[Boston Globe, Wednesday, May 3, 1995]

Bad diets hamper the poor

Children's ability to learn at risk

By Richard Saltus
GLOBE STAFF

Millions of poor children in America subsist on diets that are so nutritionally deficient that their ability to learn and become productive is jeopardized, Tufts University scientists reported yesterday.

The study found that one-third to one-half of impoverished children consume significantly less than the federally recommended amount of calories and key nutrients like iron, zinc and vitamins needed for normal learning and thinking.

That translates to between one million and four million poor children who do not get enough food energy or important nutrients, the report concluded.

"We had not anticipated that the differences between poor and non-poor children would be this significant," said Dr. J. Larry Brown, director of the nonpartisan Center on Hunger, Poverty and Nutrition. He said the study is the first to document differences in consumption of specific nutrients between poor and non-poor American children.

Brown presented the findings earlier this week to officials at the US Department of Agriculture and the Health and Human Services Nutrition Policy Board. They are likely to figure in a new round of the contentious debate over welfare reform and proposals to replace the federal food stamp program with block grants to states, which would set their own nutritional standards and food assistance programs.

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food assistance programs.

Conservative groups have challenged the notion that children in poverty are significantly malnourished, and an analyst for the Heritage Foundation, a Washington think tank, yesterday disputed the findings of the Tufts researchers.

"It's ludicrous to say that poor people eat the same as middle-class people," said Robert Rector, a welfare policy specialist, "but in many respects they are eating better than [non-poor] people did in the 1950s."

But Dr. Deborah Frank, director of the Grow Clinic for Children at Boston City Hospital, said, "We're very concerned about what projected cuts are going to do to an already bad situation." She was not involved in the study.

"The concern is because that brain function is exquisitely vulnerable" to insufficient nutrition, said Frank. Underfeeding, she said, can cause learning, thinking and behavioral problems even when it isn't severe enough to stunt growth.

The Tufts report, authored by John T. Cook and Katie S. Martin, used US Census data and information from USDA surveys to estimate how well-nourished children are in various economic categories. Children were termed "poor" if their household income was below 130 percent of the federal poverty threshold, $19,192 for a family of four in 1993.

The researchers deemed a child's intake of calories and 16 nutrients to be substandard if it was less than 70 percent of the government's recommended dietary allowance for each nutrient. The allowance is the amount needed to prevent nutritional deficiency, but is not necessarily enough for optimal development and mental function, Frank said.

The analysis found that 15.8 percent of 1- to 5-year-old poor children get less than 70 percent of the allowance for food energy, or calories, compared to just 6 percent of non-poor children. More than 40 percent of poor children don't get enough iron, which is crucial for making red blood cells, and more than 51 percent eat too little zinc – an element needed for brain function. For non-poor children, the figures were 25.2 percent for iron and 34.8 percent for zinc.

Rector said the biggest dietary problem of those in poverty is obesity, not eating too little.

Brown, however, cited research indicating that low-income children are not more obese than children from more affluent homes, but are more likely to have stunted growth.

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Differences In Nutrient Adequacy Among Poor And Non-Poor Children

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Foreword

This analysis of federal government data reveals that a significantly high proportion of poor children suffer from deficient dietary intakes. Compared to non-poor children ages one to five, the diets of poor children are seriously compromised in ten of sixteen major nutrients analyzed.

These data reveal that millions of poor American children have significantly inadequate dietary intakes. Moreover, these outcomes confirm that mild to moderate undernutrition is directly associated with insufficient household income.

These findings come at a time in which an emerging body of scientific evidence reveals that children are far more susceptible to inadequate dietary intake than previously known. Even "mild" undernutrition, the kind prevalent among the poor, can produce serious and even permanent cognitive impairments. The implications of this new evidence are enormous: billions of dollars invested in public education are jeopardized by permitting children to go hungry; the productivity of the workforce is threatened as a result; and ultimately America's competitive standing in the international economy may be undermined by the heavy burden of childhood hunger and poverty.

As Washington policymakers debate important policy issues, it is important to recognize that proposed "reforms" may have serious and even unintended consequences. At a time when millions of American children are the victims of hunger, for example, it is not a good idea to weaken the critical child nutrition programs which supplement their meager dietary intakes.

Recently, physicians from every state in the nation advised Congress that tampering with food stamps, infant feeding programs, and school meals is medically unwise. This advice, from deans of medical schools and officers of the American Academy of Pediatrics, is professional opinion based on sound research evidence.

The data released in this new analysis provide further evidence that many children already are exposed to developmental damage associated with hunger. To weaken the very programs which have the capability of helping them is insupportable not only ethically, but scientifically. These new findings constitute further scientific evidence that a nation which fails its children may be jeopardizing its future.

Dr. J. Larry Brown, Director
Center on Hunger, Poverty and Nutrition Policy
Tufts University School of Nutrition

Highlights

* Millions of poor children have substandard intakes of important major nutrients.

* Analysis of government data reveals major differences in the intakes of poor and non-poor children for ten out of sixteen nutrients (food energy - calories, folate, iron, magnesium, thiamin, vitamin A, vitamin B6, vitamin C, vitamin E, and zinc).

* For several major nutrients analyzed, between one to four million poor children have substandard intakes on each (food energy, folate, vitamin B6, vitamin C, vitamin E, iron and zinc).

* The proportion of poor children with substandard intakes of food energy is more than two and a half times as great as for non-poor children.

* The proportion of poor children with substandard intakes of some nutrients (e.g., vitamin A and magnesium) is nearly six times as large as for non-poor children.

* The proportion of poor children with substandard intakes of zinc is over 50 percent, for iron it is over 40 percent, and for vitamin E it is over 33 percent.

* The extent of substandard nutrient intakes among millions of poor youngsters corresponds with independent data on widespread hunger among the nation's poor children.

I. Introduction

This analysis examines differences in the proportion of children ages 1-5 whose intakes of key nutrients are substantially below the Recommended Dietary Allowances (RDAs). Intakes of all sixteen nutrients covered by the 1986 Nationwide Food Consumption Survey, Continuing Survey of Food Intakes by Individuals (CSFII) are analyzed using data published by USDA[1]. This nationally representative household survey consists of two main subsamples; an overall sample drawing households from all income levels, and a low-income subsample. This analysis uses data from both the overall sample and the low-income sample[2].

In the CSFII, children are categorized as poor if their household income is equal to or below 130 percent of the federal poverty threshold. Children are categorized as non-poor if their household income is above 130 percent of poverty. We followed this federal government convention in this analysis. The income level represented by 130 percent of the poverty threshold for an average family of four in 1986 was $14,564. The equivalent income level in 1993 (the most recent year for which poverty data are available) was $19,192.

RDAs have been carefully established to protect the health and development of the American public. In this analysis, however, we adopt a more conservative measure of dietary inadequacy, with a cutoff of 70 percent of RDAs indicating that children are at high risk of serious undernutrition (Senauer, 1991, p. 222; Hamilton, Whitney, and Sizer, 1994, pp. 31-35). The procedure for setting food energy RDAs means that children consuming less than 70 percent of the RDAs are receiving fewer calories than are consumed by about two-thirds of all children their age.

Nutritionists advise that children, especially, maintain nutrient intakes close to the RDAs in order to insure adequate intakes over time. Since intakes are measured over an entire year in the CSFII, children with intakes below 70 percent of RDAs can conservatively be considered to have intakes well below recommended standards.

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[1] While an additional administration of the CSFII was completed in 1989-91, and unpublished preliminary tabulations of intake data from this more recent round of CSFII are available, they lack the income and age detail necessary for an updated replication of the analysis presented here. Neither detailed tabulations nor primary data from the 1989-91 CSFII have been made available as of this time. Replication of these analyses using the new data will be an important extension of this work.

[2] The data used in these analyses can be found in NFCS, CSFII Report No. 86-3, "Women 19-50 Years and Their Children 1-5 Years, 4 Days," and Report No. 86-4, "Low-Income Women 19-50 Years and Their Children 1-5 Years, 4 Days," published by the USDA Human Nutrition Information Service, Nutrition Monitoring Division.

II. Dietary Intake Research Background

In recent years some have argued that there are no significant differences between nutrient intakes of poor versus non-poor children in the U.S.[3] Some analysts have gone so far as to argue that poor children do not experience hunger[4]. These conclusions appear to have been reached using unsophisticated statistical techniques. They are reached by comparing average nutrient intakes rather than analyzing actual distributions of frequencies or proportions, a more standard approach in the scientific research community.

Although averages can be useful summary measures of central tendencies in data, they can obscure important information about the data distribution. Most researchers are familiar with the example of a person standing with one foot frozen in ice and the other in scalding hot water. On the "average" this person feels fine, yet reality is quite different.

Similarly, while average intakes of a particular nutrient for poor and non-poor children might not differ significantly when averaged over large numbers of children from each income group, such average comparisons do not tell how intake levels at other points in the distribution compare. There may be significant differences, for example, in the numbers or proportions of poor versus non-poor children with substandard intakes of some nutrients. Comparing average intake levels does not provide sufficient information about important differences.

A second flaw in the analysis purporting to show no significant differences in nutrient intakes among poor versus non-poor children, is that it uses protein intake as an indicator of *overall* nutrient intake[5]. Reliance on protein as an indicator of the adequacy of nutrient intake is inconsistent with current nutrition science which emphasizes the importance of a much wider range of nutrients in human health. Though some other nutrients are also found in protein-rich foods, protein intake alone provides insufficient information about the adequacy of intakes of other important nutrients. Moreover, since protein is not a public health concern among the U.S. population, comparisons of protein

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[3] See for example the Heritage Foundation Backgrounder # 843, "Hunger and Malnutrition Among American Children," August 2, 1991.

[4] This is the primary theme of the reference cited in footnote 3 above, though no empirical evidence is presented to support such an argument.

[5] This error appears, for example, in the reference cited in footnote 3 above.

intakes of poor and non-poor populations are not likely to yield useful information about their relative overall dietary adequacy[6].

Rather than analyzing average nutrient intakes, and focusing only on protein, this analysis compares the proportions of poor and non-poor children whose intakes are below 70 percent of the Recommended Dietary Allowances (RDAs), for sixteen nutrients reported in the 1986 CSFII. This approach allows a more thorough comparison of the adequacy of nutrient status of poor versus non-poor children.

Overall nutrient adequacy depends on the level of intake over time. For some nutrients, short-term intake fluctuations may not appreciably change the overall level available to the body, while for other nutrients even brief periods of limited intake can dramatically reduce supplies available for use by the body. Frequent intake of food energy is especially important for young children, as explained later. Persisting levels of nutrient intake below 70 percent of the RDAs is considered indicative of nutrient deficiency (Senauer, 1991, p. 222).

The CSFII measures nutrient intake at six different time periods over an entire year. A twenty-four hour dietary recall instrument is used for nutrient data collection. Intake levels were transformed at the time of data processing into percentages of the RDAs. These percentages were cross-tabulated by age and poverty status to yield proportions of poor and non-poor persons within each age category with intakes below different percentages (50, 70 and 100 percent) of the RDAs.

Following established convention, 70 percent of the RDAs is used as the primary cutoff point for this analysis. As shown in Table 1 below, the results of these comparisons yield statistically significant differences for ten of the sixteen nutrients examined.

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[6] Protein deficiency has been largely eliminated in the U.S., in part due to the success of several food assistance programs administered by the U.S. Department of Agriculture. Most notable among these are the Food Stamp Program, the National School Lunch and Breakfast Programs, and the Special Supplemental Food Program for Women, Infants and Children (WIC). A recent USDA assessment of the National School Lunch Program shows that it is available to 92 percent of all students in the country, and provides 95 percent of the RDA for protein, on average.

III. Summary of Results

The differences in nutrient adequacy among poor and non-poor children are shown in Table 1 below. Significantly larger proportions of poor children have intakes below 70 percent of the RDAs for ten of the sixteen nutrients. Moreover, these differences in intakes appear for nutrients considered crucial to sound health and normal development. The proportions in Table 1 were derived from both CSFII samples, and reflect results with the greatest statistical significance. Where differences were not statistically significant, the proportions with the largest difference are shown (see the Technical Appendix for additional detail on the samples).

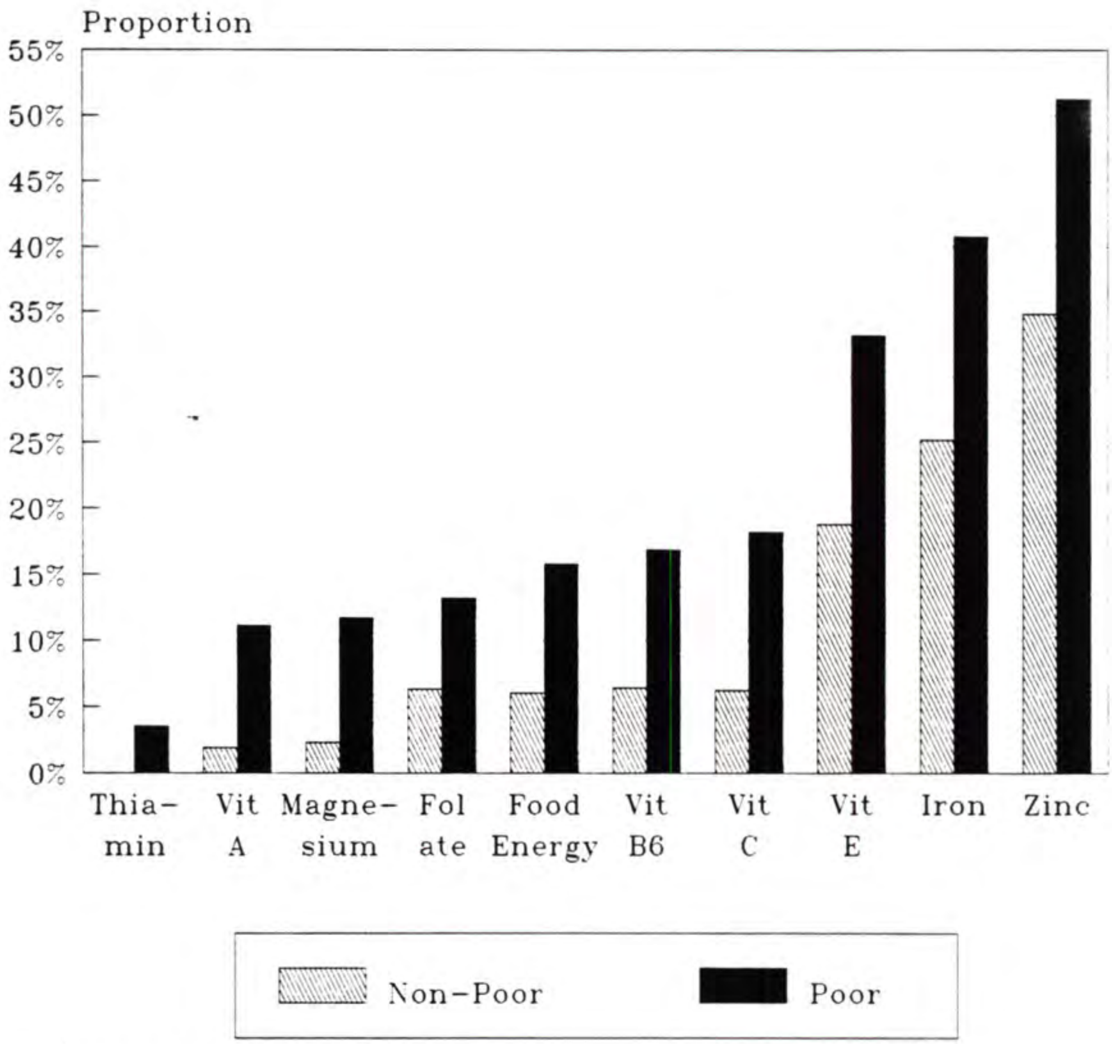
Table 1: Proportion of Children Ages 1-5 With Nutrient Intakes Below 70 Percent of the Recommended Dietary Allowances

Nutrient	% Non-Poor Children	% Poor Children
Food Energy *	**6.00**	**15.80**
Calcium	15.80	19.40
Folate *	6.30	13.20
Iron *	25.20	40.80
Magnesium *	2.30	11.70
Niacin	1.32	4.30
Phosphorus	3.50	6.10
Protein	0.00	0.80
Riboflavin	0.00	1.70
Thiamin *	0.00	3.50
Vitamin A *	1.90	11.10
Vitamin B6 *	6.40	16.90
Vitamin B12	1.90	3.10
Vitamin C *	6.20	18.20
Vitamin E *	18.80	33.20
Zinc *	34.80	51.20

* Differences statistically significant at the .05 level.
Source: CSFII; Women 19-50 Years and their Children 1-5 Years, and Low-Income Women 19-50 Years and their Children 1-5 Years, 4 Days, 1986, Tables 6A-6H.

The results from Table 1 above are also shown in Figure 1 below. This figure graphically illustrates the magnitude of differences in the proportions of poor versus non-poor children with substandard intakes found to be significant.

Figure 1: Proportion of Poor and Non-Poor Children Ages 1-5 With Nutrient Intakes Below 70 Percent of RDAs



Source: CSFII, 1986, overall and low-income samples.
Differences significant at .05 level.

Table 2 below shows the differences in percent of poor and non-poor children with intakes below 70 percent of RDAs for the selected nutrients. Also shown are the estimated numbers of poor children with inadequate intakes of each nutrient, based on Census Bureau child poverty data for 1986 and 1993.

The proportions of poor children with deficient intakes are significantly higher than the proportions for non-poor children on ten of the sixteen nutrients tested[7]. These findings suggest that large numbers of American children are not receiving adequate nutrients, and that poor children are at greater risk of inadequate nutrient intake than non-poor children. These findings also corroborate other evidence indicating that food insecurity and hunger are widespread problems among poor children.

Table 2: Percent Differences in Proportions of Poor and Non-Poor Children With Nutrient Intakes Below 70 Percent of RDAs in 1986, and Estimated Number of Poor Children Affected in 1986 and 1993

Nutrient	Percent Differences, Poor vs Non-Poor	Estimated Number of Poor Children Affected in 1986	Estimated Number of Poor Children Affected in 1993
Thiamin	NA	0.2 million	0.3 million
Vitamin A	484.21%	0.7 million	0.9 million
Magnesium	413.16%	0.7 million	0.9 million
Folate	118.91%	0.8 million	1.0 million
Food Energy	163.33%	1.0 million	1.2 million
Vitamin B6	164.48%	1.1 million	1.3 million
Vitamin C	192.60%	1.1 million	1.4 million
Vitamin E	76.60%	2.1 million	2.6 million
Iron	61.90%	2.5 million	3.2 million
Zinc	46.96%	3.2 million	4.0 million

Source: CSFII; Women 19-50 Years and their Children 1-5 Years, and Low-Income Women 19-50 Years and their Children 1-5 Years, 4 Days, 1986, Tables 6A-6H. Bureau of Census, Current Population Reports, Series P60-188 (Preliminary Excerpts), and unpublished reports from the March 1987 CPS.

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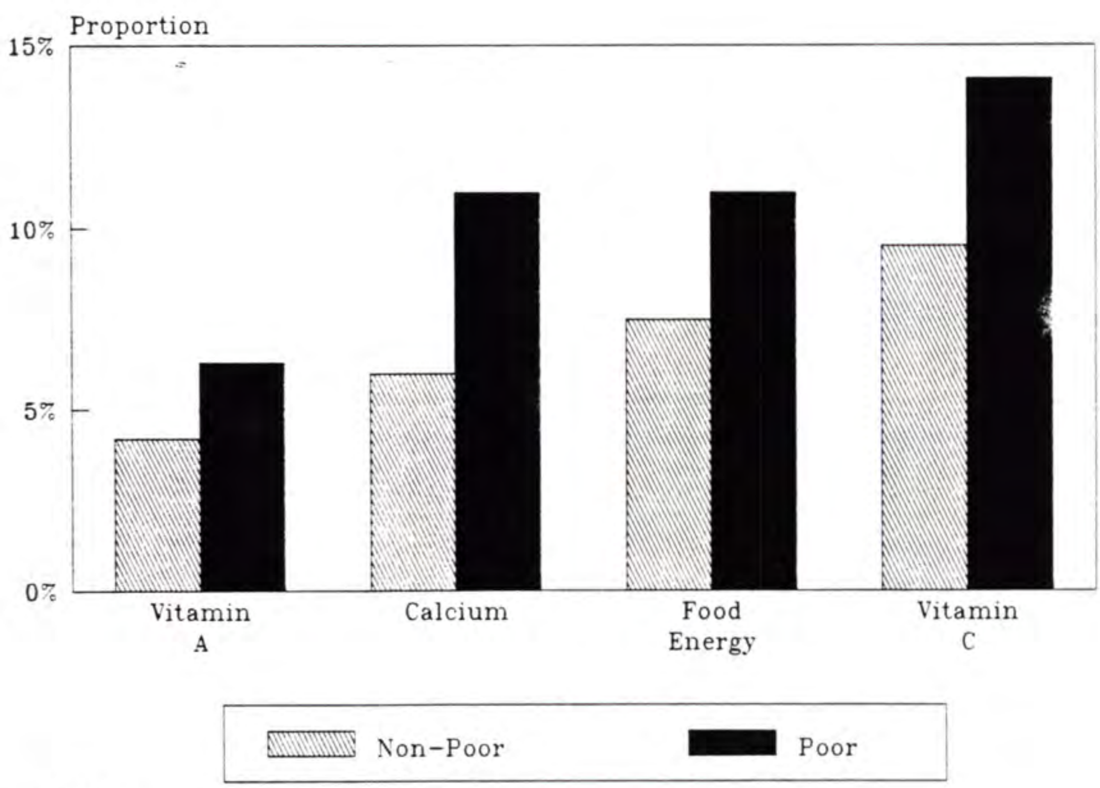
[7] Tests were made using both a "Z score," or standardized score approach, and the more typical Chi-Squared statistic. The significance levels used in the tests are indicated in the text tables. The estimated number of poor children affected in 1993 assumes the 1986 proportions are also applicable in 1993. Several factors which might influence their applicability in years after 1986 are discussed in the Technical appendix.

These findings are consistent with the National Health and Nutrition Examination Survey (NHANES II). Data from the NHANES II for children ages 3-5 show significantly higher proportions of poor children with intakes below <u>50 percent</u> of the RDAs for three important nutrients for which significant differences are found in the CSFII data (food energy, vitamin A, and vitamin C). In addition, the NHANES II data also show a significantly higher proportion of children with inadequate intakes of Calcium.

The results from the NHANES II analysis are shown in Figure 2 below. While the ages of children reported from the NHANES II differ from those surveyed in the CSFII, as do the time periods covered and the methods used, both show significant differences in nutrient intakes among poor and non-poor children. Taken together, the results from analysis of these two nutrient intake datasets provide consistent and compelling evidence that a sizeable proportion of poor children suffer from inadequate intakes of key nutrients.

Figure 2: Proportion of Poor and Non-Poor Children
Ages 3-5 With Nutrient Intakes Below 50 Percent of RDAs



Source: NHANES II, 1976-1980.
Differences significant at .05 level.

IV. Description of Nutrients and Their Importance for Child Development

Food Energy

Food energy (measured by overall caloric intake), stored in the liver as glycogen, is required for all life processes, including maintenance of body temperature, muscle movement, and growth and repair of bones and tissues. Unlike the RDAs for other nutrients which are set above observed average intake levels, the RDAs for food energy are set *at* the observed average of the intake levels for various sub-populations. Thus children with food energy intakes below 70 percent of the RDAs are consuming fewer calories than are consumed on average by about *two-thirds* of the people of comparable age and gender[8].

The small size of children's livers, relative to total body mass, necessitates that they eat more frequently than adults to ensure adequate supplies of food energy for normal activity, learning and functioning. Whitney & Rolfes (1993, p. 520) note, for example, that "a child's liver can store only about four hours' worth of glycogen - hence the need to eat fairly often." Inadequate food energy intake can cause problems with attention, concentration, learning, and other important daily activities. For children who have not eaten breakfast, the educational value of a morning spent in the classroom may be lost. Repeated episodes of inadequate food energy intake can lead to cumulative deficits in learning, lower academic achievement, higher rates of school failure, and even cognitive impairment (Center on Hunger, Poverty and Nutrition Policy, Tufts University School of Nutrition, 1995).

The proportions of poor and non-poor children with intakes of food energy below 70 percent of the RDA from the CSFII are shown in Figure 3 below. The principle importance of the results shown in Figure 3 is that the proportion of poor children with substandard food energy intake is nearly three times that for non-poor children. This difference is statistically significant at the .05 level.

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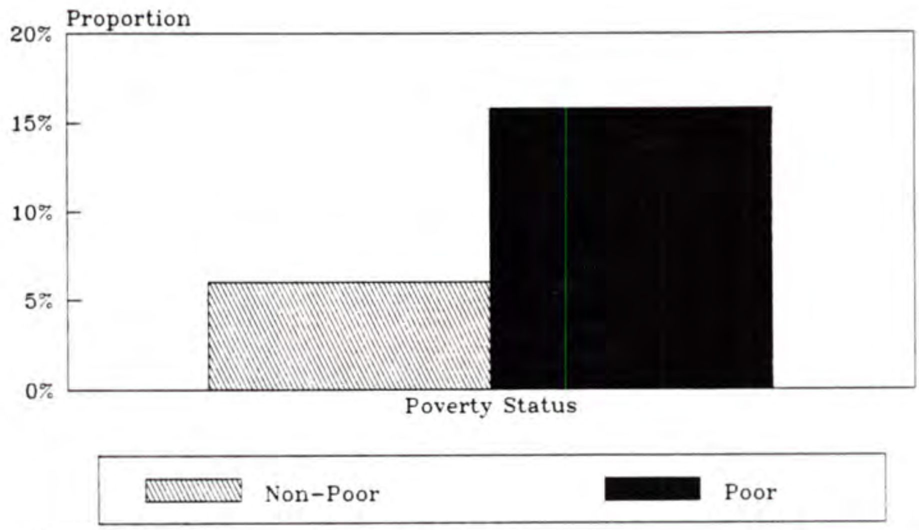
[8] Since the RDAs for food energy are set at the observed mean intake levels for each age-gender subgroup, 70 percent of the RDAs is approximately one standard deviation below the mean. Since the mean of a normal distribution plus or minus one standard deviation unit comprises approximately 64 percent of the distribution, 70 percent of the RDAs is an intake level above which approximately two-thirds of the distribution falls.

Figure 3: Proportion of Poor and Non-Poor Children
With Intakes of Food Energy Below 70 Percent of RDAs



Source: CSFII, 1986.
Difference Significant at .05 level.

Micro-nutrients, Vitamins and Minerals

The National Academy of Sciences sets RDA's for the fifteen other nutrients examined in this study above the observed average population intakes (rather than at the mean, as is the case for food energy) to provide a "safe nutritional margin" for most people. Therefore, as Senauer (1991, p. 222) points out, "The proportion receiving less than 70% of the RDA is a better indicator of potential nutrition problems than the average or mean percent of the RDA consumed for a nutrient."

In the following paragraphs the roles of the nutrients for which significant differences were found in this analysis are described, along with primary food sources, and potential results of deficiencies. As these paragraphs indicate, adequate nutrient intake is critical to maintenance of sound health and prevention of disease. Children with intakes of key nutrients below 70 percent of RDAs are at greater risk of health problems, are less likely to succeed in school, and are more likely to require costly interventions and support as they grow older (Center on Hunger, Poverty and Nutrition Policy, Tufts University School of Nutrition, 1995; Hamilton, Whitney nd Sizer, 1994; Karp, 1993; Pollitt, 1994).

Vitamin A

Vitamin A is essential for vision, bone growth, tooth development and reproduction. Vitamin A acts as an antioxidant -- and helps decrease the risk of chronic diseases such as cancer and cardiovascular disease. Vitamin A deficiency can lead to night blindness, growth failure due to poor bone growth, and, in severe cases, neurological damage.

Food sources of vitamin A include liver, eggs, dairy products and breakfast cereals. Sources of carotenes, which can be converted to vitamin A, include dark-green leafy vegetables, yellow vegetables, and yellow fruits.

Recent research by Semba (1994) indicates that vitamin A "has a dramatic impact on the severity of infectious disease morbidity and on childhood mortality." Semba also reports that "improved vitamin A nutriture is expected to prevent 1.3 to 2.5 million deaths annually" among children worldwide.

According to a report from the National Nutrition Monitoring and Related Research Program (NNMRRP), "Households with higher income per capita reported using food with more vitamin A per person than did lower income households. Both White and Black individuals with incomes above the poverty level were more likely than those below poverty level to have intakes of at least the RDA" (Nutrition Monitoring in the U.S., 1986, p.101). Smallwood, Blisard, and Blaylock (1991) report that average weekly expenditures for fresh fruits and vegetables are up to 25 percent higher among families whose incomes fall in the highest quintile (the highest 20 percent) than for families in the lowest quintile.

Iron

The human body needs iron to form red blood cells and for fighting infections.

Food sources of iron include red meat, chicken, fish, grains, eggs, beans, and dark green leafy vegetables. Vitamin C also aids in the body's absorption of iron.

A person deficient in iron can experience reduced productivity, fatigue and increased distractibility. Iron deficiency in children can lead to reduced learning ability and impaired cognitive development (Pollitt, 1994).

According to data from the U.S. Department of Labor's Consumer Expenditure Survey for 1988 and 1989, average annual expenditures for meats, poultry, fish and eggs by households from the highest two income quintiles combined (the top 40 percent of households) were 64-69 percent higher than for the bottom two quintiles combined (the lowest 40 percent of households).

Vitamin E

Vitamin E is needed by the body as an antioxidant and for stabilizing cell membranes. It also helps protect the lungs against air pollutants.

The major food sources of vitamin E are foods containing fats and oils.

Symptoms of vitamin E deficiency include a loss of muscle coordination, weakness, and difficulty walking. Prolonged vitamin E deficiency causes problems in the nervous and muscular systems.

Magnesium

The primary functions of magnesium are in muscle contraction, maintenance of healthy teeth, and the building of proteins.

Food sources of magnesium include whole-grain products, most dark green vegetables and milk.

When magnesium deficiency occurs, a person experiences weakness or confusion, and in children growth failure can occur. "Dietary levels of magnesium appeared to be positively associated with economic status. Households with higher income per capita reported using food providing more magnesium per person than did lower income households" (Nutrition Monitoring in the U.S., 1986, pp. 159-160).

Vitamin B6

Vitamin B6 is critical for red blood cell production, and aids in various kinds of cell reactions.

Food sources for vitamin B6 include meat, chicken, fish, bananas and nuts.

Vitamin B6 deficiency causes weakness and irritability. Advanced symptoms include growth failure. "Households with higher income per capita reported using food providing more vitamin B6 per person than did lower income households" (Nutrition Monitoring in the U.S., 1986, p. 127).

Vitamin C

Vitamin C plays several roles in the body. It strengthens blood vessel walls, aids in formation of scar tissue, strengthens resistance to infection, and helps in the absorption of iron. Similar to vitamin A, vitamin C helps reduce the risk of a number of chronic diseases, including cancer.

The major food sources of vitamin C are citrus fruits. Other fruits, potatoes, and dark green vegetables also contain vitamin C.

Vitamin C deficiency causes bone fragility, failure of wounds to heal, and in extreme cases can cause scurvy. Anemia and infections are also more common when there is a lack of vitamin C in the diet. "Economic status appears to be positively correlated with dietary levels of vitamin C; that is, individuals above the poverty level had higher intakes than those below had." (Nutrition Monitoring in the U.S., 1986, p.9)

Zinc

Zinc assists in the immune functions of white blood cells, in blood clotting, and in growth and development. Zinc also affects behavior, learning and task performance.

Zinc is found in relatively expensive foods, such as shellfish, meat, chicken, cheese, and nuts.

Research has shown that even mild zinc deficiency can result in impaired immune response, night blindness, and mental lethargy (Whitney and Rolfes, 1993, p. 420). Both iron and zinc deficiencies are associated with growth retardation. Like iron, zinc is displaced by lead ingested or absorbed from the environment. Thus, maintenance of adequate levels of zinc in the body is also important in preventing the systemic damage caused by lead toxicity in children.

Folate

Folate is required by the body for the production of red blood cells and genetic material. Deficiencies of folate can cause anemia, weakness and forgetfulness.

Food sources of folate include dark green vegetables, fruits, meat and grain products.

Research has shown that even mild folate deficiency reduces the capacity of immune cells to kill infection. Folate deficiency also causes similar mental symptoms as anemia, tiredness, apathy, weakness, forgetfulness, mild depression, irritability, headache, disorientation, confusion, and inability to perform simple calculations (Hamilton, Whitney and Sizer, 1994).

Thiamin

Thiamin is involved in the release of energy, plays an important role in cell reproduction, and is necessary for normal functioning of the nervous system.

Food sources of thiamin include grain products, meat, poultry, fish and vegetables.

Thiamin deficiency negatively impacts the nervous and cardiovascular systems. Advanced thiamin deficiency disease (which is extremely rare in the U.S.), known as beriberi, is characterized by loss of sensation in the hands and feet, muscular weakness, advanced paralysis, and abnormal heart action.

V. Health Outcomes

Because poor children receive significantly lower amounts of key nutrients than non-poor children, they also face greater health risks. A number of studies have shown that poor children are at greater risk of being born with low or very-low birth weights, are at greater risk of iron deficiency anemia, and have a higher prevalence of stunting (low height for age) and wasting (low weight for height) when compared to non-poor children (see for example, Nutrition Monitoring in the U.S., 1986 and Yip et al., 1992).

Iron Deficiency and Anemia

Iron deficiency is the most common nutrient deficiency in young children and adolescents. There are three stages in the depletion of iron in the body. First, iron stores begin to decline in the body. Second, as the level of iron in the bloodstream declines, production of red blood cells is reduced. The third stage results in anemia, characterized by the production of small pale-red blood cells incapable of carrying sufficient oxygen from the lungs to the tissues of the body to maintain adequate energy levels. Anemia causes fatigue, weakness, headaches, and apathy.

Iron not only aids in transport of oxygen through the blood, but is also used in the synthesis of neuro-transmitters. These highly important substances are critical to the ability to pay attention, and concentrate. Therefore, iron deficiency not only leads to a lack of energy, but also shortens attention span, interferes with concentration and task completion, and impairs the ability to learn. It also can contribute to depression and other dysfunctional affective states.

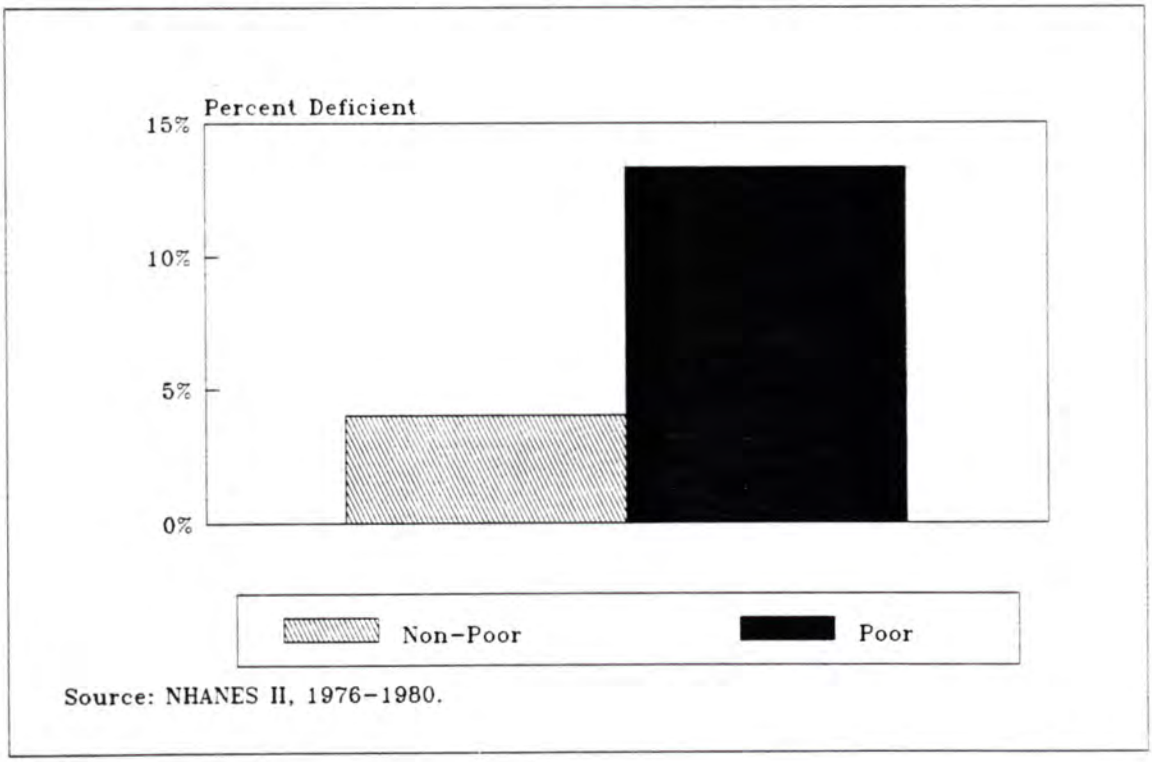
Numerous studies consistently have shown that children with iron-deficiency anemia score lower than non-iron-deficient children in control groups on a wide range of psychological tests, including developmental scales, intelligence tests, and tasks of specific cognitive function (Politt, 1994, pp. 284-286). Anemic children also have more behavior problems than their non-anemic classmates, and are more likely to be labeled "hyperactive," "depressed," or "unlikable" (Hamilton, Whitney & Sizer, 1994, p. 483-84).

Iron is also a critical element in dealing with toxic exposure to lead among children. Since lead is similar chemically to iron, it competes with iron for "sites" within the body. Displacement of iron and other similar nutrients is one of the primary ways lead damages the developing systems of young children, especially the nervous system, kidneys and bone marrow. Maintaining adequate iron nutriture (as well as iron therapy) is one of the most effective ways of ameliorating the effects of lead toxicity.

Several studies point to the high prevalence of iron deficiency and anemia among the poor. According to the NNMRRP, "Income below the poverty level was associated with higher prevalence of abnormal iron status in children 1-5 years of age." (Nutrition Monitoring in the U.S., 1986, p.164). The Second National Health and Nutrition Examination Survey (NHANES II) showed that 20.6 percent of poor children 1-2 years of age had impaired iron status, compared to 6.7 percent of non-poor. Moreover, 96 percent of poor children in the age group 1-2 years had diets that did not provide their RDA for iron.

Yip et al. (1992, p. 18) report data from the Pediatric Nutrition Surveillance System (PedNSS) indicating that the overall prevalence of anemia among the low-income population of children under two years of age monitored by this system ranges from 20 to 30 percent. This prevalence for young low-income children is much higher than the national prevalence of 5 percent for children of comparable age from all income levels combined. Overall measures of the prevalence of iron deficiency for poor and non-poor children ages 1-4 from the 1976-80 NHANES II are shown in Figure 4 Below.

Figure 4: Prevalence of Iron Deficiency Among
Poor and Non-Poor Children Ages 1-4 Years



Stunting and Wasting

When height is shorter than normal for a child's age, it is referred to as "stunting." Stunting is an indicator of a child's long-term or chronic nutritional status. The prevalence of stunting is much greater for poor children than for non-poor children. According to data from the NHANES II, the prevalence of stunting is about twice as high for poor children. Over 14 percent of poor girls and over 11 percent of poor boys (ages 2-5 years) are stunted, whereas slightly less than 6 percent of non-poor girls and boys the same age are stunted (Nutrition Monitoring in the U.S., 1986, p. 213).

Data from the NHANES II show that stunting is "consistently higher among the population below the poverty level than among persons above the poverty level." (Nutrition Monitoring in the U.S., 1986, p. 198). Data compiled for the Pediatric Nutrition Surveillance System (PedNSS) over the period 1973-1988 consistently show 9-11 percent of the low-income population it monitors is stunted (Nutrition Monitoring in the U.S., 1989, p. 86). The expected prevalence of stunting in the reference population is 5 percent.

If food energy intake is severely inadequate, a child loses weight and has a low weight-to-height ratio. This condition is termed "wasting," sometimes called "thinness". Data compiled for the Pediatric Nutrition Surveillance System (PedNSS) over the period 1973-1988 consistently show 3-4 percent of the low-income population it monitors having weight for height indicative of wasting (Nutrition Monitoring in the U.S., 1989, p. 85-86).

Obesity

It has been argued that the prevalence of obesity among some low-income populations provides evidence that hunger is not a problem for poor Americans[9]. The consensus within the medical and nutrition fields is "that obesity is not a single, unitary disorder, but rather a collection of disorders that share the common feature of excess accumulation of fat tissue and a series of associated metabolic disorders" (Greenwood et al., 1993, p. 116).

Multiple factors contribute to the etiology of obesity, including nutritional, metabolic, endocrinological, and genetic factors. Moreover, recent evidence from epidemiological studies indicates that the prevalence of obesity is also strongly influenced by cultural and social determinants. Economic, racial, gender, and ethnic factors interact with physiological factors to produce diverse prevalence of obesity in the population (Greenwood et al., 1993, p. 116).

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[9] See for Example the Heritage Foundation Backgrounder # 843, "Hunger and Malnutrition Among American Children," August 2, 1991.

Analyzing anthropometric data for children from the NHANES II and the PedNSS covering the period 1976-92, Yip, Scanlon, and Trowbridge (1993, pp. 413-415) find that, though the prevalence of overweight is less stable over the period than that for thinness, there is "no definite increasing trend over the 10-year period" (1980-89) among children below age 5 years. Yip and his colleagues conclude that "low-income children have a greater prevalence of shortness" (stunting), but "do not have a greater prevalence of overweight when compared with children from higher income families" (Yip, Scanlon, and Trowbridge, 1993, p. 409).

Dietz and Gordon (1981) and Dietz (forthcoming) present evidence that, in some cases, obesity may be a normal adaptive response to periodic episodes of insufficient food intake. Weight-cycling patterns among people suffering from periodic episodes of severe food deprivation lead to higher levels of body fat and less fat-free mass. Greenwood et al. (1993, pp. 117-118) also present evidence from a variety of ethnic groups that obesity follows leanness when people move out of conditions of severe deprivation caused by poverty, and into less severe conditions of poverty with adequate quantity (but substandard quality) of foods.

VI. Conclusion

Examining data from the CSFII, we found substantially higher proportions of poor children than non-poor children with intakes below 70 percent of the RDA's for 14 of 16 nutrients measured. Tests of the significance of differences between these proportions showed that for 10 of the 16 nutrients, the differences between the proportions were statistically significant.

Poor children are at risk of nutrient deficiencies which can lead to serious health problems, including impaired cognitive development, growth failure, physical weakness, anemia and stunting. Several of these problems can lead to irreparable damage to young children.

Millions of poor children suffer from chronic undernutrition, the under-consumption of essential nutrients and food energy. This undernutrition is apparent from the large proportions of poor children receiving less than 70 percent of recommended dietary intakes for the ten nutrients highlighted in this analysis.

According to current consensus within the scientific community, household food insecurity and hunger manifest in a progressive manner. As food insecurity worsens, it may eventually lead to hunger among members of the household, first among the adults, then among children. If hunger persists among the children in a family, or occurs with sufficient frequency, reductions in food intake lead to observable inadequacies in nutrient intakes of the kind identified in this analysis. The results of this analysis provide evidence consistent with widespread hunger among low-income American children.

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Technical Appendix

The variable used for comparisons in this analysis is the proportion of children age 1-5 years with intakes of each nutrient below 70 percent of the RDA. These data can be found in Tables 6A-6H of CSFII Reports No. 86-3 (Women 19-50 Years and their Children 1-5 Years, 4 Days) and 86-4 (Low-Income Women 19-50 Years and their Children 1-5 Years, 4 Days). Both the proportions and frequencies are weighted according to the proportions of the sample from each group.

The major analytical procedure undertaken was testing for significance of the differences in proportions of children with intakes of each nutrient below 70 percent of the RDAs from the "below low income" and "above low income" cells from each sample separately. In the CSFII the low income cutoff is household income at 130 percent of the poverty threshold. We compare proportions of children with intake below 70 percent of the RDA in households whose incomes were below 130 percent of poverty, to proportions of children with intake below 70 percent of the RDA in households whose incomes were 130 percent of poverty or above.

In this appendix we describe the CSFII samples and data sources in more detail, and comment on possible weaknesses arising from the nature of the data and methods used in this analysis. We also present results from tests of differences made from the two CSFII samples.

Description of the Two Samples and Sample Design Effects

A "low-income subsample" was derived from the overall CSFII multistage, stratified area sample, by oversampling sample-area segments in areas where the proportion of the population with income below 125 percent of the poverty threshold was higher (three poverty strata were created based on the proportion of the population with income below 125 percent of poverty). The sample was drawn from all private households in the 48 contiguous states. The sampling and data collection procedures are described in some detail in Appendix A of both the reports listed above.

Due to variation in the spatial distribution of poverty within the U.S., the overall sample may not accurately represent the low-income population. Since nutrient intakes of poor families was a specific interest in the CSFII, and since poor families tend to be concentrated in urban areas, and in some rural areas, they may be under-represented in the overall sample. For this reason the "low-income" subsample was designed by CSFII researchers to oversample areas where the proportions of families with incomes below 125 percent of the federal poverty threshold were higher. Since the "low-income" sample oversamples poor families, the non-low-income component of the "low-income" sample may not accurately represent the total non-low-income population. For these reasons, we made the comparisons and tests in this analysis using each sample separately.

In making the comparisons, we found significant outcomes for some nutrients within the overall sample for which the outcomes were not significant in the "low-income" sample, and vice versa. In Table 1 in the text, the proportions for which significant differences were found from either sample are combined to simplify presentation. The proportions and results of tests using data from the two different samples are presented separately in Appendix Tables 1 (overall sample) and 2 (low-income sample) below.

Appendix Table 1: Proportion of Children Ages 1-5 With Nutrient Intakes Below 70 Percent of the Recommended Dietary Allowances

Nutrient	Non-Poor	Poor	Significant
Food Energy	**7.58**	**13.80**	**
Calcium	16.61	17.80	
Folate	6.30	13.20	*
Iron	44.80	47.50	
Magnesium	2.30	11.70	*
Niacin	1.32	4.30	**
Phosphorus	1.45	2.70	
Protein	0.00	0.00	
Riboflavin	0.35	0.00	
Thiamin	0.00	3.50	*
Vitamin A	2.16	6.00	**
Vitamin B6	6.40	16.90	*
Vitamin B12	1.06	1.80	
Vitamin C	6.20	18.20	*
Vitamin E	30.71	40.30	**
Zinc	34.80	51.20	*

* Differences statistically significant at the .05 level.
** Differences statistically significant at the .08 level.
Source: CSFII; Women 19-50 Years and their Children 1-5 Years, and their Children 1-5 Years, 4 Days, 1986, (overall sample) Tables 6A-6H.

Appendix Table 2: Proportion of Children Ages 1-5 With Nutrient Intakes Below 70 Percent of the Recommended Dietary Allowances

Nutrient	Non-Poor	Poor	Significant
Food Energy	**6.00**	**15.80**	*
Calcium	15.80	19.40	
Folate	11.80	8.70	
Iron	25.20	40.80	*
Magnesium	5.50	10.20	
Niacin	0.00	2.80	
Phosphorus	3.50	6.10	
Protein	0.00	0.80	
Riboflavin	0.00	1.70	
Thiamin	0.00	0.60	
Vitamin A	1.90	11.10	*
Vitamin B6	4.00	12.00	*
Vitamin B12	1.90	3.10	
Vitamin C	5.50	7.50	
Vitamin E	18.80	33.20	*
Zinc	40.40	40.50	

* Differences statistically significant at the .05 level.
Source: CSFII; Low-Income Women 19-50 Years and their Children 1-5 Years, and their Children 1-5 Years, 4 Days, 1986, (low-income sample) Tables 6A-6H.

The tests of significance were made using a Z-score (standard score) statistic, and were then repeated using the more typical Chi-square test. The overall test results were essentially the same for both statistics[10]. Note that for the nutrient folate in the low-income sample the proportions with intakes below 70 percent of RDAs are not significantly different (i.e., statistically they may in fact be the same), yet the order of the comparative difference is reversed from its appearance in the overall sample. Since the proportions are statistically indistinguishable in the low-income sample, this is most likely an artifact.

[10] These test statistics are described in detail in most applied statistics texts. See, for example Matlack, W. F., (1980) Statistics for Public Policy and Management, pp. 290-297, Duxbury Press, Boston, MA.

Part of the dissimilarity in results from the two samples may derive from differences in the sizes of the low-income and non-low-income components in each. In the overall sample, for example, there were a total of 98 children from families below the low-income cutoff, and 260 from families above the cutoff. In the "low-income" sample, on the other hand, there were 395 children from low-income families and 67 from families above the low-income cutoff. While there were no "sparse" cells (cells with fewer than five children) in the 2X2 (two income categories by two intake levels) tables used for calculating the test statistics, the differences in relative composition of each sample may explain some of the differences in results from the two samples.

Because of the multi-stage stratified sampling design used in the CSFII, there may be correlation among the proportion estimates derived from the data. To the extent that these design effects are present in the CSFII data, they introduce an additional source of potential error which could lead to underestimation of variances (and standard errors) of estimates derived from the CSFII data. The underestimation could be greater the more the sampling design deviates from simple random sampling.

Statistical techniques for estimation of, and adjustment for, design effects in survey data have been incorporated into computer software for analysis of primary survey data. The data used in this analysis were obtained from summary tabulations compiled and published by the USDA, as the primary data were not readily available. Since it was not possible to determine design effects adjustments, no further adjustments were made in the tests performed in this analysis.

Evolution of the USDA Food and Nutrient Database

Refinement of the food and nutrient databases developed by USDA and used in national food consumption and nutrient intake surveys is ongoing. As technological advances are made in the assessment of nutrient content of foods, and as food industries create and market greater variety, the food and nutrient databases used to analyze nutrient intakes are improved and changed. Nutrient intakes measured and reported in the 1989-91 CSFII will vary somewhat as a result of improvements in the food and nutrient data bases.

Likewise, the databases used to analyze nutrient intakes in 1986 may not have allowed as accurate measurement of actual nutrient content of foods as the more recently updated versions. To the degree that the food and nutrient databases used in compilation of the 1986 CSFII were incomplete, the nutrient intake data may not be complete, and the results of the analysis may be biased. Any source of error affects the extreme parts of any distribution more than the middle part. Thus any error in measurement of nutrient intakes would increase the variance more among children with intakes below 70 percent of the RDAs, and tend to make standard errors of estimates involving these children larger. This could lead to nonsignificance of differences which might otherwise be statistically significant, by making confidence intervals around the proportions larger. To the extent that this happened, estimates herein could be conservative.

Effects of Nutrient Fortification of Foods

Increasing nutrient fortification of pre-packaged and prepared foods available to Americans may also affect measures of nutrient intake among children. Though largely beneficial, nutrient fortification can introduce additional sources of error into measurements of nutrient intake. More important for this analysis, if either poor or non-poor children tend to systematically consume more (or less) fortified foods, this could introduce additional error into nutrient intake differences among poor and non-poor children. Moreover, if poor children tend to consume greater amounts of fortified foods, measures of their nutrient intakes may present a distorted view of their overall food intakes. This may also partially explain why the analysis detected significant differences for some nutrients and not others.

Current nutrition science emphasizes the benefits of food variety in dietary consumption, with special importance placed on fresh fruits and vegetables, and foods high in dietary fiber. This is because there are benefits derived from foods in addition to their narrowly measured nutrient content. Moreover, nutrients provided by fortification or supplementation alone do not provide all the benefits which accompany consumption of a varied and balanced diet. As the state of nutrition science evolves, the understanding of the overall benefits of foods increases. At present that understanding strongly suggests that children need to eat a varied and well-balanced diet, and that they cannot obtain the same benefits from fortification and supplementation alone.

Effects of Federal Nutrition Programs

Many poor children ages 1-5 benefit from several federal nutrition programs, including the WIC program, food stamps, child care feeding programs, and the national school lunch and breakfast programs. Evidence from a number of studies indicates these programs have had dramatic success in improving the overall nutritional status of poor children in the U.S.

The significant differences in proportions of poor and non-poor young children with inadequate nutrient intakes identified in this analysis occurred in spite of the federal nutrition programs. Without the federal programs there may well have been even larger proportions of poor children with inadequate intakes, and even greater differences between poor and non-poor children. It is known, for example, that while federal programs significantly improve the nutrition and health status of the pediatric population, the programs are unavailable to many youngsters who need them.

Changes in the RDAs Between 1980 and 1989

The RDAs upon which the 1986 CSFII tabulations are based were updated in 1989. Some of the standards changed for children ages 1-5. To the extent that RDAs for a particular nutrient declined (or increased) with the 1989 update, the proportion of children with intakes below 70 percent of the RDAs under the updated standards may also decline (or increase).

The RDAs are established for age intervals 0-5 months, 6-11 months, 1-3 years, 4-6 years, and 7-10 years. Since the age interval 1-5 includes two separate RDAs, the overall effects of changes in the RDAs depend on the change for each age interval (1-3 years and 4-6 years), and the nutrient intakes of children within each age interval. For some nutrients the RDAs changed for only one of the two age intervals, while for others they changed for neither or both. Appendix Table 3 shows the combinations of changes resulting from the 1989 update of the RDAs.

Appendix Table 3: Changes in the Recommended Dietary Allowances For Age Intervals 1-3 Years and 4-6 Years From 1980 to 1989

Nutrient	Ages 1-3	Ages 4-6
Food Energy	**No change**	**Increased**
Calcium	No change	No change
Folate	Declined	Declined
Iron	Declined	No change
Magnesium	Declined	Declined
Niacin	No change	Increased
Phosphorus	No change	No change
Protein	Declined	Declined
Riboflavin	No change	Increased
Thiamin	No change	No change
Vitamin A	No change	No change
Vitamin B6	Increased	Increased
Vitamin B12	Declined	Declined
Vitamin C	Declined	No change
Vitamin E	Increased	Increased
Zinc	No change	No change

Source: Hamilton, Whitney and Sizer, 1991, pp. 133-34; NFCS, CSFII Report No. 86-3, Appendix D.

As can be seen from Appendix Table 3 above, the overall net effect on the results of this analysis from changes in RDAs resulting from the 1989 update is ambiguous. For three of the nutrients for which significant differences were found, the RDA for at least one of the two age intervals increased (food energy, vitamin B6, and vitamin E). For four of the nutrients with significant differences the RDA for at least one of the two age intervals declined (folate, iron, magnesium, and vitamin C). And for three of the nutrients with significant differences there was no change (thiamin, vitamin A, and zinc). It is noteworthy that the food energy RDA for children ages 4-6 increased, further underscoring the importance of food energy in young children.

About the Center

The Center on Hunger, Poverty and Nutrition Policy was established at Tufts University in 1990. Its purpose is to advance public policy choices which reduce hunger and poverty, and enhance the development and productive capacities of American families and children. The Center carries out policy research and analyses, and works with governmental leaders and the media to promote greater understanding of policy alternatives for the nation.

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ERRATA SHEET FOR

Differences in Nutrient Adequacy Among Poor and Non-Poor Children

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The following changes should be made to the document dated March 1995. We apologize for any inconvenience caused by these errors.

1) Page 9, Table 2: Make the following changes. These errors are largely due to rounding.

   Magnesium: Change 413.16% to 408.70%

   Folate: Change 118.91% to 109.52%

   Vitamin B6: Change 164.48% to 164.06%. Change "1.1 million" to "1.0 million."

   Vitamin C: Change 192.60% to 193.55%

   Vitamin E: Change "2.1 million" to "2.0 million."

   Zinc: Change 46.96% to 47.13%. Change "3.2 million" to "3.1 million."

2) Page 11, Footnote 8: Change "64 percent" to "68 percent." Change "two-thirds" to "three-fourths."

3) Page 4, third paragraph, last sentence: Change "two-thirds" to "three-fourths."