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*Guatemala, C. A., 1979*



**PRENATAL  
AND PERINATAL  
NUTRITION**



**IV LATIN AMERICAN NUTRITION CONGRESS**

**Caracas, Venezuela, 21-27 November, 1976**

**Colloquium on**

**PRENATAL AND PERINATAL NUTRITION**

**Participants:**

**P. D. Paez (Venezuela)  
P. Rosso (USA)  
A. Lechtig (INCAP, Guatemala)  
L. Mata (Costa Rica)  
G. Solimano (USA)  
H. Bourges (Mexico)**

**Coordinator:**

**A. Lechtig  
INCAP, Guatemala, C. A.**



## PREFACE

This Colloquium on "Prenatal and Perinatal Nutrition" was held as part of the IV Latin American Nutrition Congress organized by the Latin American Nutrition Society (SLAN), the Government of Venezuela through its National Institute of Nutrition, and the Venezuelan Nutrition Society.

Its purpose was to analyze the biological, clinical and public health aspects of the problem of prenatal and perinatal nutrition in the Latin American Region.

The support and partial financial aid of the United Nations University (World Hunger Program), provided through INCAP as Associated Institution of this University, made possible this Colloquium. Partial financial help was also received from the Research Corporation. Special mention of the Ex-President of SLAN, Dr. Guillermo Arroyave, should be made, since during his service period he promoted and took the necessary steps for the celebration of the Colloquium and coordinated with great enthusiasm this important event.

We wish to acknowledge our most sincere appreciation to the Latin American Nutrition Society and to its present President, Dr. Werner G. Jaffé. The collaboration and valuable support of the Society made possible the publication of the Proceedings of the Colloquium on "Prenatal and Perinatal Nutrition". The assistance rendered by Mrs. Amalia G. de Ramírez, Chief of the Editorial and Publications Office of *Archivos Latinoamericanos de Nutrición*, who translated and edited the papers presented, was most helpful in the publication of this English version of the Colloquium.

Aaron Lechtig  
Division of Human Development  
Institute of Nutrition of Central  
America and Panama (INCAP),  
Guatemala, C. A.

José Aranda-Pastor  
Division of Applied Nutrition  
Institute of Nutrition of Central  
America and Panama (INCAP),  
Guatemala, C. A.



# **PAPERS PRESENTED**



## INTRODUCTION

### THE PROBLEM\*

Aaron Lechtig\*\*

Institute of Nutrition of Central America and Panama (INCAP),  
Guatemala, C. A.

In Latin America, as well as in other developing regions, the term *low birth weight* has quite different implications in terms of causes and sequelae than in the developed countries.

*Low birth weight* includes all those children born with a weight of 2,500 g or less. There are two main groups of these children: those whose *low birth weight* is due to a short gestational age (prematurity) and those whose gestational age is normal (fetal growth retardation). It is probable that in the Latin American countries the high prevalence of *low birth weight* is fundamentally due to fetal growth retardation more than to prematurity. This is why in the developed countries the use of the *low birth weight* term is not satisfactory, while in the technologically underdeveloped countries—as are the countries of our Region—the *low birth weight* term is still useful and practical for public health purposes.

We estimate that about 22 million children throughout the world were born with *low birth weight* in 1975. The incidence of *low birth weight* is closely related with the socioeconomic level indicators. Thus, 90% of the countries with less than 2,800 calories *per capita* per day, presented a high incidence of *low birth weight*, and the underdeveloped countries were responsible for 94% of all the children with *low birth weight*. In Latin America where the population estimated in 1975 was of 324 millions, 12 million births occurred that same year, and of these, 1.5 million (13%) or more had *low birth weight*.<sup>1</sup>

The sequelae associated with *low birth weight* are many and varied, principally due to the multifactorial etiology of growth retardation and the changing emphasis of the different etiologic factors from one population to another. In the premature

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\*\* Head, Program of Human Development, Division of Human Development of INCAP.

child, for example, the most prominent problem is respiratory difficulty with the consequent hypoxia and injury to the central nervous system. In contrast, children with *low birth weight* due to retardation of fetal growth show a tendency to hypoglycemia and hypothermia, frequent and severe infections, loss of subcutaneous fat and of the skin turgescence, high mortality and suboptimal postnatal development. Fetal growth retardation is also associated to light perinatal hypoxia, small postnatal weight loss, polycythemia and high erythropoietin levels as well as to an increase of congenital malformations.

A positive correlation between birth weight and physical postnatal growth has also been found. This is important because physical growth retardation, in its turn, is associated with psychomotor and mental development retardation and with a reduced survival capacity.<sup>2</sup> Lastly, these children show a high prevalence of anomalies in the electroencephalogram, a lower performance in vocabulary and reading tests, and a trend to low school performance.<sup>3-6</sup>

The low survival capacity associated with *low birth weight* is primarily due to a lower resistance to infection and, consequently, to a greater frequency and severity of infections. It has been shown that babies with *low birth weight* have reduced levels of IgG at birth, an important reduction in the number of peripheral lymphocytes T, and a lower capacity to produce an immune cellular response. Furthermore, a reduced opsonic function in the plasma due to reduced C<sub>3</sub> levels and a notorious diminution of the bacterial capacity and of the metabolism of polymorphonuclears during the phagocytosis process have been frequently informed.<sup>7</sup> Thus, considering the high level of exposure of these babies to postnatal malnutrition and infection, it is not surprising to find that their probabilities of surviving during their first year of life are much more lower than those of children with normal birth weight.<sup>8-10</sup>

For the above-mentioned reasons, the high prevalence of *low birth weight* in Latin America represents not only a problem in human terms, but also a serious obstacle for the social and economic development of these countries that, up to the present moment, has not been sufficiently recognized nor adequately approached.<sup>1</sup>

In order to analyze the biological, clinical and public health aspects of this problem, the physiologic and clinical implications of *low birth weight* are first presented, and the different mechanisms of materno-fetal transference of nutrients are discussed. Then the more important causes of *low birth weight* in Latin America are identified, followed by a discussion of its implications for action programs. The different alternatives for action constitute the final focal point of concentration of the Colloquium, to which all the presentations are oriented, particularly the last three where planned and ongoing programs in several Latin American countries are discussed.

In our opinion, this Colloquium should be followed by workshops aimed to improve the understanding of the problem and to facilitate to the Latin American Governments, the planning, implementation and evaluation of programs which pursue a dramatic reduction of the high prevalence of low birth-weight babies in the Subcontinent.

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**LOW BIRTH WEIGHT:  
CLINICAL IMPLICATIONS\***

*Pedro Daniel Páez\*\**

Maternidad "Concepción Palacios", Caracas, Venezuela

**SUMMARY**

At present, the study of pre-term babies (prematures) has acquired special interest, mainly due to the great scientific advances achieved in this field, and because of their complicated handling, and the high risks implied by incorporation of the survivors to the society we live in.

Retardation in fetal development observed in the Latin American countries is the first cause of neonatal mortality, of perinatal clinical implications and of sequelae in the child's development, furthermore, it is a conditioning factor of postnatal mortality and morbidity.

This group of *in utero* malnourished babies or small-for-date infants, merits particular interest, since it is the most unfortunate group of newborns, especially in what concerns their future mental development.

Results of a statistical and clinical analysis of the characteristics that define low birth weight babies are given.

Finally, a series of recommendations with obstetric, perinatal and pediatric implications are provided, all of which tend to improve medical assistance for this group of newborns.

**I. INTRODUCTION**

The study of infants born with less than 37 weeks of gestation has taken great importance in the course of the past years, with the appearance of perinatology, as a

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\*\* Assistant Director of the Neonatal Intensive Therapy Unit, Department of Pediatrics of the Maternidad "Concepción Palacios", Caracas, Venezuela.

discipline which analyzes in depth the obstetric and pediatric events that take place around parturition. This concern has led to a greater knowledge of these phenomena which are directly reflected in the future of the newborns with the consequent implications for the community that watches over their physical, mental and social welfare.

A low birth-weight or premature baby has been traditionally accepted as a child whose weight is 2,500 grams or less. However, with the incorporation of the gestational age parameter,<sup>1</sup> a new classification has been suggested that groups them as follows: pre-term, at term and post-term babies, according to whether their birth takes place before 38 weeks, between the 38th and 42nd weeks, or after 42 weeks, respectively. In turn, each of these categories is subclassified in small, adequate or large for its gestational age, if his weight is below the 10th percentile, between the 10th and 90th percentile, or above the 90th percentile, in that order. Some authors only speak of small for their gestational age when children are born below the third percentile according to their weight.<sup>2,3</sup>

## II. INCIDENCE

In the developed countries, approximately 8% of all babies born alive weigh from 1,500 to 2,500 grams, which correspond to a gestational age of 31 to 36 weeks, with a neonatal mortality of 2 to 8%.

If we consider only the children who at birth weigh from 500 to 1,500 grams and who correspond to the 24-30 weeks of gestation group, we find that neonatal mortality rises up to 70%. The magnitude of this problem acquires greater evidence when these figures are compared with those of neonatal mortality observed in at term newborns, which is of 0.2%.<sup>4</sup>

In Costa Rica, babies weighing less than 2,500 g at birth represent from 12 to 15% of all born-alive babies, and 15% in Colombia.<sup>5</sup>

In a recent study carried out in a rural community of Guatemala, 48% of the newborns whose average weight was 2,564 grams were found, with a neonatal mortality of 8%.<sup>6</sup>

Besides, congenital malformations incompatible with life are more frequent in premature infants. The majority of the deaths occurring in this group with a birth weight under 2,500 g, are due to the "Respiratory Distress Syndrome" on account of pulmonary immaturity of the lungs or hyaline membrane disease. Sequelae, especially of neurologic order, affect these prematures in a transitory or definite form after parturition, in a greater proportion than at term newborns.<sup>7</sup> The greater the degree of prematurity, the greater the incidence of mortality and sequelae.

## III. CLINICAL CHARACTERISTICS OF LOW BIRTH WEIGHT INFANTS

The perinatal *asphyxia* represents a frequent problem in pre-term newborns,

and is fundamentally explained by the degree of immaturity of the nervous system, cerebral hemorrhages, infections and fetal injury.

These babies need external help to control the *temperature*. In view of the impossibility of producing heat through muscular contractions, they use its chemical thermogenesis mechanism which is activated by the action of epinephrine on the brown fat. This system starts functioning every time that the child is below its thermic neutral zone (37°C).

*Nutritionally*, they are at disadvantage since their gastric capacity is limited, the incomplete myelination of the nervous system prevents a good motor function of the digestive system and, lastly, their caloric requirements per kg of weight are high (120-150 calories/kg/day after the first week of life). That lack of caloric supply generates malnutrition situations which are fundamentally reflected in the nervous system, a problem that is more accentuated in the newborn with a weight below 1,500 g, especially if other problems are associated to it. Multiple food systems have been designed which vary from parenteral hyperalimentation, whether this is performed with hyperosmolar or iso-osmolar solution, "gavage", to continuous pyloric feeding. All of them require specialized personnel and equipment, since they are not free from complications. In some specialized centers, mother's milk is being administered which benefits the neonate from the well-known immunologic protection from infections of the respiratory and gastrointestinal tract.

From the *respiratory* point of view, if the newborn has less than 37 weeks of gestation, its alveolar surfactant content with tensoactive properties (lecithyn) will be reduced, and this leads to atelectasis, hypoxia and death. The Hyaline Membrane Disease will occur in 10% of the newborns with less than 2,500 g, with a neonatal mortality of about 20% in the more specialized centers equipped with intensive care units,<sup>8</sup> and 80% in the less well-equipped centers. The aspiration syndrome and the pulmonary and retinal complications of hyperoxia also occupy an important place in the morbidity of these neonates.

*Jaundice* is particularly common in this age group, partly due to hepatic immaturity and partly because of their low plasma albumin content. It is a well-known fact that the frequent acidosis and hypoxia situations make the neurone more vulnerable to the neurotoxic effect of indirect bilirubin, with the consequent possibility of a greater incidence of *kernicterus*.<sup>9</sup>

There is a deficient absorption of minerals such as calcium, magnesium, copper, zinc,<sup>10</sup> which explains the frequent tetany episodes.

The hemoglobin concentration in pre-term fetuses is diminished, and so is the erythropoietic activity; also, the red cell membrane is more susceptible to peroxidation and destruction due to the transitory deficiency of tocopherol (vitamin E).<sup>11, 12</sup> All of these factors contribute in one way or another to the *anemia* of the premature.

The carbohydrate stores of the pre-term child are lower than those of the at term newborns, and this conditions *hypoglycemia* situations in the first hours of life.

Pre-term newborns have another obstacle to surpass: *infections*. Their immunologic system is not altogether developed; there are immunoglobulin A deficiencies which they acquire at an early date through the maternal colostrum; the immunoglobulins M do not cross the placenta, thus placing them at disadvantage, mainly against gram-negative germs. The *acute necrotizing enterocolitis*, with its high mortality, is rather common in newborns with a history of hypoxia, prematurity, Hyaline Membrane Disease, umbilical catheterization, and patent *Ductus arteriosus*.

#### IV. SMALL FOR GESTATIONAL AGE

As mentioned previously, this group of newborns is under the 10th percentile for their weight and gestational age. The incidence of morbi-mortality in them is higher than in any other group of newborns.

Studies carried out in the United States of America and Great Britain establish that approximately 30% of the newborns weighing less than 2,500 g are not real prematures, but small for their gestational age.<sup>13</sup> For the Latin American countries, this figure is of approximately 60%, being such low weight the first cause of perinatal death.

Interest for studying these groups of newborns started in 1963 when Gruenwald<sup>3</sup> wrote in regard to the "Chronic fetal suffering and placental insufficiency." Then, in 1968, Dobbing established that the brain is permanently affected from the intellectual and neurologic points of view when there is malnutrition during its rapid growing phase, especially during the third trimester of pregnancy.<sup>14</sup>

The incidence of congenital malformations is 1.5% in pre-term babies, particularly if these are malnourished *in utero*, which suggests the existence of a genetic factor in its etiology. In addition there is a conjunction of factors that include maternal, environmental, placental and fetal aspects which try to explain their etiology, very well described in the literature.<sup>15,16</sup>

A study of 96 children born with a weight under the 10th percentile who were followed during six years fundamentally to analyze the course of their growth and development was carried out. We shall now describe only the most salient aspects. The general growth pattern was the same for pre-term and at term babies, with a greater growth velocity in the first six months in the malnourished *in utero*. A significant retardness in their weight and height occurred, noting, for example, that at the age of six years 35% of them were under the third percentile for their weight and height and only 8% were over the fiftieth percentile. The bone age was under the third percentile in half of the children included in the study.

In 25% of the cases minimal cerebral dysfunction was observed. The electroencephalographic tracing was abnormal in 70%, while the percentage of abnormalities in the control group was 27%. School performance was poor in 40% of the children who, in turn, presented a 30% language deficit.

A whole conglomerate of physiologic changes can be appreciated in these children in function of their gestational age, which can be summarized as follows:

1. Acceleration of pulmonary maturity, a fact that explains the lower incidence of disease of the hyaline membrane.
2. Retardness in the epiphiseal ossification centers.
3. Minimal weight loss during the neonatal period.
4. High hemoglobin values.
5. Increase of the plasmatic volume.
6. Increase of the extracellular fluid.
7. Increase of the nonprotein nitrogen.
8. Hypo- and hyperglycemia.
9. Thymic atrophy.
10. Thin ribs with production of spontaneous fractures.
11. Late anemia.
12. Increase of the metabolic activity/kg weight.
13. Limited thermoregulation capacity.
14. Normal or reduced immunoglobulin G.
15. Increased immunoglobulin M in case of infection.
16. Greater incidence of asphyctic problems.

Special efforts are presently concentrated in the study of the future of these children, particularly with regard to their growth and development. It has been proved that the development of a small for gestational age child runs parallel to that of any premature baby adequate for its gestational age if they are in an environment that stimulates them to progress physically and mentally.<sup>14</sup> Studies on the intellectual

coefficient of these children failed to establish any correlation; it is concluded therefore that this parameter is not helpful for the characterization of these infants.

## V. IMPLICATIONS AND SUGGESTIONS

### Obstetric

The best solution to the problem of low birth-weight newborns is to avoid the occurrence of these types of births, or at least that their number be reduced. Multiple variables can be modified to achieve this purpose, among which the following are mentioned: promotion of health and hygiene of the mother; prevention, diagnosis and early treatments of infectious and metabolic diseases; stimulation of maternity at an optimal age, with greater interval between pregnancies, suggesting an adequate number of pregnancies in accordance to the mother's possibilities and, finally, imparting education on perinatal events.

### Perinatal

This part refers to an adequate attention of parturition with participation of the obstetrician, anesthesiologist and neonatologist, thus integrating a team of such a type as to permit decision-taking and implement working plans from which the future of the newborn shall depend. These objectives have certain implications such as: complete perinatal evaluation on the part of the members of the medical team; presence of the neonatologist or pediatrician trained in the attention of the critical neonate in every act leading to the birth of a child at high risk; availability of adequate reanimation equipment; assignment of a regional neonatal reference center with participation of the more complete obstetric-pediatric institution in the areal zone, for handling the more difficult cases. and, finally, availability of a statistical evaluation system that permits making a precise diagnosis of the perinatal problem.

### Pediatric

Analysis of the events that occur after parturition is of vital importance to ascertain the magnitude of the sequelae that remain as product of the survival of so many neonates that years back were destined to die. To achieve this goal the following is required: a complete perinatal history; establishment of referral centers for the follow-up at short and long term of the high-risk newborns; availability of facilities that allow these children to benefit from the early stimulation programs and, finally, enrollment of all lactating mothers in the La Leche International League.

## RESUMEN

### BAJO PESO AL NACER: IMPLICACIONES CLINICAS\*

El estudio de los niños pre-término (prematuros) ha adquirido especial interés

en nuestros días, principalmente debido a los grandes avances científicos logrados en este campo, lo complicado de su manejo, y los grandes riesgos que implica la incorporación de los sobrevivientes a la sociedad en que vivimos.

El retardo en el desarrollo fetal observado en los países latinoamericanos es la primera causa de mortalidad neonatal, de patología perinatal, y de secuelas de desarrollo del niño; además, es un factor condicionante de la mortalidad y morbilidad post-neonatales.

Particular interés reviste el grupo de los desnutridos *in utero* o pequeños por edad gestacional, por tratarse de que éste es el grupo más desafortunado de recién nacidos, especialmente en lo que a su futuro mental concierne.

Se dan a conocer los resultados de un análisis estadístico y clínico de las características que definen a los recién nacidos de bajo peso al nacer.

Finalmente se formula una serie de recomendaciones con implicaciones obstétricas, perinatales y pediátricas, tendientes a mejorar la asistencia médica de este grupo de recién nacidos.

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**NUTRITION AND MATERNAL-FETAL EXCHANGE OF NUTRIENTS:  
A DIFFERENT PERSPECTIVE\***

*Pedro Rosso\*\**

**Institute of Human Nutrition, Columbia University,  
College of Physicians & Surgeons, New York, New York**

**SUMMARY**

The assumption that the fetus can parasitize a malnourished mother is still widely accepted. In contrast with this concept, data reviewed here demonstrate that during a reduced availability of energy and protein the mother protects her body stores of nutrients at the expense of sustaining a normal rate of fetal growth. The mechanisms by which the mother prevents fetal parasitism would involve a reduced blood volume expansion, reduced placental blood flow and, ultimately, reduced transfer of nutrients. Whenever maternal nutritional status is not optimal some degree of fetal growth retardation tends to occur. In a large population this is reflected in a downward shift in mean birth weight and increased incidence of low birth weight infants with associated increase in neonatal mortality.

**INTRODUCTION**

Nearly four decades ago it was proposed that circulating nutrients are distributed between the maternal tissues and the conceptus, according to their respective metabolic rates.<sup>1</sup> Since the feto-placental unit was supposed to have a higher metabolic rate than any of the maternal tissues, except the brain, it was assumed that during a reduced availability of nutrients the fetus would successfully compete for nutrients with the mother, thus becoming an effective parasite.

The assumption that the fetus can parasitize a malnourished mother is still

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\*\* Associate Professor of Pediatrics, Institute of Human Nutrition, Columbia University, New York, N. Y.

widely accepted and it has fostered the idea that only extreme degrees of maternal malnutrition can produce significant degrees of growth retardation, especially in humans. However, the results of recent studies and the reinterpretation of data published in the last two decades have raised serious doubts about the validity of past assumptions on fetal parasitism and, in general, on the nature of maternal-fetal interactions during malnutrition. The purpose of this review is to analyze this new evidence and to discuss both its biological and clinical implications.

### STUDIES IN ANIMAL MODELS

The hypothesis that the division of nutrients between the mother and the fetus is based solely on metabolic rates was tested in pregnant rats kept on a food-restricted diet or injected with growth hormone to increase their food intake.<sup>2</sup> The results showed that whether the food intake of the mother was increased, normal, or reduced, the increase in conceptus weight over the last half of pregnancy could be related to the total maternal weight increase over this period by the formula  $y = 1/4 x + 4.5n$ , where  $y$  is the combined weight of fetuses and placentas (conceptus weight),  $x$  is the total maternal weight increase over the last 11 days of pregnancy and  $n$  is the number of fetuses. The results of this study apparently confirmed the initial hypothesis of the division of nutrients since, as demonstrated by the formula, the increase or decrease of the total nutrients available to the mother had been shared equally between the various maternal tissues and the fetuses. An interesting finding of this study, however, deserves further analysis. The authors reported that the derived formula did not hold when the total maternal weight increase was less than 20 g, although they found that even in the most restricted animals the conceptus weight never fell below  $4.5(n+1)$ .

Studies in rats food restricted between the first and the 20th day of gestation suggest, however, that a more severe food restriction may cause the conceptus weight to fall markedly below the  $4.5(n+1)$  limits.<sup>3</sup> Furthermore, in these circumstances, the conceptus weight as calculated by the formula discussed above, is higher than the observed weights, suggesting that in severely food-restricted rats the division of nutrients does not favor the conceptus over the mother. For example, rats fed only 25 percent of the quantity of food fed the control group had a mean fetal weight of 1.89 g. Assuming a proportional reduction in placental weight and 1.5 ml of amniotic fluid per fetus the total conceptus weight would have been approximately 48 g. The weight of the mothers, after removal of the conceptus, was 148 g. Adding the weight of the conceptus, it can be assumed that the final total maternal weight was 196 g. This would represent a loss of 4 g of maternal initial body weight. Applying the formula discussed above the weight of conceptus should have been approximately 56 g, which is 17 percent higher than the real weight as calculated above.

The apparent anomaly in the distribution of the available nutrients between the mother and the fetus is also observed when proportional reduction in maternal body weight, conceptus weight, and litter size in rats suffering increasing degrees of food restriction are compared.<sup>3</sup> Thus, in rats restricted to 75 percent of their *ad*

*libitum* intake, the mothers gained 9 g of net body weight (after removing the conceptus and the uterus) while the mean fetal weight was maintained within control values. When mothers were restricted to 50 percent of their normal intake, they lost 8 percent of their initial weight while the mean fetal weight decreased by approximately 12 percent. In addition, 23 percent of the animals had embryonic deaths and subsequent reabsorption of the fetuses. When mothers were restricted to 25 percent of their normal intake, they lost 26-32 percent of their initial body weight, 64-92 percent had embryonic deaths, and in two studies only 8 percent of the mothers were able to produce litters of 12-14 pups. In these rats mean fetal weight was reduced to 46-56 percent of control weights. The data suggest that the food-restricted pregnant rat is able to sustain fetal growth within normal limits only when the food restriction allows her to gain some weight. If the food restriction is more severe, however, both litter size and fetal growth are reduced disproportionately to the loss of maternal body weight.

As shown in Table 1 the apparent disproportion between the magnitude of maternal losses in body weight and the deficit in the body weight of the fetuses at term described in the rat, also occurs in other mammalian species when the mother is fed either a calorically-deprived or a protein-deprived diet. For example, in the pregnant guinea pig, food restriction or a low-protein diet causes a 50 percent fetal mortality and a 22-28 percent reduction in birth weight of the surviving fetuses while

**TABLE 1**  
**MATERNAL BODY WEIGHT AND BIRTH WEIGHT CHANGES CAUSED BY**  
**FOOD RESTRICTION OR PROTEIN RESTRICTION IN VARIOUS**  
**MAMMALIAN SPECIES**

Species	Type of restriction	Percent change in body weight		
		Mother*	Fetus	Ref.
Rat	50% <sub>o</sub> food intake	-10	-12	(3)
	75% <sub>o</sub> food intake	-32	-51	(3)
Guinea pig	60% <sub>o</sub> food intake	-12	-22	(4)
	low-protein diet	-10	-28	(4)
Pig	low-protein diet	-16	-33	(5)
Macaca Mulatta	low-protein diet	- 1	-10**	(6)
	low-protein diet	- 7***	-15	(8)

\* Compared with preconceptional weight.

\*\* Reduction found not significant.

\*\*\* Data taken from a graph.

the mothers lose 10-12 percent of their initial body weights.<sup>4</sup> Pigs fed a low-protein diet during pregnancy lost 17 percent of their initial body weight while the body weight of the fetuses at term was 33 percent below control values.<sup>5</sup>

Studies in Rhesus monkeys in which pregnant mothers fed a diet providing 1 g of protein per kg of body weight per day were compared with mothers fed 4 g of protein/kg/day have shown that the protein-deprived mothers maintain a normal energy intake and normal fetal growth while losing approximately 1 percent of their initial body weight.<sup>6</sup> The results were attributed to maternal metabolic adaptations to a low-protein diet.<sup>7</sup> Other studies in Rhesus monkeys also fed diets providing 1 g of protein/kg/day have shown an increase in maternal and perinatal mortality and a 15 percent reduction in mean birth weight when liveborn and stillborn fetuses were computed together.<sup>8</sup> In spite of some of the discrepancies in the results of the studies conducted in the Rhesus monkeys, they suggest that given an adequate caloric intake the mother is able to metabolically adapt to a low protein intake and sustain fetal growth apparently more successfully than in energy-deprived animals. In other species, such as the rat, a low protein diet during gestation causes a reduced food intake and, therefore, a superimposed energy deficit. Thus, a reduced availability of energy may be more deleterious to fetal growth than a reduced availability of protein.

As clearly shown by the experiments conducted in rats, the division of nutrients between the mother and the fetus seems to be influenced by different mechanisms according to the availability of nutrients. As expressed by the formula  $y = 1/4 x + 4.5n$  if enough nutrients are available since early pregnancy fetal needs are fully met and if the maternal food intake increases above normal a portion of the excess nutrients also goes to the fetus. Thus, the fetus is apparently given unlimited access to the available nutrients. However, when food intake is restricted, and the availability of nutrients reach a critical level, the fetus is not favored over the mother. On the contrary, the deviation of nutrients seems to favor maintenance of maternal body weight over maintenance of a normal rate of fetal growth. If the restriction is severe enough to induce maternal body weight losses, obviously the fetus becomes an active parasite but, in contrast with past assumptions, it does not receive a proportionally larger share of nutrients than the mother. This new concept of maternal-fetal relationships concerning the division of nutrients is strongly supported by the results of refeeding experiments of previously restricted pregnant rats.<sup>3</sup> As shown in Table 2, rats restricted to 25 percent of their normal intake from the first up to the fifth day of pregnancy and then fed *ad libitum* have a final body weight and mean fetal weight similar to controls. If refeeding is started only in the last 12 days of pregnancy the mother increases her net body weight (after removal of the conceptus and uterus) by 23 percent (versus 28 percent of controls) while the fetuses show a significant 7 percent deficit in body weight. If refeeding is started on the last 10 days the mothers gain 21 percent of net body weight and the fetuses show a significant 12 percent deficit in body weight. These experiments clearly show that when nutrients become available after a period of restriction the mother is greatly favored over the fetus. Obviously, if active fetal parasitism was taking place during the period of food restriction, it seems logical to assume that the fetus would have been favored over the mother when nutrients again become available.

**TABLE 2**  
**EFFECT OF UNRESTRICTED FEEDING ON MATERNAL AND FETAL BODY WEIGHT AFTER VARYING INITIAL PERIODS OF 75 PERCENT DIETARY RESTRICTION<sup>3</sup>**

Days of restriction (from conception)	% Change in maternal body weight*	Mean fetal weight (g)
5	+27	4.01
7	+23	3.75
9	+21	3.53
11	+19	3.39

\* Compared with body weight at conception.

Recent studies on the effect of food restriction on the body composition of pregnant and non-pregnant rats have provided new insights into the nature of maternal fetal interactions during a reduced availability of nutrients. This study<sup>9</sup> showed that at term pregnant rats fed 50 percent of the food consumed by control animals had a similar body composition of pair-fed non-pregnant rats while the mean body weight of the fetus was significantly reduced (Table 3). These results clearly demonstrate

**TABLE 3**  
**CARCASS COMPOSITION IN CONTROL AND 50 PERCENT FOOD RESTRICTED PREGNANT AND NON-PREGNANT RATS<sup>1,2</sup>**

Group	n	Water %	Fat %	Lean dry tissue %
Pregnant control	5	60.03 <sup>a</sup> ± 0.74	17.3 <sup>a</sup> ± 0.5	22.7 <sup>a,b</sup> ± 0.6
Non-pregnant control	5	63.07 <sup>b</sup> ± 0.6	13.0 <sup>b</sup> ± 0.7	23.9 <sup>a</sup> ± 0.3
Non-pregnant restricted	4	65.81 <sup>b</sup> ± 0.68	9.07 <sup>c</sup> ± 1.2	24.9 <sup>a</sup> ± 0.7
Pregnant restricted	4	65.74 <sup>b</sup> ± 0.51	9.00 <sup>c</sup> ± 0.5	25.2 <sup>a,c</sup> ± 0.4

1 Weight of the samples was representative of their groups.

2 Mean ± S.E.M. Values not sharing a common superscript letter (s) in the same column are significantly different ( $P < 0.05$  or less).

that the pregnant food-restricted rat is not parasitized by the fetus. In addition, they suggest that important metabolic adjustments must occur to allow the mother to prevent this parasitism. Comparisons of food efficiency, as determined by changes in body weight per quantity of food ingested, between the pregnant and non-pregnant animals revealed that during pregnancy there is a marked increase in food efficiency. For control rats the increased food efficiency was apparent throughout pregnancy while in the malnourished rats it was apparent only during the last 10 days of gestation.

## STUDIES IN HUMANS

During the winter of 1944-45, several Dutch cities were exposed to a severe food shortage that lasted approximately 28 weeks. It has been estimated that the *per capita* caloric intake during that period of time dropped to a low of approximately 1,200 kcal/day.<sup>10</sup> Many women were pregnant at the time of the famine and, although it is conceivable that they may have received some extra food from family members, their food intake must have fallen considerably short of their needs. An analysis of the effects of famine on birth weight<sup>10</sup> revealed a significant decrease of approximately 250 g, compared with pre-famine values for the entire population, among the women affected during the second and third trimester of gestation. This seemingly small difference of approximately a ten percent reduction in birth weight caused by conditions considered extreme has been interpreted as an indication that the human fetus is also an effective parasite or, conversely, that the mother is able to "adapt" to a reduced food intake to sustain fetal growth. Further, considering that famine conditions during the last two trimesters caused only a 250 g fall in mean birth weight, the extrapolation has been made that marginally-deficient diets should produce a negligible effect on birth weight.<sup>11</sup>

A question that is rarely considered, however, is the effect that pregnancy under famine conditions had in the mothers. No data has been made available on the pre-pregnancy weight and changes in body weight of these women. It is, therefore, more difficult to compare in severely food-restricted humans the type of changes in maternal body weight and birth weight, discussed in the previous section for food-restricted rats. However, since the postpartum weight of the Dutch women measured in the 9-10th day after delivery has been reported, it is possible to make some gross estimates of their body weight losses using some reasonable assumptions. The first assumption, considering that the average weight of a young adult female in an industrialized country is 56 kg, is that the average body weight of a Dutch woman during the pre-famine period and following many months of food rationing was 55 kg or less. The mean postpartum weight during the pre-famine period was 59 kg. Subtracting from this weight an estimated 3 kg due to extra body fluids, enlarged breasts and uterus, the women that delivered during the pre-famine period had a minimum of 1 kg of extra body stores. If the same factors are subtracted from the postpartum weight of women that suffered famine during various periods of pregnancy (Table 4) it is found that the women most affected by famine may have lost approximately an average of 1.5 kg of their initial body weight. This is less than 3 percent of their initial

TABLE 4

**ESTIMATED CHANGES IN POSTPARTUM MATERNAL BODY STORES  
AND CHANGES IN MEAN BIRTH WEIGHT IN DUTCH WOMEN  
BEFORE AND AFTER FAMINE CONDITIONS**

	Postpartum maternal weight (kg)	$\Delta$ Body stores	Birth weight (g)
Pre-famine	59.0	+ 1.0	3,338
Famine during 3rd trimester	57.6	- 0.4	3,220
Famine during 2nd and 3rd trimester	56.5	- 1.5	3,011
Famine during 1st and 2nd trimester	61.0	+ 3.0	3,370
Famine during 1st trimester	61.5	+ 3.5	3,312
Post-famine	62.0	+ 4.0	3,308

body weight. Since in this group the reduction in mean birth weight is approximately 10 percent compared with pre-famine values, it is obvious that the mothers most affected by the famine were proportionally less affected than their infants. In this regard, food-restricted women would behave similarly to other food-restricted mammals, suggesting the possibility that in spite of obvious biological differences, certain basic principles concerning maternal-fetal exchange during food restriction may be common to several mammalian species.

The disproportionate effect that small changes in maternal body weight may have on birth weight are also evident in the studies conducted in a large number of individuals in which maternal pre-pregnancy weight and weight gain during pregnancy have been correlated with birth weight. These studies have shown that both pre-pregnancy weight and weight gain during pregnancy can influence birth weight independently of each other. For example, high pre-pregnancy weights or high weight gains during pregnancy are associated with higher mean birth weights. In contrast, low pre-pregnancy weights or low weight gains during pregnancy are associated with lower mean birth weights. When the variables change in the same direction, for example, a high pre-pregnancy weight is associated with a high weight gain during pregnancy, they tend to have an additive effect on birth weight. These variables can

also neutralize each other's effects; thus, a low pre-pregnancy weight followed by a high pregnancy weight may result in a mean birth weight similar to a high pre-pregnancy weight followed by a low weight gain during pregnancy.<sup>1,2</sup> The effect on mean birth weight of some of these combinations are shown in Table 5. It must be stressed, however, that maternal body weight or weight gain during pregnancy are only one of the many variables that can influence the rate of fetal growth. Thus, in contrast with the animal models, correlation between maternal weight changes and birth weight become apparent in humans only when large numbers of cases are analyzed.

**TABLE 5**  
**JOINT RELATIONSHIP OF PRE-PREGNANCY WEIGHT**  
**AND MATERNAL WEIGHT GAIN WITH BIRTH WEIGHT**  
**IN 622 TERM PREGNANCIES IN WHITE WOMEN,**  
**JOHNS HOPKINS HOSPITAL, BALTIMORE, 1954-1961<sup>1,2</sup>**

Maternal group	Mean birth weight (g)	% of low birth weight infants
High pre-preg. weight, high weight gain	3,831	0.0
High pre-preg. weight, low weight gain	3,628	2.3
Low pre-preg. weight, high weight gain	3,453	1.5
Low pre-preg. weight, low weight gain	3,044	5.8

Definitions: high pre-pregnancy is  $> 72$  kg (160 lb); high weight gain is  $> 13$  kg (20 lb); low pre-pregnancy weight is  $< 54$  kg (120 lb); low weight gain is  $< 4$  kg (9 lb).

The changes in both pre-pregnancy weight and weight gain during pregnancy are reflected in the maternal postpartum weight. Preliminary results of a study including 254 singleton term deliveries from uncomplicated pregnancies<sup>1,3</sup> has shown that mean birth weight increases linearly with increasing postpartum weights until postpartum weight is 100-110 percent of maternal ideal body weight. At that point birth weight remains constant while postpartum weight continues to increase (Fig. 1). This correlation suggests that optimal fetal growth occurs only when the mother is able to accumulate a critical amount of extra body stores during pregnancy. While

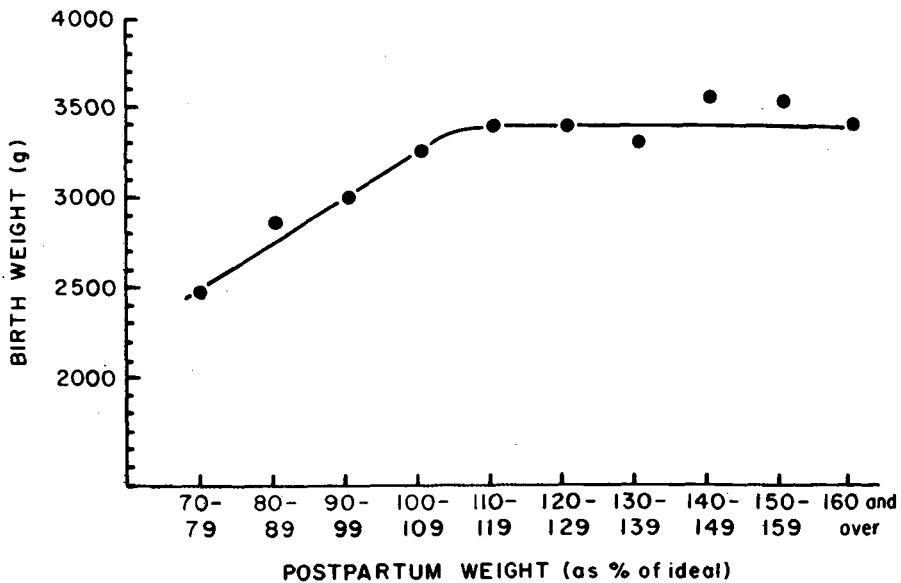


Fig. 1. Gestational changes in maternal stores, plasma volume, placental weight, fetal weight and uterine blood flow in human pregnancy. Values are expressed as percent of maximal increments. Data derived from Hytten and Leitch.<sup>11</sup>

accumulation of body stores beyond what seems to be desirable does not have any further positive effects on birth weight, it is evident that when the mother fails to accumulate extra body stores the rate of fetal growth begins to decrease progressively. Again, as observed in the animal models, the evidence clearly contradicts the concept that the fetus is protected by the mother when nutritional status is less than optimal or that the fetus can protect itself by parasitizing the mother. Further, the uneven distribution of available nutrients that occurs when food-restricted rats are allowed unrestricted amounts of food may also occur in humans. This is suggested by a correlation between birth weight and maternal weight gain in women with low pre-gravid weight.<sup>14</sup> This correlation demonstrates that for each 100 g increments in mean birth weight the mother gains 2.3 kg of body weight. Again, this observation seems to conflict with the idea of active fetal parasitism.

## MALNUTRITION AND MATERNAL-FETAL EXCHANGE

The animal and human data clearly demonstrate that in contrast with prevailing concepts, the undernourished mother does not adapt to sustain fetal growth but rather to maintain her own body stores of nutrients. An important role seems to be played by the quantity of maternal body stores of energy. If the mother has extra quantities of these stores she can maintain a normal rate of growth even if her food intake is inadequate. If the body stores are small, then food intake has a crucial role in maintaining fetal growth.

Teleologically, the fact that among eutherian mammals nature protects the mother more than the fetus seems reasonable from the point of view of survival of the species. For example, during a famine caused by a serious drought a normal size newborn delivered by a nutritionally-depleted mother would have little chance to survive if the mother cannot initiate lactation, cannot defend herself and the young, or cannot cover enough distance during the day to search for food. A stronger female that produces a runt or a smaller litter probably has a better chance to survive and conceive again the following season.

The metabolic and physiological mechanisms used as adaptive response by the food-restricted mother are still largely unknown. In protein-restricted rats the rate of urea synthesis and the levels of certain hepatic enzymes involved in amino acid catabolism are reduced.<sup>15,16</sup> Reports of a reduced urea excretion in women receiving low-protein diets<sup>17</sup> suggests that similar mechanisms to reduce urinary nitrogen losses are also present in humans. The results, previously discussed, on Rhesus monkeys fed low-protein diets can also be considered as indirect evidence of major adaptations in protein and amino acid metabolism.<sup>6-8</sup> The nature of these changes in amino acid metabolism, however, still remain elusive. Similarly, the mechanisms responsible for the increased food efficiency observed in pregnant rats<sup>9</sup> are also unknown. Probably many factors, including the changes in amino acid metabolism and the degree of physical activity, are involved. All these possibilities, however, require further investigation.

During normal pregnancy a great number of physiological adjustments take place. Obviously all these adjustments are either directly or indirectly involved in sustaining fetal growth. Among the earliest and best known changes are the expansion of blood volume and the deposition of maternal stores of nutrients, presumably mostly fat. As shown in Figure 2, in humans these changes are occurring at a maximal rate at midgestation and therefore they precede by several weeks the period of maximal placental and fetal growth. They also precede the period of maximal increase in the rate of uterine blood flow which coincides with the peak of fetal growth. It is tempting to speculate that this sequence represents an orderly chain of events in which only the adequate completion of the earlier maternal changes allows the adequate completion of the final ones involving the growth of the conceptus. For example, a woman who receives an adequate diet can both deposit adequate amounts of extra stores and also expand blood volume. Obviously, blood volume expansion is a process influenced by many variables besides nutrition. The need to expand red cell mass and to a lesser extent circulating protein mass, must depend,

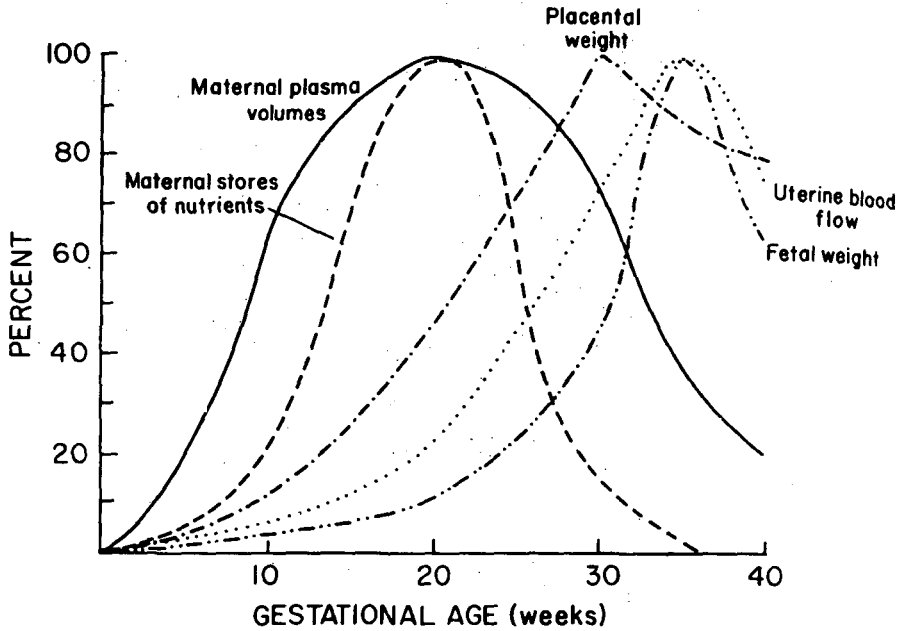


Fig. 2. Mean birth weight in 254 singleton term deliveries in women with different postpartum weights.<sup>14</sup>

however, on the adequate availability of substrate and energy. The need for an expand blood volume during gestation is not entirely clear, but it is conceivable that it may be necessary to compensate for the major hemodynamic changes caused by the expansion of the uterine blood flow. In the rat as well as in humans and other species uterine blood flow increases many-fold during the course of pregnancy.<sup>18,19</sup> In order to maintain this high rate of blood flow to the uterus without reducing the rate of blood flow to other organs an expansion of blood volume and an increased cardiac output would appear to be an appropriate compensatory mechanism. Consequently, if blood volume expansion early in pregnancy is inadequate, uterine blood flow may also be inadequate to sustain optimal fetal growth. A correlation between these two factors has not been established yet. It has been reported, however, that maternal plasma volume expansion correlates with the birth weight of the infants.<sup>20</sup>

In the rat either a 50 percent food restriction or a protein restriction from day 5 of gestation produced a significant reduction in the degree of expansion of plasma volume.<sup>21</sup> Most affected were the protein-restricted animals. When plasma volume was expressed per 100 g of net maternal body weight no differences were found

between controls and food-restricted rats indicating that both plasma volume expansion and the deposition of maternal stores were equally dependent on the level of food intake. Still, the protein-restricted rats had significantly lower values than any of the other groups suggesting that the availability of certain amino acids may have an important role in plasma volume expansion (Table 6).

In more recent experiments blood flow to the kidney, the uterus and the placenta has been measured in food-restricted rats.<sup>22</sup> Results demonstrate that compared with control animals, food-restricted rats have a marked reduction in the rate of blood flow to the uterus and the placenta while maintaining adequate blood flow to the kidneys. These data support the idea that plasma volume/blood volume expansion is necessary to adequately expand uterine and placental blood flow and that no redistribution of blood flow from other vital organs occurs as an alternative adaptation.

The reduced placental blood flow most likely reduces the availability of nutrients to the fetus. This possibility is supported by earlier studies demonstrating that protein-restricted rats have a reduced rate of transfer of glucose and amino acids from the maternal circulation into the fetus.<sup>23, 24</sup> A reduced maternal-fetal transfer of nutrients in the malnourished animals not only helps to explain the fetal growth retardation of the restricted mothers but it may also explain why the fetus is not able to actively parasitize the maternal stores.

## CONCLUSIONS

The consequences of maternal malnutrition during pregnancy have been the focus of considerable controversy in the past. As pointed out in a recent review of this subject, an important source of controversy has been the results of studies in which obvious flaws of design and data analysis can be recognized.<sup>25</sup> One of the arguments most frequently used against the importance of adequate nutritional management during pregnancy, involving active counselling and, when necessary, food supplements has been that the mother can "adapt" to protect the fetus and that the fetus is an active maternal parasite. Therefore, at least in humans, no harm to the fetus will result from moderate inadequacies in the maternal nutritional status. The evidence presented in this review clearly demonstrates that these ideas are unfounded, as is the theory of the division of nutrients from which they originated.

The importance of maternal nutrition on the outcome of pregnancy becomes obvious when the focus of attention is shifted from the possible consequences in a single individual to a large population. As shown by perinatal mortality curves, a "small" downward shift in mean birth weight increases disproportionately the mortality rates. In the U.S., for example, the black population has a mean birth weight that is 150 g lower than the white population and a perinatal mortality twice as high.<sup>25</sup> One of the factors influencing the higher mortality rates is the higher proportion of low birth weight infants that results from a shift to the left in mean birth

**TABLE 6**  
**MATERNAL PLASMA VOLUME (PV) IN PREGNANT AND NON-PREGNANT RATS FED**  
**VARIOUS DIETS DURING PREGNANCY\***

Group	n	PV (ml)	PV per 100 g of total body weight	PV per 100 g of net body weight	PV per 100 g of conceptus
Standard diet	15	16.96 ± 0.61 <sup>a</sup>	4.48 ± 0.18 <sup>a</sup>	5.91 ± 0.10 <sup>a</sup>	24.68 ± 1.01 <sup>a</sup>
50 % restricted	17	13.14 ± 0.34 <sup>b</sup>	4.70 ± 0.16 <sup>a</sup>	6.03 ± 0.14 <sup>a</sup>	22.32 ± 0.71 <sup>a</sup>
25% casein	15	17.91 ± 0.58 <sup>a</sup>	4.84 ± 0.21 <sup>a</sup>	5.95 ± 0.17 <sup>a</sup>	27.83 ± 0.89 <sup>b</sup>
6% casein	11	10.50 ± 0.34 <sup>c</sup>	3.70 ± 0.10 <sup>c</sup>	4.70 ± 0.17 <sup>b</sup>	19.57 ± 0.93 <sup>c</sup>
Non-pregnant (standard diet)	10	10.94 ± 0.35 <sup>c</sup>	—	4.14 ± 0.11 <sup>c</sup>	—

\* Means are given ± S.E.M. Values not sharing a common superscript letter in the same column are significantly different ( $P < 0.05$  or less).

weight. The opposite happens when the mean birth weight of a population shifts upwards. This has been clearly demonstrated in a rural Guatemalan population when the increase in mean birth weight associated with a higher caloric intake provided by a food supplement decreased by 50 percent the number of low birth weight babies and associated mortality.<sup>2,6</sup>

Although the incidence of maternal malnutrition is closely associated with the prevailing socio-economic conditions of a country, there is ample evidence that even the most affluent nations are not immune to the problem. As shown here, and in contrast with past assumptions, seemingly small inadequacies in maternal nutritional status can significantly affect fetal growth. The realization of this fact should make adequate care of the nutritional needs of the pregnant mother an integral part of comprehensive prenatal care.

## RESUMEN

### NUTRICION E INTERCAMBIO MATERNO-FETAL DE NUTRIENTES: UNA PERSPECTIVA DIFERENTE

La suposición de que el feto puede parasitar a la madre desnutrida continúa siendo un concepto de amplia aceptación. En contraste, datos revisados en el presente trabajo demuestran que ante una disponibilidad reducida de energía y proteínas, la madre protege sus reservas orgánicas de nutrientes a expensas del sostenimiento de una tasa normal de crecimiento del feto. Los mecanismos por los que la madre evita el parasitismo fetal implicarían una menor expansión del volumen sanguíneo, disminución del flujo sanguíneo placentar, y la transferencia reducida de nutrientes. Siempre que el estado nutricional de la madre deja de ser óptimo, tiende a ocurrir un retardo del crecimiento fetal. En una población grande esto se refleja en una tendencia a declinar del promedio del peso al nacer, y en una mayor incidencia de niños con bajo peso al nacer asociada a un aumento de mortalidad neonatal.

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**CAUSES OF LOW BIRTH WEIGHT IN LATIN AMERICA\***

*Aaron Lechtig\*\**, *Hernán Delgado\*\**, *Reynaldo Martorell\*\**, *David Burd\*\*\**  
*Charles Yarbrough\*\** and *Robert E. Klein\*\*\*\**

**Institute of Nutrition of Central America and Panama (INCAP),  
Guatemala, C. A.**

**SUMMARY**

Analysis of the different studies reported in the literature leads to the conclusion that weight of the newborn is remarkably better in the high socioeconomic groups than in the low socioeconomic groups, and that this association also prevails in small poor population sectors of the rural area of Guatemala. In these villages, the association between the score of the socioeconomic scale developed for this research work and the proportion of children with low birth weight, disappears in the groups of tall, well-supplemented mothers during pregnancy. The data presented suggest that both nutritional history since conception, as well as nutritional status of the mother during pregnancy, constitute one of the important mechanisms of the causal relation that exists between socioeconomic characteristics and fetal growth. Another mechanism of great importance in Latin America is the high prevalence of infection in both mother and child from its prenatal stage. It is estimated that the causal complex poverty-malnutrition-infection is responsible for at least half of the newborns with low weight in Latin America. All the other known causes determining most of the babies with low weight at birth in industrialized countries are responsible of no more than one-fourth of these babies in Latin America. For this reason, the strategies used

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\*\* Scientists from the Division of Human Development of INCAP.

\*\*\* Research Associate of the same Division, 1976.

\*\*\*\* Chief of the above-mentioned Division.

in developed countries to decrease the incidence of low birth-weight babies are not applicable in the Region. For example, in many populations of the Subcontinent, very simple indicators such as height, head and arm perimeter, and housing characteristics, can be very useful to select groups of mothers with high risk of delivering low birth-weight babies, and that, for this reason, require priority attention in health programs. The use of these risk indicators will contribute to notably improve the efficiency and effectiveness of these programs, particularly in populations with inadequate health resources.

Based on the above-mentioned statements, the authors conclude that an improvement of the nutritional status and of the health of gestating women, may conduct to a significant decrease of the prevalence of low birth-weight babies in the majority of the Latin American Region. This, in turn, will help reduce the high infant mortality rates observed in these countries, and permit new generations a greater probability of developing all of their genetic potential.

## I. INTRODUCTION

The purpose of this work is to discuss the most important determinants of low birth-weight (LBW) babies in Latin America. We consider this step as crucial for the planning, implementation and evaluation of programs oriented to reduce the incidence of low birth weight in the Latin American countries.<sup>1-8</sup> To this effect, we will review the influence of the socioeconomic, nutritional and maternal infection factors during pregnancy on the weight of the newborn. We will then discuss the influence of various miscellaneous factors such as the smoking habit, toxemia of pregnancy, altitude and genetic factors. Finally, we will comment the determinants that should merit priority attention in programs aimed at reducing the incidence of low birth-weight children in the Latin American countries.

## II. SOCIOECONOMIC LEVEL AND BIRTH WEIGHT

The relation that exists between socioeconomic factors and birth weight will be discussed in the following paragraphs. The main differences between the high and low socioeconomic levels will be analyzed to this effect, trying to integrate them in a simplified model of causal relations. The differences associated to socioeconomic characteristics of families in the rural villages of Guatemala will then be examined.

Figures 1 to 3 summarize the results of various studies where the weight of newborns and the height of mothers of high and low socioeconomic level are compared.<sup>9-11</sup> Women of the low socioeconomic groups in both rural and urban populations are smaller and give birth to a greater proportion of LBW babies than those of the high socioeconomic groups. Nevertheless, the latter show a height and LBW proportion similar to those of middle-class white women of urban populations of the United States.

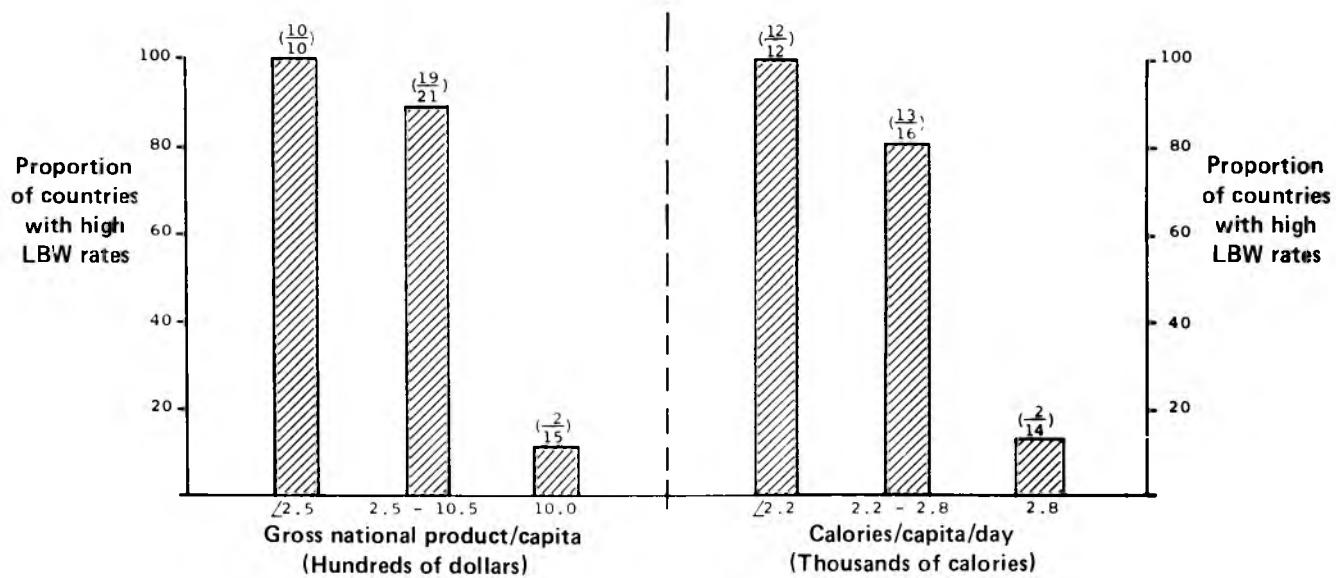
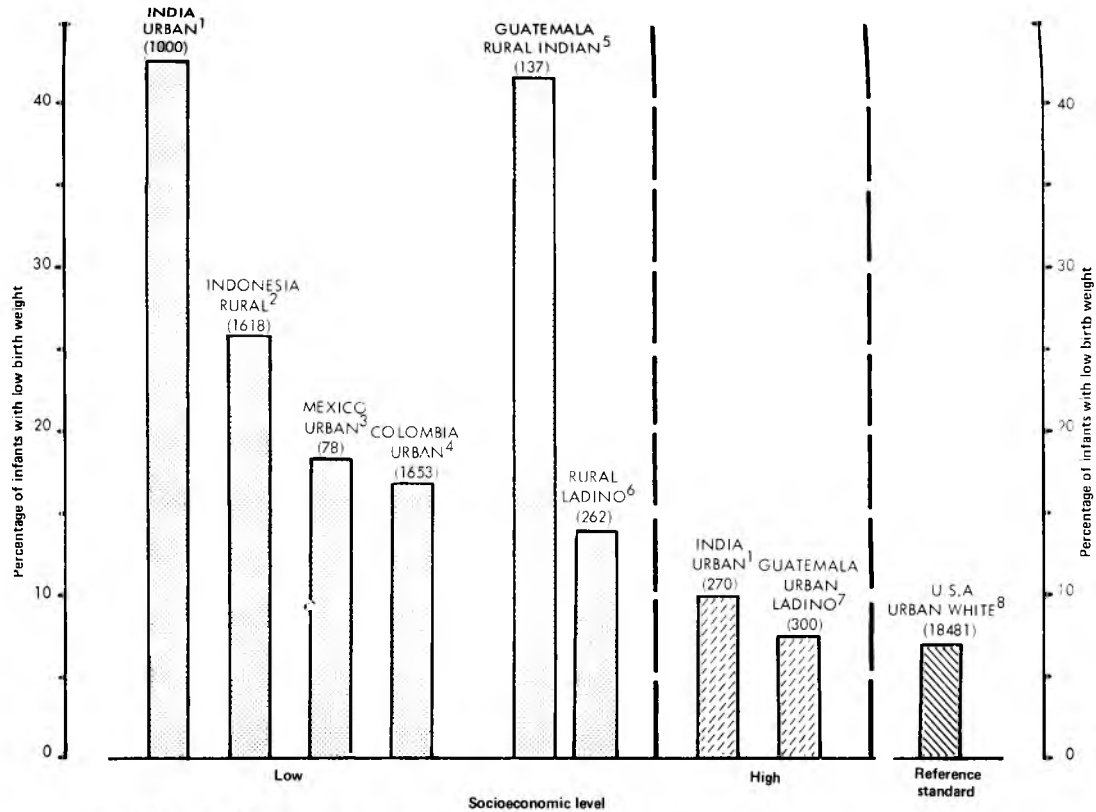


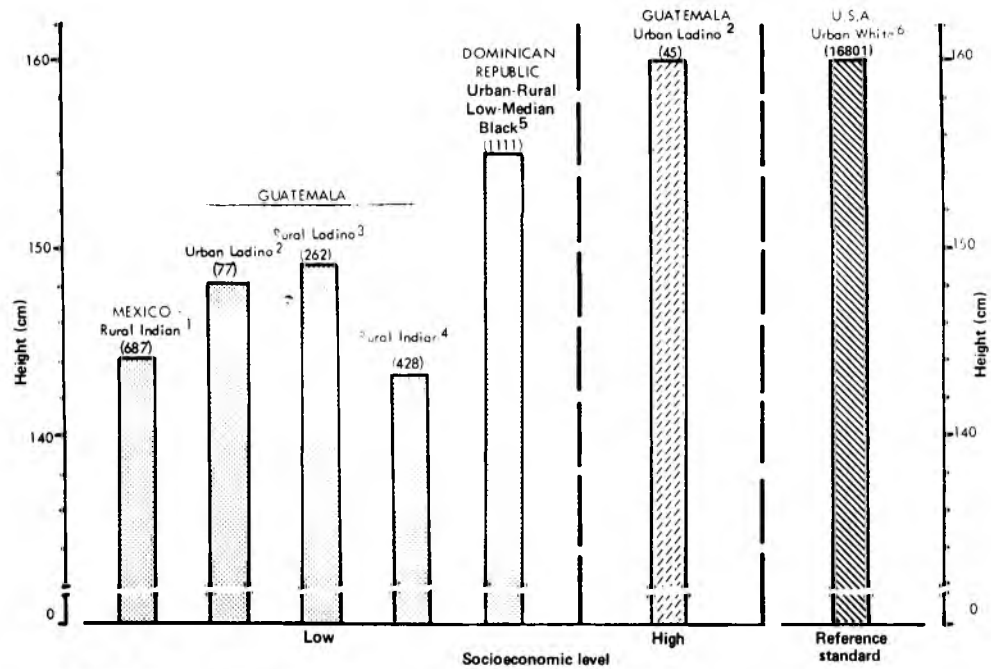
Fig. 1. Proportion of countries with high LBW ( $\leq 2.5$  kg) rates according to national per capita gross product and available calories per capita/day.



In parenthesis number of cases.

Calculated from: <sup>1</sup>Udani (36); <sup>2</sup>Shattock (35); <sup>3</sup>Crayioto *et al.* (31); <sup>4</sup>Oberndorfer, Mejia & Palacios (34); <sup>5</sup>Mata, Urrutia & Lechtig (23); <sup>6</sup>Lechtig *et al.* (21); <sup>7</sup>Hurtado (32), and <sup>8</sup>Niswander & Gordon (25).

Fig. 2. Relationship between socioeconomic level and percentage of children with low birth weight.



In parenthesis number of cases.

Calculated from: <sup>1</sup>Faulhaber (20); <sup>2</sup>Arroyave *et al.* (19), and Lechtig *et al.* (69); <sup>3</sup>Lechtig *et al.* (21); <sup>4</sup>Mata, Urrutia & Lechtig (8); <sup>5</sup>Sobrell *et al.* (26), and <sup>6</sup>Niswander and Gordon (25).

**Fig. 3.** Relationship between socioeconomic level and height of adult women in developing countries.

In the developing societies, the socioeconomic level is also associated to other maternal characteristics, even within the same ethnic group. Thus, dietary protein and calorie intake,<sup>12-18</sup> weight before pregnancy,<sup>19-26</sup> and weight gain during the gestational period<sup>21, 25, 27-30</sup> are notably lower in mothers of poor rural sectors than in those of high socioeconomic level. As mentioned in the Introduction, in these countries the proportion of low birth-weight babies is much higher in the urban and rural groups of low socioeconomic level than in groups of high socioeconomic level.<sup>21, 23, 25, 31-36</sup>

In the majority of these studies, the socioeconomic status has been almost exclusively defined on the basis of notorious differences in the family income. Practically no information is available on other sociocultural factors that could explain the variations observed in regard to maternal nutrition and birth weight.

However, it must be noted that in the developing societies various common characteristics participate, such as a low gross *per capita* national product; an almost total external dependency in regard to the marketing of raw materials; inefficient systems of land tenure, and a rudimentary technology. Furthermore, these societies are characterized by marked differences between the high and low socioeconomic strata, particularly in terms of purchasing power, food availability and environmental sanitary conditions. These are the causes why malnutrition and infectious diseases are highly prevalent in these populations, principally during the first 5 to 7 years of life.<sup>23</sup> A simplified model of the relation between socioeconomic factors, malnutrition, infection and retardation of development is described in Figure 4. Maternal malnutrition, whether caused directly by dietary deficiencies, or indirectly through increased nutrient losses (due to intense physical activity or to infectious disease) is an important cause of growth and development retardation which starts in the fetal stage. This retardation, in turn, tends to perpetuate the poverty-malnutrition-poverty vicious cycle through generations.

These interrelations are being explored in the INCAP longitudinal study (ILS) on nutrition and mental development,<sup>37</sup> currently underway in four rural Ladino villages of the East of Guatemala. These villages have a total population of around 3,000 inhabitants, half of whom are under 15 years of age. Fundamentally, these villages have an agricultural subsistence economy and grow mainly corn and beans. The annual income is around \$200.00 (US) per family, and the greater part of this amount is used for food and clothing. The environmental sanitation conditions are extremely deficient; drinking water is obtained from brooks or public wells, and only 65% of the houses have latrines.

On a purely empirical basis, a socioeconomic scale (SES) was designed based on the house characteristics, clothing and education of the children. Figure 5 shows that as the score in this scale ascends, the percentage of children with low birth weight diminishes. These results demonstrate that even in small rural villages where almost all of the inhabitants are poor and illiterate, very simple socioeconomic scales can serve to identify groups of mothers at greater risk of delivering low birth-weight babies.<sup>11</sup>

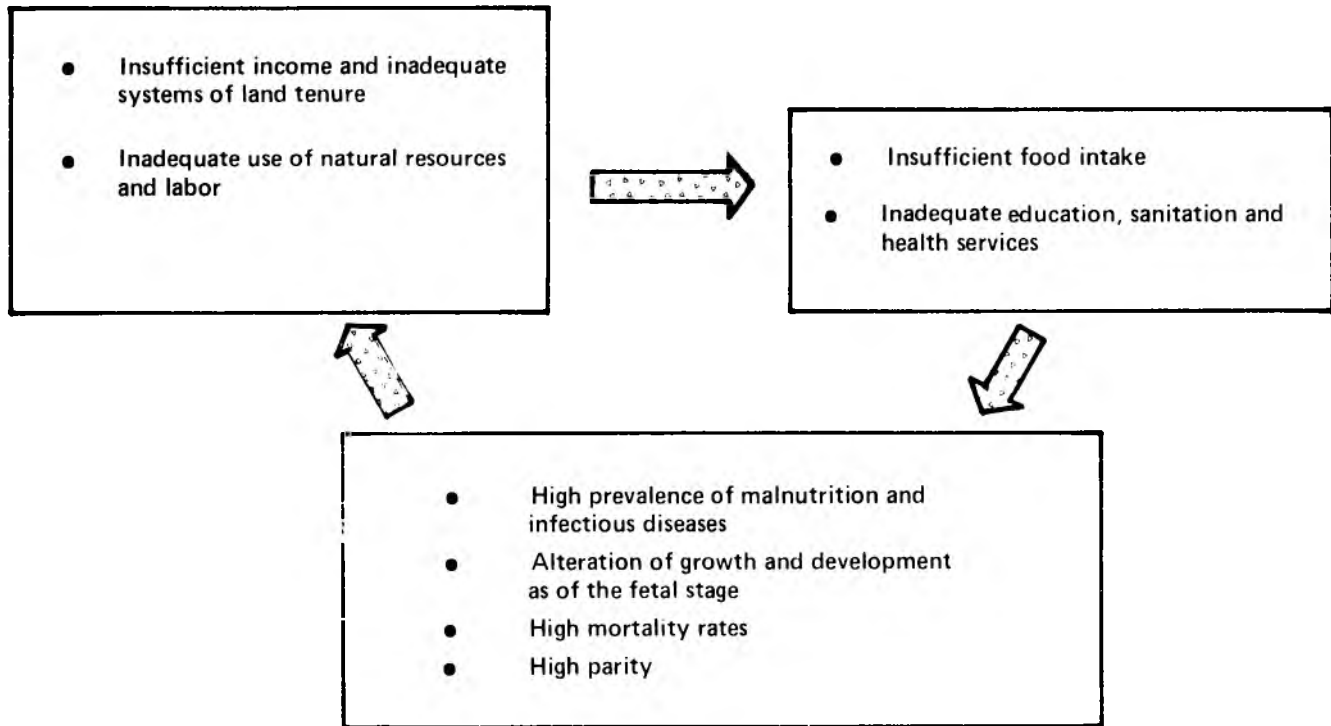
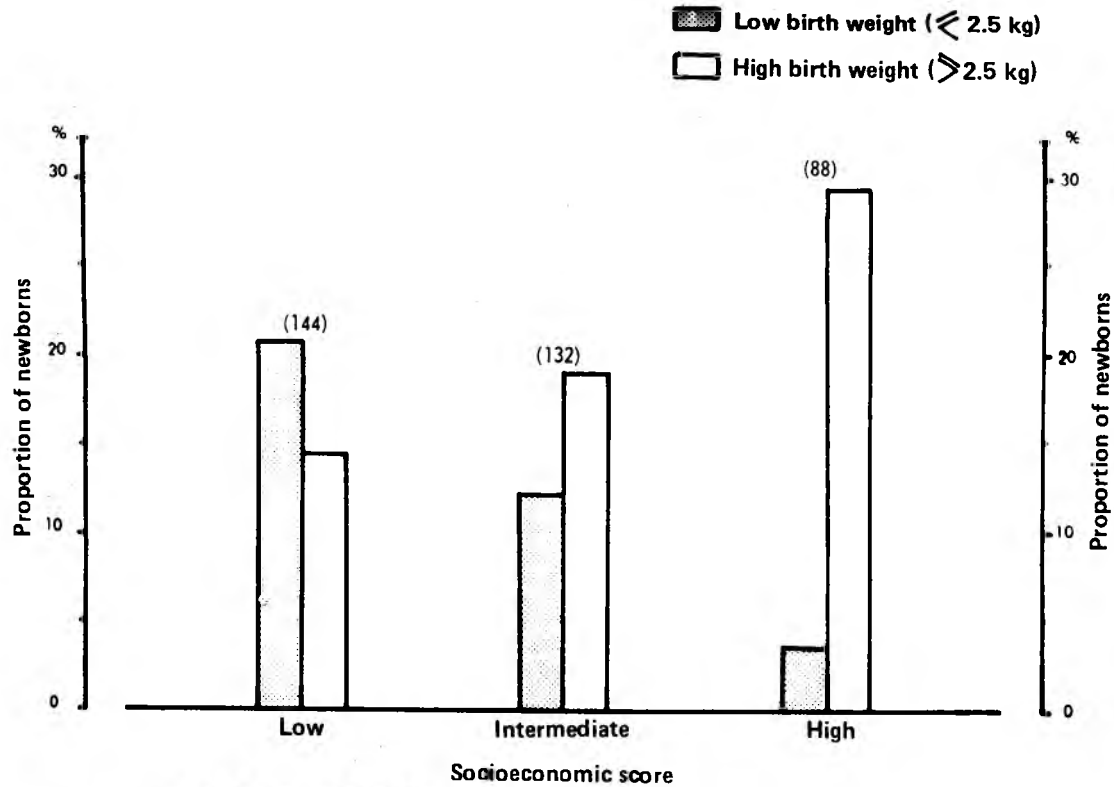


Fig. 4. Socioeconomic determinants of maternal nutrition and fetal growth in preindustrialized societies.



In parenthesis number of cases.

\*\*  $P < 0.01$ .

Fig. 5. Relationship between socioeconomic score and the proportion of children with high and low birth weight in four rural villages of Guatemala.

The SES score also showed a direct association with maternal height, with the head circumference of the mother, and with weight at the third trimester of pregnancy. In contrast, an inverse relation with maternal morbidity during pregnancy was detected.

The relation between the SES score and the low birth weight of the children, within two categories of the mother's height, is shown in Figure 6. The magnitude of this association is greater in the small mothers than in the tall ones. A similar pattern was observed when instead of using the mother's height, her weight was analyzed together with her cephalic circumference or her morbidity during pregnancy. The fact that the relationship between the SES score and the proportion of children with low birth weight varies when controlled by some maternal characteristics is of great interest, since it suggests that said characteristics can be important mechanisms of the relation between socioeconomic factors and low birth weight.

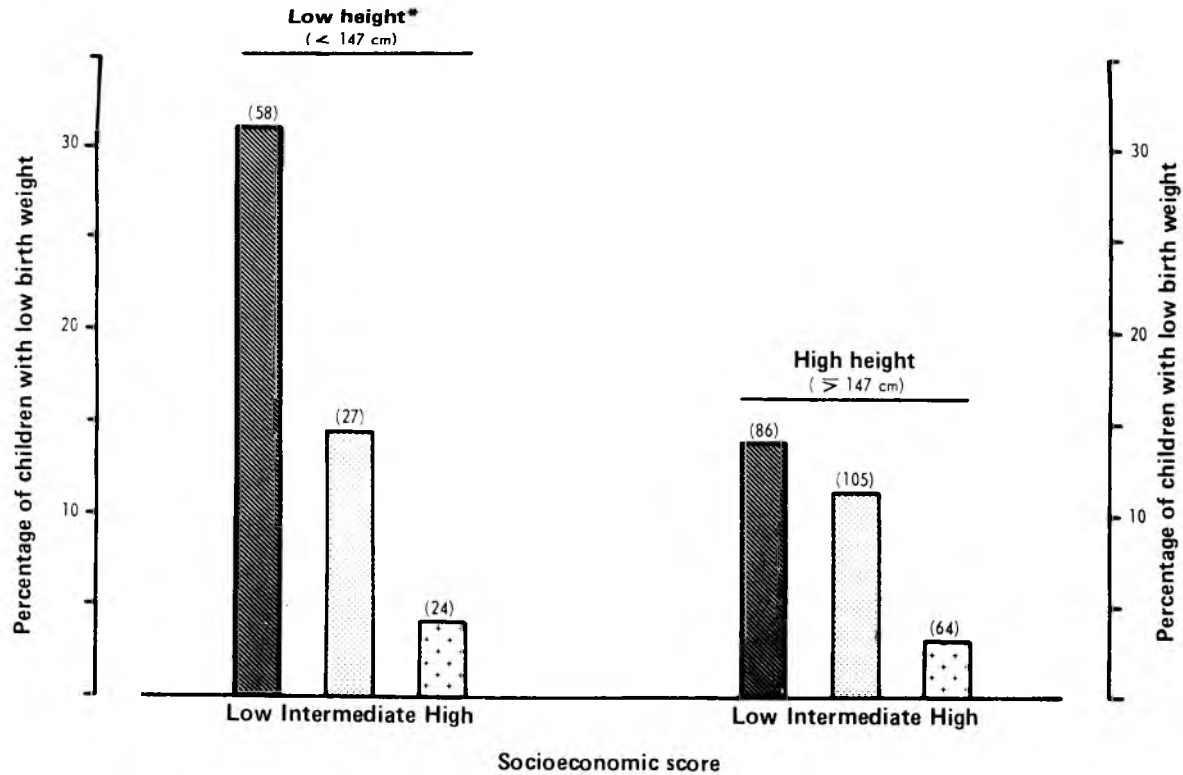
Thus, a reasonable interpretation of this finding is that the score in the socioeconomic scale reflects economic and cultural conditions which result in malnutrition and other diseases in the mother since the very early stages of her life and which, in turn, produce fetal growth retardation of her child. Of course, there are other possible interpretations of these findings. For example, it could well be that the score in the socioeconomic scale and the maternal characteristics are risk indicators not causally related with the responsible mechanisms of fetal growth retardation. Nevertheless, this is a remote possibility, since there is evidence that improvement of the mother's nutrition during pregnancy is associated with birth weight.<sup>30, 34, 35</sup> Nonetheless, whatever the causal relations between these variables, there is no doubt that in these villages the SES score has a biological significance since it is associated with the risk of low birth weight.

### III. INFLUENCE OF MATERNAL NUTRITION ON BIRTH WEIGHT

Animal experiments have demonstrated that the severe calorie and protein malnutrition of the mother delays fetal growth.<sup>38</sup> These effects could be irreversible in the case of those organs where malnutrition has affected the velocity of cellular division.<sup>39</sup>

The effect of maternal nutrition on birth weight in the human beings is clear under severe and acute malnutrition situations. Thus, it has been repeatedly observed that babies born of pregnancies that took place during famine periods had a lower birth weight than those born during periods of adequate food availability.<sup>40-42</sup>

On the other hand, studies on the influence of chronic, moderate malnutrition on fetal growth have rendered less clear-cut results. These studies can be divided into two groups: those that explore the effect of the maternal nutrition history *before* pregnancy (since conception) and those that study the effects of nutritional status *during* pregnancy.



\*  $P < 0.05$ .

Fig. 6. Influence of maternal height on the relationship between socioeconomic score and the proportion of children with low birth weight ( $\leq 2.5\text{ kg}$ ).

### A. Influence of Maternal Nutritional History Since Conception

The indicators used to estimate the nutritional history of the mother are principally anthropometric measurements such as height and weight.

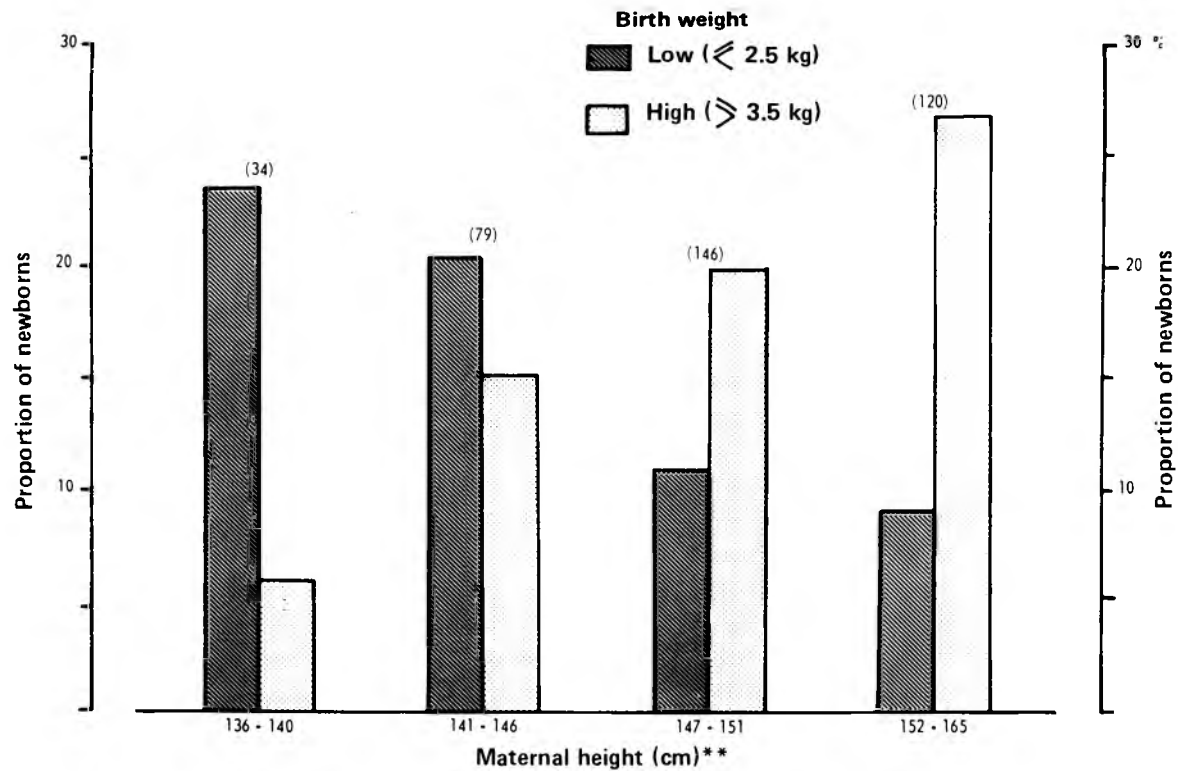
It must be kept in mind that most of the difference in the mean height of adult women between the low socioeconomic groups of Guatemala and the white middle-class populations of the United States of America already exists among 7-year-old children of the same populations. Therefore, it seems that the majority of the height differences found between adult women groups is due to growth retardation during their first seven years of life.<sup>43-46</sup> More still, research work carried out in various technologically underdeveloped countries (TUC) have revealed that the height of the 7-year-old children of high socioeconomic level is similar to that of the standards of industrialized countries, and greater than the height of children of low socioeconomic level of the same ethnic groups.<sup>47-53</sup> These findings suggest that, particularly in the TUC, the environmental conditions associated with socioeconomic level such as malnutrition and infection can be important determinants of height in the adult age. The observation that there is an effect of food supplementation on the growth of preschool children,<sup>53</sup> and the negative association found between the duration of diarrhea and growth in the ILS,<sup>54</sup> offer additional support to the hypothesis that in these population groups, height reflects in part the nutritional history of the mother.

Now, in approaching the relation between maternal nutrition and fetal growth, a consistent association has been found between the mother's height and the weight of the child at birth.<sup>21, 25, 55</sup>

The relation between the mother's height and the proportion of children with low and high birth weight in the four rural villages where the INCAP longitudinal study (ILS) is carried out, can be appreciated in Figure 7. As the data clearly reveal, the proportion of children with low birth weight decreases as the height increases, and the proportion of children with high weight at birth increases.

The weight of the mother before pregnancy has also showed a consistent association with birth weight in mothers of the same height.<sup>25</sup> A similar association has been found between the arm circumference of the mother and the weight of her baby at birth.<sup>56, 57</sup>

Another anthropometric measurement to be considered is the head circumference of the mother. Available information suggests that the differences in head circumference between adult populations are fundamentally due to differences in the growth velocity of the head during the first two years of life. Head circumference of children who have suffered severe malnutrition in very early stages of their lives has been reported to be smaller,<sup>58</sup> and within the same ethnic group, in children of low socioeconomic level.<sup>59, 60</sup> It has also been found that protein-calorie supplementation during early life improves the growth velocity of the head circumference.<sup>56, 61</sup>



In parenthesis number of cases.  
 \*\*  $P < 0.01$ .

Fig. 7. Relationship between maternal height and the proportion of children with low and high birth weight.

The relation observed in the ILS between the mother's head circumference and the proportion of children with low and high birth weights is shown in Figure 8. The reviewed literature does not include other reports on this association, which is of great importance because it continues to be significant even after controlling for height and weight of the mother. Consequently, it could well reflect the specific influence of the very early nutritional history of the mother on the growth of her child.

In summary, maternal height, weight before conception, and the arm and head circumference of the mother show consistent association with birth weight in populations of technically underdeveloped countries. These relationships probably reflect the influence of the maternal nutrition history of fetal growth.

## B. Nutritional Status during Pregnancy

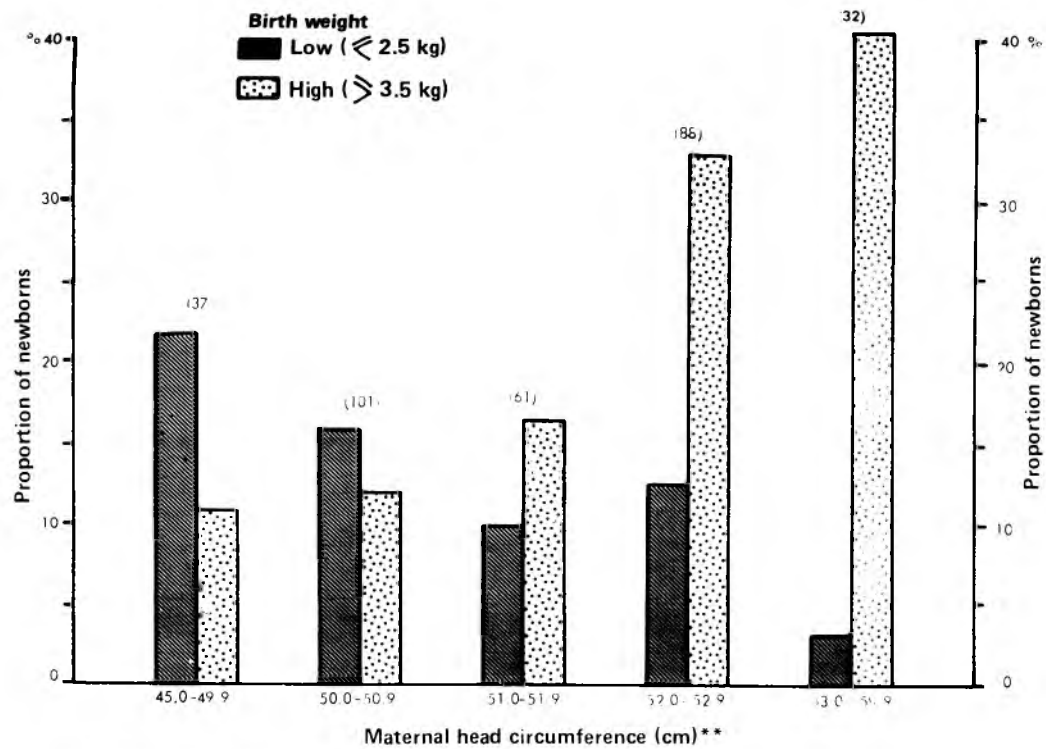
Under field conditions, the most commonly used indicators to estimate nutritional status of the mother during gestation are the weight gain during pregnancy and the estimations of dietary intake.

Weight gain during pregnancy is directly related with birth weight, both in industrialized and nonindustrialized countries.<sup>21, 25</sup> On the contrary, in the majority of studies where dietary surveys or food supplementation programs have been used, no association whatsoever has been detected between the intake of nutrients during pregnancy and birth weight.<sup>62, 63</sup> It could be that this lack of association is due to the low reliability of the data on nutrient consumption, and/or to the fact that the majority of the women under study were relatively well nourished.<sup>64</sup>

In the technically underdeveloped countries (TUC), several studies both of a dietary and nutritional intervention nature, have revealed an association between maternal dietary supplementation and weight of the child at birth. However, variables such as infectious diseases and medical care, which could complicate this association, were not explicitly controlled.<sup>64</sup> Thus, the results of Iyengar's experiment in India<sup>65</sup> suggest a strong effect of food supplementation of the mother on birth weight. Nevertheless, these results are difficult to interpret, since in order to develop the food supplementation program, the mothers of the experimental group were hospitalized during the last trimester of gestation. This hospitalization could have resulted in lower infection rates or in less physical exercise, factors which in turn could have been responsible for the observed increment in birth weight.<sup>66-68</sup>

The relation between the dietary intake of pregnant women who have not had food supplementation and birth weight in rural populations of Guatemala is presented in Figure 9.

It is obvious that the average birth weight increased progressively as the dietary intake increased. This relation between the home diet and the weight of the child



In parenthesis number of cases.  
 \*\*  $P < 0.01$ .

Fig. 8. Relationship between cephalic circumference of the mother and the proportion of children with low and high birth weight.

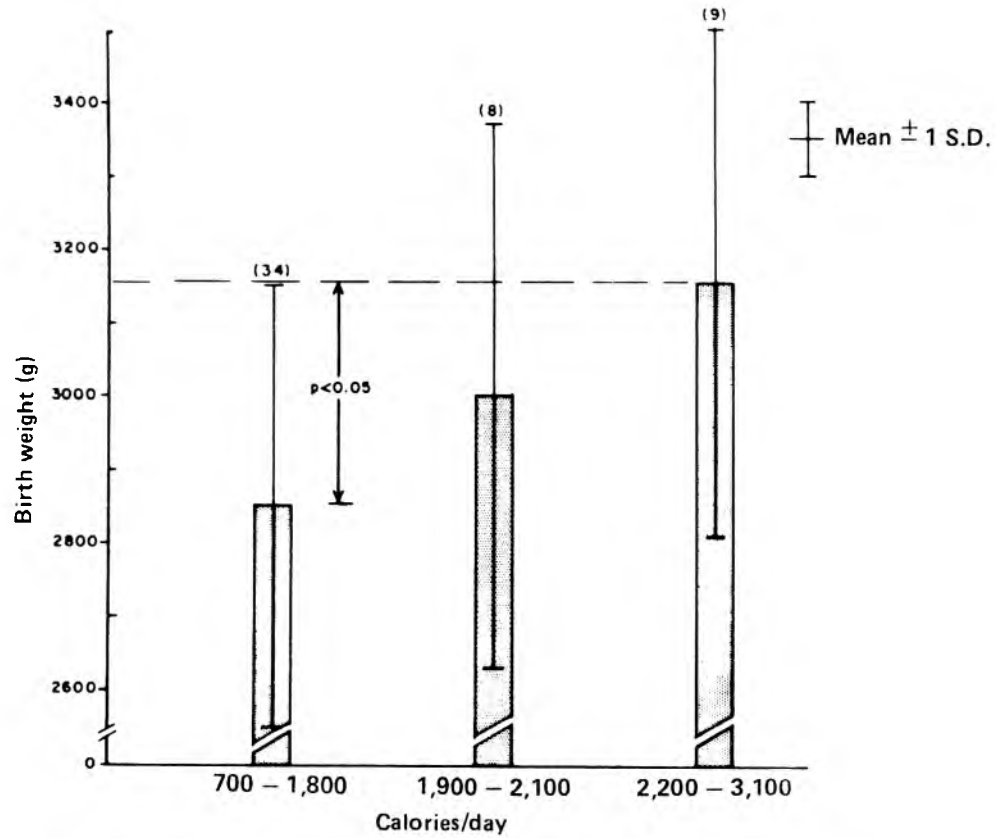


Fig. 9. Relationship between dietary intake during pregnancy and birth weight.

at birth was maintained after controlling for the influence of height, parity, duration of diseases of the mother during pregnancy and sex of the newborn. The INCAP longitudinal study to which we have referred has provided additional data on this relationship. It should be noted that this research contemplates administration of two types of supplement: "Atole" and "Fresco." The nutrient content of both preparations is presented in Table 1. As observed, the "Fresco" does not contain protein and its caloric concentration is approximately a third of that of the "Atole."

TABLE 1  
NUTRIENT CONTENT PER CUP\* (180 ml)

Nutrients	Type of supplement	
	Atole	Fresco
Total calories, kcal	163	59
Protein, g	11	—
Fat, g	0.7	—
Carbohydrates, g	27	15.3
Ascorbic acid, mg	4.0	4.0
Calcium, g	0.4	—
Phosphorus, g	0.3	—
Thiamine, mg	1.1	1.1
Riboflavin, mg	1.5	1.5
Niacin, mg	18.5	18.5
Vitamin A, mg	1.2	1.2
Iron, mg	5.4	5.0
Fluor, mg	0.2	0.2

\* Figures approximated to a decimal.

Attendance to the supplementation centers is voluntary and consequently there exists an ample variation in the intake of the supplement during pregnancy. The amounts of supplement ingested both daily and at periodic intervals, were measured as well as the physical growth and mental development of the children. In addition, morbidity, the habitual diet of the families and sociocultural characteristics were also measured.<sup>69</sup>

For the purpose of determining the effect of food supplementation during pregnancy on birth weight, the magnitude of the association between food supplementation and birth weight was first investigated in order to explore if the observed association was an artefact produced by any interfering variable.

The percentage of children with low birth weight for the groups with high and low supplementation is shown in Figure 10. As the data show, this proportion was approximately half in the groups with high supplementation than in those with low supplementation, and no difference was found between the populations who consumed "Fresco" and those who ingested "Atole."

Table 2 presents the observed correlations between caloric supplementation during pregnancy and birth weight. As observed, the values for the slope (or dose-response relationship) both in reference to "Fresco" as well as to "Atole" were very similar. This Table also indicates that a significant correlation between caloric supplementation during pregnancy and birth weight was observed in the total population ( $P < 0.01$ ).

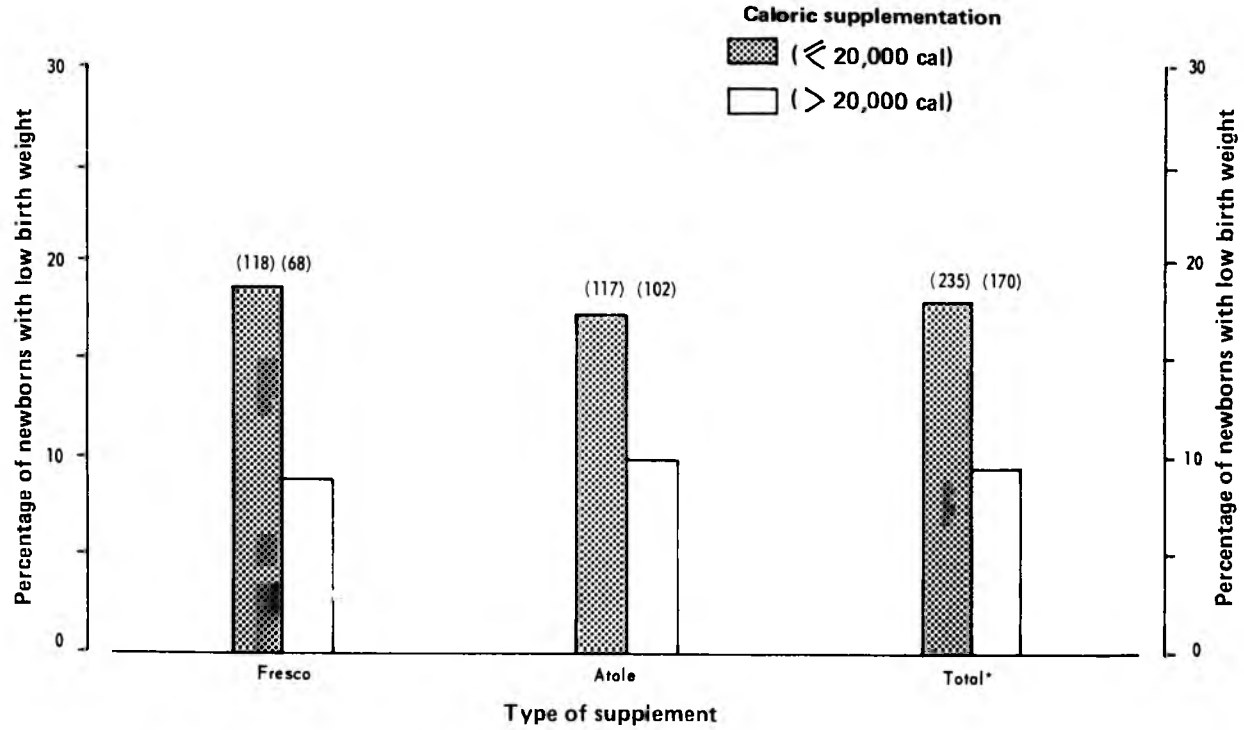
**TABLE 2**  
**CORRELATION BETWEEN SUPPLEMENTED CALORIES**  
**DURING PREGNANCY AND BIRTH WEIGHT OF THE CHILD**

Supplement	r	Dose-response relationship* (weight in g/10,000 supplemented cal )	n	P <
Atole	0.113	23	219	0.10
Fresco	0.123	30	186	0.10
Total (Atole and Fresco)	0.135	29	405	0.01

\* Dose-response relationship for Fresco greater than for Atole; covariance test: N.S.

Investigations were then undertaken to determine whether this association was due to a systematic error or to an artefact introduced by interfering variables. For this purpose, approximately 50 maternal variables were studied, including home diet and morbidity during pregnancy, anthropometry, obstetric history and socio-cultural characteristics of the family. As Table 3 shows, the dose-response relationship between the supplemented calories and the weight of the newborn was basically the same after controlling for the influence of the previously mentioned maternal variables. Consequently, these findings reveal that none of these variables can explain the observed association between caloric supplementation during pregnancy and birth weight.

Finally, the possible effect of autoselection of the pregnant women in regard to the supplement intake, as an explanation for the observed association between



In parenthesis number of cases.

\*\*  $P < 0.05$ .

Fig. 10. Relationship between the amount of supplemented calories during pregnancy and the prevalence of low birth weight ( $\leq 2.5\text{ kg}$ ).

TABLE 3

## DOSE-RESPONSE RELATIONSHIP BETWEEN CALORIC SUPPLEMENTATION DURING PREGNANCY AND BIRTH WEIGHT (n = 405)

	Dose-response relationship birth weight (g/10 <sup>4</sup> cal )	S.E.
1. Before controlling for interfering variables	29**	10.6
2. After controlling for interfering variables <sup>1</sup> (in multiple correlation)	30**	10.6

\*\* P < 0.01.

1 Home diet, height, cephalic and arm circumference, weight at 1st trimester, parity, gestational age, anorexia and diarrhea during pregnancy.

caloric supplementation during pregnancy and birth weight was investigated. Differences in birth weight between consecutive children of the same mother were calculated in order to explore the possibility that any factor not measured in the study could be producing both effects: high food supplementation consumption during pregnancy, and newborns with a higher weight.

The differences in birth weight for the subsample of consecutive siblings, divided into three groups according to differences in regard to caloric supplementation of the mother between the two pregnancies can be appreciated in Figure 11. As the data reveal, when caloric supplementation during the last pregnancy was lower than during the preceding one (bar A), the average birth weight of the last baby was also lower than that of the preceding child. When caloric supplementation in the course of the last pregnancy was higher than during the previous pregnancy (bar C), the mean weight of the last newborn was also greater than that of the preceding child ( $r = 0.295$ ,  $n = 82$ ,  $P < 0.01$ ). Hence, the relation observed between the supplemented calories during pregnancy and birth weight was consistent not only in all the population studied but also between siblings of the same mother. Consequently, it was concluded that caloric supplementation during pregnancy produced an increment in birth weight.<sup>69</sup>

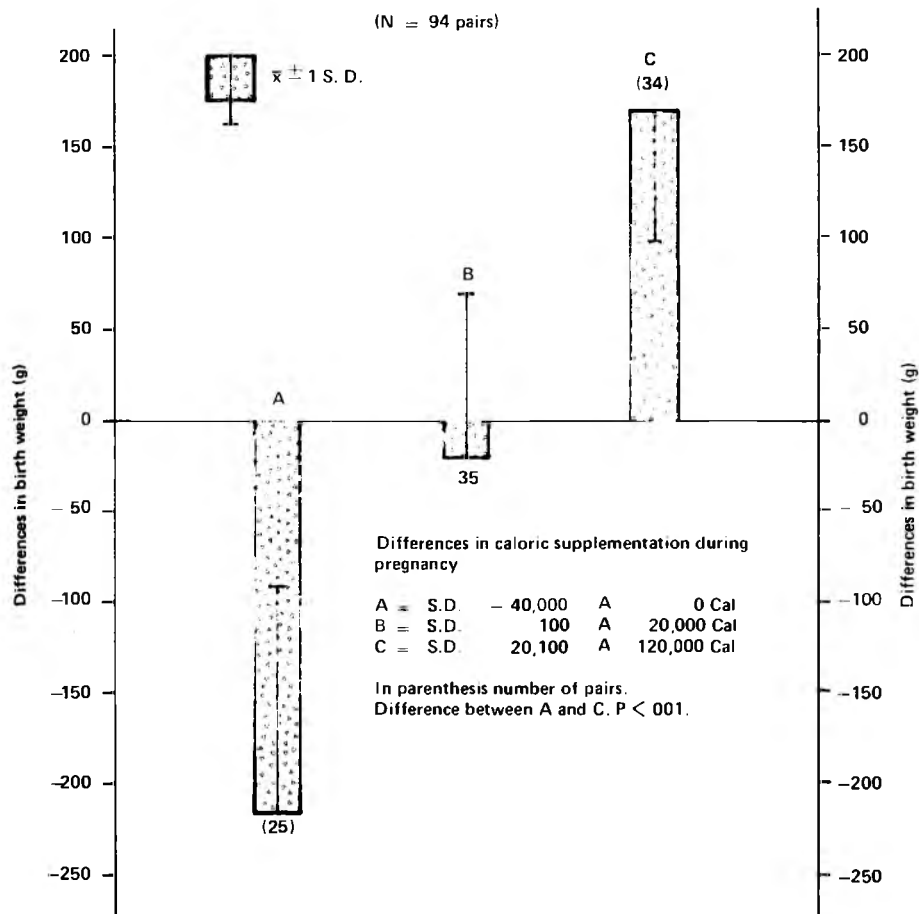


Fig. 11. Relationship between differences in caloric supplementation during pregnancy and differences in birth weight between two consecutive siblings (last pregnancy minus preceding pregnancy) ( $n = 94$  pairs).

### C. Which are the Mechanisms of this Effect?

It is generally accepted that malnutrition during pregnancy induces changes that lead to a reduction of the materno-fetal transference of nutrients.<sup>22, 70</sup> Furthermore, there is evidence that children of malnourished mothers also present biochemical changes which reflect the nutritional alterations of the mother.<sup>71</sup> Consequently,

reduction of the materno-fetal transference of nutrients would lead to a retardation in fetal growth through metabolic changes in the fetus, which in some aspects would be similar to those produced by malnutrition in the pregnant woman.

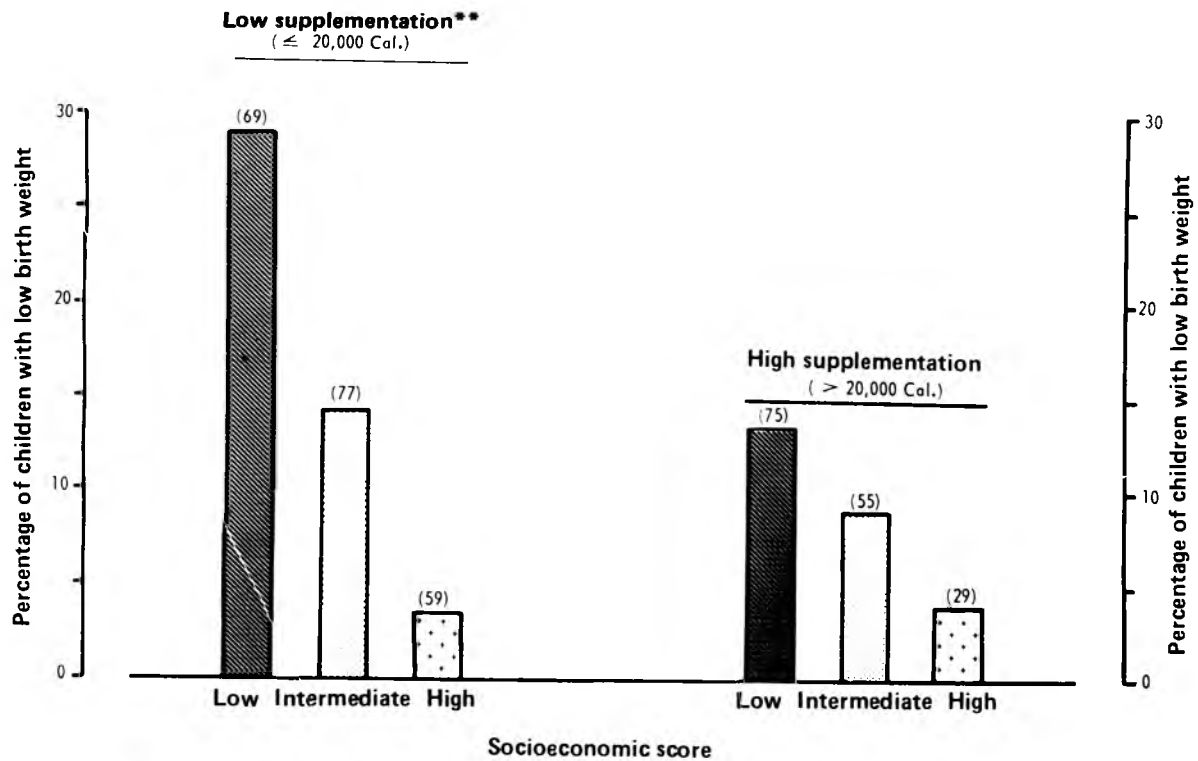
It should be noted that in the present study protein did not cause an additional effect to that of calories. This is probably due to the fact that calories are the most important limiting nutrient in the home diet. It is possible, therefore, that part of the protein of the diet is being used to supply calories.<sup>72, 73</sup> Consequently, up to a certain point, the caloric supplementation of this population group is equivalent to a protein-calorie supplementation, since it permits to spare protein for synthesis and growth. It is possible that in populations where the protein-calorie ration is very low,<sup>74</sup> a specific effect of protein supplementation may be observed. The best food supplement for a population is not necessarily the most adequate, and could be even harmful for other populations if their diets are limiting in other nutrients.

The public health implications of the association between food supplementation during pregnancy and fetal growth are obvious. As already mentioned, children with low birth weight present high rates of infant mortality.<sup>8-10</sup> This means that the efficiency of nutritional programs designed to reduce infant mortality could be greatly increased if these were oriented to mothers with a high risk of having low birth-weight babies.<sup>75</sup>

The relationship between the socioeconomic score and the children with low birth weight for two categories of caloric supplementation during pregnancy is shown in Figure 12. As the data reveal, the magnitude of the association between socioeconomic score and low birth weight is higher in mothers with low supplementation than in mothers with high supplementation. More still, in the group with high socioeconomic score, food supplementation practically did not produce differences in the proportion of children with low birth weight. These results clearly indicate that the effects of caloric supplementation are greater in the group with low socioeconomic score. Furthermore, these results suggest that differences in the proportion of children with low birth weight among groups of different socioeconomic score, may be notably reduced if mothers improve their nutritional status during pregnancy.

The relationship between the socioeconomic score and the proportion of children with low birth weight, in regard to two variables, height of the mother and her caloric supplementation during pregnancy, is observed in Figure 13. As the data show, the association between the socioeconomic score and low birth weight is quite strong in the group of mothers of small stature and low supplementation. On the other hand, no association is observed between the socioeconomic score and birth weight in the group of tall, well-supplemented mothers during pregnancy. The two intermediate groups also show an association of intermediate magnitude between the two extremes.

Finally, Figure 14 shows an example of the implications that these considerations have both in terms of effectiveness as well as in terms of the cost of programs



In parenthesis number of cases.

\*\*  $P < 0.01$ .

Fig. 12. Influence of caloric supplementation during pregnancy on the relationship between socioeconomic score and the proportion of children with low birth weight ( $\leq 2.5$  kg).

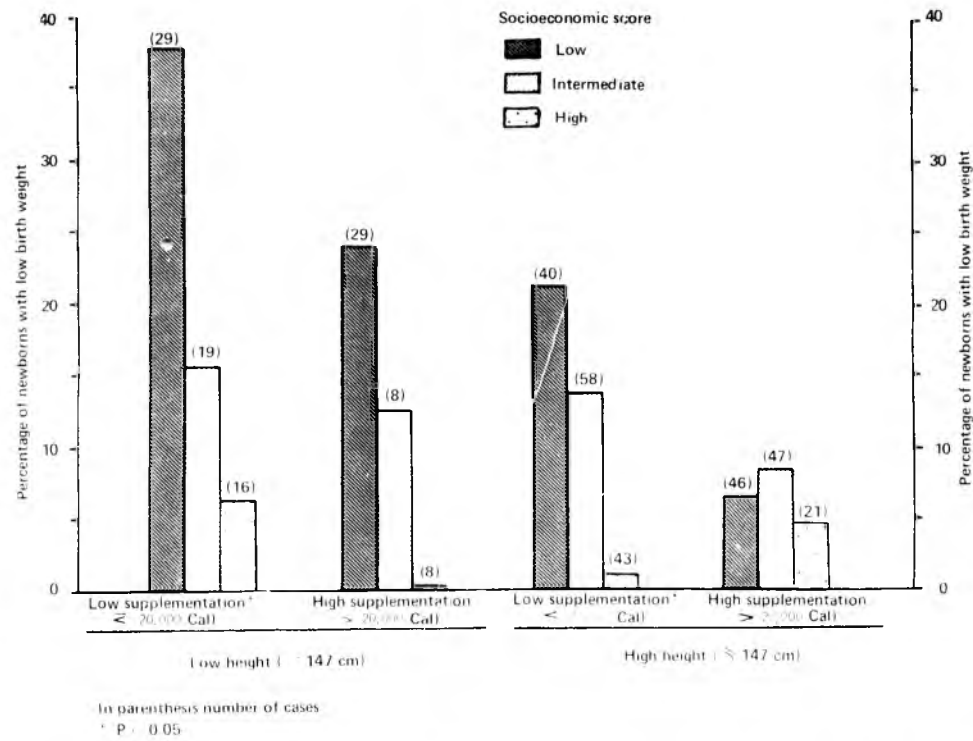


Fig. 13. Influence of maternal height and of caloric supplementation during pregnancy, on the relationship between socioeconomic score and the proportion of children with low birth weight.

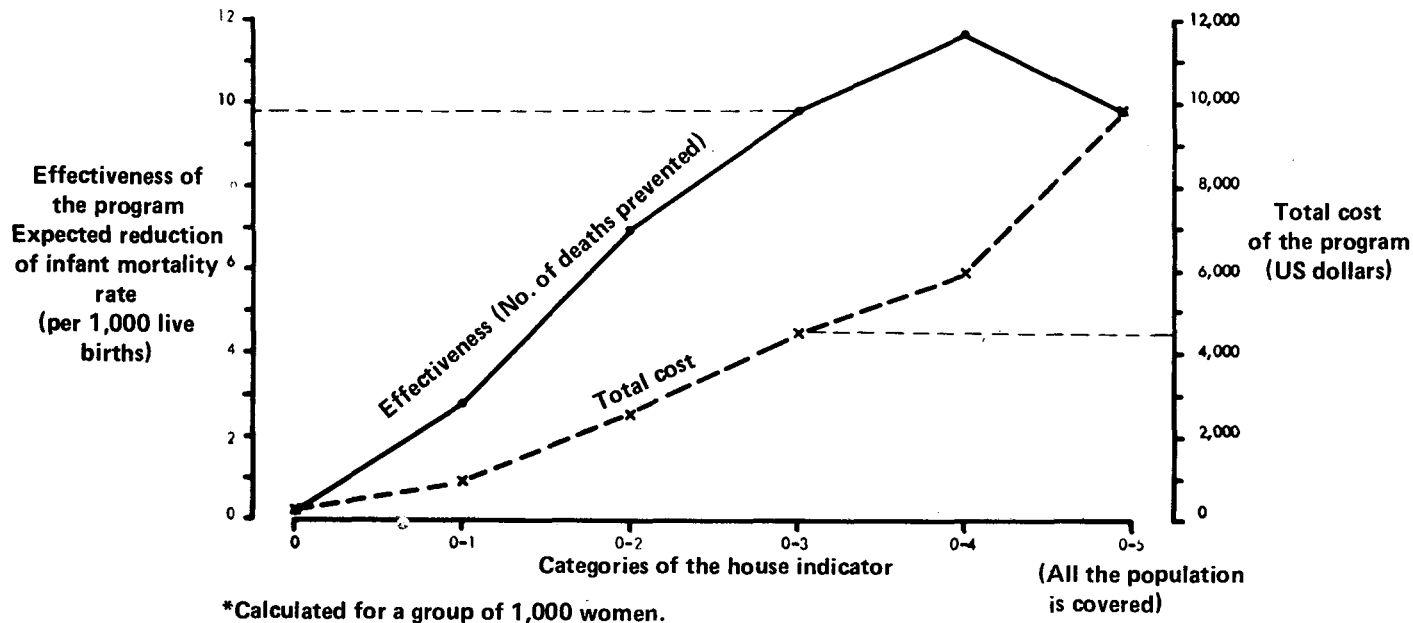


Fig. 14. *Expected changes in the effectiveness and cost of a program\* according to the categories used to identify women with high risk of delivering low birth-weight babies.*

aimed at reducing the prevalence of low birth weight or of infant mortality. For this analysis we have selected the house characteristics as a risk indicator, and the reduction in the infant mortality rate as a measure of the effectiveness of the program in a group of 1,000 women.<sup>75</sup> Examination of data in the same Fig. 13 indicates that the expected effectiveness of the program—estimated by the number of prevented deaths—increases in the measure that the superior limit selected to detect groups at high risk increases up to a point beyond which no greater increment is observed. The total cost of the program, however, continues to increase regularly even though its efficacy does not increase any more. In other words, it is evident that if the category 0 to 3 in the housing scale is used to identify women at high risk and the program is applied exclusively to this group, the resulting effect would be similar to that obtained if the program were applied to the total population. Since the cost of applying the program exclusively to the more at-risk group is half the cost resulting from the coverage of the total population, the use of this indicator—house—would permit obtaining twice the expected benefit for the same cost.<sup>75</sup>

#### IV. INFECTION

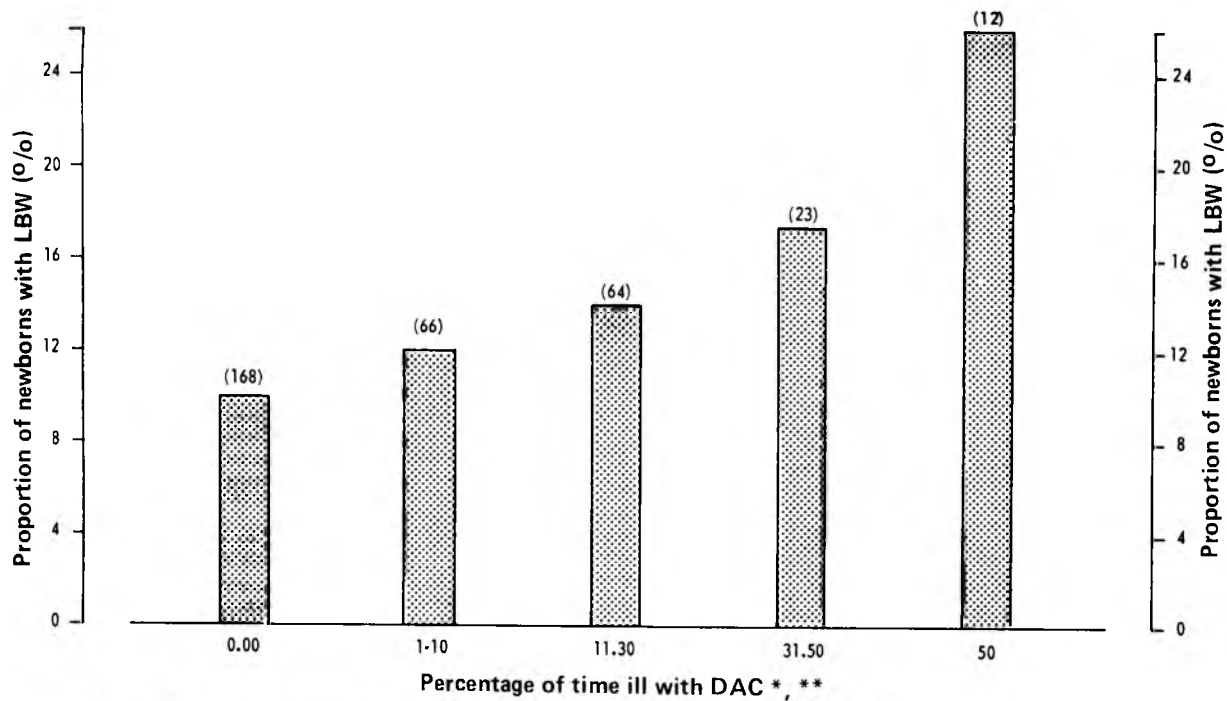
Discussion of the association between infectious disease and fetal growth retardation can be divided in two sections: maternal morbidity during pregnancy, and intrauterine infection.

##### A. Maternal Morbidity During Pregnancy

The available evidence suggests that mothers of low socioeconomic level with endemic protein-calorie malnutrition, also suffer from a high prevalence of infectious diseases.<sup>8, 66, 67</sup>

A preliminary work has shown<sup>66</sup> that morbidity of the mother during pregnancy is inversely related with birth weight. This association disappeared after controlling for the mother's diet during pregnancy, a fact which suggested that the majority of the maternal morbidity effects on birth weight were due to an intake reduction resulting from the anorexia that accompanies almost all of the infectious diseases. However, during that occasion we were unable to investigate which were the most important symptoms.

In a more recent study<sup>67</sup> an inverse relation between common infectious diseases during pregnancy and birth weight was again observed (Fig. 15). The proportion of children with low birth weight increased gradually from 10% in the group of healthier mothers up to 26% in the small group of mothers who reported any type of disease symptoms during more than 50% of their pregnancy. In conclusion, high morbidity levels during pregnancy were associated with a significant increase in the proportion of low birth-weight children, and this association remained constant after controlling for the more important maternal variables.



\* Percentage of pregnancy days ill with diarrhea and/or anorexia and/or cephalgia (Compound Indicator ACD).

\*\* Test of the direction sign:  $\binom{1}{2}^5$ ;  $P = 0.03$ .  
In parenthesis number of cases.

Fig. 15. Relationship between the percentage of time ill during pregnancy (DAC)\* and the proportion of low birth-weight ( $LPW < 2.5$  kg) babies\*\* (four Guatemalan rural villages,  $n = 334$ ).

The possible mechanism of this effect appears to be the reduction of the nutrient transference from the mother to the fetus. Studies in humans suggest that this can occur due to a reduction in food intake and to the metabolic response to infection.<sup>76, 77</sup> Nevertheless, it should be emphasized that in observational studies such as the ones previously mentioned, assignment of gestating women to determined maternal morbidity categories was not based, of course, on specific criteria designed by the researcher. For this reason it is necessary to interpret the findings with great caution, and to explore in what degree do these results replicate in different populations.

## B. Intrauterine Infection

The term "intrauterine infection" will be used in this discussion to indicate the invasion by microorganisms of the fetus tissues, the placenta and its membranes.

### 1. *Etiology and prevalence*

One of the most serious problems in exploring the effect of intrauterine infection on growth and fetal development lies on the diagnosis of intrauterine infection. Although various techniques have been employed and are available to the researcher, up to this moment there does not exist a totally reliable methodology to make this diagnosis.<sup>78-90</sup>

The more common causal agents of intrauterine infection are shown in Table 4 divided in two main classes: microorganisms that have been wholly demonstrated to be causes of intrauterine infection, and microorganisms that possibly cause this infection.

In relation to the prevalence of intrauterine infection few data are available from underdeveloped populations. In the prospective study of 88 mothers from four rural villages of the East of Guatemala, to which we already referred in a previous paragraph, 66% showed one or more days of infectious disease during pregnancy.<sup>66</sup> The prevalence of antitoxoplasma antibodies was between 60 and 94% in population groups of Guatemala and Costa Rica.<sup>91, 92</sup> Studies carried out in Latin American countries have shown that the IgM levels in cord blood are frequently high in rural or urban populations with deficient sanitary conditions. In these populations the proportion of children with high IgM levels is approximately 50% compared with 5% in Latin American populations with satisfactory environmental conditions.<sup>93</sup> This prevalence is similar to the one found in children with suspected clinical intrauterine infection in Birmingham, Alabama, USA.<sup>82</sup> In Children who have suffered confirmed intrauterine infection, the prevalence of high IgM levels in cord blood is 85%.<sup>80</sup> Taking into account these observations, the total prevalence of intrauterine infection in developing populations is probably much higher than in the developed societies, possibly as high as 10% of all babies born alive.

TABLE 4  
ETIOLOGIC AGENTS OF INTRAUTERINE INFECTION

Agent	Demonstrated	Probable
Virus	Cytomegalovirus	Coxsackie B
	Rubella	Echo
	Herpes simplex	Measles
	Chicken pox	Mumps
	Vaccinia	Influenza
	Polio	Hepatitis
	Western equine encephalomyelitis	"Attenuated virus"
Mycoplasma		T strain
	The majority, particularly:	
Bacteriae	Enterobacteriae	
	<i>Listeria monocitogenes</i>	
	<i>Vibrio fetus</i>	
	<i>Treponema pallidum</i>	
	<i>Mycobacterium tuberculosis</i>	
Protozoa	<i>Toxoplasma gondii</i>	
	<i>Plasmodium</i>	
Fungus	<i>Candida</i>	

## 2. Effects on birth weight

Low birth weight for gestational age is frequently found associated with intrauterine infection. This association has been particularly evident in infections caused by the rubella virus. The average weight of newborns with congenital German measles is below 2,500 grams,<sup>94</sup> in comparison with 3,300 to 3,500 grams for normal children of the same populations.<sup>95</sup> Other viral agents have been associated with fetal growth retardation. From 30 to 100% of children with cytomegalovirus infection<sup>96</sup> and all those infected by herpes virus<sup>97</sup> have been reported to have fetal growth retardment. Fetal infection by poliovirus is probably a cause of prematurity and low birth weight, especially if it occurs during the first trimester of pregnancy and is clinically severe.<sup>98</sup> A similar observation has been reported in relation to the smallpox vaccine.<sup>99</sup> In cases of fetal infection caused by influenza, mumps, smallpox, chicken pox and measles, the information on this subject is contradictory.<sup>100-102</sup>

In relation to the effects of bacterial infection, an association between the presence of bacteriuria during pregnancy and fetal growth retardation has been reported.<sup>103-105</sup> Nevertheless, more recent information has not confirmed this association.<sup>106-109</sup> Also, the presence of mycoplasma T strains in the cervix or in the urine of gestating women has also shown to be associated with low birth weight.<sup>110</sup> The weight of children with congenital syphilis also is reduced when compared with that of healthy children.<sup>111</sup> Furthermore, an association between low birth weight and the presence of positive seroconversion for toxoplasma during pregnancy has been shown.<sup>112</sup> Lastly, it has been observed that the birth weight of children with placental infection caused by plasmodium was, as an average, 260 g lower than in the control group.<sup>113</sup>

Table 5 describes the principal routes and action mechanisms on intrauterine infection as well as the factors that influence its final impact.

**TABLE 5**  
**PATHWAYS, MECHANISMS AND FACTORS INFLUENCING THE FINAL EFFECT OF INTRAUTERINE INFECTION**

- 
- A. Pathways of intrauterine infection:**
- Placental
  - Vaginal
  - Others
- B. Mechanisms of intrauterine infection:**
- Reduction of placental flow
  - Inhibition of the mitosis velocity
  - Chromosomal ruptures
  - Cellular necrosis
  - Increment of catabolic velocity
  - Tissular hypoxia
- C. Factors influencing the final effect of intrauterine infection:**
- Nature of causal agent
  - Gestational age at which infection is initiated
  - Severity of the infection (extension, localization, duration)
  - Materno-fetal response (nutrition, immune response)
- 

In the greater part of the reported cases, infection was produced through the placental pathway, a finding that indicates that the agent must have been first in

the maternal blood.<sup>114, 115</sup> In other cases, particularly of infections produced by herpes virus and bacteriae, infection was produced through the vaginal pathway<sup>116</sup> originating the so-called amniotic infection syndrome.<sup>14</sup> There are other possible infection routes, including transmission through the maternal ovary.<sup>117</sup> The agent is then disseminated in the fetus, producing acute or chronic infection which may not be clinically detectable at birth.<sup>82</sup>

One of the mechanisms which explains fetal growth retardation is the reduction of the placental blood flow,<sup>118</sup> mainly due to injury of the placenta's endothelium.<sup>119</sup> Another important mechanism is the inhibition of the cellular multiplication which results in hypoplasia.<sup>120</sup> Furthermore, a high frequency of chromosomal ruptures has been reported, and this leads to the production of a great number of nonviable cells and, hence, to low growth rates.<sup>121</sup> In contrast, cellular necrosis does not appear to be an important mechanism in the production of fetal growth retardation.<sup>111</sup> In addition, the increment in the catabolic velocity<sup>122</sup> and the tissular hypoxia<sup>113</sup> can play an important role as mechanisms of the effect of intra-uterine infection.

One of the most important factors which influences the final effect of intra-uterine infection, naturally, is the agent. Thus, infection by rubella is found consistently associated with fetal growth retardation, while infection produced by cytomegalovirus shows an association with mental retardment independently of the physical growth of the fetus.

The gestational age at which infection occurs is also of importance in determining the magnitude of the injury, its nature and reversibility. For example, intra-uterine infection is more dangerous and probably of irreversible effects if it occurs during the first months of pregnancy, since at this stage many organs, including the brain, are in the hyperplastic growth phase.<sup>123</sup>

Another factor is the severity of the infection defined by the extension of the infectious process and the localization of the lesions. Under similar conditions of extension and localization, processes of longer duration will probably produce a more profound effect on fetal growth than relatively short infectious processes.

In addition to the above-mentioned factors, those modifying the physiologic state of the fetus are also important. Among these we can cite nutritional status, which may be reduced due both to maternal malnutrition or to a restriction of the placental blood flow.<sup>119</sup> Other factors are the immune response capacity of the fetus, the magnitude and efficiency of which determine the final result of the infectious process.

After the third month of gestation, the fetus is capable of producing immunoglobulins and components of the hemolytic system complement.<sup>124</sup> At birth, the fetus can show retarded hypersensitivity reactions<sup>125</sup> and a phagocytic activity similar to that of the adults.<sup>126</sup> The efficiency of these mechanisms is sufficient to

protect the newborn, even if he lives in environments with very high infection risks. Demonstration of immunologic reactions of fetal origin has been possible in the majority of intrauterine infections.<sup>127</sup> In some cases,<sup>128</sup> however, reactions have appeared tardily or have not been detected, thus suggesting an alteration of the recognition mechanisms of the agent as strange to the fetal organism. This observation has been reported in some types of infection produced during the first trimester of gestation, and have profound implications for the immunologic theory.<sup>129, 130</sup>

The maternal defense mechanisms against infection also play an important role. The majority of the antibodies produced by the mother are IgG type and, consequently, pass to the fetus and contribute to protect him.<sup>131</sup> In infections occurring through the vaginal route, the passage of antibodies and other factors of the mother to the fetus can also be an important factor in the protection of the product.

It must be emphasized that, excepting the studies carried out during German measles epidemics, these data are originated from studies that have not been designed for the specific purpose of exploring the effect of intrauterine infection on birth weight. For example, the retrospective information on gestational age does not permit to infer if the low birth weight observed was due to fetal growth retardation or to a short-term gestational age. In spite of these difficulties, the reviewed data suggest that fetal infections produced by German measles, cytomegalovirus, herpes virus, toxoplasma and plasmodium exert unfavorable effects on fetal growth. In the case of other infections, evidence is doubtful.

The mechanisms of this effect are principally the reduction of the placental blood flow and the inhibition of the mitosis velocity in the fetal organisms. The injury produced depends on the type of infectious agent, the time at which the infection occurs and its severity, the nutritional status of the fetus, and the effectiveness of his immune response. Estimates of the prevalence of intrauterine infection vary in accordance to the environmental sanitation conditions, and can possibly be as high as 10% in the alive newborns in technologically underdeveloped societies.

## V. OTHER FACTORS

### A. Altitude

The Andes region in South America is the area of higher altitude (more than 3,000 m above sea level) more densely populated in the world. Obstetricians working in the Andean Region frequently report that children born in that zone are generally smaller. Various reports from the Andean Region in Peru have consistently shown that a lower birth weight and a greater neonatal mortality correspond to the highest altitude. Thus, a sample of children born in Cuzco (at an altitude of almost 4,000 m) weighed an average of 200 g less than children born in Lima (200 m altitude). More still, children born in Cuzco from mothers of European origin also showed a lower average birth weight than that of populations living at sea level.<sup>132, 133</sup> Similar data have been observed in the United States.<sup>134, 135</sup>

In summary, the available evidence suggests the existence of an inverse relationship between altitude and birth weight. Populations who live at higher altitudes tend to have a high percentage of children with low birth weight. Analysis of the published data suggests that the altitude effect can produce an increase of 4 to 5% in the prevalence of low birth weight for each increment of 1,000 meters above sea level.

### B. Genetic Factors

There is consensus in the scientific community as to the importance that genetic factors play as determinants of birth weight. Nevertheless, available data are difficult to interpret given the different genetic or ethnic differences usually found associated to environmental differences. Various authors<sup>136, 137</sup> have found a clear difference in the average birth weight among different ethnic groups. Thus, for example, the North American Indians show the greatest average birth weight while the Mayan Indians and Hindus show lower averages. On the basis of this incidence, it is assumed that there exists a strong genetic component in the causal complex which determines birth weight. The variables to correlate in studies on the genetic influence on intra-uterine growth, are the growth potential of the parents and newborns. In the developed societies, environmental conditions can permit a complete expression of the genetic potential for physical growth. This is why it is considered that in the developed countries, variability in height is to a great extent due to a different genetic growth potential.<sup>138</sup> In these societies high correlations between the size of the parents and the size of the children have been found.<sup>138</sup>

It has been shown that the relation between the size of the mother and the size of the newborn is consistent in many mammal species, including the human species.<sup>139</sup> Data collected from various independent groups of researchers suggest that this relationship is mainly a function of the size of the mother, and not of the size of the father, both in animals<sup>140, 141</sup> as in humans.<sup>142, 143</sup> These data suggest that birth weight depends more on the environment provided by the mother than on genetic influences. A possible mechanism of this effect is the placental blood flow.<sup>144</sup> However, in undernourished populations, the physical growth of both parents and newborns does not appear to be a total expression of the genetic potential for growth. This notion is derived from numerous studies which indicate that chronic malnutrition and the high morbidity rates associated to it, cause physical growth retardation.<sup>53, 54</sup> In other words, in these societies environmental factors, principally malnutrition and infection, determine the extent of how the fetus can develop its growth genetic potential.<sup>145</sup>

### C. Miscellaneous Factors

Great attention is paid in the literature originated from the developed countries, to a series of factors that are found with relatively less frequency in the developing countries of the world. These factors will be briefly reviewed in the following paragraphs.

The incidence of pre-eclampsia is three times higher among primigravidae than among multigravidae and occurs with exceptionally high frequency in women who

have had serious systemic diseases previous to initiation of pregnancy. A high incidence of toxemia of pregnancy also exists in low socioeconomic populations where maternal protein-calorie malnutrition is highly prevalent.<sup>146</sup>

In a study of 947 cases of preeclampsia carried out in the United States of America, it was found that both the fetus and the placenta showed important alterations in growth and development in comparison with the conception product of normal women. Furthermore, women with toxemia of pregnancy tended to give birth at a shorter gestational age than normal women.<sup>147</sup>

There is also evidence of association between the cigarette-smoking habit during pregnancy and birth weight. The average birth weight is around 200 g less in mothers who smoke than in those who do not smoke during pregnancy.<sup>148</sup> In a sample of non-smoking mothers of the United States, the incidence of low birth weight was approximately half (3.6%) than that observed in a comparable sample of smoking mothers (7.6%).<sup>149</sup> The cigarette-smoking habit during pregnancy has also been associated to a short gestational age, and it is estimated that around 10% of the effect of the smoking habit on birth weight is due to a short gestational age.<sup>150</sup> The principal mechanisms of this effect seem to be the vaso-constrictor effect of nicotine on the blood vessels of the placenta, a high concentration of carbon monoxide in the blood and, consequently, fetal hypoxia and a small-size placenta.

Besides, various complications of pregnancy can produce low birth weight. These include diabetes, cardiac disease, Rh incompatibility, severe anemia, excessive vomiting or hemorrhages during pregnancy, abortion induced through various means, previous placenta, multiple pregnancies, and previous abortions.<sup>151, 152</sup>

Finally, in some mothers from developed countries, a repetitive tendency to give birth to children with low weight, commonly due to their short gestational age, has been observed. This tendency, found in apparently normal women, has been called idiopathic prematurity in view of the fact that the causes of these phenomenon are unknown.<sup>153</sup>

## VI. ESTIMATION OF THE IMPORTANCE OF THE REVIEWED FACTORS

Due to the scarcity of information, it is impossible to provide a precise estimate of the relative importance of the various factors previously described, in respect to their contribution to the high incidence of low birth-weight babies in Latin America. However, some points merit consideration in this regard.

The triad formed by maternal malnutrition, infection and low socioeconomic level constitutes a very complex interaction and it is difficult to estimate the relative importance of each one of its individual components. Thus, in contrast to the developed countries, 70% or more of the developing societies are in the low

socioeconomic level stratum, where a high prevalence of malnutrition and infection exists. Furthermore, in populations of the Andean Region, it is possible that the altitude exerts a negative interaction with malnutrition and maternal infection. However, although the Andes Region is the more populated high-altitude region of the world, its contribution to the high incidence of low birth weight in Latin America appears to be relatively small.

In general, the cigarette-smoking habit is quite uncommon in Latin American mothers, so that this is also a factor of little practical importance as determinant of the total incidence of low birth weight in the Region. Reports on the incidence of toxemia of pregnancy in the developing countries vary between 3 and 26% of the number of born-alive babies,<sup>146, 154, 155</sup> and it has been observed that this condition is more prevalent in the low socioeconomic classes. It is possible that maternal malnutrition be one of the contributing factors to the development of toxemia of pregnancy,<sup>156</sup> and it is also possible that toxemia of pregnancy produce a greater number of low birth-weight babies in the developing countries than in the developed countries. However, due to the high prevalence of malnutrition and infections, it is probable that even under these circumstances, the contribution of toxemia of pregnancy to the total incidence of low birth weight in Latin America is small when compared to the contribution of maternal malnutrition and infection. The same conclusion is applied to the series of miscellaneous factors mentioned previously.

The known causes of LBW are summarized in Table 6, divided into two groups in terms of their relative importance in the Latin American countries.

**TABLE 6**

**DETERMINANTS OF LOW BIRTH WEIGHT IN LATIN AMERICA**

A. Predominant	B. Of minor importance
1. Low socioeconomic level	1. Altitude
2. Malnutrition	2. Toxemia of pregnancy
3. Infection	3. Smoking habit
	4. Hemorrhage
	5. Repeated abortions
	6. Previous child with low birth weight
	7. Diabetes
	8. Cardiovascular disease
	9. Multiple pregnancy
	10. Hyperemesis
	11. Genetic factors
	12. Other

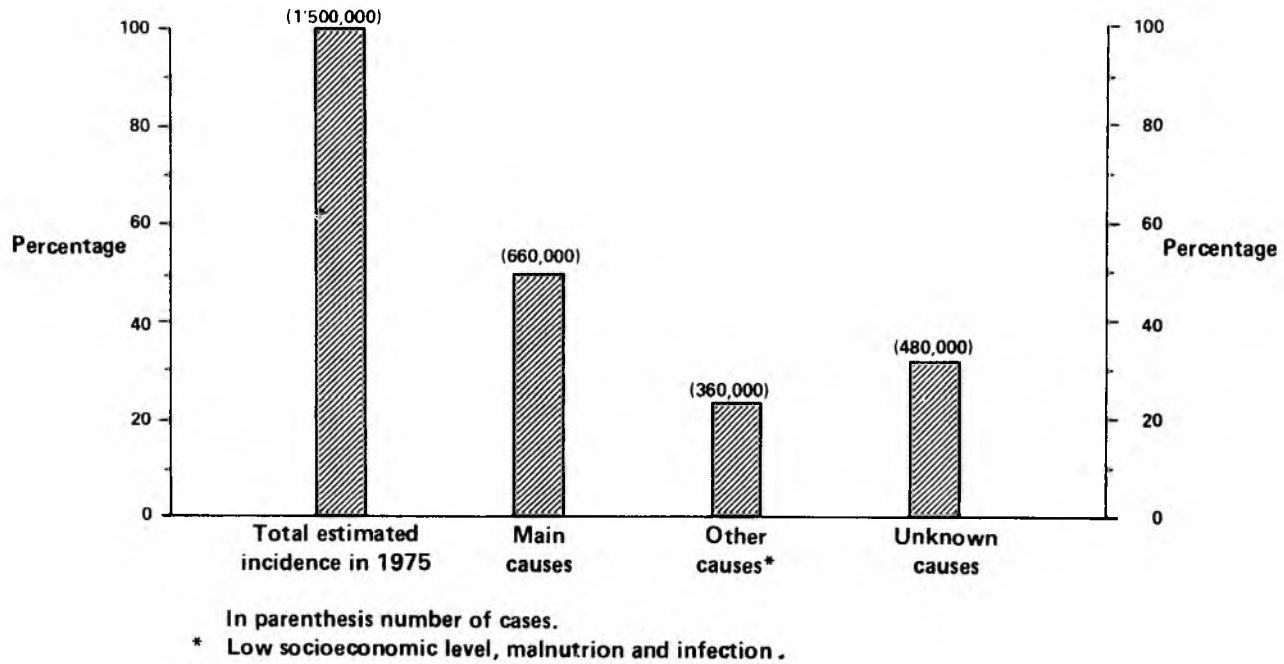


Fig. 16. *Estimated incidence of low birth weight in Latin America, by causes.*

A proximate estimation of the importance of three groups of causes as determinants of the incidence of LBW in Latin America is presented in Figure 16. It is estimated that the causes considered as predominant were responsible for 44% of the babies born with LBW in 1975. All of the other known causes would be responsible for approximately a fourth of the total incidence. The remaining group—a third of the total incidence— would correspond to causes which have not been determined as yet.

In conclusion, the available data suggest that the high incidence of low birth weight in Latin America is primarily the result of the high prevalence of maternal malnutrition, of common infectious diseases during pregnancy, and of factors that interact with poverty or economic, social and cultural deprivation of the majority of the Latin American populations. These three factors interact in a very complex form for the purpose of finally producing a high incidence of low birth weight in our countries.

It is essential to recognize that this high incidence is directly related to the malnutrition, infection and poverty conditions. For these reasons, when adoption of measures for reducing the incidence of low birth weight is considered, it is important to approach the problem not only as a specific public health problem, but also in its global context in relation to the social and economic development of the population.

Many public health specialists have not recognized the contribution of maternal malnutrition to the prevalence of low birth weight, and feel that the problem can be solved by massive immunization programs and with the establishment of curative medical services. Nonetheless, these programs are not only very costly but their effective utilization in the developing countries is quite limited unless there exists a simultaneous improvement of both the environmental conditions and of the basic social and economic parameters of the community. On the other hand, one of the considerations to be kept in mind is the frequent failure of traditional nutritional actions in the Latin American countries. The fact that maternal malnutrition is an important causal factor in the etiology of low birth weight does not necessarily mean that the supplementary feeding programs herein discussed will solve the problem. It must be emphasized that these programs were implemented as research procedures. As routine service activities such programs are generally very expensive, they consume too much time and personnel, contribute to create dependent populations, and frequently induce unfavorable effects on the local food industry. Consequently, it is possible that such programs are inadequate as unique and massive measures aimed at great population groups and during long time intervals.

## RESUMEN

### CAUSAS DE BAJO PESO AL NACER EN LATINOAMERICA

Del análisis de la literatura se concluye que el peso del recién nacido es notablemente mejor en los grupos de alto nivel socioeconómico que en los grupos de bajo

nivel socioeconómico, y que dicha asociación también existe en pequeñas poblaciones pobres del área rural de Guatemala. En estas aldeas, la asociación entre el puntaje de la escala socioeconómica desarrollada para esta investigación y la proporción de niños con bajo peso al nacer, desaparece en los grupos de madres con alta talla y bien suplementadas durante el embarazo. Los datos presentados sugieren que tanto la historia nutricional desde la concepción, como el estado nutricional de la madre durante el embarazo, constituyen uno de los mecanismos importantes de la relación causal existente entre características socioeconómicas y crecimiento fetal. Otro mecanismo de gran importancia en Latinoamérica es la elevada prevalencia de infección, tanto en la madre como en el niño desde su vida prenatal. Se estima que el complejo causal pobreza-desnutrición-infección es responsable de por lo menos la mitad de los niños nacidos con bajo peso en la Subregión. Se considera, además, que el conjunto de causas conocidas como responsables de la mayor parte de niños con bajo peso al nacer en los países industrializados, determina no más de la cuarta parte de estos niños en la América Latina. Por esta razón, las estrategias utilizadas en países industrializados para disminuir la incidencia de bajo peso al nacer no son aplicables en Latinoamérica. Por ejemplo, en muchas poblaciones del Subcontinente indicadores muy sencillos tales como la talla, el perímetro de la cabeza y del brazo, y las características de la vivienda, pueden ser muy útiles para seleccionar grupos de madres con alto riesgo de dar a luz niños con bajo peso al nacer y que, por lo tanto, requieren con carácter prioritario, la atención de los programas de salud. El uso de estos indicadores de riesgo contribuirá a mejorar notoriamente la eficiencia y la efectividad de dichos programas, particularmente en las poblaciones con recursos de salud inadecuados.

Se concluye que un mejoramiento del estado nutricional y de la salud de las mujeres gestantes, conducirá a un descenso significativo de la prevalencia de niños con bajo peso al nacer en la mayor parte de la población latinoamericana. Esto, a su vez, ayudará a reducir las altas tasas de mortalidad infantil que se observan en estos países, y permitirá a las nuevas generaciones una mayor probabilidad de desarrollar toda su potencialidad genética.

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**PUBLIC HEALTH IMPLICATIONS OF LOW BIRTH WEIGHT\***

*Leonardo Mata\*\**, *Juan J. Urrutia\*\*\** and *Edgar Mohs\*\*\*\**

**Institute of Investigations in Health (INISA), University of Costa Rica  
and Ministry of Health of Costa Rica**

**Institute of Nutrition of Central America and Panama (INCAP),  
Guatemala, C. A.**

**National Children's Hospital, Caja Costarricense del Seguro Social (CCSS),  
Costa Rica**

**SUMMARY**

The present paper interprets the significance of anthropometric data of newborns from a typical Indian village of Guatemala and from the general population of Costa Rica. A good correlation exists between a deficient fetal growth and infant mortality and retarded physical growth. The significance of fetal growth retardation on early and late anomalies and defects is discussed.

The existing information reveals a high incidence of neonates with altered fetal growth and development in Latin America. This circumstance is the main factor associated with the high infant mortality and retarded development observed in many populations of the Subcontinent.

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\*\* Director of the above-mentioned Institute and Adviser to the Ministry of Health of Costa Rica.

\*\*\* Member of the Division of Biology and Human Nutrition of INCAP.

\*\*\*\* Member of the Hospital, CCSS, San José, Costa Rica.

Certain countries have attained a substantial improvement in the conditions affecting fetal growth, by implementing comprehensive health and development programs with a holistic approach. The interventions that need to be strengthened in order to improve fetal development in our nations are reviewed.

## I. INTRODUCTION

Knowledge of the incidence and causality of low birth weight is of singular importance for the formulation of health policies and programs, especially when interventions of great coverage and extension are planned. This condition is particularly true for the developing countries, since in them, fetal growth retardation and premature delivery occur with greater frequency than in the industrialized countries.

As was to be expected, practically no information is available on fetal growth in the developing countries, especially for suburban and rural populations. In general, the existing information is deficient in quality and not representative of the total population. Even in the case of urban areas, information is also scarce and not representative.

These considerations explain why sufficient importance is not given to low birth weight as a health problem in developing countries.

## II. STUDY MATERIAL

To illustrate the implications of low birth weight on health, data derived from a prospective study (The Cauqué Study) of a rural community of Guatemala will be employed,<sup>1-3</sup> as well as data from the Instituto Materno-Infantil CARIT (Mother and Child Health Institute CARIT) and from the General Direction of Statistics and Census, both in Costa Rica.<sup>4, 5</sup> The rural community of Guatemala is located at an altitude of 2,000 m above sea level and belongs to the linguistic Maya-Cakchiquel group. During the 1964-1973 period careful information was collected for practically the totality of newborn cohorts; these were observed in a prospective form. As a whole, the population consisted of 430 liveborn infants who represented more than 95% of the total births. Among many other determinations,<sup>3</sup> studies included measuring in a prospective way the weight and height, and survival of all the children.

The Costa Rica data correspond to a random sample of 10% of all liveborns in certain years at the CARIT Institute. The study period comprised from 1965 to 1974. During these years, this hospital center provided medical attention to a population representative of all social sectors of the country, including the rural population. Information on infant mortality and birth rate in Costa Rica corresponds to the total population of the country in the stated period.

### III. LOW BIRTH WEIGHT IN THE DEVELOPING COUNTRIES

Available information in Latin America reveals a serious fetal growth problem.<sup>6-8</sup> For example, the mean birth weight in the Guatemalan village (Table 1),<sup>9</sup> is one of the lowest registered in the literature and is significantly under that observed in industrialized populations located at similar altitudes than those of the Guatemalan highlands,<sup>10</sup> as well as of Indian groups with better economic situation.<sup>11</sup> Furthermore, the fact that the anthropometric characteristics of the newborn in the Indian village studied did not appear to change during the 10-year period of observation, is suggestive that the factors which determine a deficient fetal growth remained constant during such period.

TABLE 1  
WEIGHT OF LIVE NEWBORN COHORTS,  
SANTA MARIA CAUQUE, GUATEMALA

Year	No. of children	Weight, g Average $\pm$ D.E.	% < 2,501 g
1964	37	2,595 $\pm$ 360	35
1966	46	2,506 $\pm$ 321	46
1968	57	2,510 $\pm$ 422	44
1970	67	2,558 $\pm$ 412	36
1971	60	2,564 $\pm$ 328	48

Classification of the 415 neonates by weight at birth and by gestational age showed that 7% were pre-term and that an additional 34% were term-small-for-gestational age. The ratio "pre-term: term-small-for-gestational age" which was of 1:4.7 in the village contrasts with that observed in more developed societies, where it is generally of 2:1 (Table 2).

A high incidence of low birth weight has been described in pre-industrialized populations, including Latin America.<sup>7, 8, 12-18</sup> Nevertheless, truly representative data for this Region do not exist, particularly in what concerns rural areas; in addition there is no information on fetal maturity due to the difficulties inherent to the collection of information on gestational age.

**TABLE 2**  
**FETAL MATURITY OF 415 NEONATES,**  
**SANTA MARIA CAUQUE, 1964-1972**

Classification	No. %	Birth weight, g	Gestational age, weeks
Term	43 (10.3)	> 3,000	37 - 42
	199 (47.8)	2,501-3,000	37 - 42
	143 (34.4)	< 2,501	37 - 42
Pre-term	6 ( 1.4)	2,001-2,500	35 - 37
	24 ( 5.8)	< 2,001	31 - 36

#### IV. CORRELATION OF LOW BIRTH WEIGHT WITH MORTALITY

The influence of low birth weight and fetal immaturity on the neonatal mortality has been amply demonstrated.<sup>19-23</sup> In the Cauqué Study the correlation between birth weight and infant mortality (Table 3) was so marked as to characterize said variable as the best predictive survival index in similar rural populations. Actually, the indicator is closely correlated with gestational age (Table 4) which also showed a strong association with survival. A birth weight of at least 2,750 g and a gestational age of more than 36 weeks was associated with absolute survival during the neonatal period, and with a relatively good survival during the rest of the first year of life. It must be taken into account that the totality of the neonates who survived the first 48 hours were adequately breast-fed for long periods of time. Definitive weaning takes place during the second or third years of life.<sup>3</sup> Introduction of liquid foods starts at the age of 3 to 6 months, and of solid foods, at 6 to 12 months.

The combination of both variables has been proposed by several authors<sup>24-26</sup> and is shown in Table 5 for the Cauqué Study. The pre-term infants constituted the group with the highest and sustained mortality during all the course of their first year of life. However, the surviving babies showed a high survival during the rest of their preschool period.

The born at-term infants but small for their gestational age (malnourished fetuses) manifested a high mortality during all of the first and second years of life, as well as a high mortality during the rest of the preschool age.

Infants born at term but weighing more than 2,500 g exhibited the lowest neonatal mortality (8 per 1,000) and a post-neonatal infant mortality also relatively low. However, many of these were vulnerable during the preschool years, resulting in a high age-specific mortality in each one of the three preschool years.

TABLE 3

**INFANT MORTALITY AND BIRTH WEIGHT, SANTA MARIA CAUQUE,  
GUATEMALA, 1964-1973**

Birth weight, g	No. of children	Age			< 1 year
		< 29 days	29 days-5 months	6-11 months	
< 1,501	5	3 (600)*	1 (200)	0	4 (800)
1,501-1,750	11	2 (182)	3 (273)	1 (91)	6 (545)
1,751-2,000	17	4 (235)	4 (235)	1 (59)	9 (529)
2,001-2,250	47	2 ( 43)	2 ( 43)	2 (43)	6 (128)
2,251-2,500	99	3 ( 30)	0	1 (10)	4 ( 40)
2,501-2,750	125	2 ( 16)	3 ( 24)	2 (16)	7 ( 56)
2,751-3,000	82	0	2 ( 24)	2 (24)	4 ( 49)
3,001-3,250	32	0	0	0	0
3,251-3,500	11	0	0	1 (91)	1 ( 91)
≥ 3,501	1	0	0	0	0
<b>Total</b>	<b>430</b>	<b>16 ( 37)</b>	<b>15 ( 35)</b>	<b>10 (23)</b>	<b>41 ( 95)</b>

\* Figures in parentheses represent deaths and mortality per 1,000 liveborns of said weight.

TABLE 4

INFANT MORTALITY AND GESTATIONAL AGE, SANTA MARIA CAUQUE,  
GUATEMALA, 1964-1973

Gestational age, weeks	No. of children	Age			
		< 29 days	29 days- 5 months	6-11 months	< 1 year
31-32	3	2 (667)*	0	0	2 (667)
33-34	8	3 (375)	3 (375)	0	6 (750)
35-36	20	5 (250)	1 ( 50)	2 (100)	8 (400)
37-38	47	0	2 ( 43)	0	2 ( 43)
39-40	261	6 ( 23)	7 ( 27)	8 ( 31)	21 ( 80)
41-42	77	0	1 ( 13)	0	1 ( 13)
Total	416	16 ( 38)	14 ( 34), <sup>†</sup>	10 ( 24)	40 ( 96)

\* Figures in parentheses represent deaths and mortality per 1,000 livebirths of said gestational age.

TABLE 5

**MORTALITY BY FETAL MATURITY, 416 COHORT CHILDREN,  
SANTA MARIA CAUQUE, GUATEMALA, 1964-1972**

Classification	1st year			2nd year	3rd year	4th year
	< 29 days	29 days- 11 months	< 1st year			
Pre-term > 37 g	10(323)* <u>31</u>	6(286) <u>21</u>	16(516) <u>31</u>	0 <u>15</u>	0 <u>15</u>	0 <u>8</u>
Term < 2,501 g	4(28) <u>143</u>	8(58) <u>139</u>	12(84) <u>143</u>	8(76) <u>105</u>	3(39) <u>78</u>	3(50) <u>60</u>
Term > 2,500 g	2(8) <u>242</u>	10(42) <u>240</u>	12(50) <u>242</u>	9(44) <u>204</u>	5(33) <u>153</u>	1(8) <u>122</u>
Total	16(39) <u>416</u>	24(60) <u>400</u>	40(96) <u>416</u>	17(52) <u>324</u>	8(33) <u>244</u>	4(21) <u>190</u>

\* Figures in parentheses represent deaths and mortality per 1,000 livebirths at the initiation of the period. The underlined figures under mortality rate indicate number of children in cohort at initiation of period.

The importance of an adequate fetal development to avoid neonatal deaths is obvious when this is compared with infant mortality in two contrasting populations: one of them, the Indian village, and the other a population of the East Coast of the United States of America (Table 6).<sup>27</sup> No differences are noted in neonatal mortality between the Indian community and the North American population if one takes into account the weight category at birth. Consequently, the high neonatal mortality rates observed in the Indian community and in the developing societies are in great measure due to the higher incidence of low birth weight. Rates higher than those observed in the Cauqué Study may be due to the joint action of a deficient diet (particularly during early weaning) and infections.<sup>3, 27-29</sup>

**TABLE 6**  
**COMPARISON OF INFANT MORTALITY OF TWO POPULATIONS,**  
**BY WEIGHT AT BIRTH**

Birth weight, g	Neonatal			Postneonatal			Infantile		
	S.M.C.*	B.	R.**	S.M.C.	B.	R.	S.M.C.	B.	R.
1501-2000	273	210	1.3	303	26	11.7	576	199	2.9
2001-2500	34	45	0.8	34	13	2.6	68	54	1.3
2501-3000	10	10	1.0	43	7	6.1	53	17	3.1
3001-3500	0	5		23	5	4.6	23	10	2.3

\* S.M.C. = Santa María Cauqué, Guatemala; B. = Baltimore, USA.<sup>46</sup>

\*\* S.M.C./B ratio.

## V. RELATIONSHIP OF LOW BIRTH WEIGHT WITH PHYSICAL GROWTH

The Cauqué Study demonstrated a marked weight and height deficit of the Indian population with respect to accepted standards.<sup>1-3</sup> Other authors have described similar deficiencies.<sup>7, 30, 31</sup> The Cauqué Study also revealed that physical growth deficiencies correlated with the fetal growth.<sup>1-3</sup> Birth weight and gestational age, or both variables combined, showed a good correlation with physical growth of the lactating and preschool child (body weight, height and head circumference). Children with low birth weight exhibited a clear tendency to remain in the lower weight tracks (Figure 1) while those with better birth weight occupied the upper growth tracks.

Correlation with gestational age also was high, but only two populations were noted separated by the limit of 36-37 gestational weeks (Figure 2).

As was to be expected, with regards to fetal maturity, the at-term infants with a birth weight of more than 3,000 g grew better than any other group; the pre-term infants weighing less than 2,001 g grew the worst (Figure 3). However, the pre-term group of children with a birth weight greater than 2,000 g grew as well as the term children.<sup>1</sup>

The relation between birth weight and physical growth has been explored by other authors through retrospective and prospective analyses, who found a positive correlation between both.<sup>32, 33</sup> The few prospective investigations carried out in industrialized countries showed an abnormal growth on the part of pre-term and

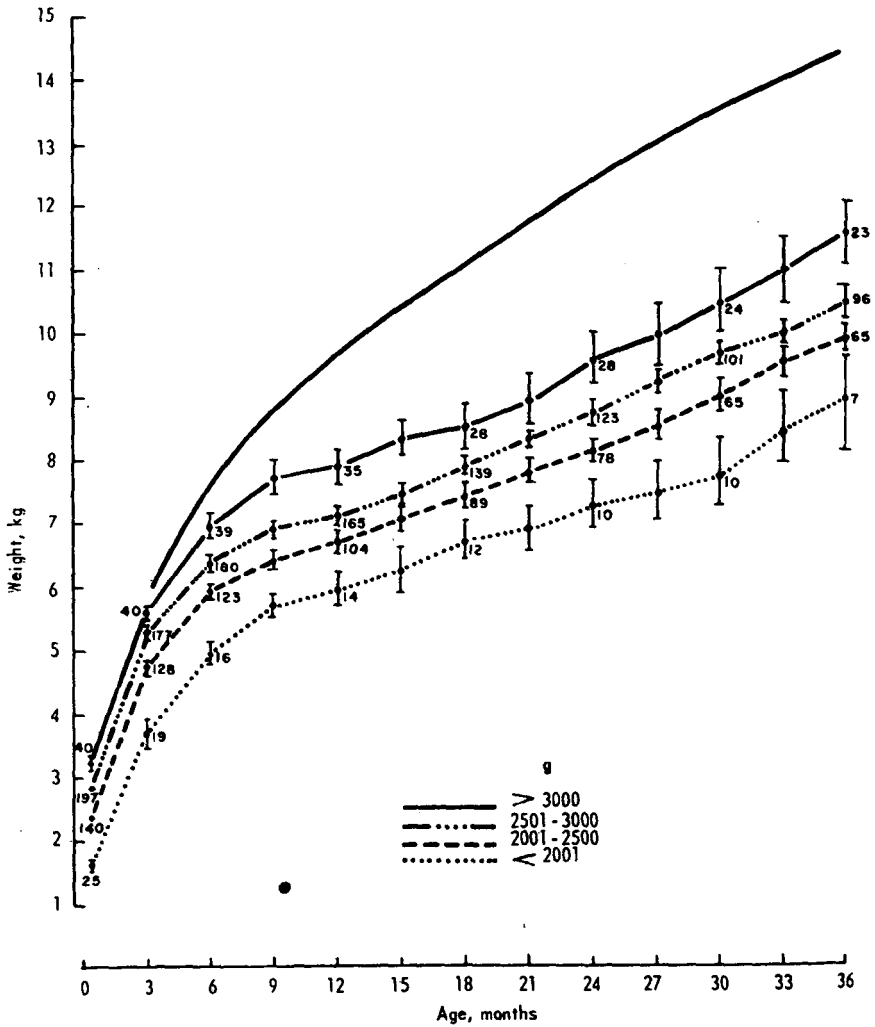


Fig. 1. Weight curves (average  $\pm$  2 E. E.) of four cohorts of children defined by birth weight in comparison with the mean of the Iowa standard curve.<sup>4,7</sup> Prospective study, Santa María Cauqué, Guatemala, 1964-1972. Figures in curves are number of children measured.<sup>2</sup>

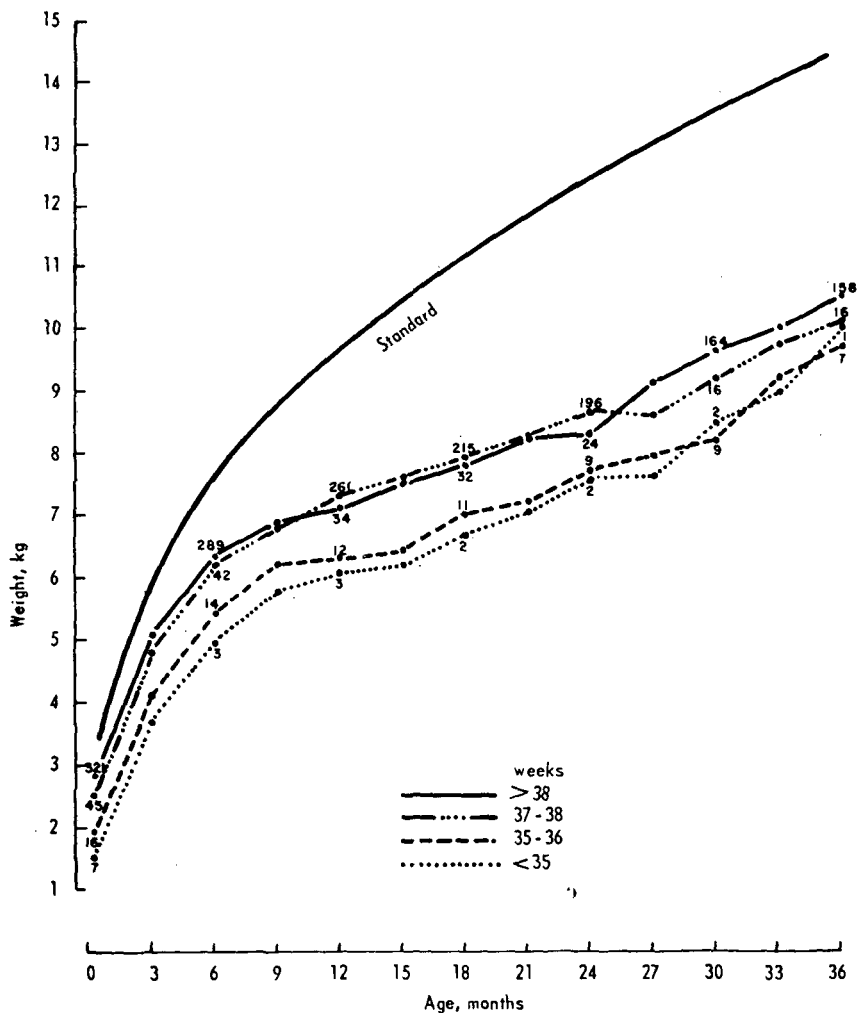


Fig. 2 Average weight curves of four cohorts of children defined by gestational age, in comparison with the mean of the Iowa standard curve. Prospective study, Santa María Cauqué, Guatemala, 1964-1972. Figures in curves are number of children measured.<sup>2</sup>

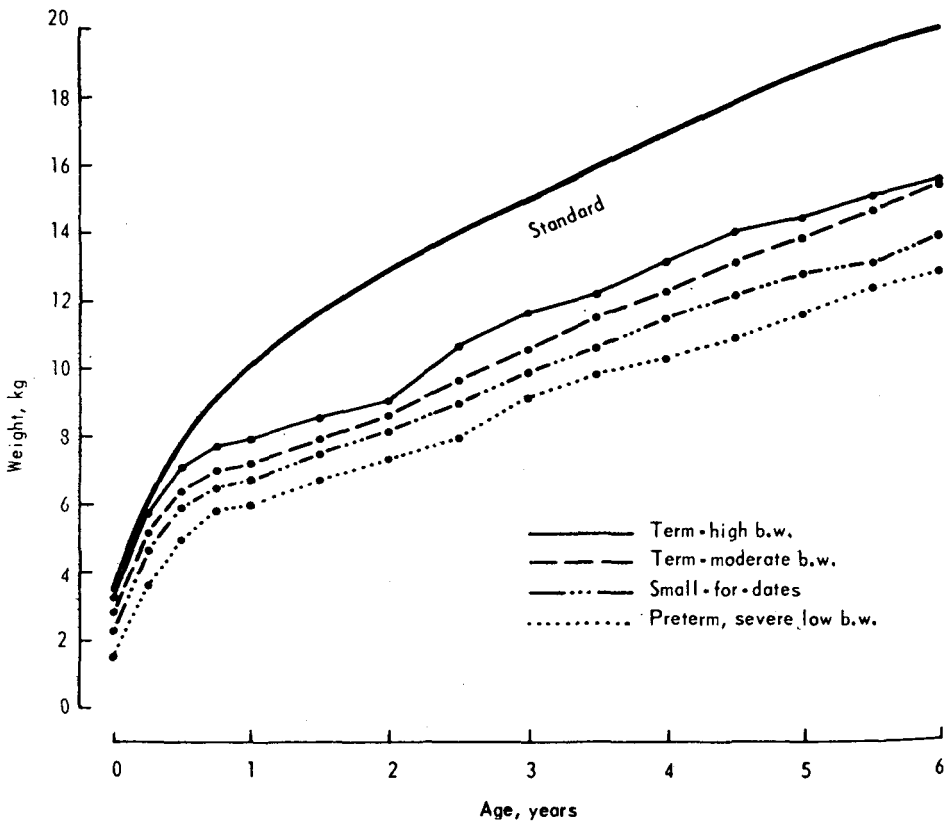


Fig. 3 Average weight curves of four cohorts of children defined by fetal maturity at birth, in comparison with the mean of the Iowa standard curve. Prospective study, Santa María Cauqué, Guatemala, 1964-1972.<sup>1</sup>

small-for-gestational age infants,<sup>34, 35</sup> despite the fact that the environment where these children developed was more favorable than is to be expected in developing countries, particularly in rural areas.

There are no similar data to those of the Cauqué Study for other developing populations, but a follow-up of Nigerian and Gambian infants showed a deficient weight gain in those with low birth weight.<sup>36, 37</sup>

The correlations between fetal growth and postnatal growth do not imply that the total variability depends mainly from intrauterine growth. Nevertheless, in view of the fact that the observed differences between cohorts defined by birth characteristics are established at an early age (usually in the first months of life), the influence of antenatal events and factors immediately associated with it acquire great importance for understanding the child's growth.

The relationship between birth weight and physical growth is of interest, because neurologic sequelae, suboptimal intelligence and low survival are problems frequently associated to deficient fetal growth and development.<sup>38-42</sup>

## VI. OTHER SEQUELAE OF LOW BIRTH WEIGHT

Immediate and late morbidity and sequelae that may result in permanent handicaps are counted among the serious consequences of low birth weight. In pre-term neonates, mortality is fundamentally due to physiologic immaturity, which generates alterations in breathing, in metabolism and in neurological function, as well as in resistance to infections.

Small-for-gestational age infants generally suffer from hypoglycemia and frequently exhibit a similar pathology to that of the pre-term neonate. A chronic deficiency in the quantity and function of the T immunocyte has been described in these infants<sup>39</sup> which could explain their greater susceptibility to infection during infancy and preschool age, as the Cauqué Study has demonstrated.<sup>1-3, 9, 27</sup>

It has been described that low birth weight induces sequelae demonstrable at short and long term intervals, which constitute an important cause of defects and disability.<sup>40-42</sup> Among these are congenital malformations, early infantile malnutrition, infections, sudden death in infancy, alterations of the central nervous system, mental retardation and behavioral disorders.<sup>42</sup>

## VII. CHANGES IN FETAL GROWTH AND IN NEONATAL MORTALITY

There is great expectation in learning results obtained from the holistic approach in public health to improve problems such as low birth weight. This approach appears to give excellent results judging by changes recently registered in Cuba and Costa Rica.

In 1920, infant mortality in Costa Rica was around 250 per 1,000 livebirths<sup>5</sup> (Table 7). At that time measures to improve the quality of life were beginning to

TABLE 7  
INFANT MORTALITY PER 1,000 LIVEBIRTHS IN COSTA RICA

Year	<29 days	29 days - 11 months	Infants
1920			250.0
1965	27.2	48.9	76.0
1967	24.3	38.0	62.3
1969	25.4	41.7	67.1
1970	25.2	36.3	61.5
1971	28.7	27.8	56.4
1972	22.8	31.7	54.4
1973	20.8	24.0	44.8
1974	17.7	19.8	37.6
1975	17.7	19.3	37.1

receive particular attention and the result was a progressive increase in the economic income, education and quality of the environment. In the 1950 and 1960 decades infant mortality became stable around figures of 80 per 1,000. The increment in magnitude and coverage of environmental sanitation, nutrition, and medical care programs, as of 1963 ran parallel with a slow descent in infant mortality which then suffered an even more markedly decrease after 1970, coinciding with the strengthening of maternal and child health, sanitation and nutrition programs.

At that time the Rural Health Program (RHP) was implemented taking advantage of the infrastructure created for the control and prevention of malaria in the past decades. The development of the RHP was escalated since 1972, and its goal for 1978 was to cover 600,000 persons of the rural population dispersed in localities of less than 500 inhabitants. This segment represents approximately 30% of the nation's population. At present (1975) a 70% of the dispersed rural population is being covered by nurse auxiliaries and health assistants who are displaced from the Health and Post Centers by jeep, motorcycle, horse, boat or foot.<sup>43</sup> Their functions are to carry out census; to vaccinate (tuberculosis, measles, poliomyelitis, smallpox, diphtheria, whooping cough and tetanus) to treat parasitosis (malaria and intestinal parasites), to promote maternal and child health, to promote family planning and nutrition; to treat and refer sick persons; to collaborate in environmental sanitation programs; to give education in hygiene and nutrition, and to participate in community organization efforts.

Data in Table 7 reflect a marked decline in infant mortality as of 1970 when an increase in the level of life, health and development programs was recorded. The change also reflects in part a decrease in neonatal deaths, notorious after 1971 as a result of improvements achieved in the quality of the matroenvironment. Table 8 summarizes the fetal growth situation in a 10-year period at the Instituto Materno-Infantil Carit. Already in 1965 the average birth weight was relatively good and the registered frequency of low birth weight was only 11%. The situation was maintained rather stable up to 1973 when a fall in the frequency of low birth-weight babies was registered reaching a 9.4% value.

The reasons that seem to explain the decrease in neonatal and postneonatal mortality and in incidence of low birth-weight babies at that date are: a better attention of pregnant women and substantial improvement in family planning. It is quite probable that nutritional changes of secular type which improved the height of the population in a notorious form in the last years<sup>5</sup> also affected the incidence of low birth-weight neonates. These factors are reflected in a decrease in fetal and maternal mortality observed in previous years (Table 9) and in a decrease in mean parity, which, as illustrated in Tables 7 and 8, were parallel to the reduction in birth rates.

## VII. CONTROL AND PREVENTION OF LOW BIRTH WEIGHT

Prevention of low birth weight cannot be achieved through unilateral actions oriented, for example, at control of maternal morbidity or towards the improvement of calories consumption during gestation. The diversity of etiologic factors that intervene, usually in a simultaneous way, in the causality of low birth weight, is sufficient reason for planners of health actions to apply the integral (holistic) approach to its prevention. Table 10 succinctly summarizes different actions that must be implemented within a holistic approach for the prevention of low birth weight.<sup>42</sup>

Improvements in health and hygiene during childhood are fundamental, particularly in societies where the intergenerational effect, of low maternal stature must be reduced, as this reflects a past of malnutrition.<sup>1</sup>

The practice of optimal reproductive patterns is crucial to diminish the incidence of low birth weight due to premature conception. Measures of this type appear to have had a notorious effect on fetal growth in countries that achieved a marked decrease in mortality in the course of a few years, such as China.<sup>44</sup> Antenatal care is another important factor for control and prevention of low birth weight of neonates given the high frequency of abnormalities in "high-risk" pregnant women.<sup>42, 44, 45</sup>

Finally, control and care of the child since early life is fundamental for diagnosis and treatment of present defects and for control and prevention of their sequelae.<sup>42, 45</sup>

TABLE 8

**ANTHROPOMETRY OF THE NEWBORN AND PARITY, INSTITUTO MATERNO-INFANTIL CARIT,  
COSTA RICA, 1965-1974**

	1965	1971	1972	1973	1974
Number of cases	409	506	588	551	551
Average weight $\pm$ D. E., g	3,106 $\pm$ 516	3,090 $\pm$ 499	3,089 $\pm$ 489	3,071 $\pm$ 471	3,109 $\pm$ 455
Average height $\pm$ D. E., cm	49.7 $\pm$ 2.6	50.9 $\pm$ 3.0	50.7 $\pm$ 3.6	50.2 $\pm$ 3.2	50.8 $\pm$ 2.7
% with $< 2,501$ g*	11.25	11.07	11.73	9.44	9.21
Average parity	3.9	3.7	3.4	3.0	3.0

\* No data for gestational age were obtained.

**TABLE 9**  
**BIRTH RATE AND FETAL AND MATERNAL MORTALITY,**  
**COSTA RICA, 1959-1975**

Year	Births per 1,000 population	Mortality per 1,000 live births	
		Maternal	Fetal
1959	48	1.26	20.9
1969	34	1.33	15.2
1973	29	0.93	12.0
1974	30	0.50	12.1
1975	29	*	*

\* Pending calculation.

**TABLE 10**  
**PREVENTION OF LOW BIRTH WEIGHT AND ITS SEQUELAE**

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1. *Promotion of health in childhood and adolescence*

- Achievement of good nutrition and hygiene
- Prevention of infectious diseases
- Health education on reproduction
- Promotion of good mental health

2. *Practice of the optimal reproductive pattern*

- Promotion of conception at optimal ages
- Increment of interval between pregnancies
- Prevention of undesired pregnancies

3. *Antenatal care*

- Treatment and prevention of infectious diseases
- Promotion of good nutrition and hygiene
- Education on drugs and stressing agents
- Identification and control of high-risk factors
- Education on perinatal events

4. *Care of neonate and child*

- Control of labor and parturition
  - Perinatal and neonatal care
  - Diagnosis and control of sequelae
  - Child care
  - Strengthening of infrastructure and recording systems
-

## IX. COMMENT

It is estimated that around 20 million children are born with low birth weight in the world every year; approximately a million and a half of these correspond to Latin America. Low birth weight is the main cause of perinatal mortality and of morbidity and long-term sequelae. Consequently, the control and prevention of low birth weight must constitute one of the higher priorities for national health and development planning programs, particularly in nations that still have high infant mortality rates.

The effects of low birth weight detectable in the field are a high infant mortality (particularly neonatal) and a deficit in physical growth of infants and preschool children.

Studies in a community of the Guatemalan highlands demonstrated that if birth weight is at least 2,750 grams and the child is breast-fed during the first months of life, neonatal survival approaches 100%. The high neonatal mortality observed in underdeveloped areas is therefore due more to the greater number of low birth-weight neonates, than to environmental deficiencies. In effect, neonatal mortality figures observed in the rural community in question, adjusted for weight at birth, were not different from those of an industrial population of a much higher socioeconomic development. Such observation questions the need for creating special resources for the care of premature and fetally malnourished infants in developing countries, in excess of true demands, while it favors the recommendation of measures of preventive nature.

Experience registered in other countries suggests that the holistic approach is the best possible solution for the low birth-weight problem. This approach comprises actions of different nature leading to improve the nutritional status and health of the child and of the future mother, to improve the maternal environment during gestation, and to favor those circumstances which permit an optimal care of the pregnant and lactating mother and of the neonate and preschool child, for the purpose of guaranteeing a corrective and preventive action of defects and sequelae associated to low birth weight. Such appears to be the reason to explain a achievements observed in Costa Rica and Cuba, where health programs have received priority attention. This position is contrary to the recommendation of isolated measures or interventions whether these are maternal and child health programs or of food supplementation of pregnant mothers, or of any other kind.

A more in-depth analysis of existing information in developing countries is required in regard to benefits derived from different actions and changes in fetal growth. It is also necessary that holistic health and community development plans be structured, comprising actions and recommendations necessary to promote optimal fetal development.

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## RESUMEN

### IMPLICACIONES DE BAJO PESO AL NACER PARA LA SALUD PUBLICA

El presente estudio interpreta la significación de las características antropométricas del recién nacido de una aldea indígena típica del altiplano de Guatemala y de la población general de Costa Rica. Se ilustra la correlación que existe entre las deficiencias del crecimiento fetal y la mortalidad infantil y el retardo del crecimiento físico. Se discute la significación del retardo del crecimiento fetal en el desarrollo de anomalías y defectos demostrables a corto y a largo plazo.

La información existente indica una alta incidencia de niños con alteraciones de crecimiento y desarrollo fetal en Latinoamérica. Esta circunstancia parece ser la causa principal de la alta mortalidad infantil y del retardo en el desarrollo de muchas poblaciones del Subcontinente.

Algunos países han logrado mejoras substanciales en las condiciones que promueven un adecuado crecimiento fetal mediante la implementación de programas en forma integral (holística). Se proponen las áreas de acción en salud necesarias para lograr un desarrollo fetal adecuado en nuestros países.

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**MATERNAL NUTRITION PROGRAMS:  
A CRITICAL ANALYSIS\***

*Giorgio Solimano\*\* and Janina R. Galler\*\*\**

**Institute of Human Nutrition, Columbia University, College  
of Physicians & Surgeons, New York, N.Y.**

**Department of Child Psychiatry and Child Development,  
Boston University, and Department of Nutrition and Food Sciences,  
Massachusetts Institute of Technology, Cambridge, Mass.**

**I. INTRODUCTION**

The fact that an adequate diet has positive effects on the pregnant woman and her progeny is a generally accepted fact. This knowledge is in great part responsible for the establishment of programs oriented to improve the nutritional status of the pregnant woman.

The first evidence of the diet effects on reproduction had its origin in the 1930 decade, when studies in animals carried out by Hale,<sup>1</sup> and in humans by McCance *et al.*<sup>2</sup> and by Orr,<sup>3</sup> suggested that a deficient diet was associated with a greater incidence of fetal abnormalities and low birth weight.

The Second World War supplied the natural environment to prove these observations in a national context, through selective supplementary programs for pregnant

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\*\* Associate Professor, Institute of Human Nutrition, Columbia University, College of Physicians & Surgeons, New York, N.Y.

\*\*\* Member of the Department of Child Psychiatry and Child Development, Boston University, and of the Department of Nutrition and Food Sciences, Massachusetts Institute of Technology (MIT), Cambridge, Mass.

women and children. In England, between 1940 and 1945 it was found that improvement of the diet was related with a significant reduction in the rate of stillborn infants. Since pregnant women did not count with adequate medical attention during this period, Thomson<sup>4</sup> later suggested that reduction in the mortality rates was primarily a consequence of a better nutrition during pregnancy, under extraordinarily deficient social and health conditions.

In a similar way, "natural food experiments" carried out in Oslo during the II World War also supported a possible relation between supplementation during pregnancy and the decline in the prematurity and mortality rates.<sup>5</sup>

Ebbs, Tisdall and Scott<sup>6</sup> in Toronto, provided supplementation to 90 women of low socioeconomic level, comparing them with 120 women of the same condition, not supplemented, and with 170 women of medium socioeconomic level. Even though weight at birth was similar in the three groups, the low socioeconomic women exempt of supplementation, exhibited a greater incidence of perinatal complications.

Balfour<sup>7</sup> on his part, evaluated the effects of an extensive supplementation program which included 11,618 women of low socioeconomic level, and his results supported those of previous studies. A lower fetal and neonatal mortality rate was observed in children whose mothers had received the supplemented diet.

Research carried out after World War II can be classified in three categories:

1. Controlled experiences in pregnant women carried out in the United States of America, Canada and Great Britain.
2. Transcultural studies in countries where malnutrition is prevalent.
3. Studies in animals.

Kasius *et al.*<sup>8</sup> provided vitamins, proteins and vitamins, and only proteins, to three groups of women in Philadelphia, without observing differences between birth weight, height and thoracic perimeter of children born from supplemented women with respect to those of a control group. Goldtich<sup>9</sup> in San Francisco, California, was also unable to demonstrate effects resulting from protein supplementation during pregnancy on the birth weight of children delivered by women of medium and low socioeconomic level.

Certain number of studies, however, back the favorable effects of supplementation, including those of Higgins,<sup>10</sup> Harrell, Woodyard and Gates<sup>11</sup> and Kasius *et al.*<sup>8</sup> For example, Higgins found a reduction in the incidence of prematurity in women of low socioeconomic level who received supplementation, even though the higher birth weight of the child was not considered related to supplementation. On their part, Harrell and his group informed of higher IQ's in the children of black women to whom supplementation had been provided. Kasius and co-workers also observed a decline

in prematurity and toxemia in supplemented women, but without proving any effect on the physiological conditions of their children.

In general, these last two studies are difficult to interpret and do not sustain the evidence of a clear impact of supplementation. Birch and Gussow<sup>12</sup> have formulated a series of methodologic considerations which could be the responsible factors of these findings.

Among them, the impossibility of establishing the relative effects of factors such as maternal diet, the mother's health and the product of pregnancy should be mentioned. Furthermore, the probability exists that the studies in question did not include those women of low socioeconomic level subjected to the risk of severe nutritional deficiencies, both before and during pregnancy.

The transcultural-type of research has permitted to study populations affected by chronic malnutrition for various generations. These studies have shown a positive relation between supplementation and the pregnancy product, particularly when improvement of the diet reaches the more at-risk groups. Studies carried out by the Division of Human Development of INCAP in four rural villages of Guatemala,<sup>13-15</sup> revealed that birth weight was significantly higher in the case of those children whose mothers received greater supplementation during pregnancy, thus suggesting that the effect of the calories would be the most important. In addition, recent results show advantages in the development of these children as a consequence of the higher intake of the mother.<sup>15</sup> Chávez, Martínez and Yashine<sup>16</sup> have supplemented the diet of women and children in a village of Mexico. Their results demonstrate an improvement in the health of both groups, a more positive attitude of the parents towards the children that have received supplementation, and a more independent behavior of the children themselves. In view of the fact that the supplemented group has had greater contact with the investigators and no basic nutritional information is available for the experimental nor for the control groups, it cannot be definitively clarified whether the positive effects observed can be attributed exclusively to dietary factors. Both studies, however, support a positive relation between food intake during pregnancy and the product, and the newborn and the breast-fed child when supplementation is provided to severely deficient populations.

Recently, some transcultural studies have been aimed at the relationship between low socioeconomic level and inadequate conception products. Since malnutrition is highly prevalent in these sectors, it may not be useful to try to separate the nutritional effects from those resulting from social stratification.

The central objective of the research carried out in animals has been to study the effect, on the product, of dietary restriction during pregnancy and lactation. Winick<sup>17</sup> has demonstrated that nutritional restriction during pregnancy is associated with a decrease of 15% of the cerebral cells at birth, and that reductions of up to 60% are observed when the animals are subjected to malnutrition *in utero* and during lactation.

Chow and Lee<sup>18</sup> and Chow *et al.*<sup>19</sup> also demonstrated growth arrest and abnormalities in the protein and carbohydrate metabolism as a result of dietary restrictions during only pregnancy, and in the pregnancy and lactation periods, with more markedly effects in the latter case.

These studies together with those of Smart and Dobbing,<sup>20</sup> Barnes *et al.*<sup>21</sup>, Frankova and Barnes<sup>22</sup> and others, indicate that in the rat, the nutritional status during pregnancy is associated to anatomic and behavioral changes of the product.

However, the intergenerational malnutrition models in animals are more comparable to human groups who have suffered from malnutrition for various generations than the ungenerational models. These studies have shown that malnutrition present in more than one generation is associated to more serious effects, and that their correction requires more prolonged periods of dietary supplementation.<sup>23</sup>

Galler and Rosenthal<sup>24</sup> have studied a rat colony with intergenerational malnutrition supplemented from birth, by crossing them with well-nourished female animals. These rats rapidly increased their weight and at the moment of weaning did not differ from the well-nourished animals in weight or in body length. Nevertheless, the differences in behavior persisted, observing that the intergenerational malnourished rats were fed less frequently by the female rats than the well-nourished animals. When the females with intergenerational malnutrition were supplemented before pregnancy, the product weight at weaning was higher than that of those who received an adequate diet only as of birth; this indicates that the earlier the supplementation is instituted, the greater the favorable effects on the pregnancy product.<sup>25</sup> In summary, the studies in animals on the consequences of malnutrition in pregnancy and in their products have not always rendered the type of evidence expected from them, due to problems in the methodology and design employed.<sup>26, 27</sup>

In spite of it, these data in general suggest significant effects when the pregnant females are exposed to malnutrition. On the other hand, even though these results cannot be extrapolated to the conditions existing in the human being, together with the studies previously referred to, they permit to point out an important number of relations which require more at depth research.

## II. NUTRITION PROGRAMS

Programs leading to improve the nutritional status of the pregnant woman are becoming increasingly more common in the developing countries, for the purpose of modifying the high infant mortality and malnutrition rates that exist in the majority of them. Supplementary feeding and nutrition education constitute the interventions more frequently used. Although the importance of these programs cannot be overlooked, they are subject to numerous limitations in their design and implementation which need to be examined and corrected if the purpose is to improve them in the future.<sup>28</sup> A direct consequence of these limitations has been the inability to seriously evaluate the nutritional impact of such programs.

As happens with educational activities, supplementation has also been almost totally implemented through the health services that in addition provide prenatal care. But it has been proved that, unfortunately, important groups of women do not benefit from these services, a fact which limits their scope in a considerable degree. The experiences of Chile with the National Leche Program is illustrative in this respect (Tables 1 and 2). Having an extensive net of health services, in 1972 only 54% of all the pregnant mothers could be supplemented. On the other hand, even though through studies carried out in the rural areas it was proved that 78% of the program beneficiaries regularly received their milk quota, certain marginal and rural sector groups were excluded not only from dietary supplementation but also from all health care measures.<sup>28</sup> As already commented in this paper, if the effects of supplementation can only be detected in those populations who are more at risk of malnutrition and poverty, it is quite possible that in the case of Chile, the Leche Program did not cover an important group of pregnant women who really were in need of said supplementation.

**TABLE 1**  
**COVERAGE OF THE NATIONAL LECHE PROGRAM,**  
**CHILE 1972**

Beneficiary groups	Population*	Coverage, %	
		Programmed	Carried out
Breast-fed infants (0-23 months)	523,000	85	57
Preschool children (2-5 years)	981,000	70	59
School children	2,027,000	80	90
Pregnant women	437,000	70	54

\* These figures were obtained from the Annual Report of the United Nations, 1972. The age structure is based on the percentages utilized by the Public Health Department of the University of Chile.

Taken from Hakim and Sofimano.<sup>28</sup>

In addition, the effectiveness of these nutrition activities depend in a great measure of access means to the health services. Firstly, in the majority of the

developing countries, the rural and marginal urban communities do not have or have only a limited access to such services. Secondly, the possibility of absence of perinatal complications is closely related with the good health conditions of the mother during pregnancy, so that the lack of medical attention itself and, *per se*, determines negative consequences for these at high-risk communities.

**TABLE 2**  
**FAMILY CONDITION AND PARTICIPATION IN**  
**THE LECHE PROGRAM, CHILE, 1972**

Socioeconomic level of the family	Percentage of families participating in the Program
Medium and high income	65
Medium-low income	78
Low income	82

*Participation according to number of beneficiaries*

Number of beneficiaries in the family	Percentage of families participating in the Program
1	69
2	72
3	80
4 or more	88

Taken from Hakim and Solimano.<sup>28</sup>

Another concept that should be taken into consideration and that obviously makes the evaluation of these programs a difficult task, is that maternal nutrition constitutes one of the many independent variables that affect the fetal viability and survival. More still, fetal viability may not have any relation with the nutritional measures if other necessary conditions are not fulfilled. The observed changes in the infant mortality rates in Chile during the last 40 years, when food supplementation has been provided to women and children at risk of malnutrition are illustrative in this sense.<sup>29</sup> Even though this rate has significantly diminished (Table 3), the reduction has been proportionally greater in the medium and high-income sectors who did not receive supplementation through public programs (Tables 4 and 5).

**TABLE 3**  
**INFANT MORTALITY RATES (PER 1,000 BORN ALIVE),**  
**CHILE, 1927-1973**

Year	Rate	Year	Rate
1927	226	1964	105.3
1930	234	1965	99.8
1935	251	1966	101.9
1940	192	1967	98.4
1945	164.5	1968	86.6
1950	136.2	1969	78.7
1955	119.2	1970	79.3
1960	126.2	1971	70.5
1961	114.1	1972	71.1
1962	113.6	1973	65.3
1963	105.5		

Taken from Solimano and Hakim.<sup>29</sup>

**TABLE 4**  
**INFANT MORTALITY IN PROVINCES WITH HIGH, MEDIUM**  
**AND LOW INCOME, CHILE, 1940-1947**

	Infant mortality rates (per 1,000 born alive)		Per cent change
	1940	1947	
Provinces with high income	179	144	20%o
Provinces with medium income	199	163	18%o
Provinces with low income	205	184	10%o
National average	197	167	15%o

Taken from Solimano and Hakim.<sup>29</sup>

**TABLE 5**  
**INFANT MORTALITY IN PROVINCES WITH MEDIUM AND LOW INCOME,**  
**CHILE, 1958-1959 AND 1968-1969**

	Infant mortality rates (per 1,000 born alive)		Per cent change
	• 1958-1959	1968-1969	
Provinces with high income	98	59	40%o
Provinces with medium income	130	96	26%o
Provinces with low income	136	105	23%o
National average	116	81	30%o

Taken from Solimano and Hakim.<sup>29</sup>

In certain countries like Cuba, China, and others, programs oriented to improve the nutrition of the pregnant woman, form part of the integral health care that the Government provides to all citizens. As a result of these integrated programs, significant reductions in perinatal mortality (see Table 6) have been observed in Cuba<sup>30</sup> in spite of the fact that the percentage of children born alive with a weight of 2,500 grams or less has somewhat increased during the 1968-1974 period (Table 7).

**TABLE 6**  
**PERINATAL MORTALITY, CUBA, 1968-1974**

Years	Fetal mortality*	Mortality < 7 days	Perinatal mortality**
1968	17.2	16.8	33.4
1969	16.3	17.4	33.2
1970	15.3	17.2	32.1
1971	14.8	17.1	37.4
1972	13.5	15.7	28.8
1973	13.1	15.9	28.7
1974	12.9	15.6	28.2

\* Of 7 months and more of gestation according to fetal death certificate.

\*\* The denominator includes born alive and fetal deaths.

Taken from Riverón.<sup>30</sup>

The integral health care in Cuba is possible thanks to measures such as: 1) distribution of the service units and human resources throughout the country, including the rural areas. This measure allowed provision of institutional attention to 96.6% of all parturitions occurring in 1974. 2) Equality of access to the health services and gratuitous attention as the State's responsibility. In this manner, an average of 9.0 prenatal consultations have been achieved, and 5.5 consultations per child during his first year of life. Maternal mortality decreased from 11.8 in 1972 to 5.6 per 10,000 born alive in 1974.<sup>30</sup>

**TABLE 7**  
**MORTALITY RATES AND PREMATURITY INDEX,**  
**CUBA, 1968-1974**

Years	Fetal mortality*	Neonatal mortality	Percentage of born alive with 2,500 g or more**
1968	17.2	23.1	8.1
1969	16.3	25.7	8.5
1970	15.3	22.8	10.3
1971	14.8	22.4	9.9
1972	13.5	19.2	9.8
1973	13.1	19.4	10.4
1974	12.9	18.6	10.7

\* Of 7 months and more of gestation according to fetal death certificate.

\*\* Born alive in institutions.

Taken from Riverón.<sup>30</sup>

The integral care program of women carried out at the levels of primary attention unit, polyclinic or rural hospital, include activities destined to prevent and minimize the risk of the pregnant woman and of the fetus. Among these, early captation, nutrition education and provision of income to maternal homes as of the 8th month of pregnancy for those women who live in very isolated zones or who have been catalogued as at high risk, have first priority.

Another limiting factor of supplementation is that foods are generally not exclusively consumed by the pregnant woman, but are distributed among the different members of the family. Although the available evidence is limited, this fact must be taken into account when designing interventions of this type.<sup>31, 32</sup>

An assumption accepted up to this moment is that the poor do not utilize their food budget in a nutritionally efficient way and, therefore, their diet would significantly improve as a result of nutrition education. However, recent studies have demonstrated that with the existing income levels, only marginal effects are to be expected as the result of changes in the purchasing habits of these groups.<sup>33</sup>

Birch and Gussov<sup>12</sup> have expressed that "it is evident that even though differences in habits and beliefs are very important, poverty constitutes the fundamental factor, that joined to ignorance, maintains the low-income woman badly fed." The same authors cite the studies of Grant and Groom<sup>34</sup> who, in 1956, found a direct relationship between protein intake and economic level in black women of South Carolina.

During the last years new approaches have been and continue to be tested to improve the food supplementation programs. Based on the evidence that it is difficult to effectively supplement only one member of the family unit, the need of providing foods to all members of the at high-risk families with children and women in their reproductive age, is recognized. When these population groups do not have access to health services, especially in the rural sectors, foods are directly delivered to the beneficiaries.

In 1974 Panama initiated a program of this type in the Province of Veraguas whose impact is now being evaluated.<sup>35</sup> Nevertheless, it must be recognized that the health policy followed by this country since 1969 has placed special emphasis in the integration of the Health Services; the organization and participation of the community in all health activities; the priority of the rural sector, and the reallocation of human and material resources in accordance to the needs. The evolution of certain health indicators can be appreciated in Table 8.<sup>36</sup> Consequently, it is a rather difficult task to elucidate the specific effect of nutritional interventions, even at province level.

In spite of this, even countries that count with the best health services have not assessed at national level their maternal supplementation programs, through the use of indicators that could supply more sensible and direct information in regard to their effects. The weight increment during pregnancy, the incidence of small for gestational age newborns, and certain perinatal morbidity are extremely useful indicator if collected systematically and in a reliable way. The follow-up of representative population samples constitutes a mechanism not difficult to implement if established opportunely.

In synthesis, we believe that the available experience supports the increasing need for integrating the nutrition programs with the health programs directed to the more vulnerable groups, that is, to women in the reproductive age and growing children. More still, protection of the mother and child binomial must go further than mere health care, by establishing social, legal and economic measures, especially for working women. The character of these measures will vary according to the political and institutional organization of each country, but undoubtedly, it is necessary to exchange experiences and obtain maximum benefit from them.

**TABLE 8**  
**HEALTH INDICATORS IN PANAMA**

Year	Mortality						Maternal***
	General*			Infantile**			
	Total	Urban	Rural	Total	Urban	Rural	
1969	7.0	5.7	8.2	39.9	30.2	47.0	1.4
1970	7.1	6.0	8.2	40.5	36.1	51.0	1.4
1971	6.7	—	—	37.6	34.0	41.0	1.1
1972	6.0	—	—	33.6	28.6	39.5	1.1
1973	5.8	5.0	8.2	33.3	22.8	45.7	1.0
1974	5.6	5.1	6.0	33.0	24.7	37.2	0.8
1975 (p)	5.2	4.8	5.6	29.2	24.2	37.4	0.9

(p) Preliminary figures.

\* Per 1,000 inhabitants.

\*\* Per 1,000 born alive.

\*\*\* Per 1,000 born alive.

— Figures not available.

Taken from Saied.<sup>36</sup>

Actual knowledge on the at-risk factors permits a better definition of populations who should benefit from nutritional interventions considering not only their biologic vulnerability, but also their social vulnerability. These elements must be taken into account when planning these programs. The participation of researchers in the different countries, and the integration of interdisciplinary teams, constitute a very useful mechanism if established in an adequate manner.

Finally, all nutritional intervention programs must include in their budget an allotment for applied evaluation and research work, the latter destined to study alternatives that permit maximizing the impact of such programs.<sup>37</sup>

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**ACTION PROGRAMS:  
A SKETCH OF THE STANDING APPROACHES IN MEXICO\***

*Héctor Bourges\*\**

**Instituto Nacional de la Nutrición de México**

**SUMMARY**

The subject of this Colloquium, *Prenatal and Perinatal Nutrition*, can not be separated from that of primary collective malnutrition, a phenomenon observed within incohesive societies, traditionally ravaged by exploitation, under- and unemployment, external or internal colonialism and, very especially, by ignorance. Nutrition and social development are mutually dependent so they must be promoted together; nutrition, however, is specifically the direct responsibility of nutritionists.

Among applied nutrition programs the most commonly used are those of *education and food supplementation*. When adequately planned and performed, education programs are more likely to succeed since they modify attitudes and ways of living. Food supplement programs, in contrast, are only symptomatic, tend to be self-perpetuating and to create dependence; in addition, they are expensive. Therefore, they are used for the correction of acute situations or as a measure of initial attack in critical regions. Both kinds of programs are not exclusive; thus, they may be combined.

The paper briefly describes some experiences of the National Institute of Nutrition (INN) in Mexico. An account is presented of how an educational program achieved an important decrease in preschool children malnutrition and mortality rates in an extremely poor community. A brief description is also made of a Basic Rural Health Program proposed in 1976 for the next six years including actions in five areas: a) nutrition, b) responsible paternity, c) hygiene, d) vaccination, and e) promotion of high nutritional efficiency products.

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\*\* Researcher and Chief of the Department of Physiology of Nutrition and Food Technology, Instituto Nacional de la Nutrición, México, D.F., México.

In the five previous presentations, profiles of the *fetal growth retardation* were outlined with precision. Although this phenomenon is not known as yet with the depth it merits, it is clearly frequent and extraordinarily transcendental in the Latin American countries. Its multifactorial character and the crucial role that the history of nutrition and maternal health play in its genesis, has been underlined. The existence of a chain of adverse factors that perpetuate malnutrition from one generation to another has also been pointed out. This starts —if the use of this term is acceptable— with malnutrition of the mother throughout her life, follows with pregnancy under inadequate nutritional conditions and with insufficient lactation, and reaches its critical moment at the weaning stage. Fatally, of this series of events emerge mothers even more deteriorated in their health and nutrition, on the one hand, and on the other, a decimated preschool population whose “survivors” are seriously affected in their growth and in their physical, intellectual and social development. Later on, as adults, these children will virtually “transmit” malnutrition to their descendants not only through biological mechanisms, but also through those of a cultural and social nature<sup>1</sup>. Thus, the “social malnutrition cycle” will be closed.

I deem it advisable to strictly present the approaches that have been proposed in Mexico and the pertinent antecedents, with the understanding that I do not pretend that any of them necessarily have validity in other countries.

For practical purposes, it is artificial to dissociate perinatal nutrition from nutrition through the rest of the life stages since, as mentioned previously, they are links of the same chain; in other words, one is dealing with a *global phenomenon*.

In its turn, nutrition is the product of a multitude of factors<sup>2</sup> that, in an effort to classify them, can be interpreted as a reflex or consequence of the degree of development of the society where they occur. Massive primary malnutrition is observed in societies with little cohesion, chronically subjected to external and internal colonialism, where exploitation, unemployment and underemployment are common, and where ignorance is prevalent.

Nutrition, therefore, is limited by the degree of social development but, in its turn, the possibilities of reaching a greater development depend, among other factors, on the degree of prevalent nutrition in a given human group. This mutual relation generates a vicious circle from which it is difficult to escape; discussions on whether this vicious circle must be broken by improving nutrition or by improving social development fall, as is to be expected, in another interminable circle.

Ideally, a thorough solution would require the parallel promotion of both elements: *nutrition* and *development*. The temporary dimension where this promotion must originate, however, is radically different in one case and the other, since promotion of development requires a much longer term. On the other hand, the latter task is considerably more complex and difficult: it requires modification of the attitude and behavior of the population and only by exception does it fall in the field of direct action of the common nutritionists who have to limit themselves to express

their opinion or recommend measures to the political sector. In contrast, it is the immediate responsibility of the nutritionist to act at short and long term on the nutrition factor, including in their actions and programs the greatest possible number of change elements for development.

In the case of malnutrition there is abundant biomedical essential information for planning the programs. However, this is not the case regarding adequate psychosocial data that, among other things, must include a detailed view at regional level, of the food habits, food production, local social problems, income levels, etc. This deficiency, which is not remedied with the simple transfer or extrapolation of data from other regions or countries, gives an aleatory character to many programs. Since the urgency to carry out resolute efforts whose initiation cannot await obtainance of the necessary data for an orthodox planning is indisputable, it seems justifiable and even desirable to initiate these programs based on a realistic generic sense, foreseeing the mechanisms which permit exploring the regional problem at the same time that this is attacked and which also allow modifying the plans already under way.

According to the experience of the National Nutrition Institute (INN) in Mexico, the nutritional panorama in the rural areas is so severe that application of simple measures that appear to be of no consequence on account of their obviousness, can represent real revolutions in the communal life. Probably this is also valid for the majority of the Latin American countries.

In the last decades, programs have been essayed throughout the World that, as Dr. Solimano pointed out, can be artificially classified in *educational* and of *supplementation*. In both cases results have been poor due to quite diverse causes: from the ineptitude or corruption of those who apply them, to the lack of sensitivity in their realization or in their deceitful foundations.

At the level of a theoretical analysis, it is evident that a well-planned educational program, with clear objectives and well carried out, changes the *way of life* and *acting* of the individuals and of the society. Since after all, primary malnutrition is an element of a special way of living, this type of programs have high probabilities of being effective.

On their part, the supplementation programs are based on biological unquestionable premises. It is quite easy to demonstrate, both in laboratory animals as well as in human beings, that the sustained intake of an adequate diet usually corrects the clinical picture of malnutrition and, according to circumstances, can also partially correct various of its sequelae. Undoubtedly, a supplement adequately administered for a sufficient period of time, is effective; for this reason, it is correct to carry out supplementation programs in acute situations (for example, emergencies caused by natural catastrophes such as earthquakes, floods, droughts, etc. or because of war effects), as an initial attack in zones affected by malnutrition where there is a clear danger for the lives of the people and as a general measure in crisis situations.

The disadvantage of the supplementation programs is that they do not attack the problem by root, but only their symptoms. Malnutrition is the last link of a chain of facts that will persist even though the nutrition problem is corrected.

As is to be expected in the case of any symptomatic measure, when for any reason these programs are suspended, malnutrition reappears again sometimes even with greater intensity than before because the population has lost, partially or totally, the biological, social and cultural adaptation mechanisms to the phenomena that generate malnutrition. Another disadvantage of the supplementation programs is their tendency to prolong indefinitely. This is serious if one considers their high cost, their scarce resolutive efficiency, and the fact that they foment dependency from a paternalist structure that castrates the elements of an at-depth solution.

The educational and supplementation programs are in no way mutually exclusive. They can be complemented in a combined execution or as different stages, but in any case education must have priority in attacking chronic malnutrition, since it is effective from root, requires less inversions and yields greater benefits for a longer period of time, thus resulting ideal in weak economies. Nevertheless, the educational programs require careful preparation and an intelligent selection of the messages, a great clearness in their objectives, and pragmatism and simplicity in their execution.

Several years ago, the INN of Mexico carried out a research study that, among other objectives, pretended to evaluate the effectiveness of education as a change agent in nutrition.<sup>3</sup> A small rural village of Southern Mexico was selected for this purpose, where material poverty was so severe that, at first sight, the economic factor appeared to be the main determinant of malnutrition. Under these conditions, positive results would only be seen if education is really an effective agent.

A nutritionist was installed in the community and her work was limited to instruct mothers on the correct way of nursing and feeding the infant and on basic hygiene. At no moment did the population receive food or money. Even though the program covered only those two aspects —breast feeding and hygiene— that are far from being the only ones involved in the global problem, in a few months a significant improvement in the nutrition of infants and preschool children was achieved, and the mortality rates in these age groups were dramatically reduced. The fundamental conclusion derived from this experience is that *ignorance*, the “way of life” in that region, *added a component of inefficiency to the already extreme poverty*, and that there existed resources that were not utilized sufficiently to achieve a minimum dietary level. Something essential was also confirmed: *quite frequently, marginated populations are avid for this type of help and they accept strange persons when these are honest and well-intentioned.*

Other important antecedents are the longitudinal studies on nutrition and human development that the INN has been carrying out during the last 7 years in Tezonteopán, Puebla.<sup>4-9</sup>

Essentially, the design of the program was based on the study of two groups of others and their respective children; one of the groups (control) was studied in its natural state and the other received an adequate diet. In the first of these groups mothers consumed their habitual diet, which is insufficient in quality and quantity, although none of them showed obvious signs of malnutrition.

It is pertinent to comment on this occasion only some of the findings in the lactation field. In general, all the mothers in the control group presented a marked hypogalactia,<sup>4</sup> especially as of the third month of lactation, a phenomenon which chronically kept deteriorating the nutrition of the child up to the weaning crisis. In other regions of the country transversal data have been obtained which permit to suspect that hypogalactia could be a general phenomenon in the poor-fed populations, whose effects would be prevented by an early and effective supplementary feeding that should have priority in the educational programs.

In 1973 the Mexican Government decided to carry out a nutrition education program in the rural area, which should be highly efficient given the limitation of material resources and availability of personnel. The INN judged pertinent to concentrate the program on the weaning problem, based on the antecedents described in previous paragraphs.

The *small child* was taken as the *central beneficiary* of the program, not only because it represents the most vulnerable group to malnutrition and where the higher morbidity and mortality rates are observed, but also because it is at this age where action is more timely and, in absolute terms, requires less efforts.

The ideal *educational message* for this program should be very *simple*—both for the receptor as for the transmitter—in order to guarantee its assimilation. It should also have immediate practical application.

Transmission of the message should be *intense and repetitive* utilizing various parallel ways. Particular emphasis was placed in avoiding distraction from the central objective by introducing messages of other nature, a very frequent temptation in this type of programs.

Lastly, the “messenger” should be *reliable*, have *prestige* in the community and remain in it for a *long period of time*.

On the basis of the preceding considerations, the following methodology was established:

1. The “messengers” would be *voluntary* mothers of the rural area identified by their tendency to participate in communal life and by their local prestige. Preferably, they would be mothers with a lactating child, who would receive theoretical and practical training during 1 or 2 weeks and would then return to their place of origin to practice and diffuse the acquired knowledge. In principle, the fact that they

were mothers of the locality assured their interest and permanency. More than 50,000 of these "B Promoters" were prepared in the first stage.

In their turn, B Promoters had been trained by various generations of "A Promoters", women with minimal primary studies who, in turn, were instructed by personnel from the Institute thus achieving considerable and rapid multiplication of the number of persons who knew the message.

## 2. The message covered three basic concepts:

- a) To introduce solid food to the infant's diet around the third month of lactation without reducing breast feeding.
- b) To utilize for this purpose the available home resources, which varied according to the case, and that had been previously identified as not being used.
- c) To prepare these foods hygienically and in such a way that they could be consumed by the child.

It should be pointed out that in the Mexican rural area many a time the existence of taboos on weaning are observed.<sup>10, 11</sup> For example, food such as beans, available in the majority of the homes, as well as eggs, milk and meats are considered by the people as inconvenient and even dangerous for the child. This is why they prefer to give them starchy foods such as "atole" and others derived from cereals or the bean "broth", which is the water where this legume is cooked and which contains only from 1 to 1.5 g of protein per 100 ml. Even the animal products cited are periodically available in the poor homes in amounts that would be sufficient to benefit the child. In regard to the propitious time for introduction of solids, people believe that this should take place not before the infants are 7 or 8 months old. On the other hand, the prevalent culinary techniques in the rural area are very poor, since simple preparation such as purées, boiled eggs, grated meat, etc. are unknown and, in general, the hygiene in the preparation of foods is inadequate. The poor culinary technique is, then, another obstacle for the use of appropriate foods in the weaning stage and a mechanism of contamination of the infant diet.

The design of the program message here described and the pragmatic content given to it, reinforced with demonstrations and practical sessions was based on the already mentioned experience. There is no space to detail it more at depth. Suffice is to state that in mid 1976 an evaluation of the results was made by selecting at random various communities and, in each of them, some mothers were interviewed without considering the fact of whether they had been subjected to the program's influence or not. Around 30% of them answered satisfactorily the questionnaires employed.

Early in 1976 the gearing of this type of nutrition education programs was started, transforming them into more ample communal development programs.

Among the proposals presented to the new Government that will take power on December 1st, the implementation of a *Basic Rural Health Program* is cited. This would function through the work of promoters such as those who intervened in the nutrition program. The Plan would cover 5 areas:

### **Nutrition**

The same general scheme of the educational program on weaning would be used with other aspects added to it, trying to cover in an integral manner the nutrition of the family. As the families of the marginated rural area base their meals on corn and beans, but ingest insufficient quantities of the latter, a greater and better consumption of this legume will be promoted for the purpose of achieving not only a better total protein ingestion, but also a better complementation with the corn proteins. In the same way, introduction to the habitual diet of a "third dish" which will vary according to the region and whose importance not only lies in enriching the diet but in making it more attractive and varied, will be promoted.

### **Responsible Paternity**

In the experience obtained by the INN, it must be pointed out that, often, the peasant women ignore the existence of control reproduction means, and that among them there exists an increasing desire of doing it, in the measure that some modernization traits penetrate the rural life. Thus, the alternatives would be presented and the population would be induced to benefit from the formal programs of responsible paternity.

### **Hygiene**

Special care would be given to the attitudes and behavior of the population, in contrast with the unbound habitual programs (for example, those related to the mere availability of drinking water and means of excreta disposal) that fail because of the persistence of old human attitudes.

### **Immunization and Basic Medicine**

The habitual vaccines would be administered to the infantile population, and first aid basic concepts and for preventing and treating common infections—gastro-intestinal and respiratory—which represent the gross of the pathology in these regions, would be divulged.

### **Promotion of Consumption of Products of High Nutritional Efficiency**

In the course of the last three years various products developed by the Food Technology Program of Social Interest of the INN have been placed in the market under the sponsorship of the National Food Program. Their purpose is to increase the availability of products that unite high nutritive value, low cost, and easiness of

conservation with the best possible sensorial acceptability.<sup>12-15</sup> Within the Plan in reference, the goal is to obtain the greater possible utilization of these products, clarifying the fact that they are complementary resources whether they are produced with a minimum of subsidies or without them.

I have briefly described the type of approaches and programs that in Mexico have been estimated as more reasonable in combating the more urgent and immediate problems in the nutrition and rural health fields. I must insist on the fact that, in their design, circumstances and very particular characteristics which are only ours, have been taken into account, and that they are not necessarily valid in other countries.

## RESUMEN

### PROGRAMAS DE ACCION:

#### ESBOZO DE LOS ENFOQUES VIGENTES EN MEXICO

El tema de este Coloquio, *Nutrición Prenatal y Perinatal*, no puede desligarse del de la desnutrición primaria colectiva, fenómeno que se observa en sociedades sin cohesión, víctimas crónicas de la explotación, del desempleo, del subempleo, del colonialismo externo o interno y, particularmente, de la ignorancia. La nutrición y el desarrollo social deben ser promovidos paralelamente ya que dependen el uno del otro, aunque sólo la nutrición cae dentro de la responsabilidad directa del nutriólogo.

Entre los programas de nutrición aplicada, los dos tipos más socorridos habitualmente son los *educativos* y los de *suplementación*. Los primeros, cuando son adecuados, tienen mayores posibilidades de éxito ya que modifican actitudes y formas de vida de la población de las que depende muy especialmente la nutrición. Los programas de suplementación, en cambio, corrigen solamente el síntoma (la desnutrición) y no el complejo conjunto de factores que lo causan, tienden a perpetuarse y a crear dependencia; además, tienen un elevado costo por lo que su mayor utilidad radica en la corrección de situaciones agudas o como ataque inicial en zonas críticas. Ambas clases de programas no son excluyentes y pueden combinarse.

El trabajo describe algunas experiencias del Instituto Nacional de la Nutrición (INN) en México. Se menciona un programa, exclusivamente educativo, que logró reducir las tasas de desnutrición y mortalidad preescolar en una población extremadamente pobre. Se describe en forma breve, asimismo, el Plan de Salud Rural Básica propuesto en 1976 para el período 1977-1982, que comprende acciones en cinco áreas: a) nutrición del preescolar, b) paternidad responsable, c) higiene, d) inmunización, y e) promoción del consumo de productos de alta eficiencia nutricia.

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## CONCLUSIONS AND RECOMMENDATIONS

On the basis of the presentations to this Colloquium on "Prenatal and Perinatal Nutrition" and on the discussion these originated between the speakers and distinguished members of the Auditorium, the following Conclusions and Recommendations were reached:

### CONCLUSIONS

1. In the Latin American countries, fetal growth retardation is the most frequently associated factor with infant morbi-mortality and retardation of postnatal growth.

2. Contrary to what is generally accepted, the analysis of fetal-maternal relations indicate that the fetus is not a parasite of the mother; therefore, it is logical to expect that intrauterine development be adversely affected by suboptimal maternal nutrition.

3. The high incidence of low birth weight observed in the Latin American countries is the resultant of a causal complex, the important components of which are:

a) the nutritional history of the mother since conception and her present nutrition during pregnancy;

b) the high exposure to infection during pregnancy, and

c) other conditions resulting from the economic, social and cultural deprivation which define the low socioeconomic level of the great majority of the Latin American populations.

4. In our countries, different types of nutritional actions directed to the pregnant woman have been implemented, the majority of which have not been adequately evaluated.

5. It is considered that the nutritional actions oriented towards the improvement of reproductive efficiency of Latin American women must form part of comprehensive health care systems, focusing in the high-risk groups and taking into consideration the specific characteristics of each population group.

### RECOMMENDATIONS

1. Proposal is made to the Latin American Nutrition Society (SLAN) to carry out actions with the following objectives:

a) to promote planning, implementation and evaluation of programs aimed to the reduction of the incidence of low birth weight and infant mortality in Latin America, and

b) to stimulate the development of investigations to attain a better definition of the magnitude of the problem of low birth weight, its causes and sequelae, and the application of the more appropriate actions in the countries of the Region.

Aaron Lechtig  
Moderator

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