

## Malnutrition: A Deterrent to Human Progress

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*Malnutrition is an environmental stress that can damage the developing brains of the world's children. In the United States, it's most prevalent among low-income families. Sufficient protein in the diets of expectant mothers and infants at critical times is necessary to prevent retardation of mental development and intellectual capacity. Research findings on undernourished experimental animals are cited here as well as studies involving children suffering the effects of malnutrition in infancy. The authors suggest ways Extension professionals can help solve the problem of malnutrition.*

Major emphasis has been, and will continue to be, placed on Extension programs dealing with the quality of life in our nation. Currently, people are greatly concerned about environmental contamination, ecological relationships, and general deterioration of our human and natural resources. Environmental stresses may provoke subtle, almost imperceptible, changes in man . . . changes that eventually become highly significant. Malnutrition should be considered one of these environmental stresses. And, an extremely important national resource—our children—may become permanently damaged by exposure to this stress.

Research studies suggest that malnutrition early in life can be an influencing factor in retarding mental development and perhaps less-

ening intellectual capacity.<sup>1</sup> While this is a dimension of human waste that, as yet, can't be adequately measured, some implications for the future are clear. Imposing a nutritional stress on the developing brain of many of the world's children, indeed, even children in this nation, may result in a population that can't function adequately to solve the complex problems of our society.

### Malnutrition in U.S.?

Preliminary results from the recently conducted National Nutrition Survey<sup>2</sup> show that malnutrition exists in our very midst. It's of a nature and proportion that nutrition experts hadn't expected to find. Particularly vulnerable are low-income families who exhibit up to five times

as many deficits as higher-income populations. This evidence, accompanied by an increased awareness that inadequate nutrient intakes may result in abnormal brain development, deeply concerns many health professionals.

Malnutrition doesn't occur in isolation. Not only does poor diet have definite, specific effects on the individual, but poor diet also mediates between social-biological factors and mental development. Each influence, social and biological, may have separate and confounding effects on nutritional state. Social factors such as father absenteeism, alcoholism, large families, and the presence in the home of one or two children under two years of age contribute to an environmental stress associated with malnutrition in children.<sup>3</sup> In addition, lack of adequate housing, health care, and educational opportunity are factors commonly found among families from low socioeconomic strata. These factors add to social environmental stress.

To date, we do know that a good diet contributes markedly to a child's reaching his full physical growth potential. Conversely, an inadequate nutrient supply can result in debilitating diseases such as kwashiorkor and marasmus. Kwashiorkor is characterized by poor growth, apathy, dermatitis, pigment changes in hair and skin, and sometimes edema; marasmus results from starvation and is characterized by muscle and tissue wasting.<sup>4</sup>

Recent investigations of children recovered from starvation and protein-calorie malnutrition indicate that the subjects can't perform well on intelligence tests or on tests of adaptive behavior.<sup>5</sup> Even adult males subjected to starvation and, at the same time, hard physical labor show decreases in endurance, speed of movement, deterioration of coordination, and a decreased ability to concentrate.<sup>6</sup>

Assuming that early undernourishment was found and corrected at a later time in the life of the child, would this erase the deficits produced by early underfeeding? It's possible it wouldn't. There are some indications that the resultant damage may well be irreversible.

### Experimental Animal Studies

Studies using experimental animals have shown that restricted food intake causes retarded cell growth and maturation of the brain.<sup>7</sup> Studies such as these raise a number of questions. Can results of animal studies be projected to human populations? Does an effect on cellular growth and maturation lead to impaired learning ability? If a child is exposed to early malnutrition will he recover or is the damage permanent?

There's evidence that undernourished human beings and animals develop similar physical and chemical changes.<sup>8</sup> There's also good evidence that in animals malnutrition leads to impaired learning ability and behavioral changes.<sup>9</sup> Early

malnutrition and later malnutrition result in different effects on cellular development. These effects are particularly important in brain tissue.<sup>10</sup> Thus, if nutritional damage is imposed at a critical time during cellular and brain development, the damage could well be irreparable.

Evidence of a nutritional effect on learning was provided by a few early studies on animals that were deprived of B vitamins.<sup>11</sup> The impairment of learning ability was more obvious when deprivation started early in life. In addition, effects of deficiencies persisted after deprivation ended.

Pigs, rats, and monkeys subjected to food restriction have been studied for changes in behavior that may be associated with malnutrition.<sup>12</sup> Young pigs, previously underfed and then nutritionally rehabilitated were given a test to determine behavioral responses. The pigs snorted, vocalized, and continued active movement after being excited by a buzzer signal. In fact, they had great difficulty calming down and seemed to fear a new environment. Investigators reported that feeding a low protein diet to the animals seemed to have an even greater detrimental effect than simply underfeeding them.<sup>13</sup>

Restriction of the mother's diet during pregnancy is known to affect growth and development of young animals, and also to result in a reduced number of cells in fetal organs, including the brain.<sup>14</sup> Responses to dietary restriction during pregnancy vary depending on the

species of the animal, type of restriction, and stage of pregnancy at which the restriction is imposed on the mother.<sup>15</sup> Young rats born to undernourished mothers spent more time in an experimental maze and made more errors in trying to get out of the maze than control animals.<sup>16</sup> A few animals exhibited tremors and seizures, and in one case, an animal maintained a bizarre posture, catatonic in nature, for more than 25 minutes.<sup>17</sup>

Thus, increased emotionality and behavioral problems have been observed both in animals born to malnourished mothers and in animals themselves malnourished from birth through infancy.

### Changes in Brain Composition

The brain develops and grows in the early stages of life, both before and after birth, just as other organs in the body do. Growth of an infant's brain is greatest in the first year of life and is almost complete by the end of the second year.<sup>18</sup> During periods of rapid growth, there are critical times during which the developing brain is most susceptible to damage related to malnutrition.<sup>19</sup>

Research investigators have observed different effects on different brain regions of animals, depending on the time the nutritional stress was imposed.<sup>20</sup> Cell division in the cerebellum, a receiving area for auditory and visual impulses in the brain, proceeds at a fast pace in rats. Cells in the cerebrum, which is

involved in memory and perception, continue to increase in number more slowly and cell division ceases at a later time than in the cerebellum. Animals undernourished early in their development have fewer cells and less protein in the cerebellum than control animals. At the same time, cerebral areas in brains of these animals have less protein content, but the number of cells isn't changed.

In humans, regional brain studies indicate that cell division is more rapid in the cerebrum than in the cerebellum and stops at about 8 to 12 months in both areas. Early malnutrition reduces the rate of cell division in both areas. The magnitude of the effect on cell division of underfeeding the young is directly related to the rate of cell division at the time the undernourishment occurs. Thus, the brain region affected by malnutrition depends on the time the nutritional deficit occurs.<sup>21</sup>

Myelin, a fat-like material that surrounds the long nerve fiber, is another important constituent of the brain that's adversely affected by undernourishment. Myelination proceeds in various areas of the brain at different times and at different rates.<sup>22</sup> A recent experiment in rats<sup>23</sup> demonstrated that myelin-related constituents that decreased most as a result of underfeeding were those undergoing the greatest rate of development so that the amounts of these substances were more typical of those of younger, faster-growing animals. These observations suggest a delay in mat-

uration in the brain of undernourished animals. Brains of malnourished infants were examined and cerebral fat-like materials or lipids were reduced as much as 70 to 80 percent.<sup>24</sup>

Undernutrition in animals clearly results in changes in brain composition; however, conditions under which these changes occur must be quite drastic. Certainly, it's valid to question whether such changes would ever occur in human populations except under very restrictive circumstances. Unfortunately, similar observations are being made in human population groups. Children who have died from severe undernutrition experienced during the first year of life have smaller brains, less brain protein, fewer brain cells in both cerebellum and cerebrum,<sup>25</sup> and less cerebral lipid.<sup>26</sup>

### Developmental Consequences

In human beings, the assessment of the developmental consequences of malnutrition experienced during infancy or the preschool years can rarely be fully evaluated at the time malnutrition occurs. Damage to the central nervous system resulting in learning disorders or perceptual inabilities may not become noticeable until later in childhood.

Data obtained during a recent study conducted in the United States confirmed previous observations that undernutrition in the first year of life delays growth and affects intellectual development in children.<sup>27</sup>

Doctors tested several children three to four years after the time during which they had been treated in a hospital for undernutrition. These children were physically small in height, weight, and head circumference. Also they scored poorly in all five areas of the Yale Revised Developmental Examination—gross motor, fine motor, adaptive, language, and personal-social—especially in the area of language development. Of these children, the ones who suffered from undernutrition for longer than 4 months after birth were the ones most severely impaired with mean developmental quotients of 70 compared to 90 for control children. The duration of undernutrition seemed to have a pronounced adverse influence on both the physical and mental development of these children.

Another report concerned with the effects of malnutrition on physical and psychological development comes from Chile.<sup>28</sup> Severely malnourished children, from three to six years of age, who had been rehabilitated after a period of nutritional stress were subjects for the study. The children were of normal weight for age, but smaller in height and head circumference. The average intelligence quotient for the study group was 62, significantly lower than the average for Chilean preschool children of similar low socioeconomic status.

From the results of the physical and psychological tests, investigators concluded that brain damage in infancy is permanent at least up

to the sixth year of life. This was the conclusion despite the fact that there was an improved nutritional situation for each subject studied, not only during rehabilitation but following discharge from the hospital. Apparently, early malnutrition restricts the genetic and intellectual potential of children and even subsequent improvement in nutritional conditions wasn't enough to overcome the original deficit.

### Summary of Research

Malnutrition is an environmental stress with far-reaching consequences for our most priceless resource, our children. Efforts to improve the quality of life must, of necessity, include programs designed to alleviate this stress and to provide a food resources environment that will permit adequate growth and development, both physical and mental, for the young of this nation.

In this country, evidence is mounting that some children, particularly those living in poverty, are exposed to nutritional stress early in life. The problem is that, unwittingly and unknowingly, society may be permitting children to live under conditions that contribute to nutritional deficits early in life, potentially impairing mentality and limiting human potential.

Obvious signs of malnutrition, such as extremely thin arms and legs, bloated bellies, and skin and hair color changes, don't occur in the area of mental development. Damage is subtle, insidious, difficult

to measure, and even more difficult to evaluate. Still, existence of even a subtle retardation in intersensory performance, perceptual ability, or problem-solving capability limits individual intellectual attainment.

Research studies using laboratory animals have provided strongly suggestive evidence that malnutrition, either undernutrition or protein deficiency, affects brain growth and development, and can produce behavioral changes in these animals. Direct effects of food or nutrient deprivation on learned responses of animals are difficult to demonstrate and even more difficult to interpret. Nevertheless, recent research indicates that deprived young animals who have been poorly nourished and then rehabilitated are more emotional than control animals. And, similarly, nutritional deprivation of mothers during pregnancy results in behavioral abnormalities of their offspring.

Projection of these research findings to the more complex situation of man is a process fraught with difficulties. Attendant social, psychological, economic, and physical environmental factors interact to influence behavior and intellectual development. Man has great intellectual capacity and differs markedly from animals in physical and mental development as well as in life style. However, one point is clear. Organic brain damage, fewer cells, less protein, and less cerebral fat-like material occurs in undernourished animals, and similar findings have been reported in children

who were undernourished in infancy. These observations give impetus to societal concern and a sense of urgency to continue research in this vital area.

### **Implications for Extension Programming**

At least in the United States, lack of enough food or sufficient protein in an infant's diet is most apt to occur through ignorance or indifference. Safe and convenient formulas for infant feeding are available in this country and mother's milk is still an excellent food for small babies. Presently, only about 25 percent of the infants in the United States are breast-fed, a feeding procedure that is simple, relatively inexpensive, easy to explain to mothers with limited educational backgrounds, and more importantly, one that would prevent malnutrition in the first few months of a baby's life. Supplemental feeding programs for expectant mothers and young children also provide food resources that can prevent fetal or infant undernourishment.

An intensified effort to inform teen-age boys and girls—young parents-to-be—of the consequences of nutritional deprivation during critical stages of growth and development must be made by 4-H leaders and others working with young people. Although teen-age girls must know about the dietary requirements during pregnancy, both boys and girls should know something about infant nutritive needs.

In some families in this country, father absenteeism contributed to an environmental stress related to the development of malnutrition in children.

Since malnutrition exists in a milieu of health, social, cultural, economic, and political factors, educational programming becomes more complex. The solution to the problem of infant malnutrition may require concomitant solutions to a host of other problems. Collaborative efforts combining the expertise of the Extension professional with that of workers from other organizations are necessary for effective programming in this vital area.

Presently, Extension professionals and nutrition program assistants can and do help low-income families . . . the population group at greatest risk. However, in some local communities nutrition and other health-related educational programs for infants and expectant mothers are minimal or nonexistent. The concerned Extension professional must design, develop, and implement both educational and service programs that have as a primary goal the elimination of malnutrition as a contributing environmental factor in arrested mental development of children.

#### Footnotes

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