In recent years, almost all poor regions of the world, especially Latin America, have witnessed a relative increase in malnutrition occurring during the first year of life (1). This is particularly true in urban areas. Large numbers of poor peasants migrate to the cities, in the hope of finding a better life. This migration, together with the rapid natural increase in population, has exceeded the possibilities of an organized and organic growth of the cities. Almost all cities are now surrounded by belts of poverty, where families lack adequate housing and live in overcrowded facilities in very bad sanitary conditions. In addition, the habit of breast-feeding has been lost, thereby exposing children to a highly contaminated environment at a very early age (2). Poverty, ignorance, infection, and diarrhea explain the high incidence of malnutrition during the first and second years of life.

The treatment of severe malnutrition during the first year of life is difficult and its mortality very high (3–5). This can be explained in several ways: (a) malnutrition produces a series of metabolic disturbances, affecting both the absorption and utilization of different nutrients (6); (b) the immunologic mechanisms are also affected, increasing susceptibility to infection (7); and (c) the mechanisms that regulate acid-base balance are altered. Acid-base balance is particularly precarious during the first months of life when there is an increased susceptibility to severe dehydration (8).

ENERGY REQUIREMENTS

Recovery from malnutrition is frequently delayed by intercurrent infection, which increases nutritional requirements and the morbidity and mortality associated with protein-energy malnutrition (PEM). Some infants fail to gain weight even though their diet provides the usual amounts of energy and protein (9–11). Recovery of these patients requires intakes that exceed 150 kcal/kg-day (9–11). “Energy efficiency,” expressed as the relation between energy intake and weight gain, is much lower in malnourished infants than in controls (Fig. 1). Nevertheless, by increasing the energy intake in malnourished patients, considerable improvement in their condition is seen, even during the first weeks of treatment (Fig. 1). This shows that nei-
ther the weight gain nor the rehabilitation of malnourished infants will begin unless the energy intake exceeds 150 kcal/kg-day. It is important to keep this fact in mind, in view of the excessive caution of some pediatricians in the treatment of these patients (11).

The intestinal absorption of fat is decreased in PEM, though more so in kwashiorkor than in marasmus (12–14). Administration of lipase improves absorption (14). Medium chain triglycerides are also more easily absorbed than the long chain triglycerides (14).

Similarly, patients with both marasmus and kwashiorkor frequently suffer from lactose malabsorption. A selective decrease in lactase activity has been shown in biopsies of the jejunal mucosa in children with PEM (12). These alterations may explain some of the diarrheal episodes observed in children during refeeding with skimmed milk. Other sugars and starches are well-tolerated (12).

PROTEIN REQUIREMENTS

Some studies suggest that an intake of 2 g of high-quality protein per kg body weight is adequate to initiate nutritional rehabilitation (9–11,15). We fed 3 to 4 g milk protein per kilogram per day to our marasmic patients with satisfactory results. There seems to be no valid reason to give larger amounts. Renal function is altered in malnourished infants, and as a result, they may not be able to excrete the metabolites that are produced when large amounts of protein are ingested (16).

Poor countries must give a high priority to economic factors. Less expensive, high-quality foodstuffs are essential. It might theoretically be possible to use modified milks, low in lactose, with medium chain triglycerides, partially hydrolyzed...
proteins and an adequate osmolar charge. However, this is impracticable, because of their high cost. On the other hand, in our experience, dilute whole cow's milk, with the addition of simple carbohydrates and vegetable oil to increase its energy density, is an inexpensive and effective formula (17). The need for proper hygiene in the preparation and storage of such formulas is extremely important.

TRACE ELEMENT REQUIREMENTS

In the past few years, considerable emphasis has been placed on the role of micro-nutrients such as iron, copper, and zinc in the recovery of malnourished infants. Although marasmic infants do not seem to suffer from iron deficiency (18,19), this condition may become apparent when growth resumes or accelerates during recovery (18). Since the iron content of cow's milk and its bioavailability are low (20), we provide an additional 1 to 2 mg/kg-day of iron after the start of recovery.

Cordano et al. (21) described a microcytic anemia refractory to iron supplementation in patients with copper deficiency. Leukopenia with neutropenia and alterations of bone structure were also noted. They disappeared when copper was added to the diet. Low levels of plasma copper and ceruloplasmin were also detected in marasmic infants (22). The activity of superoxide dismutase (a copper-dependent enzyme) is also depressed (22). The disturbance became particularly evident during a period of rapid growth, typical of the early phase of nutritional rehabilitation. Infants who were never breast-fed and those who suffered from episodes of acute diarrhea were especially susceptible to deficiencies of this element (23). For this reason, we provide a copper supplement (80 μg/kg-day) during the nutritional treatment of marasmus.

Zinc is also important. Even though plasma zinc concentrations in marasmic infants are normal, supplements of this micronutrient increase the speed of recovery and rate of growth and decrease the frequency of infections during refeeding (24).

VITAMIN REQUIREMENTS

Plasma vitamin levels are usually normal in marasmic infants. Vitamin supplements are not necessary if fresh cow's milk and other foodstuffs are provided in the diet during treatment. We supplement with vitamins A, C, and D if powdered milk is used as the basis of the rehabilitation diet. Perhaps vitamin B12 deserves special mention, since deficiency of this vitamin affects several metabolic processes in severely undernourished infants (25–27).

ANTIBIOTICS AND OTHER DRUGS

Antibiotics and drugs should be given only to patients who absolutely require them, since numerous animal studies have shown that malnutrition affects hepatic
function (28). For example, among other alterations, the oxidative capacity of the liver is depressed, and the activities of cytochrome P-450, flavoprotein reductase, N-methylase, and analinine hydroxylase are all decreased (29). These affect the metabolism, conjugation, and detoxification of drugs and antibiotics such as chloramphenicol and gentamicin, resulting in prolonged half-life in infants suffering from severe malnutrition (30–33). The excretion of sulfadiazine is retarded, and a smaller percentage is excreted in the acetylated form (34). Drug dosage should therefore be carefully controlled, and the dosage per kilogram should be lower than in well-nourished children.

Extreme care should be taken when administering analgesics and antipyretics. Small infants are especially sensitive to aspirin, and severe intoxication may result from dosages far below those administered safely to older children (35). Furthermore, excretion of aspirin in children suffering from malnutrition is decreased, thereby making its use even more dangerous, especially after repeated doses are given (36). Similarly, a prolonged half-life of antipyrin (37,38) and acetaminophen (paracetamol) has been observed in seriously undernourished infants (39).

This area requires more research, although the data already available suggest that extreme care must be taken when prescribing drugs and antibiotics. These products should be used only in patients who absolutely require them and always in smaller amounts per kilogram of body weight than recommended for normal children.

PSYCHO-AFFECTIVE STIMULATION

An important factor that has not received enough consideration to date in the treatment of severely malnourished children is the effect of psycho-affective stimulation. Recent observations make it clear that adverse emotional factors delay the recovery of severely malnourished children. In our experience, when a carefully planned program of psychomotor and affective stimulation is implemented in addition to nutritional support, recovery is significantly accelerated (6,7,17,40).

We undertook a study to compare treatment of two groups of malnourished infants under 1 year of age, both of which received identical dietary treatment (Table 1). One group (group B) was treated in a specialized center, which provided psycho-

<table>
<thead>
<tr>
<th>Group</th>
<th>Age on admission (days)</th>
<th>Weight on admission (kg)</th>
<th>Birth weight (kg)</th>
<th>Psychomotor development quotient</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Admitted to pediatric hospital</td>
<td>154 ± 32</td>
<td>3.6 ± 1.2</td>
<td>2.8 ± 0.3</td>
<td>56 ± 8</td>
</tr>
<tr>
<td>B Admitted to Chilean Nutritional Foundation (CONIN) center</td>
<td>148 ± 36</td>
<td>3.5 ± 1.3</td>
<td>2.7 ± 0.5</td>
<td>55 ± 16</td>
</tr>
</tbody>
</table>
affective and motor stimulation. The other group (group A), which served as a control, was treated in a conventional children’s hospital without a special program of stimulation. The outcome was completely different in the two groups. Infants in group B began to recover immediately without the noticeable “adaptation period” that is characteristic of these children (17). Weight and length gain were significantly different (Fig. 2; Table 2). In addition, infection was reduced, and there was no mortality in group B in contrast to 29% in group A (Table 3).

Metabolic studies also showed improvement in nitrogen retention in group B. Both groups absorbed similar amounts of nitrogen, but urinary excretion during nutritional rehabilitation in group A was significantly greater (Table 4).

It appears that psycho-affective and motor stimulation has a favorable effect on children suffering from severe malnutrition. We also found that stimulation resulted in improved recovery from the physical and intellectual sequelae of severe malnutrition. When previously malnourished children were adopted by families from a

<table>
<thead>
<tr>
<th>TABLE 2. Clinical progress of marasmic infants during 4 months of treatment*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Weight deficit for age</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Height deficit for age</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Psychomotor development quotient</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>p &lt; 0.01</td>
</tr>
</tbody>
</table>

* A, 80 infants treated in a conventional pediatric hospital. B, 80 infants treated in a Chilean Nutritional Foundation (CONIN) center.
TABLE 3. Incidence of intercurrent infections and mortality among severely malnourished infants during treatment

<table>
<thead>
<tr>
<th></th>
<th>Infections (episodes/month)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>4.5 ± 0.2</td>
<td>29</td>
</tr>
<tr>
<td>Group B</td>
<td>0.3 ± 0.6</td>
<td>0</td>
</tr>
</tbody>
</table>


TABLE 4. Nitrogen balance at admission and after 30 days of treatment in two groups of marasmic infants

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Group A (mg/kg-day)</th>
<th>Group B (mg/kg-day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Admission 30 Days</td>
<td>Admission 30 Days</td>
</tr>
<tr>
<td>Ingest</td>
<td>842 ± 63</td>
<td>880 ± 40</td>
</tr>
<tr>
<td>Urine</td>
<td>648 ± 41</td>
<td>635 ± 42</td>
</tr>
<tr>
<td>Stools</td>
<td>78 ± 18</td>
<td>96 ± 33</td>
</tr>
<tr>
<td>% Retention</td>
<td>13.8</td>
<td>17.0</td>
</tr>
</tbody>
</table>

\[ p < 0.001 \]


Higher socioeconomic and cultural level, they achieved normal growth and intellectual quotient (I.Q.) for their age. This is not the case when malnourished children return to impoverished homes after recovery (Figs. 3 and 4).

Numerous researchers have observed a relationship between growth and psychological stimulation in children. Widdowson (42) pointed out that lack of affection may retard growth, in spite of an adequate energy intake. Similar observations have been made by other authors studying children deprived of maternal care (43,44).

Powell et al. (45) described 13 children who had emotional deprivation characterized by delayed growth. The study included children who had been abandoned or neglected by their parents and who suffered affective deprivation. Growth was retarded in all the subjects, in spite of a normal energy intake, to a point where they appeared to be suffering from hypopituitary dwarfism. The authors designated this condition as "psychosocial dwarfism." A depressed I.Q. was also observed in these children. Growth was re-initiated when the environment was modified, without the administration of growth hormone (46). Plasma concentrations of growth hormone were depressed in these patients, thus justifying the assumption that the mechanism was secondary to pituitary hypofunction (46).
FIG. 3. Development quotient (DQ) of marasmic infants at admission (6 months of age, on average), after 3 months of treatment, and 7 years later (IQ). A, adopted after discharge; I, institutionalized after discharge; BF, with the biological family. INTA, Instituto de Nutrición y Tecnología de los Alimentos (Universidad de Chile).

FIG. 4. Weight-for-age and height-for-age in marasmic infants on admission (6 months of age, on average), after 3 months of treatment, and 7 years later. A, adopted after discharge; I, institutionalized after discharge; BF, with the biological family. INTA, Instituto de Nutrición y Tecnología de los Alimentos (Universidad de Chile).
Numerous studies have shown the profound influence of maternal deprivation on infant growth. They range from changes in body temperature and changes in heart-beat frequency to an important degree of retardation of growth and development. These effects have been widely studied in rats and monkeys (47,48).

In our experience, marasmus is associated with endocrine changes similar to those of hypopituitarism (49). This has been confirmed by other workers (50,51). Administration of growth hormone during the recovery phase significantly increases nitrogen retention in these patients (52). Meites and Fiel (53) have observed a fall in the hypothalamic releasing factor for growth hormone in malnourished rats, resulting in retarded growth. Powell et al. (45,46) suggested the same mechanism in children with psychosocial dwarfism.

According to our own observations, severely undernourished infants from marginal social groups almost invariably suffer from maternal affective deprivation. Generally, they are unwanted children of unmarried mothers (17). It is possible that two growth retarding factors affect these children simultaneously: malnutrition and psycho-affective deprivation. It is also possible that there is a synergistic effect between these factors, via the pituitary.

Shamberg et al. (54) observed a marked drop of the enzyme ornithine decarboxylase in rats following maternal deprivation. The decrease was observed in most tissues examined (brain, liver, heart, kidney, lung, and spleen). The levels rapidly returned to normal when the mother–offspring relationship was reestablished. In rats, tactile stimulation was sufficient to cause the restoration of normal levels of this enzyme.

Ornithine decarboxylase is the first enzyme in the synthesis of the polyamines, such as putrescine, spermine, and spermidine (55). The published literature frequently links the polyamines with stabilization of nucleic acids in the ribosome structure. This suggests that they play an important role in protein synthesis and growth (55,56). The concentration of ornithine decarboxylase increases in rapidly regenerating tissues (embryonic tissue or regenerating hepatic tissues), reflecting an increased concentration of polyamines. It is interesting that growth hormone increases the concentration of this enzyme (57). All these data lead to the assumption that both malnutrition and emotional deprivation, acting through the hypothalamic–pituitary axis, can depress polyamine synthesis, thereby decreasing growth. They could explain our observations that psycho-affective stimulation plays an important role in the recovery of seriously undernourished children.

One might speculate that psycho-affective intervention may affect the immune system, thereby decreasing the rate of infection. Numerous studies in laboratory animals and in humans appear to confirm the likelihood that stress may depress the immune system (58–60). It has also been shown that hypothalamic injury may affect the immune response (61–63). Corticosteroids may decrease the antibody response and reduce the size of the lymph nodes, a source of lymphocytes. Corticosteroids can also reduce both the number and responsiveness of lymphocytes in the bloodstream.

Corticosteroids are not the only link between stress and the immune system.
Stress can elicit changes in the levels of several hormones, neurotransmitters, and neuromodulators, including growth hormone, insulin, vasopressin, testosterone, prolactin, epinephrine, norepinephrine, endorphin, and enkephalin. Many of these substances also affect the immune system. There is considerable evidence that immune cells also carry on their surfaces receptors for hormones and neurotransmitters (64–67). Therefore, psychological factors could influence the immune system via any or all of these chemical messengers.

It is also well known that some neuropeptides (beta endorphin and met-encephalin) produced in the brain, and also in other cells, are capable of influencing the white cells. There is evidence that the hypothalamus acts on T lymphocytes in order for them to evolve to natural killer cells (68). Moreover, receptors for neuropeptides have been found in the surface of lymphocytes, and after their attachment, their activity is altered, especially that of the natural killer cells. It seems clear that the cells of both systems can communicate reciprocally through molecular messengers with similar receptors (69). It is not strange that the acquired immunodeficiency syndrome (AIDS) virus destroys the T lymphocytes as well as the neurons. This is because both types of cells have similar receptors for the proteins of that virus (70).

Recently, Gurney et al. (71,72) have described a new messenger, which is recognized by the immune system as well as by the nerve cells. It was denominated "neuroleukin," and it acts on certain motor cells of the spinal cord and in B lymphocytes responsible for the production of antibodies. Moreover, some messengers are shared by the immunologic system and by cells of the nervous system. Interleukin-1 is not only produced by monocytes but also by glial cells of the brain. That means that interleukin-1 not only develops immunomodulatory functions, but neuroendocrine ones as well (73). This biochemical similarity between the immunologic system and the nervous system is a fact that is just beginning to be recognized.

There also exists the possibility that the brain may influence directly the immune system by sending messages along the nerve fibers. Detailed anatomic studies have made it possible to observe that nerve cells are linked to many important components of the immune system, including the thymus, spleen, lymph glands, and bone marrow. These nervous links are probably not essential for the operation of the immune system (many immunologic responses have been studied in isolated cells in vitro), but they could regulate or modify its activity (74). In summary, although it is true that the immune system has been considered autonomous to date, many observations now indicate that it might be integrated with the central nervous system. Thus, this could also explain the beneficial effect of psycho-affective stimulation during treatment of the malnourished child.

THE ROLE OF REHABILITATION CENTERS IN THE TREATMENT OF MALNOURISHED CHILDREN

Malnutrition in underdeveloped countries results from poverty. For this reason, it is difficult to prevent if underdevelopment and poverty persist. Nevertheless, much
can be done if efficient and widespread programs are developed that affect health, nutrition, education, and sanitation.

Several countries have made substantial advances in primary health care, food distribution, education, and improvement in environmental sanitation. Chile is a good example. Although poverty continues to exist, considerable progress has been made during the past 30 years in the prevention of malnutrition (75). Current levels of infant mortality are 19 per thousand and preschool mortality is 0.9 per thousand. At the national level, the percentage of malnourished children under 6 years is 8%, and most of these are first-degree undernourished children (simple growth retardation) (7.7%) (76).

Nevertheless, and in spite of efforts in this regard, there are still severely malnourished children, almost all of them (89%) under 1 year of age. Follow-up studies (in 1975) (39) of children with severe malnutrition under 1 year of age showed that their risk of death before they reached their second year of life was almost 65%.

In practice, it is very difficult for an infant with severe malnutrition to recover in his own home. Even in hospitals, the mortality rate is high. Clinically, such infants are very labile. At the same time, they belong to extremely poor families. The extreme poverty in which they live represents a high environmental risk: Family income is low or nonexistent, illiteracy rates are high, housing conditions are inadequate, and there are crowding and poor sanitation. The severity of the clinical picture is such that admission to hospital and intensive care in specialized units are required, since most of these children are very young. However, treatment in conventional pediatric hospitals is too expensive, and the results are very poor. In a study done 12 years ago in several pediatric hospitals in Chile, it was noted that on average, severely malnourished children under 1 year of age required 2.8 hospital admissions per year. The average duration of each admission was 120 days per year, and mortality reached 28%. The pressure of new admissions forces premature discharge, leading to a recurrence of the condition. In 1974, 58% of the hospital beds occupied by infants in the entire national hospital system were occupied by severely undernourished infants, thereby limiting the possibilities for the care and treatment of children with other diseases. All this pointed to the need for other solutions that would lower the cost and increase the efficiency of treatment and thereby reduce the likelihood of relapse. This could be done only in specialized centers, with a highly motivated professional staff. At the same time, there was an obvious need to integrate the family into the recovery process.

All these factors led to the creation of the Chilean Nutritional Foundation (CONIN), a nonprofit private foundation whose main objective is the treatment of severely malnourished children. This corporation is sponsored by the Ministry of Health, which provides a proportion of the operating budget. CONIN is responsible for organizing the community to obtain the resources necessary to build and equip the recovery centers.

Between 1975 and 1980, 33 centers with 1,360 beds were built and placed in operation. The total investment was approximately $8 million. The centers have been responsible for the treatment of 33,000 children under 2 years of age. Special pro-
grams were developed and implemented to achieve complete nutritional recovery of the child and at the same time, to modify the family environment to prevent relapses.

Each center is directed by a pediatrician, who heads a multiprofessional team consisting of a registered nurse, a nutritionist, a specialized preschool teacher, and a social worker. Each center has approximately 36 nursing aides who work 8-hr shifts and from 30 to 180 volunteers. A central team of health professionals and technicians outlines roles and curricula. They oversee the treatment given in the centers, and during the follow-up, they determine the activities to be undertaken by the families. The same group is also in charge of the permanent evaluation of the program and responsible for incorporating new technologies in the diagnosis and treatment of the children.

The activities of the recovery centers include: (a) adequate feeding, based on cow’s milk and other foods prepared under the strict supervision of the nutritionist; (b) early psychosensorial stimulation, based on Piaget’s concepts, supervised by a specialized preschool teacher; (c) physiotherapy; (d) affective stimulation by auxiliary nurses and volunteers; and (e) involvement of the mother in the care and stimulation of her child.

The results to date in the treatment centers and during follow-up in the homes have been extremely encouraging, exceeding all expectations. The advantages are summarized below:

1. Nutritional recovery occurs in a much shorter period than with conventional treatment in a children’s hospital (17) (Figs. 5 and 6).

2. There is a very low risk during treatment. Mortality rates in the centers are below 2%, whereas the mortality rate of infants with severe malnutrition in children’s hospitals is about 30% (17).

3. The recovery of undernourished children has a positive effect on the economic and social development of the family.

Accumulated experience allows us to infer that the nutritional status of the child is an excellent indicator of impoverished families, an important fact when designing

![Graph](image)

**FIG. 5.** Weight and height deficit in 7,000 marasmic infants during recovery in Chilean Nutritional Foundation (CONIN) centers.
and implementing programs aimed at the development of this sector of the population. The malnourished child is the result of a very adverse environment. As a general rule, a family with severely undernourished children belongs to the lowest socioeconomic level.

Obvious changes occur during the recovery of a malnourished child. They can be used to attract the interest of the parents and to integrate them into the process. It is possible to influence their habits and modify their attitudes toward the child. Extremely impoverished families frequently distrust anyone attempting to modify their environment. The integration of the family in the process of a child’s recovery is a way of gaining that family’s confidence, something that is absolutely necessary if they are to achieve real participation in the recovery process.

Families living in extreme poverty generally adapt to their environment and are not aware of the abnormality of their situation. This is an obstacle to the success of any program designed to improve the standard of living. For the family, the undernourished child is not the result of poverty. When asked about the condition of the child, it is usually explained as being due to inherent factors and not to the environment. The recovery of the child facilitates participation by the family in other programs designed to improve the quality of life.

4. A follow-up study of 35,000 recovered children revealed that only 4% failed to continue to grow at normal rates after they returned to their families. Moreover, only 1% required another hospital admission. The education of the mother in child care and the need for psycho-affective stimulation made possible the continued recovery from physical and psychomotor retardation.

5. Treatment of severely undernourished children in these centers costs less than that in conventional children’s hospitals: $8 per day in the center versus $42 per day in the children’s hospital.

6. The implementation of the recovery centers has made it possible to operate the hospital system better. The centers have reduced hospital admissions, making beds available for patients suffering from other diseases.

7. The program has stimulated community solidarity through the process of providing the resources needed to build and operate the recovery centers.
These centers have been very positive, from all points of view, since they have improved health indices and most important, have lowered mortality rates.

TREATMENT OF THE IMPOVERISHED FAMILY

A treatment program would lack meaning if aimed only at the child's recovery. Since the malnourished child is the product of poverty and misery, a return to such an environment could cause relapse. Therefore, changes must also be fostered in the family. This is not an easy task. These families suffer from "sociogenic-biological" damage as a result of chronic poverty (77), which has often persisted for generations. They are isolated from the economic and social structures of the society and historically have never participated in its obligations or advantages. A high proportion (54%) of the mothers in this group are illiterate, as compared with the average for the country often less than 4% (Table 5). Fathers are often unemployed or work occasionally, and their incomes tend to be very low and their housing is always inadequate and unsanitary.

A new strategy, which takes into account these factors, must be designed if significant results are to be achieved; active participation is required. Any program must simultaneously consider education, health, labor capability, and housing. New expectations must be created and the tools with which to achieve them provided. It is necessary to reawaken human dignity and stimulate a sense of self-esteem (9).

Any factor that could be misconstrued as charity, paternalistic, or missionary in nature must be eliminated from these programs. What are important are the stimulation of self-esteem and the promotion of active participation in the program.

Despite the objectives, intervention sometimes fails, and up to 10% of children cannot be returned to their parents after recovery because of a lack of acceptance by the mother or because of maternal mental retardation, alcoholism, or other causes.

Table 5.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of illiteracy of the mother</td>
<td>54%</td>
</tr>
<tr>
<td>Father's work</td>
<td></td>
</tr>
<tr>
<td>Full-time work</td>
<td>8%</td>
</tr>
<tr>
<td>Part-time work, self-employment, unemployment</td>
<td>92%</td>
</tr>
<tr>
<td>Legal situation of the parents</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>35%</td>
</tr>
<tr>
<td>Unmarried</td>
<td>65%</td>
</tr>
<tr>
<td>Mother's age</td>
<td></td>
</tr>
<tr>
<td>Over 18 years</td>
<td>62%</td>
</tr>
<tr>
<td>Under 18 years</td>
<td>38%</td>
</tr>
<tr>
<td>Housing conditions</td>
<td></td>
</tr>
<tr>
<td>Adequate</td>
<td>8%</td>
</tr>
<tr>
<td>Inadequate</td>
<td>92%</td>
</tr>
</tbody>
</table>
In these cases, children are placed in permanent or temporary foster homes, or they remain in state institutions.

Results to date indicate that it is possible to rescue these marginal groups, provided that there are adequate resources and structures capable of reaching established goals effectively.

Our rehabilitation program has been operating for 13 years. The number of severely malnourished children has significantly decreased during this period. Thus, the number of centers in operation has dropped steadily to 26, generally located in the larger cities. The centers not used to treat malnourished children are now used for the admission of children suffering from chronic metabolic or genetic diseases.

**SUMMARY**

Malnutrition is the final result of poverty. Any strategy to eliminate malnutrition must include the causes of and the effects associated with poverty. Undernutrition can be countered even before poverty has disappeared, if adequate programs are implemented. In Chile, recovery from severe malnutrition not only meets humanitarian objectives but also supplements and improves the effects of the national nutrition policy.

The treatment of severely undernourished infants is difficult even in a conventional pediatric hospital. In our experience, it is much more advantageous to treat them in specialized centers, where in addition to the nutritional treatment, these children also receive psycho-affective and motor stimulation.

The treatment of the whole family group is essential, in order to prevent relapses.

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DISCUSSION

Dr. Suskind: Professor Monckeberg has provided Chile with the mechanism to decrease infant mortality with a self-sustaining, nongovernmental program. My question is whether the recovery of these children would be essentially the same without a stimulation program.

Dr. Monckeberg: For ethical reasons, we do not have centers that give food without stimulation, as one might with animals. Our stimulation programs are carefully designed and monitored. They have two facets: direct stimulation through a set curriculum and indirect, by enriching the environment with colors, toys, music, etc. While we ethically could never withdraw stimulation from a group of children, we can compare our results with those from conventional hospitals, where stimulation virtually does not exist, while nutrition and hygiene may be comparable.

Animal studies by us and others support the theory of the effect of psycho-affective stimulation on recovery of brain function as well as on physical growth and immunity.

Dr. Grantham-McGregor: I am not convinced of the theory attributing recovery to psychosocial stimulation. In Jamaica, in units similar to yours, before I introduced psychosocial stimulation, the recovery rate in weight-for-height was at least as good as that in your centers. The mortality rate was equivalent. I attribute your results to the excellent physical care given.

I spent the first year in Jamaica observing the development of the children in order to have baseline data. The introduction of psychosocial stimulation was not accompanied by any unexpected improvement in growth. In our follow-up study, the height and the head circumference of the stimulated group were identical to the nonstimulated group, although the developmental level was higher. I am not saying that psychosocial stimulation may not affect growth, but we do not have conclusive evidence that it does.

Could you describe more fully the data on your adoption studies? Also, I am surprised at the large number of malnourished children assessed at 2 years of age with an IQ of 98.5. Deprived children, even those who have never been malnourished, are rarely to be found functioning at that high a level. Are you saying, therefore, that children who have been malnourished are functioning better than the average deprived child?

Dr. Monckeberg: We compared three groups of malnourished children who, after rehabilitation, went to three different environments. Children who returned to their predisease home, even when receiving free milk and food supplements, did not reach normal height-for-age or normal IQ. A second group was institutionalized. The children had adequate food intake, but
they also did not reach either normal height-for-age or normal IQ. A third group was adopted into families of a higher socioeconomic level. These children attained both normal height-for-age and normal IQ.

While it is true that human studies have not provided definitive conclusions related to the positive effects of psycho-affective stimulation on treatment and recovery from malnutrition, I personally feel that it plays an important role. Results from animal studies, however, are very definitive. In addition, several publications have clearly correlated immunity to stress and psychological factors.

**Dr. Suskind:** In a follow-up of recovered malnourished children, we found that they continued to have catch-up growth in weight-for-height. We also found that previously marasmic patients were anthropometrically the same as their siblings, as were siblings of kwashiorkor patients. However, the siblings of the two groups were significantly different, indicating that the marasmic children and the kwashiorkor children came from environmentally different populations.

**Dr. Monckeberg:** Recently, in Chile, the pattern of malnutrition seems to be less economic than social. The children are now generally first children of very young mothers. Second children of the same mothers tend to be less likely to have problems, perhaps because the mothers have learned to care for the children.

**Dr. Husaini:** Have you been describing the care given in your best center, or are these standards consistent in most of your facilities? Second, do you provide nutritional supplementation to mothers who may be malnourished? In our study, we found that malnourished mothers were not able to play or interact with the child, while the well-nourished mother was very active.

**Dr. Monckeberg:** Each center has about 50 beds and is directed by a pediatrician and an administrator. There are also a nurse, about 35 assistant nurses, a teacher, and a nutritionist. In addition, we have an average of 150 trained volunteers who work with the children, as well as with the families.

An important part of the program is training the mother to feed and care for her child. This is complemented by having a social worker who helps solve broader family problems by teaching families to utilize services and programs developed by the state.

There is a marked change in maternal–child interaction from the time of admittance to recovery. We believe that it is not only the recovery that helps restore these bonds, but that the successful continuance of the recovery is strongly affected by this reestablished relationship.

We have been very careful, because of the size of our program, to maintain strict controls based on very specific guidelines. A professional team periodically visits each center, observing its performance and the execution of its program, as well as overseeing the effectiveness of its staff. A clinical record is prepared monthly for each child and is kept in a central file.

Physical construction has been carefully planned and developed at a cost of approximately $12 million. Funding has come mainly through individual or institutional donations without governmental help. It costs $1.5 million per year to treat about 3,000 children.

**Dr. Grantham-McGregor:** It is commendable that there has been so much invested in the rehabilitation of these children. If, however, after such a large expenditure of money and effort, the IQ of the children returned to their families is still only 80, we must wonder whether we can really rehabilitate these children.

**Dr. Monckeberg:** The question is not IQ, of course, but life versus death. Before our program, the majority of these children were in much more expensive pediatric hospitals. The treatment was inefficient, and the children were generally discharged prematurely. In-hospital mortality was about 20%, and of those who did survive, there was a high probability of recurrence and rehospitalization.
A study done before the inception of our centers demonstrated that a child who was severely undernourished before 6 months of age had an 80% chance of dying before his second birthday. That is, before our program, most of the children we now see would be dead. At present, infant mortality in Chile is 18%, one of the lowest in Latin America.

Dr. Soriano: You show that even well-rehabilitated children, except those who were adopted, never reached the normal percentile height-for-age. Do you think that growth hormone therapy would be an appropriate consideration?

Dr. Monckeberg: I believe that nutrition and stimulation are sufficient during the treatment of severe marasmus.

Dr. Suskind: Could they be zinc-deficient?

Dr. Monckeberg: These children probably do present zinc deficiency during recovery. A decrease in zinc, manganese, iron, and selenium in the liver of these patients has been reported (1). While we have found normal zinc values in the blood, if zinc is supplemented, the velocity of recovery, as well as the immune response, improves.

Dr. Truswell: In Australia, we have data indicating that children from low socioeconomic groups have lower height- but not lower weight-for-age.

Dr. Monckeberg: Universal similarities in attained height seem more closely correlated to socioeconomic status than to nationality, racial ties, or whether one is from a developed or underdeveloped country. My own position is that the differences one observes are environmentally determined and that within racial perimeters, growth will be similar if nutrition and health status are the same.

Dr. Bates: In the Gambia, simply by having a physician stationed in small village areas, the infant and toddler mortality decreased from about 25% to the developed-world mortality of 4% (2).

Dr. Suskind: Concerning the higher calorie requirement during recovery: We place the children on 150% of the recommended daily allowance (RDA), which is about 170 to 180 cal/kg-day of actual body weight, plus about 4 g protein/kg-day. Could you comment on where the energy is going in terms of the requirements for weight gain?

I should also like to comment on the role of infection and antibiotics. We found these children to be significantly immunocompromised, similar to premature infants. We initiated measures similar to what would be done in the neonate, covering the children for 48 to 72 hr with antibiotics until all the culture results came back negative. As a result of this aggressive intervention, the mortality rate decreased from 25% to less than 5%.

Dr. Monckeberg: Our experience has been corroborated by numerous published reports. A marasmic infant will not begin recovery until intake is over 150 calories per kg. At an intake less than 120 calories, his weight will remain stationary.

Dr. Jackson: The experience in Jamaica was somewhat different. Ashworth et al.’s (3) studies indicated that the rate of weight gain is more closely associated with energy intake than with protein, once a certain amount of protein is provided. When the thermic effect has been accounted for, there is a close relationship between the rate of weight gain and the intake of energy in excess of the maintenance requirements of about 100 kcal/kilo-day. Above this requirement, there appears to be a linear relationship related to intake, which allows for weight gain in excess of 20 times the normal for age or height. The quality of tissue deposited will depend on the nature of the other nutrients available. There is also a range of weight gain per unit of energy ingested or deposited, depending on whether the tissue is predominantly lean or adipose (4,5). A child depositing adipose tissue will gain weight at a slower rate than one depositing lean tissue for the same energy intake.

One of the consequences of specific nutrient deficiencies is the difficulty in utilizing an excess of energy intake, resulting in a loss of appetite. A return of appetite will not take place
until the infections promoting the deficiencies as well as the deficiencies themselves are corrected. This has to be done before the energy intake is increased in excess of 100 kcal/kg-day. The treatment of infections and correction of nutrient deficiencies are essential in order to allow for the linear relationship between energy intake and rate of weight gain.

**Dr. Suskind:** Since normal children will gain weight on 120 kcal/kg-day, why doesn’t a malnourished child?

**Dr. Jackson:** Spady et al. (6) carried out careful studies of energy balance and showed the care with which feeds have to be made up and administered in metabolic studies if the subjects are to receive the amount and composition intended. Careful quantification of stool losses has to be carried out. With such care, the range of variability in maintenance requirements between subjects would seem to be quite small.

**Dr. Guesry:** In our study in the Gambia, the energy expenditure of malnourished patients was measured by direct calorimetry. The results indicated that the basal metabolic rate of malnourished adults is lower than what is considered normal.

**Dr. Jackson:** It is difficult to find an appropriate reference against which to express metabolic rate in a condition where there are significant changes in body composition with relative preservation of the more metabolically active tissues. While there is loss of tissue, the evidence suggests that what remains has a lower energy expenditure per unit of tissue. I should not call that efficiency, but rather a change in metabolic expenditure.

**Dr. Keusch:** Regarding infection and energy utilization, it is important to understand that clinical infection is not simply a matter of the contact of a host with an organism, but rather the metabolic consequences of infection. Another factor, in infectious disease, is that the earlier infections are treated, the easier they are to treat. Once a process is established, treatment may be much more difficult or even too late.

**Dr. Monckeberg:** Multiple factors may explain the higher calorie requirement of a malnourished child for recovery.

First, perhaps we should not calculate caloric requirements on body weight but rather set the parameters for weight gain on the basis of calories needed per lean body mass. The marasmic child has less fat content and higher lean body mass per kilo. This tissue is metabolically more active than deposit fat.

Another reason may be a metabolic adaptation to undernutrition, which may produce a "panhypopituitarism," resulting in a lower efficiency of the caloric intake.

Finally, there is, possibly, decreased intestinal absorption as a result of the intestinal damage caused by malnutrition that necessitates a higher caloric intake to compensate for the malabsorption.

**REFERENCES**


