When I first met Dr. Gopalan, he was Director-General of the Indian Council of Medical Research. At that time I was working in the ICMR headquarters, New Delhi, and was part of the central coordinating team for the ICMR collaborative study on short-term sequelae of induced abortion. During the ICMR scientific meetings I used to enjoy Dr. Gopalan's incisive concise comments and clear, quick decisions. I never thought he even knew of my existence, and so I was surprised when, a few months later, he sent for me. He told me that after discussions with Dr. Srikantia, the then Director of National Institute of Nutrition (NIN), he had decided that I should look after the clinical component of the WHO-ICMR collaborative study on the effects of hormonal contraceptives in undernourished women, being carried out at NIN Hyderabad. I told Dr. Gopalan that I had earlier participated in ICMR clinical trials on hormonal contraceptives and knew how to conduct them, but all I knew about nutrition was what was taught to undergraduates in medical college and most of it may not be applicable to undernourished women; and so I was not sure whether I was the right person for the task. Dr Gopalan explained that what NIN needed was a person with experience in clinical trials with hormonal contraceptives; they would help me with the nutritional aspects initially; I would have to work hard and acquire the necessary nutritional knowledge as fast as I could and complete the trial successfully. I was still not sure, but Dr. Srikantia smiled and nodded his head, and my journey in the uncharted seas of nutrition began.

NIN is a very hospitable institution; between learning and working, my initial few months at NIN flew. Beginning with Dr. Bamji, who was looking after the laboratory component of the study that brought me to NIN, I have many life-long friends among my colleagues and NIN has remained my home. At the end of one year, I knew that the study was going well. The hospital OPDs where we were recruiting cases also catered to pregnant and lactating women, and soon I was also studying IM iron therapy for moderate anemia in pregnancy, and lactation–nutrition–fertility interactions.

When I met Dr. Gopalan about a year later, he was happy with the progress of the study. He then mentioned that Dr. Sathyarayana at NIN was studying the effect of early childhood undernutrition in adolescent boys, and that it was time to initiate a study in adolescent girls in the same cohort, to assess the impact of early childhood undernutrition on their reproductive performance. I was taken aback and said I had never carried out community-based studies; the answer was, it was high time for me to learn! It was the beginning of my lifelong association with community-based interventions to improve health and nutritional status within the existing primary health care infrastructure.

The study on ‘the effect of childhood nutritional status on reproductive performance’ was completed two years later; by then both Dr Gopalan and Dr
Srikantia had retired. Even today I regret that, discouraged by the statements that the findings were along the expected lines and so not worth publishing, I did not send the data from this study for publication. I am writing a brief review of this study, as my tribute to Dr. Gopalan who created a legion of nutrition scientists by using his uncanny ability to spot the potential in persons and then pushing them into challenging tasks to hasten their professional development.

A decade in NIN was followed by a decade on the Division of Epidemiology and Communicable Diseases at ICMR headquarters and nine years as Adviser (Health and Nutrition), Planning Commission. The day after my retirement, I joined Nutrition Foundation of India – completing a full circle.

Introduction

Chronic undernutrition from early childhood continuing through adolescence into adult life is common among poorer segments of the population. There had been speculations about the adverse effects of undernutrition in childhood on reproductive performance. However, in the seventies, there had been very few studies investigating this aspect. The major problem in mounting such a longitudinal study in which follow-up for about two decades is essential, was that it is unethical to follow-up and not intervene if the children had health or nutrition problems. On the other hand, if the children were to receive appropriate intervention during this period and benefit from it, the group might not suffer from any of the consequences that may have occurred in the absence of such intervention.

During the late seventies, NIN had the unique opportunity of undertaking a study ‘the effect of childhood nutritional status on reproductive performance’. Nearly two decades earlier, in twenty-six villages near Hyderabad, children had been enrolled at birth and a nutritional survey of all children under five years of age had been carried out for five consecutive years. These children were part of a large cohort in whom prevalence of vitamin A deficiency was investigated. All the children belonged to an essentially homogenous rural population group in whom environmental and health care interventions were minimal. None of the children received any major nutritional or health intervention during the study. After a lapse of seven years their growth status during adolescence was evaluated.

In these villages, teenage marriages and conceptions were the rule. There were 912 girls belonging to the cohort who were traceable. An attempt was made to follow up these girls to obtain information on:

- age at menarche
- age at marriage
- age at first conception
- nutrition status during pregnancy
- course and outcome of pregnancy
- lactation performance and
- survival and growth of the offspring.
The relationships between childhood nutritional status, current nutrition status and reproductive performance were explored.

**Age at menarche**

There was a gradient in the mean age at menarche in the group; the girls who had been well nourished in childhood continued to be better nourished as adolescents and attained menarche earlier. The girls, who had been undernourished as children, were shorter and weighed less, as compared to those who were well nourished in childhood. The age at menarche was delayed in girls who had suffered from severe undernutrition during childhood. Because of this delay, the severely undernourished girls were able to make up early deficits in height observed through childhood and early adolescence. However, they continued to weigh less than their better-nourished counterparts.

**Age at marriage**

Girls who were normally nourished or showed mild undernutrition during childhood got married at an earlier age than those who were moderately and severely undernourished during childhood. This might partly be attributable to the fact that, in rural India, menarche is often followed by marriage within the next few months. Most of the normally nourished girls came from economically better off families; this might also have been partly responsible for their getting married at an earlier age.

**Course and outcome of pregnancy**

A majority of these girls conceived within a year of marriage. They were followed up at least once during the first, second and third trimesters of pregnancy. Data on changes in anthropometric indices of nutritional status, haemoglobin levels, and course and outcome of pregnancy were collected. There was a significant difference in mean height between the normally nourished and severely undernourished girls; nearly six percent of the severely undernourished girls had a height of less than 140cm, which is known to be a risk factor associated with low birth weight and higher perinatal mortality rates (Table 1). Girls who were normally nourished in childhood had body weights comparable to those of the rural low-income group population throughout their pregnancies. Girls who had experienced varying grades of undernutrition during childhood weighed less. The proportion of girls with body weight less than 40 kg was higher among those who had suffered moderate and severe undernutrition during childhood. In spite of differences between the pre-pregnancy weights of normally nourished and undernourished girls, there were no significant differences in weight gain during pregnancy between these two groups. Nor were there any differences in the mean haemoglobin levels and prevalence of moderate to severe anemia between girls belonging to different grades of nutritional status during childhood.
An analysis of the data relating to course and outcome of pregnancy showed that there were no significant differences in the course and outcome of pregnancy between the groups, except for a marginally lower foetal loss rate in normally nourished girls. The mean birth weight of the infants, except those of the severely undernourished girls, was comparable to those born to primipara in rural low-income groups. The mean birth weight was lower and the proportion of infants weighing less than 2.5kg at birth was significantly higher among infants born to girls who were severely undernourished during childhood (Table 2). This could be partly due to the lower maternal weight during pregnancy and partly to coexisting adverse socio-economic and environmental factors. The observed higher infant deaths among infants born to severely undernourished girls might be partly due to the higher proportion of infants born with low birth weight, and adverse environmental factors in these households.

<table>
<thead>
<tr>
<th>Group (according to childhood nutritional status)</th>
<th>Height (cm)</th>
<th>% with less than 140 cm</th>
<th>Wt (kg)</th>
<th>% less than 40 kg</th>
<th>Arm circumference (cm)</th>
<th>Skinfold thickness (mm)</th>
<th>Hb (g/dl)</th>
<th>% with Hb &lt;8.0 g/dl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severely undernourished</td>
<td>148.6± 1.02* (25)</td>
<td>5.9</td>
<td>46.3± 1.04 (27)</td>
<td>35.3</td>
<td>20.3±0.44 (27)</td>
<td>9.5±0.5 (27)</td>
<td>9.4±0.3 (20)</td>
<td>11.8</td>
</tr>
<tr>
<td>Moderately undernourished</td>
<td>151.5± 0.78 (44)</td>
<td>-</td>
<td>46.3± 0.79 (37)</td>
<td>40.0</td>
<td>21.5±0.26 (37)</td>
<td>9.7±0.4 (135)</td>
<td>9.5±0.3 (2)</td>
<td>11.1</td>
</tr>
<tr>
<td>Mildly undernourished</td>
<td>150.9± 0.76 (38)</td>
<td>1.6</td>
<td>47.2± 0.87 (45)</td>
<td>18.0</td>
<td>21.5±0.26 (45)</td>
<td>10.6±0.5 (50)</td>
<td>9.7±0.2 (9)</td>
<td>4.9</td>
</tr>
<tr>
<td>Normal</td>
<td>155.7± 0.99 (25)</td>
<td>-</td>
<td>50.2± 1.12 (25)</td>
<td>6.7</td>
<td>21.9±0.33 (24)</td>
<td>10.0±0.75 (12)</td>
<td>9.3±0.3 (9)</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Values are mean ± S.E.; Figures in parentheses indicate number of women, p< 0.05 as compared to normal; Source: Reference 1

Lactation performance

Lactation was successfully initiated in all these rural girls without any difficulty. All the girls followed the traditional pattern of unsupplemented lactation for periods up to six months. There were no differences in the pattern of introduction of supplementary feeding to breast-fed infants. There were no significant differences in the mean body weight of the infants during the first...
six months of age, among infants born to girls who had suffered from various grades of undernutrition during their childhood.

**Summary and conclusions**

This long-term follow-up study showed that the delay in age at menarche in girls who had suffered severe undernutrition during childhood is perhaps one of Nature’s compensatory mechanisms to improve adult heights; this delay also protected these girls from too early marriage and conception. In the late 1970s and early 1980s, the reproductive performance of this cohort was comparable to that of the rural women from these villages.

The villages in which these studies were conducted are no longer typical villages. They have become part of the periurban complex around the rapidly growing city of Hyderabad. Socioeconomic and life-style transitions in these erstwhile villages have been very rapid. There were no follow-up studies of these mothers–child dyads in the intervening 25 years. Now these children are in their late twenties, and their mothers are in their forties. Maybe the time has come for NIN to take up studies to assess the current health and nutritional status and assess how these mother–child dyads have fared.

**Reference**