleep, food intake, pain

sensitivity and mood (correcting depression)[12]. Supplementation with tyrosine, which is needed for the synthesis of catecholamine neurotransmitters (dopamine, adrenalin and noradrenalin), has also been claimed to have positive beneficial effects on mood[12].Choline is the precursor of acetylcholine, and is most severely affected in senile dementia of the Alzheimer type. It has been claimed that choline supplementation results in changes in behaviour and short-term memory[12]. As well, pyridoxine, vitamin C, copper, thiamine and iron may all indirectly affect neurotransmitters[12].

Hypoglycaemia has powerful effects on brain function and could be responsible for giving rise to confusional states[13]. Zinc deficiency has been associated with psychosis, anorexia and anosmia[14]. Confusion and apathy could result from potassium deficiency, and irritability from magnesium deficiency[15]. Hypokalaemia has been shown to be associated with confusional states in elderly patients[16].

It will thus be clear that, on the basis of available experimental and clinical evidence, there are reasonable prospects of retarding impairment of mental function incidental to ageing through appropriate dietary intervention and nutritional management.

The process of ageing is accelerated by a vicious cycle. The psychological effects of loneliness and a sense of being marginalized by society and the family could be aggravated by the psychological effects of undernutrition. The deleterious effects of dietary deficiencies are aggravated by impaired abilities of mastication (edentulous) and digestion of food and impaired senses of taste and smell. Nutrient deficiencies could add to the impairment of immunocompetence incidental to ageing, and proneness to infections resulting from lowered immunocompetence could further aggravate nutrient deficiencies.

Appropriate diets could therefore, to a great extent, minimise the travails of old age, but there is at present far too little research in this area in the Region. Research is needed which will help us decide what dietary interventions would be helpful in general, and what specific interventions could be helpful in correcting specific disabilities. It has been estimated that our environment contains over 750 000 different chemicals – natural and artificial – and that each year there are about 1000 to 2000 new additions[17]. Few of these substances have been investigated in detail with respect to their effects on health. The elderly are expected to be more vulnerable to these environmental hazards, partly because of decreasing efficiency of detoxifying mechanisms with ageing, and partly because of their longer exposure to the hazards. Elimination of chemicals by the kidneys and liver becomes less effective with age.

A WHO study group[17] has suggested that there are 'gerontogens', which accelerate the ageing process, and 'geronto-protectors', which slow it down. These could also exist in some foods. The high incidence of Parkinsonism and senile dementia observed among inhabitants of the Pacific Marianna islands has been linked to a vegetable substance in their diet which stimulates the ageing of the nervous system.

In deciding on appropriate diets for the aged, the 'balanced diet', based on accepted recommended dietary allowances, could serve as the core. Apart from meeting basic calorie needs for moderate activity and exercise, the diet must also contain sufficient protein of a quality that will supply key amino acids needed for optimal neurological function. Foods that can provide an adequate supply of micronutrients, such as vitamin E, vitamin C, folic acid, vitamin B1 and other vitamins of the B group, vitamin A, vitamin D, and zinc and calcium, will be necessary to prevent disabilities of critical faculties. With such dietary management, it may be possible to achieve a reasonable level of health and productivity for subjects at least up to 70 years of age. A note of caution is however necessary. In the absence of authentic data on nutrient needs in old age, the temptation may well be to provide a "cocktail of nutrients" in the form of pills, tablets or syrups, so as to err on the safe side. This approach may also be promoted by commercial interests. It is to be expected that the concentration of individual nutrients in such a "cocktail" would be unnecessarily large. Certain elements, such as zinc, have entirely opposite effects on the immune system when given in low and high doses[11,18], and trace elements such as copper, selenium and chromium are beneficial in low doses but toxic at high levels. Large daily doses of vitamins A[19] and D could also be counterproductive, and interactions of different micronutrients could also occur which may not be beneficial, e.g. molybdenum – copper. It is therefore important to rely on appropriate natural foods, and to place our faith in the "wisdom of nature".

Detailed studies designed to identify the mix of foods which will meet the currently-known nutrient requirements of the aged cannot be evaded. Recommended dietary allowances and recommended diets for the aged must be developed and made available to health workers in the same way that recommended allowances for infants and children, and for pregnant and lactating women have been drawn up. The validity of such recommendations must be continuously reviewed in the light of fresh data.

The dietary management of infections – acute and chronic – in the aged is also an important area. Appropriate diets for the aged afflicted with chronic diseases need to be identified. Where, as a result of disability and accident, elderly subjects cease to be ambulant, their dietary management can pose special

problems. Regulated exercise is an important requirement in the elderly and advice on the quantum and nature of the exercise must go hand in hand with advice on diet. It is extremely important that homes for the aged are staffed with competent dietitians with some knowledge of dietary needs of the aged. This implies that training in geriatric dietary management must form an important part of the training of dietitians in the future.

Areas of Research

The areas that merit research are the following:

- The present state of nutrition of men and women over 60 years of age in poor income groups in SEAR countries. What is the morbidity pattern? What is the dietary intake and how far does this meet the known dietary requirements of old people?
- The effects of different mixes of dietary supplements on overall functioning, mood, health and productivity in selected samples. Is it possible to identify the dietary supplementation needed to correct specific disabilities and improve specific functions?
- The changes with respect to culinary practices and eating patterns that will ensure optimal nutrition in old age.
- The identification and drawing up of specific recommendations regarding nutrition allowances for the aged and the suggestion of appropriate dietary schedules that can be used in educational programmes in the management of homes for the aged.

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11. FOOD CONTAMINATION

CONTAMINATION of food with biological and chemical agents has always been suspected of being a major public health problem in SEAR, though the precise extent of the problem has not been quantified because of lack of adequate data. In the context of widespread poverty and undernutrition, programmes directed towards the promotion of adequate access to foods that satisfy calorie needs and stave off hunger and malnutrition have taken precedence over programmes designed to ensure the wholesomeness and quality of foods. In short, the emphasis so far has been more on food adequacy than on food quality. This is not to deny that extensive administrative and institutional arrangements for ensuring food safety and food quality have been set up in some SEAR countries, and that these are being continuously improved upon. This process, however, must gather further momentum in the years ahead. With growing urbanization and industrialization and increasing use of "street foods" and "ready-to-eat" foods, programmes for ensuring food safety and food quality will demand far greater attention in the coming decades than in the past. Such programmes must be based on authentic data and be backed by research.

Food Contaminants

There is a wide range of potentially toxic chemical and microbiological agents which currently pose problems with respect to food safety. These include *biological agents*, such as bacteria and bacterial toxins, zoonotic parasites, fungi and fungal toxins, aquatic biotoxins and plant toxins; and *chemical agents* such as pesticide residues and heavy metals, veterinary drug residues, food adulterants, certain food additives, radionuclides, nitrates, nitrites and nitrosoamines. Given the insanitary conditions, poor access to safe water, lack of adequate facilities for sewage disposal and overcrowding in many parts of the countries where the majority of low-income groups live, microbiological agents are still the major

causes of food-borne diseases in SEAR. However, with increasing industrialization and the trend towards uncontrolled discharge of industrial effluents into fields and water sources, and with the growth of ill-regulated and ill-monitored food-processing industries, chemical agents are likely to gain importance as major food contaminants in the years ahead.

Among bacteria causing food-borne diseases, important ones are *Staphylococcus aureus, Bacillus cereus, Salmonella, Escherichia coli, Vibrio parahaemolyticus* and *Clostridium perfringens*. The major fungal toxins are those attributable to *Aspergillus flavus* and to Ergot[1]. More recently, deoxynivalenol tricothecene[2] and phycotoxins have also been found to play a part[3].

Chemical contaminants fall into two broad categories: (1) those entering the food chain as "naturally-occurring toxicants", e.g. *Lathyrus sativus* (lathyrism), *Argemone mexicana* (epidemic dropsy) and some varieties of *Crotolaria* (veno-occlusive disease)[4], and (2) those "external" chemicals inadvertently entering the food chain through improper use, such as pesticides and heavy metals.

Health Implications

Food contamination in SEAR accounts for a considerable part of the incidence of gastrointestinal and diarrhoeal diseases, which are major causes of morbidity and mortality, especially in children under five years.

Diseases caused by fungal contamination of foods, such as aflatoxin hepatitis, enteroergotism, tricothecene and mycotoxicosis, and diseases caused by phycotoxins, have been reported from India. Aflatoxin contamination of groundnut, maize, poultry feed, red chilies and bajra have also been reported[5].

Considerable work has been carried out in India on the biological effects of aflatoxin in normal as well as in malnourished animals, and the carcinogenicity of aflatoxin in primates was demonstrated for the first time in India[6]. Subsequent studies carried out in the veterinary institutes of agricultural universities in South India showed that crossbred Jersey cows, buffaloes, goats, fish and chickens are also affected[7,8,9].

Pesticide residues

There is evidence to suggest that pesticide contamination of foods may be widespread, dichlorodiphenyl trichloroethane (DDT) residues have been detected in a high proportion of samples of bovine milk[5]. Commercial brands of infant formulas also contain unacceptably high levels of DDT and hexachlorocyclohexane (HCH) isomers[5]. Accumulation of pesticide residues in adipose tissues due to

prolonged intake of foods contaminated with pesticide residues could have toxic and carcinogenic effects.

Metals

Contamination of foods with metals is also apparently a significant problem. The presence of arsenic, cadmium, lead, copper and zinc has been reported from samples of commercial brands of infant formula, canned food products and turmeric[5], the levels exceeding the limits permitted under Codex Alimentarius in a small percentage of cases.

In view of recent studies on the possible role of aluminium toxicity in the pathogenesis of Alzheimer's disease, and of the practices of using silver foil containing aluminium (as a contaminant) for packing sweets and using aluminium cooking utensils, the National Institute of Nutrition, Hyderabad, has initiated studies on food contamination with aluminium.

Fisheries

Contaminants pose a serious threat to the production and consumption of fish, with important nutritional and economic implications. Fish is a valuable source of nutrients, especially in coastal areas, and fishing is the major occupation of the rural poor in SEAR. More recently, fish has emerged as an important earner of precious foreign exchange for such countries as Indonesia, Maldives, India and Bangladesh. Apart from fish caught in the sea, rivers or lakes, the farming of fish (aquaculture) in rice fields has now become a growing occupation in parts of SEAR. Under the circumstances, a threat to the yield and quality of fish, arising from pollutants, could lead to major economic losses.

Processed foods

With the rapid growth of the processed food industry in recent years, processed foods, such as snack foods, dairy products, baked foods, confectionery, fruit and vegetable products and convenience foods are coming into increasing use. Apart from ensuring the quality of the basic foods in these preparations, it is also important to ensure the quality of the food additives and preservatives used, and of the packing materials such as paper, plastic, cardboard and cans. While the quality of foods for export is generally ensured because of the quality controls in the international market, procedures for ensuring the safety and quality of foods for internal use in the countries need considerable strengthening and improvement.

Storage losses

Post-harvest losses of food grains caused by insect infestation, mould damage and weed-seed contamination, which take place during harvesting, threshing, drying, processing and storage, are also considerable. Insect infestation also leads to nutritional quality deterioration since certain insects attack the germ selectively, and they also serve to accelerate undesirable chemical changes.

Apart from food grains, almost one-third of fruits and perishable foods are lost because of lack of proper facilities for hygienic storage and preservation. SEAR's problematical micronutrient deficiencies (namely those of iron, folic acid, carotene, vitamin C and zinc) can be solved through the judicious use of vegetables and fruits. The countries of the Region do not have to depend on imported pills, tablets and drugs for correcting micronutrient deficiencies because of the rich bio-diversity and horticultural wealth of the Region. However, horticultural research in general, and development of methods of hygienic preservation and storage of vegetables and fruits in particular, are unfortunately still relatively neglected areas in the SEAR agricultural and food research agendas.

Contamination of riverine and marine foods

Industrial plants located in the vicinity of banks of rivers in SEAR are now discharging effluents containing potentially toxic pollutants, which may be contributing not only to the observed diminution in fish catches but also to the metallic and toxic contamination of fish. A whole array of industries, such as pulp and paper, textiles, tanneries, sugar, distilleries, shellac, hydrogenated vegetable oils, coal washeries and petrochemicals are located on the banks of rivers and streams and are discharging such effluents.

The most notable metallic pollutants derived from such industrial establishments are mercury, lead, chromium, cadmium, copper and zinc. These contaminants are not only likely to persist over a long period but they are also generally water soluble, non-degradable and strongly bonded to polypeptides and proteins. The source of mercury is generally chloroalkali plants which manufacture chlorine and caustic soda. Mercury is extremely toxic to fish and man. The Food and Drug Authority (FDA) of the USA, on the basis of a national marine fisheries service study, earlier fixed an upper limit of 1 ppm for total mercury, in order to protect consumers. More recently, an upper limit based on methyl mercury has been proposed. Sword fish and tuna are more likely to have levels of mercury exceeding the prescribed limits.

Lead finds its way into rivers and ponds from the wastes of industries manufacturing storage batteries, cable sheathing, pigments, water pipes etc.

Cadmium pollution arises from industries manufacturing kitchen utensils and glazed potteries. Zinc, chromium and copper poisoning arises from effluents of metallic industries, mines and dye industries, and leather and explosives industries. The need to ensure the absence of chloramphenicol residues in shrimp samples meant for export has also been insisted upon by the FDA of the USA.

Fungal contamination

Fungal contamination of foods is of special concern because of the fact that climatic conditions in parts of SEAR are conducive to the growth of moulds and fungi.

Numerous outbreaks of large-scale, acute or chronic diseases in humans and farm animals in India, caused by food toxins, were reported in the 1970s. These outbreaks included lathyrism, epidemic dropsy and veno occlusive disease[4], enteroergotism, aflatoxicosis, paralytic shell fish poisoning and bacterial food poisoning. In the 1980s, studies on mycotoxins in foods attracted considerable attention. Apart from aflatoxicosis, outbreaks attributable to other fungal toxins were also reported, such as the one in Kashmir valley attributable to tricothecene mycotoxin (deoxynivalenol) contamination of wheat and sorghum[2]. As well, phycotoxin contamination of shell fish (clams) in Bombay[8], Tamil Nadu and Karnataka[10] has been reported.

Street foods

With increasing urbanization, changes in occupational patterns, and with more and more women seeking employment outside their homes and hamlets, there is currently an increasing trend towards the sale and consumption of foods at the roadside and ready-to-eat foods. Studies on the quality and safety of urban street foods are few.

Street foods are relatively inexpensive and conform to the tastes and preferences of the communities they serve. They provide appreciable amounts of nutrients. However, as has been demonstrated by a study carried out by FAO and the Department of Public Health in the state of Maharashtra in India[11], street foods can form health hazards because of pathogenic organisms, especially *Salmonella* and enteropathogenic ***E.coli***. Such contamination is attributable to the lack of proper food hygiene, use of contaminated water for washing raw vegetables, fruits, utensils and equipment, mishandling of prepared foods, use of ice made from contaminated water and contamination through exposure to dust and flies. Snacks sometimes show evidence of copper contamination because of the use of untinned brass vessels for the preparation and processing of foods.

Non-permitted colours are sometimes present in popular sweetmeats sold by street vendors.

Conventional street foods based on local food habits could, before long, give way to "fast foods" and "junk foods". The problem will thus become even more formidable in the absence of regulatory procedures to ensure food safety and food quality.

Excellent work on food toxins and food contaminants has been (and is being) carried out at the National Institute of Nutrition, Hyderabad. Some of the ongoing studies will be briefly mentioned below because these efforts provide some indication of the vast scope for research that lies ahead in this area.

Aluminium toxicity

The potential role of neurotoxicity due to aluminium in the pathogenesis of Alzheimer's disease has now been recognized. The so-called 'silver' foils widely used to decorate sweets are often contaminated with aluminium[12]. Improperly-coated aluminium vessels may also contribute to aluminium contamination. Aluminium toxicity results in decreased oxygen consumption and degenerative changes in certain areas of the brain. Aluminium contaminants may initially be deposited in bone but, during osteoporosis of old age, with the demineralization of bone, aluminium may exert its toxic effects on the brain. This could be the sequence of events leading up to some cases of Alzheimer's disease. In view of the increasing life expectancy of populations of SEAR, this is a problem that needs to be looked into very carefully.

Newer contaminants

Apart from conventional food contaminants, newer contaminants appear to be emerging. Important sources of newer contaminants are the veterinary drugs used in milch cows. Oxytetracycline residues in bovine milk could pose health hazards and significant proportions of bovine milk samples have been found to contain such residues beyond permissible limits[12].

Research on food toxins and food contaminants has been a relatively neglected area of research. Good nutrition implies intake of food that is not only adequate with respect to nutrient composition but also wholesome. It must not be forgotten that much of the undernutrition in SEAR springs from infections which tend to aggravate primary undernutrition and food contamination, and which, if unchecked, could become major sources of infection in the years ahead.

Research in this area should contribute to the development and propagation of appropriate analytical procedures, which would help to detect and quantify contamination. Since the range of potential contamination is getting broader, efforts in this area can no longer be accorded low priority.

Areas of Research

Important areas of research in this field are:

- Development and promotion of methods for the detection of food contaminants, capable of application at both central reference institutions and peripheral food laboratories.
- Monitoring of the nature and extent of contamination of riverine and marine foods with metals and other poisons derived from industrial effluents and sewage; and identification of ways of reducing contamination of such foods through more hygienic ways of disposal of industrial effluents.
- Monitoring of pesticide levels in foods, and in adipose tissues and body fluids in selected samples of the population.
- Monitoring of food grains stored in granaries and warehouses, for insect and mould contamination.
- Research on emerging newer contaminants such as aluminium.
- Investigations on the quality of street foods and fast foods in urban areas and development of appropriate methods for ensuring their safety and quality.
- A systematic programme for analysis and prescription of permissible limits for different extraneous factors in foods, taking the local context into account and applying the risk analysis approach.
- Development of methods and procedures for reducing food contamination in manufactured processed foods and ready-to-eat foods and in the household handling of foods.

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12. OTHER RESEARCH AREAS OF POSSIBLE FUTURE IMPORTANCE

AS WAS made clear at the outset, the subject areas discussed in this publication do not, by any means, represent a complete list of items that merit research but are only examples of some major areas. In this chapter, several more examples are briefly referred to, which, in the light of the opportunities and circumstances currently prevailing in SEAR countries, may merit future attention.

The effect of nutritional factors on behaviour

There is growing evidence for the importance of the role that nutritional factors play in mental development and in promoting and ensuring normal structure and functioning of the brain. The importance of optimal nutrition in the intra-uterine phase of development and in infancy in ensuring normal development of the brain and in ensuring optimal psychomotor functioning is now well recognized. Unfortunately, because of poor maternal nutrition during pregnancy, many infants among poor communities in the Region start their lives with the initial disadvantage of impaired psychomotor development. However, there is now evidence that good nutrition during infancy could correct psychomotor underdevelopment[1,2].

In the pre-school-age period, because of inadequate calorie-protein nutrition, children from poor communities lack the energy needed for the play and activities necessary for adequate stimulation and mental development. Learning abilities are therefore impaired and huge investments on schooling and primary education fail to yield expected returns. Specific nutrient deficiencies, especially including those of iron and the B complex vitamins (particularly nicotinic acid), in adolescence and adulthood, could contribute to further erosion of the mental functions of

poor communities. Hypothyroidism, including neonatal hypothyroidism, is a major factor presently contributing to mental underdevelopment in children in many parts of SEAR[3,4,5].

These factors in the prevailing nutritional environment, which tend to compromise mental development and function and which have been referred to above, are recognized and have attracted the attention of nutrition researchers in SEAR.

More recently, evidence for the key role that some nutrients play in the functioning of neurotransmitters has been growing, which indicates that diet can exert an effect on mood and behaviour. Reference has already been made to this in an earlier chapter, and it is not necessary here to review the recent literature on the subject. Suffice it to say that any comprehensive programme of nutrition research must cover this important area, which has, as yet attracted little attention in SEAR.

The problem is important both for the individual and for the society. Apathy, irritability and depression are factors which can impair individual productivity and influence behaviour. Developmental transition has raised the expectations and aspirations of communities, while social inequities are being increasingly resented and frustrations are fuelling social unrest and violence. Mental ill-health is by no means confined to the deprived, since it is also a rising problem among the urban affluent – for reasons of stress of a different kind. It is not that these disorders of mood and behaviour can be entirely prevented or modified by diet and nutrition, but the latter can, apparently, make some contribution towards beneficial changes in the mood/behaviour of individuals and, indirectly, of societies. At least this is a possibility that merits study.

The problem acquires added importance in view of the indications that some food additives can induce striking behavioural changes, such as hyperactivity, in children. In assessments of the safety of food additives, their possible effects on neurotransmitters and on behaviour in general rarely get attention. With the inevitable increased use of processed foods in the future, the need for an adequate focus on this area is obvious.

Traditionally, in practically all SEAR countries, there are ancient beliefs that dietary factors can influence mood. Some foods are believed to excite and some to calm emotions. Indeed, some foods have been traditionally "prohibited" on certain occasions or for certain groups because of their possible effects on mood and behaviour. These beliefs have generally been dismissed as part of folklore. While it may still be the case that many of these traditional beliefs are not scientifically valid, it is important, in the light of available evidence, to study the

effects of different food items in common use in SEAR on measurable parameters, related to neurotransmitters, which are likely to affect behaviour and mood, not only in experimental animals but in human subjects as well. It is also important to determine if, in the management of mental disorders such as depression or of neurological disorders such as epilepsy, it is possible to suggest beneficial dietary changes.

The effect of behaviour on nutrition

In the above discussion on nutrition and behaviour, the possible effects of nutritional factors on behaviour have been considered. There is another equally important dimension to the nutrition-behaviour inter-relationship, namely the effect of behaviour on nutrition. That dietary patterns and the consequent nutritional statuses of individuals and communities are strongly influenced by attitudes and behavioural patterns must be obvious to all field workers. Meaningful nutrition education programmes must not stop at providing information on what changes in existing dietaries are desirable. They should also attempt to understand and overcome the behavioural patterns that stand in the way of bringing about such changes. Unfortunately, far too little attention has been paid to this aspect and, as a result, many nutrition education programmes which have succeeded in imparting information have failed to bring about actual changes in practice. This underscores the need for the involvement of behavioural scientists in nutrition education programmes for communities and in nutrition research programmes.

Traditional foods and food-related belief systems

There are numerous "tribal pockets" in SEAR countries where communities who are not yet fully integrated with the mainstream populations, continue with their own special dietary practices and food preferences. Even among the so-called "mainstream" population groups, distinct regional and "sub-sect" food habits, prejudices and taboos persist. Certain foods, especially in tribal areas, are claimed to possess special nutritive value and medicinal properties. Investigating every such claim would be a time-consuming and futile exercise. However, on the basis of properly conducted diet/nutrition/health surveys of such population groups, some claims may appear to be worth investigating. Apart from foods, the eating patterns of population groups, including infant and child-feeding practices, also merit investigation. There is far greater seasonality with respect to food practices in those communities whose subsistence economy ensures that they use many plant and animal foods looked down upon by the general population. It would be unfortunate to lose the opportunity to investigate this rich cultural diversity in choice of foods and eating patterns. With developmental transition gathering

momentum, these communities will get progressively "assimilated", and the present rich diversity could be replaced by a uniformity which may not necessarily be all that beneficial. Opportunities for research of this kind today are far greater in SEAR than in other Regions, and far greater today than they will be a few decades further on.

Nutrition of athletes and sportsmen

It is perhaps understandable that this area has so far attracted little attention in SEAR countries. In a situation where large sections of the populations are still undernourished, research on problems related to adequate nutrition of athletes and sportsmen may seem an unnecessary luxury. While heavy investments in such research may not be justified, at least one or two centres in the countries of the Region should be encouraged to undertake research on this problem. The possible benefits of such studies may not necessarily be confined to athletes and sportsmen alone.

The performance of athletes and sportsmen from SEAR countries in international sporting events has not been particularly spectacular, except, perhaps, in such events as wrestling and also in such sports (e.g. badminton and table tennis) where nimbleness and alertness rather than brute strength are often the factors which determine success. It is also believed that SEAR subjects generally lack the "killer instinct" (probably meaning mental stamina) needed to clinch a victory in a sports event. While it may not exactly be necessary or desirable to identify dietary patterns that promote the "killer instinct" even in sports, it is necessary to identify dietary practices which facilitate the attainment of peak levels of physical and mental stamina. It appears that dietary regimens appropriate for events requiring heavy weight and muscular strength may be different from those for events requiring speed and nimbleness. If countries of SEAR participate in international sports events (which they do), it is important to carry out some research designed to identify dietary patterns, based on local foods and preferences, needed to achieve maximum efficiency in such events.

Investigations in the broader area of "nutrition and work efficiency" will of course be of wider concern to the population. It is important that research on optimal nutrient requirements for maximum work efficiency in the major types of occupation receives adequate attention. A considerable part of the work force in the countries of the Region in the next two decades is likely to be drawn from those segments of the populations who suffered undernutrition in childhood and adolescence. Studies of the kind that Satyanarayana *et al*[6] carried out in India will continue to be important, especially in the transtional stages of development.

The effect of specific changes in dietary habits on nutritional status

A major change in dietary habits in many SEAR countries is the progressive displacement of millets by wheat or rice as the staple food. This has resulted in a decrease in the overall fibre content of the diet, and possibly also in the calcium content[7] and the content of some trace elements e.g. chromium. Blood glucose levels following a meal based on millets are significantly less than those following a meal based on rice or wheat[8].

In an earlier chapter, the possible role of major dietary changes, consequent to urbanization, on the escalation of diabetes in the urban population and on the increasing incidence of obesity were raised. The substitution of millets by rice and other dietary changes following urban migration are also associated with parallel changes in living style and occupation pattern; and for this reason it will be difficult to design a study to investigate the specific effects of this dietary change. But it should certainly be possible, in some situations, to identify subjects who are currently subsisting on millets and to study in them basic aspects of carbohydrate metabolism such as blood glucose and insulin levels. The same subjects should subsequently be maintained for 8 to 12 weeks on a different staple food while retaining the same living style and work environment. Reinvestigation of carbohydrate metabolism parameters at the end of this period would reveal any changes. As mentioned above, opportunities for these kinds of studies will disappear with the passage of time.

Hormonal factors in growth and senescence

There is evidence that genetic differences exist between ethnic groups with respect to growth and development during adolescence. This was referred to in earlier chapters. There have been no comparative studies on oestrogen or related hormone profiles in different stages of adolescence and senescence. The increased bone accretion in black American girls, as compared to white American girls, during adolescence, and the possible role of hormonal factors in this regard was referred to earlier. Although it is not known if the decline in oestrogen level in the post-menopausal period is different in these two groups, this could be a factor that regulates the speed of senescence.

Concern has been voiced over the possible role of increased exposure to oestrogens on foetal development. Sharp declines in the sperm counts of populations of developed countries have recently been reported[9]. There is no authentic information in this regard with respect to populations of SEAR. This is an important area which calls for collaborative research by endocrinologists,

reproductive biologists and nutrition scientists. Such studies would also relate to problems of growth and ageing and to problems of fertility.

Nutrition and drug toxicology

It is well known that most potent drugs have toxic metabolic side-effects when 'safe' levels of dosage are exceeded. Where nutritional status is poor or borderline, the 'safety' limits of dosage with respect to some drugs may be lower. Chronic diseases, such as tuberculosis and leprosy, call for prolonged drug treatment, and the dangers of side-effects are greater. While some studies on drug toxicology in undernourished subjects have been carried out by the Food and Drug Toxicology Unit of the National Institute of Nutrition, Hyderabad, there is a need for much greater systematic effort in this area. This will become all the more necessary as new drugs and genetically-engineered products enter the market.

An example of the types of possible danger that can arise from pharmacological doses of nutrients (which are essential at physiological levels) is provided by recent claims regarding the effects of some drugs on the evolution of AIDS. Researchers in the Johns Hopkins School of Public Health claim that high doses of zinc and vitamin A accelerate the speed of progression of HIV infection to AIDS[10]. This claim has yet to be confirmed. Mega-doses of synthetic vitamin A in infancy are also promoted by some circles for the prevention of vitamin A deficiency. However, studies in Bangladesh have shown that ten per cent of infants subjected to such mega-dose administration develop signs of increased intra-cranial tension reflected in bulging of fontanelles, although some dismiss this finding as unimportant. It is well known that the brain largely develops during infancy, and that a third of infants in the Indian sub-continent are of low birth weight and start life with the disadvantages of intra-uterine growth retardation and its associated psychomotor defects. Is it wise to submit such infants to repeated bouts of increased intra-cranial tension while relatively safe and inexpensive methods for the prevention of vitamin A deficiency are available? What would be the effects of repeated mega-doses of synthetic vitamins on the mental and physical development of children already suffering from the effects of intra-uterine growth retardation and consequent psychomotor deficiency? These are serious ethical issues which have, unfortunately, not received the attention they should.

In any future nutrition research agenda, programmes for the identification of possible health/nutrition hazards from new chemicals, or even from old chemicals, such as synthetic vitamins, that may be promoted for pharmacological use, must find an important place.

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13. TECHNOLOGICAL RESEARCH

MUCH of the research in the area of Food and Nutrition belongs to the category of technological research. The scope for this type of research is very vast, especially in developing countries. Examples of technological research which can legitimately be considered either as part of overall nutrition research or as a most useful and necessary adjunct to it are briefly considered below.

Research designed to increase the calorie density of cereal-based diets

This area of nutrition research is of great practical importance, especially from the point of view of infant and child feeding. Cereal-based foods, when cooked, are "bulky" and of low calorie density, especially if the fat content is low. Techniques such as the malting of cereals originally developed by Desikachar[1], and further extension of these efforts to produce "amylase rich food", by Tara Gopaldas[2], are most useful contributions.

There is a great need for studies designed to improve calorie density, palatability and acceptability of inexpensive foods available in the Region and to identify cooking procedures, preservation and storage procedures which will result in minimal loss of nutrients.

Germination of pulses and legumes can facilitate their increased use in the diets of infants and children. This is an area in which dietitians, food technologists and nutrition scientists can gainfully collaborate.

Research designed to promote increased intake of green leafy vegetables

Green leafy vegetables (GLV) curently enjoy low social prestige and acceptability. They rarely figure significantly in the dietaries of infants and children or of pregnant and lactating women. Apart from the lack of sufficient knowledge of

their nutritional importance, the high fibre content of some of the vegetables may be a factor currently inhibiting their wide use. This is an area where a great deal of imaginative research is called for. How can GLV, rich in carotene, vitamin C, iron and folic acid, be successfully incorporated in adequate amounts in the dietaries of infants, children, and pregnant and lactating women?

There is perhaps no area of food and nutrition research in SEAR that is more important today than research designed to provide answers to the above crucial question. Success with respect to combating the problems of anaemia, vitamin A deficiency and micronutrient deficiency will hinge on this issue. The social-marketing efforts that have recently been initiated in Thailand, and the "horticultural intervention for nutrition improvements" being developed by the National Institute of Nutrition, Hyderabad, are steps in the right direction; but these efforts have to be greatly intensified and must result in the identification and development of acceptable and feasible methods of promoting the intake of these foods. The National Institute of Nutrition, Hyderabad, has taken the right step in practical nutrition-oriented horticulture by developing a "nutrition garden" within its own campus, which serves as an excellent educational tool to demonstrate the rich array of nutritive vegetables and fruits that can be grown with minimal input. This example deserves to be emulated.

Suitable methods of preservation of GLVs, fruits and vegetables need to be developed and propagated; and the technologies so developed need to be evaluated and continuously improved. In turn, these could become income-generating, village-based industries that can provide employment to millions of poor women in the countryside.

Carotene rich food sources

Research on *Spirulina* holds considerable promise and needs to be intensified. If *Spirulina* is to find wide use as a carotene source, especially for infants and mothers, efforts must go into increasing its acceptability and shelf life as well as its cultivation at the village level. The shelf life and acceptability of the products currently available are not adequate. The carotene content of the *Spirulina* tablets currently available seems to decrease substantially within a few weeks, and this needs to be corrected.

Research on red palm oil, which is again a rich source of carotene (but unfortunately not being wisely used at present), must be directed towards improving its acceptability. Deodorization may improve its acceptability to some extent but the technology must be such that it will not add to the cost substantially. The relatively short shelf life of the product currently poses problems with respect

to its wider use, especially since red palm can be cultivated only in certain climatic zones. Red palm is very much an asset of SEAR. The fact that the precious carotene in red palm oil is now being wastefully drained off and that only the oil is being widely used is an unfortunate instance of inverted (or perverted) priorities. Research must be directed towards eliminating this "aberration".

Technological research related to goitre control

The need for improvement of the technology for iodine fortification of common salt was referred to earlier. The stability of iodine in fortified salt is in need of improvement, especially in the situation which prevails in most countries of SEAR where poor-grade crystalline salt is used under hot and humid conditions. The problem of fortification of common salt with iron/iodine is still at a stage in which reservations about the technology for large-scale application still exist. These reservations must be overcome.

The need for the countries of SEAR to develop technologies of their own for the manufacture of potassium iodate, which they need for their goitre control programmes, was also referred to earlier. Though the fear of a nuclear holocaust has largely receded, many developed countries are apparently hoarding large supplies of iodine for the protection of their populations in the event of an accident. SEAR must seek to become self-reliant with respect to its needed supplies of potassium iodate.

Iron fortification of common salt

The National Institute of Nutrition, Hyderabad, has successfully developed a technology for this purpose although it has not yet been used on a large scale. This implies that perhaps further refinement in the technology is called for. At least if high grade, free-flowing salt can be iron-fortified at an acceptable level, it may become possible to extend the process to crystalline salt of poorer grade in due course.

Technology for growth monitoring

Nearly a decade ago, "growth monitoring" had almost become an "industry" and many new generations of fanciful weighing scales with coloured growth charts fabricated in Europe were being supplied to the countries of the Third World. Surely, the manufacture of simple weighing scales for use in growth monitoring operations in the field must be well within the competence of technologists of SEAR. What we are speaking about are not "micro" scales but weighing scales for general use in public health operations. Since nutrition surveys and public

health programmes will involve growth measurements, it is important that accurate, reliable and durable weighing scales are prepared and made available.

Ready-to-eat foods

With rapid urbanization and with more and more women seeking employment opportunities outside their homes, ready-to-eat foods will come into increasing use. Also, in the major welfare programmes in the countries of the Region (like the Integrated Child Development Services (ICDS) programme in India) and in school meal programmes and other supplementary feeding programmes which are now largely based on foods cooked daily in welfare centres, ready-to-eat foods will come into use. As a method of employment-generation, it would be wise to use village women to prepare these ready-to-eat foods. In order that such foods are hygienically prepared and based on inexpensive, locally-available foods, input from technological institutes and home science colleges will be required not only in the initial stages but also for the periodical monitoring of the quality of the foods. Large-scale supplementary feeding programmes will acquire better meaning if, instead of being give-away operations based on foreign handouts, they are operated in a manner that promotes income-generating skills among the rural populations that use local food resources. In the preparation of such ready-to-eat foods, it should be possible to use nutritious, locally-available foods, including inexpensive GLVs.

Home science colleges should undertake research and extension activities of a kind which will help to disseminate the benefits of research of high-powered research laboratories to the people of poor communities. A great deal of technological and operational research will be needed for such an endeavour.

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Section III

NUTRITION RESEARCH SUPPORT SYSTEMS

14. NUTRITION RESEARCH SUPPORT SYSTEMS

IN EARLIER chapters, some of the major issues that should find places in a future Nutrition Research Agenda have been discussed. It is obvious that nutrition research, which encompasses such a wide field, will need to be facilitated and sustained by efficient support systems.

Firstly, arrangements must be made to ensure a continuous flow of up-to-date and relevant basic data necessary for identifying problems, for formulating meaningful hypotheses to be tested and for evaluating the impact of interventions undertaken on the basis of research findings. Secondly, because of the rapid advances in technology and instrumentation, it is important that the most up-to-date and accurate techniques are employed in nutrition research, in order that the results obtained stand scientific scrutiny in the international scientific arena. This will, in turn, imply the availability of not only high-quality instruments and laboratory facilities but also, even more importantly, of well-trained scientists and technologists fully conversant with the use of these technologies and with the maintenance of the instruments. Thirdly, with the increasing need for interdisciplinary research of a collaborative nature, it is also important to provide opportunities for experts in a given field to acquire short-term orientation or exposure in other specialities related to the research project being undertaken. There will also be an increasing need for networking, both intercountry and intracountry, so that institutions can mutually reinforce their efforts and augment their respective expertise for the common good. Some of these aspects will be briefly considered in this chapter.

Ensuring an Up-to-Date Authentic Data Base

The need for updating food composition tables

Any meaningful infrastructure for improving diets in households must obviously rest on precise information of the nutritive value of foods – both raw and cooked. Excellent publications on food composition are now available in the Region, an example of which is that from the National Institute of Nutrition, Hyderabad, India[1], but unless a continuing programme for updating these is set up, the data will become progressively less useful and more outdated. As a result of intensive agricultural technology, there has been a substantial change in soil chemistry which is bound to be reflected in the nutrient composition of the foods grown on such soils. In particular, micronutrient composition is likely to suffer significant changes. More reliable techniques for the estimation of trace elements and micronutrients are now available, while some of the old data gathered through the application of earlier methods are now obsolete and in need of revision. Furthermore, with the increasing application of genetic engineering technologies, improved varieties of foods – food grains, vegetables and fruits – will be evolved, and these will need to be analysed.

Analysis of foods must include both raw foods and those foods cooked in different ways. In particular, with the increasing attempts to incorporate green leafy vegetables in weaning dietaries, the nutritive composition of infant foods (home prepared, using different recipes and different cooking procedures) will need to be known. Programmes for nutrition education, especially with respect to infant, child and maternal health, will depend heavily on such data. The extent of loss of such nutrients as carotene with different cooking practices needs to be assessed and the culinary procedures which yield products of the highest nutritive value and acceptability will need to be promoted.

Food analysis methods are becoming more and more sophisticated. Thus methods of estimation of vitamin A and carotene require the use of high pressure liquid chromatography (HPLC), a facility that is available only in a few laboratories in the Region. Equipment needed for trace element analysis is again highly sophisticated and expensive. If nutrition research in SEAR is to keep pace with that in the most advanced countries, these resources must be made available. The material and manpower resources needed to conduct high-quality food analysis will need to be provided at least in a few centres, which may also act as reference laboratories for this purpose. Indeed, some of these efforts could be undertaken on a regional basis through intercountry cooperation facilitated by the WHO Regional Office for South-East Asia.

Food contaminants

Apart from nutrients, foods will also need to be analysed for contaminants and additives. Currently, facilities available for this purpose are extremely limited and generally of poor quality. Consequent to urbanization, industrialization and changing occupation patterns, ready-to-eat foods, processed foods, street foods and fast foods are likely to come into increasing use and are likely to figure in the dietaries of poor people as well. A rigorous programme for the monitoring of such foods and for the enforcement of quality and safety standards will become an increasingly compelling requirement.

Diet surveys and nutrition surveys

In an earlier chapter, the importance of regular periodic monitoring of the nutritional statuses of populations was emphasized. It is necessary to collect, at regular intervals, reliable data on the dietary intakes and nutritional statuses of representative population groups. The methodology being adopted by the National Nutrition Monitoring Bureau in India for this purpose may serve as an example that can be improved upon. The survey population must be sufficiently representative of the different population segments and different regions of the country covered. This implies careful statistical sampling. The actual survey procedure must be feasible and inexpensive enough to be undertaken on a country-wide scale, and, at the same time, productive of essential data. More detailed surveys using more elaborate techniques may be carried out on representative sub-samples. The surveys must cover the same populations at least once every five years so that changing trends and regional differences can be identified.

Surveys of this kind can generate a great deal of useful data which, in turn, can stimulate a great deal of useful secondary research. If the methodology for surveys in all the countries can be standardized so as to ensure some degree of uniformity and comparability, the information generated will be of tremendous use. The WHO Regional Office could facilitate this effort and provide such material and technical inputs as may be necessary to sustain it.

Material and Manpower Resources

Research of high quality needs well-trained and motivated scientists; it also needs modern equipment. Currently, scientists who are engaged in nutrition research in the Region fall into four major categories: medical scientists (mostly public health scientists, paediatricians and physiologists), biochemists, food technologists and scientists from colleges of home science. There are few institutes solely devoted to human nutrition research in the Region. With the rise of the new

disciplines of biotechnology, genetic engineering, and molecular biology, more and more biochemists are being drawn into these "glamorous" areas.

Medical scientists find careers in nutrition research to be far less rewarding than careers in other areas. Food technologists are more strongly attracted to commercial establishments than to academic research establishments and the problems of poor communities. Home science colleges still accord a high place to food and nutrition training but only a few candidates trained in these institutes take up nutrition research as a career.

Nutrition research in the future will attract scientists of good calibre from diverse disciplines only if the research offers intellectual scientific challenges on the one hand, and possibilities of emotional satisfaction of contributing to public good on the other. The execution of such a research agenda will need resources.

Central national nutrition research institutes must take responsibility for the promotion and conduct of high quality nutrition research. Such institutes must be generously funded so as to provide attractive opportunities to well-qualified scientists. They must also function as training centres for prospective nutrition research scientists. Furthermore, these institutions should be nodal points for sustaining nutrition research in the Region and centres to provide scientific back-up for the formulation and implementation of national nutrition policies.

Modern scientific research calls for sophisticated and expensive equipment. The paucity of such equipment for even the basic functions of a nutrition research institute, such as food analysis, was referred to earlier. Nutrition research today involves microbiological, immunological and endocrinological techniques, all of which need modern equipment and without which it will be impossible to attract highly qualified scientists.

Investments in such equipment, at least for use in a few selected nodal nutrition research centres, must not be considered a luxury. It is sad that, in a vast country like India, there are today fewer than half a dozen institutes equipped with HPLC facilities for estimation of carotenoids and vitamin A. There are very few centres which can carry out trace element analysis and radio immunoassays, and no centre as yet which can perform bone densitometry studies using currently-accepted modern techniques. If SEAR is to be in the forefront of nutrition research in the future, as in the past, these deficiencies must be recognized and corrected.

Networking

Since the spectrum of disciplines which nutrition research has to draw upon today is very wide, it will be impossible for any one institute, however well equipped,

to do full justice to a comprehensive nutrition research agenda. Collaboration with sister institutes will become increasingly necessary. Unfortunately, the "culture" of such inter-institutional collaboration is not much in evidence in the countries of SEAR, probably because institutes which need to collaborate come under the purview of different administrative sectors.

To give some examples, in the internationally WHO-funded Monica Project on Coronary Heart Diseases, Indonesia is the only participating SEAR country. The leading cardiology institute of the country is responsible for the project in Indonesia. This is as it should be. However, it is strange that the Institute of Nutrition at Bogor in that country has no role in the project; this in spite of the fact that a project of this kind must have a major nutrition component. "Nutrition" has been designated an "optional" component at the global level; but as far as developing countries are concerned, it must be considered an "obligatory" component. Similarly, despite the proximity of the Centre of Molecular Biology, of international repute, in Hyderabad, to the National Institute of Nutrition in Hyderabad, there is not much active scientific collaboration between the two (except in the area of research on cataract).

The newly-set up and well-funded biotechnology institutes of Indonesia and Thailand do not seem to have much interaction with the leading nutrition institutes of those countries, and do not even seem to have "nutrition" on their research agendas. As well, there is little inter-institutional collaboration between agricultural and veterinary institutes on the one hand, and human nutrition research centres on the other, in the countries of the Region.

All this is unfortunate. It is extremely important to forge inter-institutional collaboration in order to achieve successful execution of research programmes, especially where resources are limited. Even where resources are plentiful, such collaboration is necessary because it is impossible for any one institute in any country, however advanced, to have under its roof expertise of the highest calibre in widely different disciplines. The greatest challenge that nutrition research of the future in SEAR will face is to achieve networking, and this will call for imaginative leadership. An example of networking is the project design for the promotion of research on green leafy vegetables (see Figure 7). This is a project design for an integrated approach towards augmenting the production, availability and intake of green leafy vegetables – objectives which are extremely relevant for combating undernutrition in many countries of the Region. It will be seen from the figure that scientists from as many as eight to ten different disciplines will need to collaborate. In the absence of such cooperation, efforts will be fragmented and results will be less rewarding.

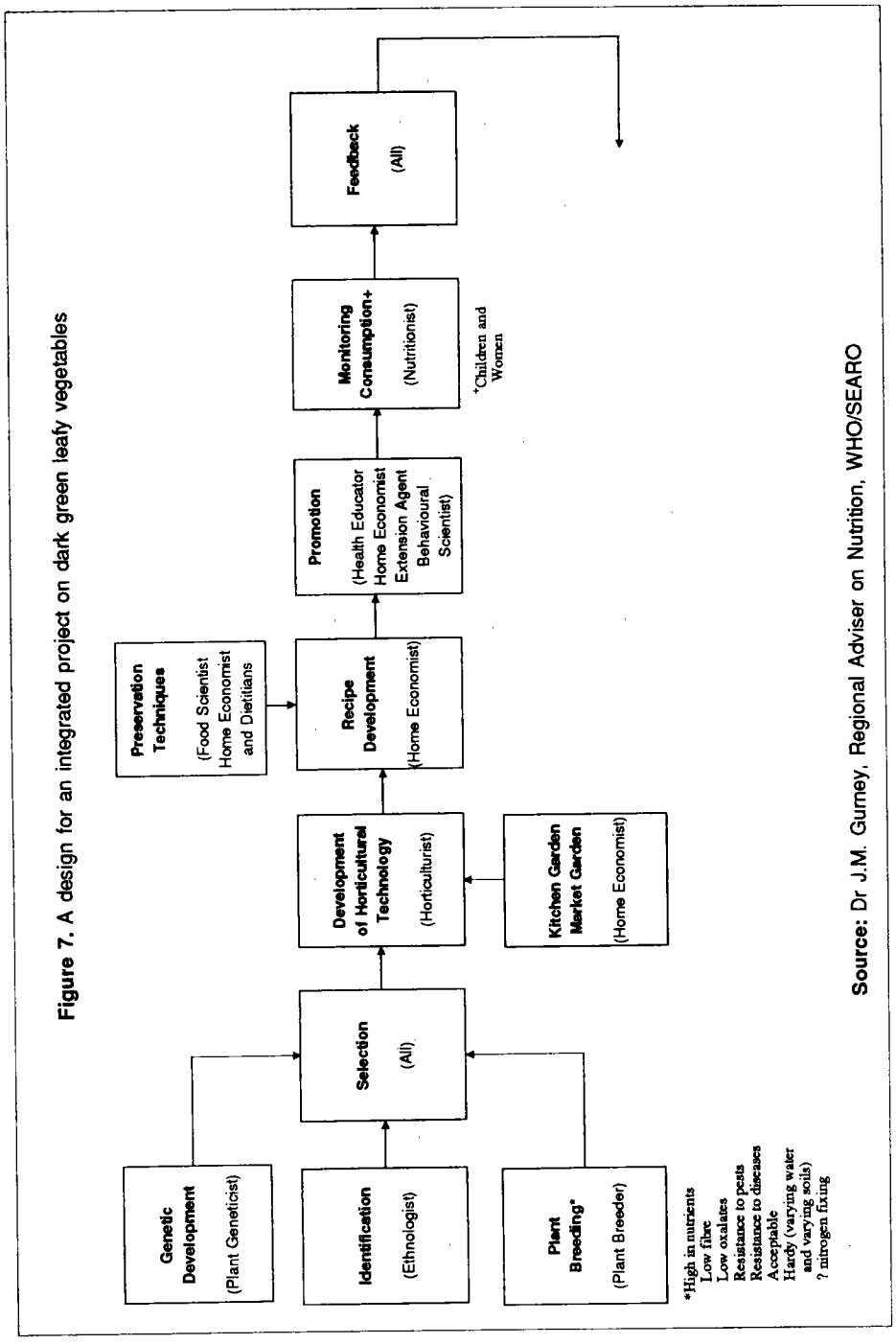

Figure 7. A design for an integrated project on dark green leafy vegetables

Source: Dr J.M. Gurney, Regional Adviser on Nutrition, WHO/SEARO

The "functional coalition" that may be needed for other areas of nutrition research, such as nutrition and cancer, nutrition and diabetes and nutrition and coronory heart disease, will, of course, be of a different kind, and involve other disciplines.

All this indicates that nutrition research programmes of the future will need scientists who, while being highly proficient in their own specialities, must also be aware of the need for forging effective links with scientists of other disciplines.

In Europe, centres for research on animal nutrition have made rich contributions to the growth of nutrition science, and centres devoted to human nutrition research have benefited greatly from the inputs of institutes of animal nutrition. There are currently no major centres of animal nutrition in SEAR, but it is gratifying that the proposal of the Indian Council of Agricultural Research to set up a National Institute of Animal Nutrition in Delhi will shortly be implemented. This step could augment the growth of nutrition science.

In order to update nutrition personnel, there is a need for short-term, high quality training courses and for programmes and workshops in frontier areas of nutrition research as well as in conventional areas of nutritional epidemiology, radio immunoassay, trace element analysis and food analysis techniques, etc. New techniques in biotechnology and genetic engineering will need to be fostered and national networking of institutes to promote training in modern techniques for nutrition research will be necessary. The certificate and the masters courses in nutrition at the National Institute of Nutrition, Hyderabad, which have been consistently supported by the WHO Regional Office for South-East Asia for some years, have yielded rich dividends. These efforts must continue and similar training programmes in other SEAR countries must be encouraged.

There is also a great need to set up a grid of nodal national nutrition institutes in the Region. The WHO Regional Office has already taken imaginative steps in this regard, but the process must gather further momentum and strength in the years to come. Networking will have real meaning and strength only if the effort is not merely confined to exchange of information and ideas, but also extends to active collaboration in specific intercountry projects.

Fortunately, SEAR can boast of excellent institutes and well-trained scientists in the field of nutrition. A strong foundation for a vigorous programme of nutrition research exists; and it is necessary to build on this rich foundation. Advances in science, including nutrition, are rapid, but unless there is continuing renewal and growth, even the best institutions and scientists of today will soon get outdated.

Since nutrition will be an area of high priority from the point of view of overall development of the Region for some decades to come, it is important that a Nutrition Research Agenda which addresses our present and future needs finds adequate national and international support.

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ANNEXES

Annex 1

A NUTRITION AGENDA FOR THE FUTURE – SUGGESTED ITEMS

1. **Problems Related to Poverty**
   - High incidence of low birth weight in infants
   - Retardation of child growth and development (physical and mental)
   - Iron/folate deficiency anaemia
   - Goitre and iodine deficiency disorders
   - Micronutrient deficiencies

2. **Nutrition and Chronic Diseases**
   - Nutrition and cancer
   - Nutrition and degenerative diseases – obesity, diabetes and coronary heart diseases

3. **Problems Related to Demographic Transition**
   - Nutrition and ageing
   - Nutrition and osteoporosis
   - Nutritional problems related to urbanization

4. **Problems Related to "Developmental Technologies"**
   - Nutritional problems related to increasing environmental degradation
   - Problems of ensuring food safety and food quality

5. Other Research Areas of Possible Future Importance

- Nutrition and behaviour
- Traditional foods and food-related belief systems
- Nutrition and drugs
- Nutrition and AIDS
- Nutrition and work efficiency of athletes and sportsmen

6. Technological Research

- Research designed to increase the calorie density of cereal-based foods
- Research to identify and selectively propagate varieties of green leafy vegetables and fruits with high nutritive value, and promotion of their increased intake.
- Research designed to achieve national self-reliance with respect to prevention and control of major nutritional problems
  - Research on new nutrient sources – red palm oil and *Spirulina*
  - Improving methods of iron and iodine fortification of common foods – including salt fortification
  - Indigenous manufacture of potassium iodate for salt fortification
  - Inexpensive ready-to-eat foods based on inexpensive food sources and with good shelf life, for national supplementation programmes and school meal programmes.

Annex 2

ESSENTIAL RESEARCH SUPPORT SYSTEMS

1. **Ensuring an Up-to-Date Authentic Database**
   - Systematic updating of food composition tables using modern analytical methods
   - Continuous monitoring of national nutritional statuses

2. **Training of Technical Manpower**

3. **Forging of Inter-institutional and Interdisciplinary Networks** (national and international) for the implementation of comprehensive nutrition research projects.

4. **Development of Appropriate Communication Tools and Strategies to Promote Salutary Dietary Habits.**