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THE IMPACT OF NUTRITION EDUCATION ON DIETARY BEHAVIOR AND
IRON STATUS IN PARTICIPANTS OF THE SUPPLEMENTAL FOOD
PROGRAM FOR WOMEN, INFANTS AND CHILDREN, AND THE
EXPANDED FOOD AND NUTRITION EDUCATION PROGRAM

by

Nedra K. Christensen

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Nutrition and Food Sciences

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1993

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Nedra K. Christensen

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ABSTRACT

The Impact of Nutrition Education on Dietary Behavior and
Iron Status in Participants of the Supplemental Food
Program for Women, Infants and Children, and the
Expanded Food and Nutrition Education Program

by

Nedra K. Christensen, Doctor of Philosophy

Utah State University, 1993

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Dr. Rodney J. Brown

Department: Nutrition and Food Sciences

This study was conducted to determine the impact of nutrition education on participants of the Supplemental Food Program for Women, Infants and Children (WIC) and the Expanded Food and Nutrition Education Program (EFNEP). The specific objectives were to: 1) determine the impact of participation in EFNEP on iron status as assessed by hematocrit (hct) and ferritin levels; 2) determine the effect of nutrition knowledge on hct and ferritin values; and 3) determine the effect dietary behavior has on hct and ferritin levels for both WIC and EFNEP participants.

Each study participant completed a 24-hour dietary recall record plus food frequency record, medical history, validated nutrition knowledge test, and finger stick blood sample prior to program enrollment or nutrition education,

and again six months later. There were 42 WIC, 26 EFNEP, 23 WIC-control, and 23 EFNEP-control participants.

Paired t-tests were used to find differences between preprogram and postprogram evaluation scores for the variables of nutrition knowledge score, hematocrit level, ferritin level, and levels of several nutrients. Nutrition knowledge test scores increased significantly from preprogram to postprogram for both WIC and EFNEP participants (14.2 ± 3.27 to 15.5 ± 2.89 for WIC, 14.2 ± 3.77 to 15.6 ± 2.79 for EFNEP). EFNEP participants also increased significantly in hct levels ($38.5\% \pm 3.78$ to $40.7\% \pm 2.13$). Hematocrit levels did not change significantly for the WIC or control groups and nutrition knowledge did not increase for the control group between preprogram and postprogram evaluations.

Mean intakes of vitamin A, vitamin C, calcium, and protein were above the RDA at preprogram and postprogram evaluations, yet the percentage of individual participants who consumed less than 67% of the RDA in this study was higher than in the Continuing Survey of Food Intake of Individuals - 1985. Improvement in nutrient intake at postprogram evaluations was encouraging.

Regression analysis indicated that nutrition education classes in college, income level, and level of formal education each had a positive effect on nutrient intake and nutrition knowledge.

CHAPTER I

INTRODUCTION

Problems involving food and nutrition and thus health are found throughout the world. Malnutrition or undernutrition can result in mild symptoms such as weakness, headaches, and irritability, or be severe such as kwashiorkor, or even death. Lack of food availability, lack of nutrition knowledge, an increasing number of unfamiliar foods with questionable nutritional content, an overabundance of unsound nutrition information, and misleading labeling or marketing information are a few reasons for suboptimal nutritional intake. Correcting these problems has been attempted by providing education programs. Nutrition education has had a positive effect on nutrition knowledge, attitude, and behavior according to a meta-analysis of 303 nutrition studies (Johnson and Johnson, 1985).

Background of the Problem

Undernutrition of iron and protein can produce irreversible health effects such as increased rates of infection, low growth rates in children, and delayed motor and cognitive development (Galler, 1987; Pollitt et al., 1985; Soemantri et al., 1985). The United States Congress has recognized this problem and has allocated money for nutrition programs to educate and to provide supplemental

foods for those at highest risk, such as women and children.

One federally funded nutrition program is the Supplemental Food Program for Women, Infants, and Children (WIC). It provides nutrition education and nutrient dense foods (milk, cheese, eggs, beans, iron fortified cereals, and vitamin C fortified juices) for pregnant or lactating women, infants, and children under the age of five. WIC uses the hematocrit or hemoglobin finger stick blood value as one indicator of malnutrition. Hematocrit and hemoglobin values correlate with each other when correct techniques are used and indicate, when used interchangeably, similar iron status of the blood (Bull and Rittenbach, 1990; Yip et al., 1987b). They are inexpensive methods to screen for low iron stores, and either one may be used as a standard for screening for low iron status in the WIC program. Serum ferritin is a reliable indicator of tissue iron stores because it correlates with tissue ferritin. In the early stages of iron deficiency, ferritin stores decrease and are depleted before hematocrit or hemoglobin values indicate a deficiency (Lubin et al., 1980; Zeman, 1991).

The benefits of normal hematocrit levels (iron status) have been studied (Blot et al., 1981; Galler, 1987; Garn et al., 1981; Lubin et al., 1980; Stockman, 1987; Worthington-Roberts, 1987). In a national collaborative perinatal

project, the incidence of low birth weight and infant mortality correlated positively with low hemoglobin values (Garn et al., 1981). Children with malnutrition (specifically protein, kcalorie, and iron deficiency) exhibited significant delays in motor and cognitive development (Galler, 1987). Galler (1987) further summarized that behavioral impairment was the most permanent outcome of infant malnutrition. The cycle may continue with women who were low birth weight having low birth weight offspring.

Participation in the WIC program correlates positively with an increase in hematocrit or hemoglobin values as well as with other health indicators (Rush et al., 1988a). The authors emphasized that good long-term nutritional status is important by saying that the "behavioral and cognitive defects in children with iron deficiency anemia are not (fully) reversed by iron therapy. There were two logical explanations: either iron deficiency is not causally related to behavior, or if causally related, the deficits are the results of cumulative insult not easily reversible by rapid restoration of iron stores" (Rush et al., 1988a, p. 406).

The WIC program provides foods high in nutritional quality compared to kcalorie level. The WIC food package has been designed to be high in iron, calcium, vitamin C, vitamin A, and protein. These are termed nutrient-dense

foods. Providing vouchers for nutrient-dense foods has led to an increased proportion of household dollars spent on this type of foods (Rush et al., 1988a). The impact of early eating habits continuing through a lifetime has been reinforced by this practice (Rush et al., 1988a).

The Expanded Food and Nutrition Education Program (EFNEP) was developed to improve the nutrition and health of low income families by participant involvement in a series of nutrition education classes to improve nutrition-related skills (shopping for and preparing nutritious foods). Eating behavior improved in EFNEP participants as assessed by improvement in dietary records (DeTredici et al., 1988; Torisky et al., 1987).

Statement of the Problem

Nutrition education has a positive effect on nutrition knowledge, attitude toward nutrition, and dietary behavior according to a meta-analysis of 303 nutrition studies (Johnson and Johnson, 1985). The next question to ask is "do the positive improvements in nutrition knowledge and dietary behavior improve health?" Two federally funded nutrition programs have helped untangle part of this question, but neither has collected all the data to answer this question. Participation in WIC results in improved hematocrit level (Rush et al., 1988a). The WIC program has not documented that an increased level of nutrition

knowledge and dietary behavior correlates with the health assessment measurement of hematocrit. The EFNEP program has shown that eating behavior improves after nutrition education (Torisky, 1987, DelTredici et al., 1988). The EFNEP program lacks hematocrit measurements that would show whether improvements in nutrition knowledge improve iron status. A complete set of data from each of these programs would show whether improved nutrition knowledge improves dietary behavior and iron status.

Objectives

The objectives of this study were to:

- 1) determine the impact participation in the Expanded Food and Nutrition Education Program has on iron status as assessed by hematocrit and ferritin values.
- 2) determine the effect of nutrition knowledge on hematocrit and ferritin values for both the WIC and EFNEP programs.
- 3) determine the effect of dietary behavior on hematocrit and ferritin values for both WIC and EFNEP participants.

Research Design

Forty-two participants who were first-time enrollees to the WIC program and 26 first-time enrollees to the EFNEP

program were assessed for initial knowledge about nutrition by taking a validated nutrition test and by providing a 24-hour dietary recall record and a food frequency record. Hematocrit and ferritin values were also obtained. The Human Subjects Committee of the Institutional Review Board at Utah State University reviewed all procedures required of study participants to ensure that safety and confidentiality were practiced. For the WIC group, a child in the family served as the study participant. A hematocrit and ferritin were drawn from the child, and the parent/guardian of the child took the knowledge test and provided the written documentation on the child's 24-hour dietary recall record and food frequency record. For the EFNEP group, the hematocrit level, ferritin level, nutrition score, and dietary behavior score were all assessed on the women participants. These knowledge test scores, dietary behavior scores, and blood values were taken at the initial appointment for enrollment in the program and repeated six months later.

Twenty-three women who received nutrition education and were in the same socioeconomic group as EFNEP participants served as the EFNEP control group. One child of each of the control women served as control subjects for the WIC program. The women in the control group were measured for hematocrit and ferritin levels, took the validated nutrition test, and provided a 24-hour dietary

recall record and a food frequency record. The control children had hematocrit and ferritin levels measured, and their parent/guardian provided the written 24-hour dietary recall and food frequency for them. The parent/guardian's nutrition test score served as their assessment of nutrition knowledge. All tests and measurements were conducted initially and six months later for the control groups. Participants in WIC and EFNEP and control subjects signed informed consent documents outlining their involvement in the study, which included their right to withdraw. Data were collected and coded by identification numbers. Confidentiality was guarded for all study participants.

Hematocrit levels were collected by health department employees for the WIC program and by trained county employees for the EFNEP program. The hematocrit levels were collected according to health department policy. Four 0.5 mm hematocrit tubes were collected and spun according to protocol. The serum was saved and frozen to determine ferritin levels. Ferritin levels were determined using the method outlined by Diagnostic Products Corporation (Los Angeles, CA). Nutrition knowledge was assessed by administering the same validated nutrition test for both the WIC and EFNEP programs. Content validity was conducted to determine if the test matched the program's objectives. Construct validity was

conducted to determine if the test required the participant to identify and analyze the information to get a correct answer. Content and construct validity were obtained from registered dietitians working in both programs. Face validity, the term used to describe whether the test takers feel the test is representative of the information learned in the program, was obtained by administering the test to graduate participants from the programs. The test was measured for internal consistency as calculated by the Kuder-Richardson method (Carmines and Zeller, 1987).

Dietary behavior was assessed by analyzing a 24-hour dietary recall record using the Computrition software package (Computrition Inc., Chatsworth, CA). The WIC program in Utah uses a 24-hour dietary recall record and a food frequency record to aid in assessing nutrient intake. The WIC dietary form was used for all participants in this study to obtain consistency in data collection. The food frequency record was used to help assess the 24-hour dietary recall record when there was a discrepancy between the 24-hour recall record (only 1 cup of milk was listed for the day) and the food frequency record (3 cups of milk per day were listed). This situation would result in further questioning by the nutritionist. Food intake records were analyzed for calcium, iron, protein, vitamin A, and vitamin C since these are the nutrients WIC and

EFNEP programs consider critical.

Group nutrition education classes and individual instruction were provided to WIC participants as usual. At least two nutrition education contacts must be offered to WIC participants every six months as stipulated by federal law. Frequent nutrition class topics include infant nutrition, cooking with dried beans, prenatal nutrition, iron, calcium, protein, and other specific nutrients. In-depth nutrition education, with practice sessions in the home, were provided for EFNEP participants as usual. Twelve nutrition education lessons are outlined for the EFNEP program, including topics such as menu planning, shopping basics, sanitation, supplementing meals with the foods in the home, nutrients, fruits, vegetables, and cooking with dried beans.

Group recruitment of EFNEP participants was initiated as well as recruitment for individual EFNEP contacts. No effort was made to control for various levels of information provided since the purpose of this study was to evaluate current nutrition education practices on dietary behavior and iron levels. Four different WIC clinics and two different EFNEP units in Weber, Salt Lake, and Utah counties in Utah were involved in the data collection. The control group participants were recruited in Logan, Utah, a small university city. Control group participants had to meet the income guidelines for WIC and

EFNEP.

A medical history questionnaire was collected on each participant by the health or county employees to rule out any disorders that would cause low hematocrit or ferritin values.

The data for the groups were analyzed separately to control for the effects of supplemental foods provided to those on the WIC program and to control for differences in the two programs.

Significance

This is a key time to conduct this research since EFNEP is charged with expanding its program in the most efficient yet effective manner possible. The Utah WIC program spent all allotted food money for the first time in fiscal year 1989 and exceeded program budget during fiscal year 1990. Conducting the research will help aid the Utah programs develop efficient nutrition education programs and also provide baseline data for future evaluations of the programs.

Hypothesis

Participation in the nutrition education programs of the federally funded WIC or EFNEP programs will result in an increase in nutrition knowledge. This increase of nutrition knowledge will correlate positively with an

improved dietary intake and with improved health status (hematocrit and ferritin levels).

Working Hypothesis

- 1) Nutrition knowledge does not change after participation in the WIC or EFNEP programs.
- 2) Dietary behavior, as assessed by 24-hour dietary recall records and food frequency records, does not change after participation in the WIC or EFNEP programs.
- 3) A change in nutrition knowledge has no effect on dietary behaviors (as assessed by 24-hour dietary recall records and food frequency records), hematocrit levels, or ferritin levels.

Delimitations of the Study

Food stamp recipients were not excluded in the study due to the regulations that nutrient-dense foods or foods of lesser quality may be purchased with food stamps. Food purchasing habits of persons using the Food Stamp Program could represent those of the total population.

CHAPTER II

REVIEW OF LITERATURE

Improvement in health is dependent on receiving the essentials of nutrition, immunization, and sanitation (Harper, 1987; Robinson and Lawler, 1982; Whitney et al., 1987). Nutrition has a major impact on health. Immunity against diseases, increased work output, and ability to concentrate are all dependent on adequate nutrition (Galler, 1987). To provide individuals with accurate nutrition facts, scientific information about nutrition must be communicated through nutrition education classes. This education provides individuals with tools to make correct decisions about foods and nutrition. The incidence and effects of anemia, nutrition education techniques, and the impact of federal food and nutrition programs have been studied in certain groups of people.

Definition of Anemia

The major functions of iron include transport of oxygen from the lungs to the tissues, transport of carbon dioxide from the cells to the lungs, and the process of cellular respiration. The transfer of oxygen and carbon dioxide is accomplished by hemoglobin in the erythrocyte and myoglobin in the muscle cell. The cytochromes, present in all cells, function in the respiratory chain by transferring electrons and storing energy through alternate

oxidation and reduction of iron. Three forms of iron comprise 60-70% of the total iron in the body and are classified as essential iron components (adult body contents average 2.5-3.0 gm of hemoglobin, 150 mg of myoglobin, and 300 mg of iron in the respiratory enzymes).

The remaining 30-40% of iron in the body is classified as storage iron or transfer iron (adult body contents average 200-1500 mg of ferritin and hemosiderin, and 3-4 mg transferrin). Ferritin is the major storage form of iron. Up to 50 mg per day can be mobilized from storage iron. Approximately 20 mg of iron are used daily in hemoglobin synthesis, and if dietary intake does not meet this need, storage iron is mobilized. Conversely, when abnormally large amounts of iron are present, the apoferritin (which in the liver becomes ferritin when iron is added) becomes saturated and hemosiderin appears in large quantities. Hemosiderin is similar to ferritin, but contains more iron and is very insoluble.

Transferrin is responsible for the transfer of iron to the site-of-need or to storage. The rate at which iron is released from the mucosal cells in the intestinal wall into general circulation is regulated by the total amount and degree of saturation of transferrin. Transferrin is usually saturated to approximately one third of its total iron-binding capacity. If iron is not needed, transferrin remains saturated, and less iron is absorbed from the

intestinal mucosa. If iron is needed, the transferrin is less saturated when it reaches the intestinal mucosal cells, and more iron passes from the mucosal cells to the transferrin.

The three main causes of iron depletion are: 1) chronic blood loss, such as from chronically bleeding peptic ulcers, hemorrhoids or parasites, or malignancy; 2) faulty iron intake or absorption; and 3) increased iron requirement for expansion of blood volume which occurs in infancy, puberty, pregnancy, and lactation.

Iron deficiency is often separated into three stages: 1) iron deficiency, which is characterized by the absence of iron stores; 2) iron-deficient erythropoiesis, which is a demonstrated insufficient supply of iron to the erythron; and 3) iron deficiency anemia, when an insufficient supply of iron to the erythron has reduced the hemoglobin concentration below two standard deviations of the normal hemoglobin distribution specific for age, sex, and altitude (Hallberg and Rossander-Hulten, 1991). To discriminate among the stages of iron deficiency, the hemoglobin (hbg) or hematocrit (hct) level must be combined with other biochemical tests. Since hematocrit and hemoglobin are affected late in the disease, they do not indicate the type of anemia. There is also a wide range of values in normal subjects, making anemia difficult to diagnose.

Serum ferritin is a simple and reliable estimate of

iron stores, provided inflammation, malignancies, infection, and liver disease have been excluded. In the normal adult, 1 mcg of ferritin is roughly equivalent to 8 mg of storage iron. To express this relationship on a per kilogram basis, 1 mcg serum ferritin is equivalent to approximately 120 mcg storage iron per kilogram. Normal serum level of serum ferritin is greater than 20 ng/ml in the adult and greater than 12 ng/ml in the child (Finch and Cook, 1984). In the early stages of iron store depletion, ferritin and hemosiderin are depleted.

Transferrin saturation is a gauge of iron supply to tissues. The total iron binding capacity (TIBC) of transferrin rises as iron stores in the bone marrow and the liver decrease. Values less than 16% in the adult and child suggest that iron deficiency is inhibiting normal erythropoiesis. Specifically, it is probable that the needs of the bone marrow for making hemoglobin and red blood cells are not being met. When the supply of iron to the developing red blood cell in the marrow is suboptimal, not all porphyrin can be used to make heme, so the levels of protoporphyrin in circulating red blood cells rise above normal. An increased red cell protoporphyrin greater than 3 mcg/gm hemoglobin in the adult or child indicates a deficient iron supply to the developing red blood cell (Finch and Cook, 1984).

These biochemical indices can be used to discriminate

the iron replete person from those in one of the three stages of iron deficiency. The iron replete individuals have normal biochemical indices. Those with depleted iron stores have a low plasma ferritin. Those with iron deficiency, but no anemia, have low plasma ferritin, low transferrin saturation, and high red cell protoporphyrin. Those with iron deficiency anemia have low plasma ferritin, low transferrin saturation, high red cell protoporphyrin, and a low hemoglobin or hematocrit (Finch and Cook, 1984).

Incidence and Diagnosis of Anemia

Hallberg and Rossander-Hulten (1991) summarized several articles that indicated a low serum ferritin value is pathognomonic for iron deficiency because there are no other conditions that lead to low values. Disorders that result in inflammation, malignancies, infection or liver disease cause an increased ferritin level, which would lead to an underestimation of the prevalence of iron deficiency. A low serum ferritin would indicate a state of iron deficiency.

Low serum ferritin has been used in several studies to monitor incidence of iron deficiency and repletion of iron stores in iron deplete individuals. Milman and Kirchhoff (1992) conducted a population survey of serum ferritin values in 1359 nonpregnant Danish women in age cohorts in their 30's, 40's, 50's, and 60's. The results revealed a

significant increase in serum ferritin in 50-year-old women from the 30- and 40-year-old women. There was another significant increase in ferritin in the 60-year-old women. In the 30- and 40-year-old women, median serum ferritin was 38 ug/l with 17.2% having values less than 15 ug/l. In the 50-year-old women, median serum ferritin was 54 ug/l, and 10.3% had values less than 15 ug/l. The 60-year-old women had a median serum ferritin of 84 ug/l, and 1.6% had values less than 15 ug/l. Blood donors had lower serum ferritin than nondonors. Hemoglobin levels were lower in those having serum ferritin less than 15 ug/l. Hemoglobin levels were lower in the 30- and 40-year-old women, which correlates with serum ferritin values and may be explained partly by menses.

Dienard et al. (1983) studied 4039 children between the ages of six months and 12 years to characterize developmental variations in serum ferritin and erythrocyte protoporphyrin. The mean serum ferritin value was found to rise through the first 12 years of life with the minus two standard deviation value of 12 ug/l rising to 21 ug/l by age 12. The authors rationalized that the linear relationship observed between increasing hematocrit and serum ferritin with increasing age is associated with improved storage and availability of iron for heme synthesis.

Other studies have further defined the role ferritin

plays in detecting iron deficiency. Carriaga et al. (1991) studied the ferritin levels and iron retention in protein-calorie malnourished Mayan children with low hemoglobin production. Treatment consisted of a 4 gm/kg protein diet, 150 kcalories/kg/day, and 60 mg of elemental iron plus vitamin and mineral supplements. The results showed that in the low ferritin-low hemoglobin group of 13 children (12 ± 8 ng ferritin/dl and hemoglobin <12 gm/dl), iron retention was 9.3% of iron intake. The high ferritin-low hemoglobin group (86 ± 32 ng ferritin/dl and hemoglobin <12 gm/dl) retained 1.4% of iron intake. The recovery of biochemical and anthropometric indicators of nutritional status was similar in both groups. The authors suggested that the homeostatic regulation of intestinal iron absorption was the same in malnourished (protein calorie malnutrition) persons with adequate iron stores as in healthy persons with adequate iron storage pools. They also proposed that in the higher serum ferritin group with low hemoglobin, the low hemoglobin concentration was mainly dependent on an adaptive adjustment to the decreased lean body mass. They suggested that during nutritional repletion, when there is an increase in lean body mass and thus an increased demand of oxygen carrying capacity, that therapeutic doses of iron be given. The high rate of hemoglobin synthesis could be supported either by exogenous iron supply or by normal or high iron reserves.

The incidence of childhood iron deficiency anemia has declined steadily since 1975 or before. Anemia declined from 7.8% in 1975 to 2.9% in 1985 as reported by the Centers for Disease Control Pediatric Nutrition Surveillance System (Yip et al., 1987b). Hematologic measurements were obtained on children ages six to 60 months that were enrolled in public health programs in six states. The prevalence of anemia declined at pre-enrollment screening visits as well as those seen at follow-up visits, suggesting a generalized improvement in childhood iron nutritional status. To determine if the decline in anemia was a function of change in the population observed, the Tennessee records were further analyzed through linkage to birth records to obtain detailed socioeconomic status information. The socioeconomic status remained stable and the prevalence of anemia declined significantly within each socioeconomic group (20% of the children in 1975 and 22% in 1984 were in the lowest socioeconomic group, and 8% in 1975 and 9% in 1984 were in the highest socioeconomic group).

Yip et al. (1987b) suggested that since the pre-enrollment prevalence of anemia had declined in WIC children, the improved iron nutritional status was due in part to the changes in infant and child feeding practices. There was greater frequency and duration of breast feeding, substitution of iron-fortified formulas for unfortified

formulas and cow's milk, a trend toward the longer duration of use of iron-fortified formulas, and increased use of iron-fortified infant cereal.

The 1985 Nationwide Food Consumption Survey (NFCS) documented a significantly higher daily intake of iron among children ages one to five years, living in the United States, compared to the 1977 NFCS. Yip et al. (1987b) attributed some of the NFCS changes to the concerted nutrition education efforts of pediatric health care providers.

To determine the incidence of anemia in middle-class children, Yip et al. (1987a) studied a population of children between nine months and six years at a private pediatric clinic in Minneapolis from 1969 through 1986. To ensure they were studying a low-risk group, the sample was restricted to children from households that had never received public assistance and at least one parent worked. They further excluded children from households headed by never-married women, black children (to avoid confusion of sickle cell anemia), and children with a history of chronic disease. The overall age-adjusted rate of anemia decreased from 6.2% in 1969 through 1973, to 5.8% in 1974 through 1977, to 3.8% in 1978 through 1981, and to 2.7% in 1982 through 1986. The prevalence of anemia from 1982 to 1986 was relatively low: 2.8% among nine- to 23-month-old children, 2.4% among 24- to 47-month-old children, and 2.7%

among 48- to 83-month-old children. The authors attributed improved childhood iron nutritional status to heightened awareness of nutritional issues.

Stockman (1987) reviewed the changes in type of iron in fortified products since 1940. Most dry food cereals produced in the 1940's and 1950's contained sodium iron pyrophosphate, which was poorly absorbed. Since 1972, dry infant cereals have been fortified with electrolytically reduced iron of small particle size. Absorption of this form of iron is approximately 4%, which is equivalent to the absorption of ferrous sulfate added to cereal.

Stockman (1987) also attributed some of the improvement in childhood nutritional status to identification of high-risk children through participation in the Women, Infants, and Children Supplemental Food Program (WIC). The author cautioned that only 25-30% of the eligible women and children were participating in WIC, and there is no good understanding of the prevalence of iron deficiency in those who would qualify for WIC but are not participating.

Iron deficiency anemia in women has also been documented. Pregnancy is considered a high-risk period to develop iron deficiency anemia. Kennedy and Gershoff (1982) monitored the incidence of anemia in pregnant women to evaluate the effectiveness of the WIC program. Hematocrit values for 134 WIC and 77 non-WIC women were used to monitor change from initial visit to final visit.

Anemia was defined as a hct < 34% during pregnancy. The mean initial hct was 35.8% for WIC and 35.6% for non-WIC women. Final mean hct levels were 36.7% for WIC and 35.1% for non-WIC women. There was no significant change for the total group of women. When conducting a separate analysis for the women with anemia, the 39 WIC women with anemia had an initial hct value of 31.9% and a final value of 35.7%. The 26 non-WIC women with anemia had an initial value of 32.2% and a final value of 34.8%. There was no significant difference between initial and final hct levels for the women with anemia, yet there was a trend for improvement.

Iron deficiency anemia in the athlete, especially the female athlete, has also been documented (Kris-Etherton, 1986; Singh et al., 1989). The term "sports anemia" was described as an increased destruction of erythrocytes and a drop in hemoglobin in response to acute exercise-induced stress. The causes have not been well defined, but contributing factors could include inadequate iron intake, decreased iron absorption, increased iron losses (sweat, gastrointestinal tract), expansion of blood volume, intravascular hemolysis due to increased red blood cell destruction, decreased red blood cell production, and inadequate dietary protein. The present recommendation is to monitor all athletes for iron deficiency anemia and to advise iron supplementation when indicated.

Farley et al. (1987) reported on characteristics

affecting dietary iron intake in the adult. The authors obtained food frequency information from 762 Utahns, ages 24 to 80, and divided them into categories of iron intake of 9 mg iron/1000 kcalories, 6 - 8.9 mg iron/1000 kcalories, and less than 6 mg iron/1000 kcalories. Twenty-seven percent of the women and 16% of the men reported consumption of more than 9 mg iron/1000 kcalories. Six percent of the women consumed 18 mg iron daily. Individuals in the high-iron intake category consumed greater proportions of their iron and energy from vegetable, fruit, and cereal products. The individuals in the low-iron intake category consumed more pastries, beverages, sweets, and added fats. When fortified breakfast cereals were removed from the diets, only 14% of the women and 6% of the men consumed diets that provided 9 mg/1000 kcalories. The authors provided the following outline for women as a guideline to meet the 9 mg iron/1000 kcalories: distribution of kcalories should be 14-16% as cereals, at least 11% as vegetables, 16-18% as meat, fish, poultry or eggs, 13-18% as fruits and juices, 15% as dairy products, and 21-31% to be used as beverages and other foods. (The authors further advised increased dairy consumption, and little to no added sugar and fat.)

Tilgner and Schiller (1990) added supporting data that iron consumption in women was lower than the recommended guidelines. They reported that women who were concerned

with nutrient intake to improve their athletic performance did not meet the recommended dietary allowance for iron. The 19 swimmers in the study reported an average of 13.2 ± 4 mg iron/day; the 8 field hockey players reported 10.5 ± 3.3 mg iron/day; and the 17 non-athlete controls reported 11.2 ± 4.7 mg iron/day.

Iron Absorption

Recommendations for dietary iron intake to prevent or correct iron deficiency anemia are influenced by body stores as well as by a variety of dietary factors that increase or decrease the availability of iron for absorption. The healthy adult male has an average loss of 1 mg iron per day (Green et al., 1968). The adult female loses an additional 0.5 mg iron per day, which accounts for menstrual blood loss averaged over one month (Hallberg et al., 1966; Hallberg and Rossander-Hulten, 1991). To cover for the loss of iron, intake is recommended at 10 mg per day for adult men and 15 mg for women. The 15 mg value was agreed upon by the National Research Council (1989) when they evaluated the data of "some impairment of iron status" in 9.6% to 14.2% of nonpregnant women 15 to 44 years of age with an average dietary iron intake of 10 to 11 mg per day. They gathered their survey reports from the U.S. Department of Agriculture, the National Center of Health Statistics, and the Food and Drug Administration. Dietary iron intake

of 10 mg per day was associated with an adequate iron status in 86% of the women ages 15-44. Meyers et al. (1983) reported that those women with high menstrual losses compensated by increased absorption of iron since the prevalence of iron deficiency in this group was low.

Iron absorption is dependent on the form of the iron and on the presence of enhancers and inhibitors of nonheme iron. About 40% of the total iron in animal tissues is heme iron although it varies in certain tissues. The remaining 60% of iron in animal tissues, and all the iron in vegetables and grains, is nonheme iron (National Research Council, 1989). Bezwoda et al. (1983) reported that 20% of heme iron is absorbed and is a function of heme iron in the meal. The total heme iron absorption ranged from 6.4% to 18% when varying proportions of heme to nonheme iron were eaten by study participants. The test meal consisted of 120 gm mashed potato with 6 mg of total iron (4 test meals had nonheme iron contents of 5.72 mg, 4.88 mg, 3.76 mg, and 1.52 mg). The percentage of absorption of nonheme iron was 7% for 5.72 mg, 9% for 4.88 mg, 6.4% for 3.76 mg, and 18% for the 1.52 mg nonheme iron preparations, respectively.

Gillooley et al. (1983) studied the effects of organic acids, phytates, and polyphenols on the absorption of iron from vegetables. The authors reported that the geometric mean iron absorption increased from 0.028 to 0.085 with 1 g

citric acid, from 0.031 to 0.081 with 15 mg ascorbic acid, from 0.048 to 0.095 with 1 gm L-malic acid, from 0.041 to 0.096 with 1 gm tartaric acid. The only exception was the addition of 1 gm oxalic acid, which resulted in a depressed iron absorption of 0.320 to 0.195.

Gillooley et al. (1983) also added 3 mg ferrous sulfate to different vegetables to determine bioavailability of their iron content. Vegetables with low iron bioavailability were wheat germ, aubergine, butter beans, spinach, brown lentils, green lentils, and beet greens. Vegetables with moderate to high bioavailability were carrot, potato, beet root, pumpkin, broccoli, tomato, cauliflower, cabbage, turnip, and sauerkraut. All vegetables associated with moderate or good iron bioavailability contained appreciable amounts of one or more of the organic acids: malic, citric, and ascorbic acids. Poor iron bioavailability was noted in vegetables with high phytate contents (wheat germ, butter beans, brown lentils, and green lentils).

To monitor the iron absorption of nuts, which are used as a dietary protein source, Macfarlane et al. (1988) compared iron absorption of a bread-alone meal to a meal of bread plus nut paste. Walnuts displayed a potent inhibitory effect on iron absorption with values of 5.9% iron absorption on the bread-alone meal, compared to 0.7% for the bread and walnut meal. Almonds, peanuts, and

hazelnuts also proved to be powerful iron inhibitors with absorption decreasing from 11.1% to 1.7% for almonds, 8.1% to 2.2% for peanuts, and 4.4% to 2.3% for hazelnuts when they were added to the bread meals. When ascorbic acid was added to overcome the inhibitory effects of certain nuts, 25 mg of ascorbic acid improved the absorption of the peanut plus bread meal from 2.2% to 3.5%. Fifty milligrams of ascorbic acid improved iron absorption in the peanut meal and restored it to the bread-alone meal value of 8.1%. With Brazil nuts, 25 mg of ascorbic acid returned the iron absorption to the bread-alone meal. Ascorbic acid was not as effective in reversing the inhibitory effects on iron absorption in soy proteins.

Iron's Effect on Development

Recovering from the effects of iron malnutrition has been studied in various situations while testing for several different performance criteria. Pollitt et al. (1985) conducted a study in a semiurban community in Egypt to associate iron status with problem solving. Of the original 203 children 28 were defined as iron deficient (hbg < 11.5 gm/dl, and either a transferrin saturation of < 25% or a serum ferritin < 20 ng/ml), and 40 children were defined as iron replete (hbg > 13 g/dl and either a transferrin saturation > 25% or a serum ferritin > 20 ng/dl). For four months, 18 iron depleted and 18 iron

replete children received 50 mg ferrous sulfate. The remaining subjects received a placebo. A test for "matching familiar figures" was administered, and the time required to make a first response plus the error rate were recorded. The efficiency of correct matching of the non-anemic children before treatment was significantly greater than for the anemic children. After treatment, the efficiency of the iron-treated anemic children was greater than that of the anemic children treated with a placebo.

Soemantri et al. (1985) used a nonverbal I.Q. test (testing biology, social science, and language) to study the effect of iron deficiency on learning performance in Indonesian children. The preselection criteria for the study were extensive and included a height and weight above the 80th percentile, mid-arm circumference above the 85th percentile, and negative parasite egg count in a stool examination; the children also had to be negative for thalassemia and malaria. Forty-one children were defined as iron deficient (hbg <11 gm/dl and transferrin saturation < 15%), and 43 were defined as iron replete (hbg >12 gm/dl and transferrin saturation > 20%). A 10 mg/kg/day oral treatment of ferrous sulfate was given the 43 anemic children and to 16 of the nonanemic children.

The results of the study conducted by Soemantri et al. (1985) showed there was no significant difference between the groups for age or socioeconomic characteristics. The

nonanemic group was slightly heavier and taller than the anemic group. The results of the school achievement tests showed a significant difference on pretest scores between the anemic and nonanemic children. Once the influence of the pretest had been removed, the iron-treated children had significantly higher increases in test scores as compared to children given the placebo treatment. The authors suggested that although the iron deficit was fully reversed, the deficits in achievement were not overcome. Although iron repletion might help the learning process, it would not compensate for the deficits accrued over a period of time.

Galler (1987) summarized her own studies and studies of others regarding the effects of severe undernutrition, including protein calorie and iron undernutrition. Her animal model consisted of rats that were fed a low protein diet for 25 generations. A parallel colony of rats was fed adequate protein for the same length of time. A third group of rats was derived from the protein deprived and were cross-fostered at birth to healthy mothers and provided adequate nutrition for four generations.

The results of the Galler (1987) rat-model study showed that after 25 generations of malnutrition, the malnourished rats were half the size of the well-nourished rats. However, within one generation of consuming an adequate diet, the rats' physical growth quickly returned

to normal. Deficits on behavioral tasks were seen in the animals after one generation of malnutrition. Following rehabilitation on the adequate protein diet, there was some recovery of behavioral function, but this was incomplete among animals with a prior history of intergenerational malnutrition. Some behaviors were aberrant up to four generations following rehabilitation.

Galler (1987) also presented human studies that were similar to the animal model described above (e.g., women who were low birth weight having low birth weight infants, and the "new morbidity" in children refers to attention deficit problems such as impaired attention, easy distractibility, poor school performance, and poor memory associated with poor nutritional status). The author concluded that malnutrition resulted in a permanent impairment of behavioral functions.

Effectiveness of Nutrition Education

Many leading causes of mortality and morbidity in the United States could be affected by dietary improvements (U.S. Senate Select Committee on Nutrition and Human Needs, 1977). In addition, benefits of consistent dietary management could reduce the need for long-term use of medication for hypertension, diabetes, and hyperlipidemia (Cohon and Zimmet, 1983; Trevisan et al., 1983). The goal of nutrition education for persons with diet-related

diseases or for the general population to prevent diet-related diseases would be implementation of lifelong dietary changes. This would be achieved through voluntary cooperation of the individual.

Glanz (1985), in a review article, summarized the basic components for effective nutrition education used in treatment of diseases (cancer, diabetes mellitus, renal disease, cardiac disease, hypertension, and weight reduction). Based on the review of literature, the author recommended the following principles for consideration in the design of all educational efforts: a) tailoring of both dietary regimens and educational strategies; b) use of social support within and outside the health-care setting; c) provision of skills training in addition to information; d) effective patient-provider communication; and e) attention to follow-up, monitoring, and reinforcement. The author placed a strong emphasis on individualized tailoring of diet prescriptions, as well as a major focus on educational and behavioral diagnosis prior to the intervention phase. This diagnosis could be used to determine what educational role would be best for family and friends and which individual or group approaches would be most suitable. Another observation was that the nutrition educator needs to understand both behavioral issues and principles of nutrition management to be effective.

To establish the current state of knowledge about the effectiveness of nutrition education, Johnson and Johnson (1985) conducted a meta-analysis of published and unpublished nutrition education studies. They reviewed 607 studies and identified 303 that had usable research findings. A coding procedure was applied, and three methods of meta-analysis were used: the voting method, the effect-size method, and the z score method. The voting method considered the findings of the original author. The findings were categorized as positive findings (meaning nutrition education had a positive, statistically significant impact), negative findings (meaning nutrition education had significant, but negative impact), or findings of no difference (meaning nutrition education had no statistically significant impact). The authors recognized the limitations of the voting method (ignoring sample size and disregarding the importance of information about the strength among variables).

The effect-size method used by Johnson and Johnson (1985) was a calculation of the differences between the means of pairs of treatment conditions divided by the within group standard deviation of the treatment conditions. This yielded a standardized mean difference. The z score method was a calculation to describe the likelihood that the overall pattern of results was generated by chance.

The results of the meta-analysis indicated nutrition education affects nutrition knowledge, nutrition attitude, and nutrition behavior positively. The voting method for published journal articles resulted in 244 positive findings, five negative findings, and 139 no difference findings for nutrition knowledge; 88 positive findings, eight negative findings, and 101 no difference findings for nutrition attitudes; and 810 positive findings, 37 negative findings, and 596 no difference findings for nutrition behavior. (Several studies had numerous findings, so the total number of findings varied.) The effect-size method indicated that the average participants' scores toward good nutrition were higher than the control group for nutrition knowledge, nutrition attitude, and nutrition behavior. The z score method indicated the probability that the superiority of nutrition education that was due to chance was less than 0.001 for all three categories.

Johnson and Johnson (1985) also calculated some correlations in the studies when they contained more than one dependent variable. In 38 studies and collected data on behavior and knowledge, the correlation coefficient was 0.50 between behavior and knowledge using the effect-size method and 0.32 using the z score method. Nutrition attitude and nutrition behavior had a correlation coefficient of 0.20 using the effect size-method and 0.47 using the z score method.

Evaluations of the WIC Program

The primary purpose of the Women, Infants, and Children Supplemental Food Program (WIC) is to enhance the health of expectant and lactating women, infants, and children under the age of five who are nutritionally at risk. The program attempts to achieve this objective by providing nutrition education and supplemental foods that are rich in calcium, iron, protein, vitamin A, and vitamin C. Several studies have been published reporting favorable outcomes of improved iron status, dietary intake, and infant birth weight that have been attributed to participation in the WIC program (Kennedy and Gershoff, 1982; Miller et al., 1985; Smith et al., 1986; Stockbauer, 1987; Stockbauer, 1986; Weiler et al., 1979; Yip et al., 1987b).

Smith et al. (1986) conducted a study on 25 WIC children and 25 control children in the Los Angeles area. The results were reported as the experimental group having a mean hbg level of 10.1 ± 0.76 gm/dl at initial enrollment and a mean hbg of 11.8 ± 0.88 gm/dl at the end of the study. The control group had a mean hbg of 10.0 ± 0.7 gm/dl at the initial visit and 10.0 ± 0.8 at the end of the study. They used a one-way analysis of variance to compute the difference between the experimental and control groups and found a significant difference at the 0.05 level. A 24-hour dietary recall conducted at the beginning of the

study showed the following percent of children did not meet the RDA for specific vitamins: 44% for vitamin A, 22% for vitamin C, 40% for calcium, 44% for iron, 32% for protein, and 1% for folacin. No dietary assessments were made for the experimental group at the end of the study. No dietary evaluations were conducted on the control group.

Miller et al. (1985) conducted a study on WIC children to consider the contribution of WIC participation in limiting development of iron depletion or iron deficiency anemia. A comparison of the hematologic status of infants from pre-WIC program era to infant participants of the WIC program was conducted using medical charts at the Children and Youth Project Clinic, Minneapolis Health Department. Subjects were matched for age, initial trimester of prenatal care, age of mother at enrollment, marital status of parent, maternal education status, number of months between pregnancies, number of prior pregnancies, and employment status. Ferritin and hematocrit values were taken on the 362 pre-WIC era infants and 478 WIC participant infants. The statistical analysis (chi square) showed ferritin concentration differences were statistically significant at the 0.005 level. The analysis on the hematocrit levels revealed no significant differences between the two groups.

Rush and the team from the Research Triangle Institute were contracted by the Office of Analysis and Evaluation,

Food and Nutrition Service, U.S. Department of Agriculture, to conduct a comprehensive evaluation of the WIC program called the National WIC Evaluation (NWE). The first step of this evaluation process was to conduct a comprehensive review of literature on the WIC program (Rush et al., 1988a). The research team reported the results as well as the problems comparing data when different methodologies were used. They specified certain strengths and weakness of studies such as the one by Smith et al. (1986), which did not account for initial disparity (mean values were calculated and evaluated and a paired t-test was not conducted).

The NWE research team then conducted four studies to evaluate the effects of participation in the WIC program on nutrition and health during pregnancy and early childhood. The first of the four studies conducted by Rush and the Triangle Research Team (Rush et al., 1988b) was the Historical Study of Pregnancy Outcomes. A total of 6563 women (5205 WIC and 1358 non-WIC women) was randomly selected from the 48 contiguous states and the District of Columbia. The authors reported that during pregnancy, the women in WIC had significantly higher intakes of protein, iron, calcium, vitamin C, energy, magnesium, phosphorus, thiamin, riboflavin, niacin, vitamin B6, and vitamin B12 than control women. The WIC participants also showed a reversal of low weight gain in early pregnancy and smaller

fat stores in later pregnancy than control women. The authors suggested that weight gain and less fat stores may have been a nutrient to fetus shuttle rather than a kcalorie to fat storage shuttle. The data also showed larger infant head circumference, but not an increased birth weight of WIC infants (the WIC infants were 23 gm heavier than the control infants which was not significant, yet there was significance when the woman was associated with a WIC program of "high quality"). There was also a trend for lower infant mortality (although not of significant magnitude) in the WIC participants over the control group.

The study of infants and children (Rush et al., 1988e) included 711 current enrollees in the WIC program, 637 children past WIC participants, and 763 control children that had never been in the WIC program. The WIC children had significantly better intakes for iron, vitamin A, and vitamin C than the control group or past WIC participants (no residual benefits of past WIC enrollment was shown). The WIC children were short in stature, suggesting effective targeting for children of nutritional risk. The WIC children also had kept their immunizations updated at a better rate and had more frequent use of health care than control children. The WIC children scored higher on vocabulary tests if WIC participation started while the fetus was in utero. The WIC children exhibited better

digit memory if infants started the WIC program after 12 months of age (significance occurred only after statistical adjustments were made for sociodemographic factors).

The historical study of pregnancy outcomes (Rush et al., 1988b) was an extensive study to relate the WIC benefits for pregnant women to perinatal outcome. Birth certificates, death records, WIC medical records, WIC participation rates, and U.S. Census and Area Resources Files were all utilized to match data for 11,154,673 births in 1392 counties in 19 states and the District of Columbia. WIC participation was associated with increased first trimester prenatal care, longer duration of gestation, decreased preterm delivery, increased birth weight (a positive 23 gm for WIC infants), and decreased fetal mortality (a decrease of 2.3/1,000).

The last of the four studies was the Food Expenditure Study (Rush et al., 1988f) that was designed to assess the impact of the WIC program on family food purchasing practices. Recalls of monthly family food expenditures were taken from the women in the Longitudinal Study of Pregnant Women (Rush et al., 1988c). Records were taken at enrollment in WIC and after the women ended their participation in WIC. Records were collected from 4219 WIC women and 785 control women. WIC benefits to pregnant women were strongly associated with larger amounts of WIC food (high nutrient density food) entering the household,

but effects on grocery spending were unclear.

Evaluations of the EFNEP Program

The Expanded Food and Nutrition Education Program (EFNEP) has a defined goal of helping low income families and youth acquire the knowledge, skills, attitudes, and changed behavior necessary for nutritionally sound diets, and to contribute to their personal development and to the improvement of the total family diet and nutritional welfare (United States Code 3175, 1988). EFNEP is a federally funded food and nutrition education program that is directed at the state government level. Evaluations of such programs are mandated since they prove important in demonstrating program effectiveness, determining to what degree the target population is being served, and in providing feedback to those involved in all stages of planning and implementing the program.

Torisky et al. (1989) conducted a study on the Virginia EFNEP program to assess the long-term impact of the program on graduated participants. Dietary intake was assessed using a 24-hour food recall record in a sample of 180 program participants who had completed six to 18 months of instruction in the Virginia EFNEP program. The food recall records were scored at program entry, at graduation, and six to 18 months after graduation. Perceived program benefit was assessed by a questionnaire addressing

consumption of "junk" food with frequency of illness, consumption of fruits, vegetables and milk, variety in family menu, willingness of family to try new foods, finding food specials and bargains, stretching food money further, help in reading labels, feeding baby, safe food storage, and finding other food resources. Participant characteristics included: 53% were single-headed families, 70% had at least one child less than five years of age, average age was 31, 69% of the families earned less than \$519 per month, 71% participated in the Food Stamp Program, 68% participated in the WIC program, and 42% received public assistance.

Results of Torisky's et al. (1989) study showed that by program completion, 37% of the participants obtained a perfect score of 100% in obtaining a diet pattern of two milk, two meat, four fruit/vegetable, and four grain servings per day. Average diet scores of 65.5 at entry to the program rose to 88 at program completion. Those who had the lowest scores at entry to the program dropped in diet score by 17%. Increases in servings from the milk, fruit/vegetable, and bread/cereal groups were responsible for the improved diet score in the total study population. A statistically significant but small decline in average diet score occurred from 88.0 at program exit to 83.8 at the follow-up visit six to 18 months later. The average follow-up score remained significantly higher than entry

score suggesting dietary improvement was retained.

The highest perceived learning skills of the Virginia EFNEP participants were learning how to get better food buys and what foods were in the basic four food groups. The area of least perceived knowledge gain was finding other food resources (some families were already enrolled in WIC [68%] and Food Stamp [71%] Programs).

The California EFNEP program was evaluated (DeTredici et al., 1988) to determine if the program had an impact on dietary intake. Study participants were recruited into the study if they met the income guidelines and were then assigned to either the EFNEP group (received EFNEP instruction immediately) or to the control group (received no EFNEP instruction during the study). There were 355 EFNEP participants and 328 control participants with the demographic characteristics outlined in Table 1.

The results revealed no difference in food recall scores at the beginning of the study (66 ± 23 vs. 66 ± 24 for EFNEP and control groups, respectively). After six months of instruction in the EFNEP group, there was a significant increase in food recall score for the EFNEP group and no change in the control group (77 ± 23 for the EFNEP group vs. 66 ± 25 for the control group). The improvements observed in the EFNEP group resulted from increased intakes from the milk, protein, and fruit/vegetable groups. The program characteristics that

Table 1. California EFNEP participant characteristics.

Variable	EFNEP		Control	
Age	28.7	± 8.3	29.9	± 9.0
Monthly income	567.0	± 186.0	581.0	± 209.0
Food stamp income	91.0	± 62.0	88.0	± 65.0
Amount spent on food	172.0	± 97.0	192.0	± 111.0
Family size with father	4.5	± 1.5	4.7	± 2.0
Family size-no father	3.4	± 1.4	3.1	± 1.2
White	23.8%		23.9%	
Black	18.4%		21.8%	
Hispanic	54.1%		51.8%	
American Indian	0.6%		0.9%	
Asian/Pacific Islander	3.1%		1.5%	

led to those changes were determined to be in the length of the EFNEP visit (mean of 80.5 ± 24.3 minutes), the number of EFNEP visits (mean of 7.8 ± 3.9 visits), and EFNEP instruction topics (cooking practices, food economics, and food safety).

Chipman and Kendall (1989) reviewed the national changes and challenges of the EFNEP program since it started in 1968. They reported the program has always served those at greatest nutritional need. In 1969, 33% of the enrollees were on welfare assistance and 15% used food stamps. Welfare assistance jumped to 45% and food stamp use to 61% by 1979. In 1987, 31% reported annual incomes under \$3,780, 67% reported incomes under \$6,228, and 94% reported incomes under \$11,000, which was poverty level for a family of four at the time. Food stamps were used by 66% of EFNEP participants and 30% were enrolled in WIC in 1987. The authors assessed that the EFNEP participants enrolled

in 1987 were less isolated, more sophisticated, better educated, and more discriminating than earlier participants. They also appeared to be more self-motivated (temporary victims of unemployment) than earlier participants.

Evaluating the most effective methods to instruct the participants was also reviewed by Chipman and Kendall (1989), and they suggested small group sessions with telephone follow-up sessions as an effective and cost efficient method for improving nutrition knowledge and nutrition practices. Combining five one-on-one sessions with seven mailed lessons was also considered cost-effective and time-efficient. The advantages of teaching in groups were larger caseload per paraprofessional, lower lesson cost per individual, increased number of program graduates, and the benefits of increased enthusiasm, friendships, and group cohesiveness.

Randall et al. (1989) added that the philosophy of using low income paraprofessionals as teachers leads to employment and provides personal growth and career development for the paraprofessional. Paraprofessionals have increased their self-esteem, been able to leave the welfare rolls, found better jobs, and improved their own and their families' nutritional status.

Summary of Literature Review

Relevance to This Study

Serum ferritin is a simple and reliable estimate of iron stores as long as inflammation, malignancies, infection, and liver disease have been excluded (Finch and Cook, 1984). Hematocrit level should be combined with ferritin level to determine iron status since hematocrit levels are affected late in the disease process, and there is a wide scatter of values in normal subjects (making anemia difficult to diagnose).

Physiological changes in normal individuals have an affect on iron status. Milman and Kirchhoff (1992) reported increased serum ferritin in postmenopausal women. Hemoglobin levels in this group were lower in women with serum ferritin less than 15 ug/l. The Centers for Disease Control (1989) have also outlined normal values for hematocrit and hemoglobin that are adjusted for age, altitude, pregnancy, and smoking status. Normal physiological variability should be considered before completing a study design to avoid unwanted variability in data.

The incidence of childhood iron deficiency declined steadily since before 1975 (Yip et al., 1987b). This improvement was attributed to WIC participation, heightened awareness of nutritional issues, and improved quality of iron in fortified products (Stockman, 1987; Yip et al.,

1987b). Stockman (1987) cautioned that only 25-30% of eligible women and children participate in WIC, and there is no good understanding of the prevalence of iron deficiency in those who would qualify for WIC but are not participating.

Dietary iron intake has been reported to be low in normal, athletic women and women who reported they were concerned about nutritional issues (Farley et al., 1987; Kris-Etherton, 1986; Singh et al., 1989; Tilgner and Schiller, 1990). The National Research Council (1989) recommended 15 mg of dietary iron be consumed daily by women ages 15-44 to maintain iron stores. Farley et al. (1987) provided an outline to obtain 9 mg/1000 kcalories and summarized that those most successful in meeting this goal consumed a higher proportion of their kcalories from vegetables, fruit, and iron-fortified cereal products.

The effect of enhancers and inhibitors of iron absorption has been studied (Bezwoda et al., 1983; Gillooley et al., 1983; Macfarlane et al., 1988). Foods with phytates and polyphenols decreased iron absorption while foods with ascorbic acid, malic acid, and tartaric acid increased iron absorption. Monitoring specific foods high in these substances on a dietary history form that is specifically designated to capture these data would help unscramble iron status data.

The importance of iron status on intellectual

development, growth, and behavioral development has been studied (Galler, 1987; Pollitt et al., 1985; Soemantri et al., 1985). The common finding was that iron repletion after a prolonged iron deficit did not overcome the intellectual and behavioral deficits accrued over time. The importance of good iron status has a dramatic impact for generations, a good reason for further research.

Nutrition education has been shown to have a positive effect on nutrition knowledge, nutrition behavior, and nutrition attitude (Johnson and Johnson, 1985). Glanz (1985) summarized basic components shown to be effective in treating diseases with dietary prescriptions (diabetes mellitus, renal disease, cardiac disease, hypertension, cancer, and weight reduction). WIC and EFNEP have incorporated nutrition education into their programs to improve the health of their program participants. Both have reported success in accomplishing certain goals of their programs. The WIC program has shown improvement in hematocrit (Kennedy and Gershoff, 1982; Miller et al., 1985; Rush et al., 1988a-e; Smith et al., 1986; Stockbauer, 1987; Stockbauer, 1986; Weiler et al., 1979; Yip et al., 1987b) and EFNEP has shown improvement in dietary nutrients (Chipman and Kendall, 1989; DelTredici et al., 1988; Torisky et al., 1989). EFNEP studies have not reported on iron status as has been done with WIC (through hematocrit levels). WIC and EFNEP have not used knowledge tests to

monitor nutrition knowledge gain.

CHAPTER III

METHODOLOGY

This study was conducted on children between the ages of one and five years, and on adult women between the ages of 20 and 45 years. The purpose of this study was to evaluate the impact of participation in the Expanded Food and Nutrition Education Program (EFNEP) and the Supplemental Food Program for Women, Infants, and Children (WIC) through monitoring iron status, nutrition knowledge, and dietary behavior. The specific objectives of the study were 1) determine the impact of participation in EFNEP on iron status as assessed by hematocrit and ferritin values; 2) determine the effect of nutrition knowledge on hematocrit and ferritin values for both the WIC and EFNEP program participants; and 3) determine the effect of dietary behavior (as measured by 24-hour dietary recall record checked against a food frequency record) on hematocrit and ferritin values for both WIC and EFNEP participants.

It was hypothesized that participation in the nutrition education sessions of the federally funded WIC or EFNEP programs would result in an increase in nutrition knowledge. The increase in nutrition knowledge was expected to correlate positively with improved dietary intake and improved iron status (hematocrit and ferritin).

Samples

The persons who participated in the study were 1) first-time WIC program children ages one to five years and their legal guardians; 2) women enrolled in the EFNEP program for the first time; and 3) children between the ages of one and five and their legal guardians who were not enrolled in either the WIC or EFNEP programs, yet would have been eligible for the WIC or EFNEP programs based on income criteria.

The WIC participants were recruited from clinics in Utah, Salt Lake, Weber, and Morgan counties in Utah. The EFNEP participants were recruited from two units that covered the same geographical area as the WIC participants. The control children and control women (the mothers or guardians of the control children) were recruited by posting flyers in trailer courts, laundromats, the Utah State University Extension campus field office, and student housing units in Logan, Utah. The control participants met the income criteria to participate in the WIC and EFNEP programs, yet were not enrolled in either program. All program and control participants were free of chronic disease and any condition that would cause a low hematocrit, hemoglobin, or ferritin level (thalassemia, inflammation, malignancies, or liver disease).

To obtain a statistical association between nutrition knowledge, dietary behavior, and hematocrit and ferritin

levels, children were chosen as the study participants for the WIC program. The physiological changes in hematocrit levels for the child have been documented, and the normal values have been outlined by the Centers of Disease Control (Appendix C). Infants enrolled in the WIC program were excluded from the study due to high neonatal reserves of storage iron (Filer, 1989) and the impact that iron-fortified formulas (which are the required formula for use if the infant is not breast fed) would have on the hematocrit levels of infants. Pregnant women enrolled in the WIC program were also excluded from the study due to the physiological variability of normal hematocrits for different trimesters of pregnancy. Another problem would be that the follow-up hematocrit level reading for pregnant women would be taken postpartum (WIC protocol). A postpartum hematocrit level would be elevated above pregnancy level and impossible to interpret.

Nonpregnant women who enrolled in the EFNEP program served as the study participants representing the EFNEP group. The control groups consisted of children of the same ages as the WIC children and their parent/guardian who were not enrolled in WIC or EFNEP.

Description of the Instruments

Used to Obtain the Data

The first step in obtaining information about the

nutrition knowledge and behavior of WIC and EFNEP participants was to develop a useful and cost-effective nutrition knowledge test. The test was validated according to the Cangelosi method (1989). Cangelosi defined the usefulness/cost effectiveness of a test as one that is usable and valid. He then described a test's validity. It is based on its relevance (including construct validity and content validity) and reliability (including internal consistency, test-retest validity, and scorer reliability).

A 30-point test was constructed to test if WIC and EFNEP participants were meeting the nutrition education goals of the program. To obtain content and construct validity, eight registered dietitians with master's degrees and who worked for the public health department were asked to evaluate a 30-question nutrition test. They were asked to review each question for content validity by deciding whether each question matched the program objective of "improving health and nutritional status through teaching nutrition knowledge and skills that result in the purchase and consumption of nutrient dense foods."

To determine construct validity the public health dietitians were asked to agree or disagree with the author's assessment of whether the question met the stated learning objective and to agree or disagree with classification of objectives into level of cognition (e.g., question #5's objective [Protein is important to the human

body because:] was to identify the functions of target nutrients in the body, with a cognition classification of simple knowledge. Question #13's objective [Which of the following foods would provide the most protein for your money?] was to analyze food labels and choose the food with the most nutrients for the same amount of money. It has a cognition classification of intellectual knowledge involving analysis and application). This process resulted in a revision of the test into a 21-question test that met content and construct validity.

The 21-question test was then administered to 10 recent graduates of each program to determine face validity (did those taking the test feel it was representative of what they were taught in the program?).

Internal consistency was measured on the tests administered to 10 recent program graduates by conducting a split-half reliability. The procedure checks on whether the same number of correct responses was scored on the odd-numbered questions as on the even-numbered questions. All test items were written in multiple choice format to assure intra- and inter-scorer reliability. Calculations of difficulty level, index of discrimination, and efficiency level were calculated on each nutrition test item (Cangelosi, 1982).

The nutrition knowledge test was administered to the study participants at the beginning of the study before

education sessions had begun. Six months later (the time frame for reapplying to the WIC program) the same test was readministered to each program participant. The exception to this was, of the 42 WIC participants in the study, 24 took the nutrition knowledge test as a posttest and 18 took the nutrition knowledge test as both a pretest and as a posttest. This was done to determine if there was a learning effect from taking the test. The 26 EFNEP and 23 control women took the nutrition knowledge test as both a pretest and a posttest. The nutrition knowledge tests taken by the control women were scored for them and for the control children.

Dietary behavior was analyzed by computer using the Computrition Nutrition Software Library (1989). Each study participant completed a dietary questionnaire that included a 24-hour dietary recall record for a typical day (if the previous day was atypical) and a food frequency record. If there was a discrepancy between the 24-hour dietary recall record and food frequency record, a registered dietitian further questioned the participant regarding her usual dietary intake.

Each participant completed the dietary records at enrollment in the study and six months later. A typical dietary intake was then analyzed by Computrition for vitamin A, vitamin C, iron, calcium, and protein. Paired t-tests were calculated on the nutrients to compare dietary

intake prior to study enrollment and dietary intake at the six month evaluation. Total amount of each nutrient consumed was recorded in grams or milligrams for each participant. A record of whether they met 67% or greater of the Recommended Dietary Allowance (RDA) for each nutrient was also kept.

A medical history form used by the WIC program was completed by each study participant. It was used to screen out any study participant who could have had a low hematocrit level for reasons other than iron deficiency.

Demographic data were collected at the initial visit. These data included information on age, gender of child participant, type of vitamin/mineral supplement, if any, educational level of parent/guardian, income level of family, family size, income level of family divided by number of members in family, hours of nutrition education while participating in the WIC or EFNEP programs, and if transportation to the grocery store was a problem.

Protocol

The WIC participants were enrolled in this study in the following manner:

- 1) First-time WIC participants who had an eligible child participant between the ages of one and five years were told about the study on their initial visit to the WIC clinic. They could not have participated in

the WIC or EFNEP programs previously. The purpose of the study, what the involvement included, who was responsible for the study, and the benefits of the study were explained to the parent/guardian of the WIC child.

- 2) The parent/guardian of the WIC child read and signed a written consent form that was approved by the Utah State University Human Subjects Committee Institutional Review Board and the Salt Lake County Advocacy Board (Appendix B).
- 3) A WIC dietary history form (including a 24-hour dietary recall record and a food frequency record) and medical history form were completed for each WIC child by the parent/guardian (Appendix B).
- 4) A nutrition knowledge test was taken by 24 of the 42 parents/guardians of the WIC children. A form detailing demographic data was also completed.
- 5) Four micro capillary tubes of blood were drawn on each WIC child with the hematocrit value read immediately, and the serum portion was frozen for later ferritin analysis.
- 6) The WIC clients participated in the WIC program as usual. No attempt was made to alter the education sessions from their normal routine. Participants had an individual consultation with a registered dietitian and two group nutrition classes that were

approximately 20 minutes in length.

- 7) Six months after the initial WIC enrollment visit, the WIC program requires another dietary and hematocrit analysis to enable the participant to continue to receive program benefits. At this time the dietary form, medical history form, and the nutrition knowledge test were administered to the parent/guardian as the postprogram evaluation. Four micro capillary tubes of blood were drawn on each child for the postprogram evaluation of hematocrit and ferritin. The EFNEP participants were enrolled in this study in the following manner:

- 1) Women who were interested in participating in the EFNEP program, or were referred to the EFNEP program, were told about the study on their initial contact. They could not have participated in the WIC or EFNEP programs previously. The purpose of the study, what the involvement included, who was responsible for the study, and the benefits of the study were explained to the women at that time.
- 2) The EFNEP participants read and signed the approved written consent form.
- 3) The WIC dietary history form and WIC medical history form were completed by each EFNEP participant. The dietary information required by the EFNEP program was transferred from the WIC forms for official EFNEP

records.

- 4) A nutrition knowledge test was given to each EFNEP woman at the initial visit. A form detailing demographic data was also completed.
- 5) Four micro capillary tubes of blood were drawn on each EFNEP woman with the hematocrit value read immediately, and the serum portion frozen for later ferritin analysis.
- 6) The EFNEP clients participated in the EFNEP program as usual. Individual as well as group nutrition education sessions were provided for them, as outlined in the Utah EFNEP program. Each EFNEP client received between six and 12 hours of nutrition education before "graduating" from the program.
- 7) Six months after the initial enrollment in EFNEP, the EFNEP client completed the WIC nutrition history form, the WIC medical history form, and the nutrition knowledge test for the postprogram evaluation. Four micro capillary tubes of blood were drawn on each EFNEP client for postprogram evaluation of hematocrit and ferritin. The six month time schedule was enforced to coincide with the WIC program time frames. The control subjects were enrolled in this study in the following manner:
 - 1) Flyers announcing the study were posted in housing units, laundromats, the Utah State University

Extension campus field office, and local neighborhoods near Utah State University. The purpose of the study, what the involvement included, who was responsible for the study, and the benefits of the study were all outlined. An incentive voucher for Utah State University premium ice cream was also offered to the control participants.

- 2) Women with children between the ages of one and five who were interested in the study called the Utah State University Extension campus field office to obtain more information. The women were screened to rule out those that had been or were currently enrolled in the WIC or EFNEP programs. The screening included verification of income guidelines that met the WIC and EFNEP income guidelines.
- 3) The woman and one of her children between the ages of one and five came to the Utah State University Extension campus field office, the Nutrition and Food Sciences building, or a local resident's home to enroll in this study. The control woman read and signed a written consent form for herself and another form for her child (control child).
- 4) The WIC dietary history form and WIC medical history form were completed by the woman for herself and another set was completed for her child.
- 5) A nutrition knowledge test and a form detailing the

family's demographic data were completed by each woman. The nutrition knowledge test and demographic data served as the control data for both the control woman and control child.

- 6) Four micro capillary tubes of blood were drawn on each control woman and each control child. The hematocrit was read immediately, and the serum portion was frozen for later ferritin analysis.
- 7) The control subjects did not receive any nutrition education for the next six months. They were excluded from the study if they enrolled in the WIC or EFNEP programs.
- 8) Six months after their enrollment in the study, the control woman completed the WIC dietary history form and the WIC medical history form for herself and her "control child." The control woman completed a nutrition knowledge test that served as the post-evaluation for herself and her child. Both the control woman and control child had four micro capillary tubes of blood drawn for postprogram evaluation of hematocrit and ferritin. The six month time schedule was enforced to coincide with the WIC program time frames.

Analysis of Blood for Hematocrit and Ferritin

Each study participant had a finger stick blood sample

drawn to determine hematocrit and ferritin levels at the beginning of enrollment into the study and six months later. An Autolance (Becton Dickinson, Franklin Lakes, NJ) finger-pricking device with disposable lancets was used to prick the finger for blood drawing. Aseptic methods as outlined by the Utah State Health Department were used by the county personnel who drew the blood. Four heparinized micro capillary tubes with an inside diameter of 0.5 to 0.6 mm and length of 75 mm were filled with blood for each of their two scheduled blood analysis days.

The hematocrit levels were determined by averaging the readings of the four micro capillary tubes spun for three minutes at 3,000 rpm in a HemataSTAT model C-70 centrifuge (Separation Technology, Inc., Salt Lake City, UT). The HemataSTAT model C-70 centrifuge has been approved as an accurate hematocrit reading device by the Utah State WIC program.

To determine the ferritin levels, the four capillary tubes were separated at the serum:packed-red-blood-cell dividing line by mechanically scratching the tube with a file at that point and breaking the tube. The serum portion of the blood was blown from the four capillary tubes into a plastic bullet labeled with the participants' identification numbers. The labeled plastic bullets with serum were frozen at -20 degrees centigrade until all samples were collected and were analyzed at the same time.

The Ferritin Double Antibody Method (Diagnostic Products Corporation) was used to measure ferritin levels. The principle of this procedure is that ^{125}I -labeled ferritin added to the blood sample competes with ferritin in the patient sample for sites on ferritin-specific antibody. After incubation for a fixed time, separation of bound from free ferritin is achieved, and the tube is counted in a gamma counter. The counts are inversely related to the amount of ferritin present in the patient sample. The procedure calls for 100 μl of serum per assay tube. The WIC county health departments refused to allow venous blood draws and limited the blood sample volume to four micro hematocrit capillary tubes. The amount of serum obtained from the participants was 5-35 μl instead of the recommended 100 μl . To adjust the Ferritin Double Antibody method to the reduced amount of serum, a trial on the blood with equal reduction in all reagents equal to the volume of serum was conducted. A procedure to adjust for the reduced serum volume by concentrating the calibration solutions to be more sensitive at a higher percent binding of the radioactive ferritin was also conducted. This second procedure was chosen because the first method did not result in a precipitate large enough to react in the gamma counter.

Adjustments were made in reagents A and B to enable a more discriminatory reading of a high percent binding of

radioactive ferritin. This was necessary since more of the radioactive ferritin would be bound because the volume of serum ferritin was reduced. Table 2 contains the adjustments made to the procedures on page 5 of the "Ferritin Double Antibody" instructions (Appendix D).

Table 2. Adjustments in reagents for the Ferritin Double Antibody Method.

TUBE	PERCENT BOUND	FERRITIN ng/ml
A	100	0
32/4A, 1/4B	91.4	2.5
1/2A, 1/2B	88.2	5.0
1/4A, 3/4B	87.0	7.5
B 2	86.4	10.0
C	76.4	25.0
D	39.4	100.0
E	19.4	200.0
F	8.2	500.0

The "altered" (concentrating the calibration solution for the small amount of serum samples and using small serum samples) ferritin procedure was conducted on two different samples of blood to check the feasibility of obtaining accurate ferritin levels from small samples of serum. The following procedures were taken:

- 1) The "radioimmunoassay" procedure of the Ferritin Double Antibody instructions (Appendix D) was adjusted in step 1 of page 4 as outlined in Table 2.
- 2) Step 2 of page 4 in the Ferritin Double Antibody instructions was altered by adding different amounts of one patient's serum to the tubes. One patient's

blood was separated into 24 tubes (three tubes each of 5, 10, 15, 20, 25, 30, 35, and 100 μ l of serum). This was repeated for a second patient's blood.

- 3) Steps 3-9 on page 4 of the Ferritin Double Antibody instructions were conducted on the serum samples with no alterations.
- 4) The "Net CPM" (counts per minute) was calculated by subtracting 450 (the NSB [non-specific binding] count) from the "Average CPM." This calculation is outlined on page 5 of the Ferritin Double Antibody instructions.
- 5) The "percent bound" was calculated by dividing the Net CPM by the "Net MB" (maximum binding) counts and multiplying by 100. The Net MB count was 113.79. This calculation is outlined on page 5 of the Ferritin Double Antibody instructions.
- 6) A logarithm curvilinear line was established to calculate the patients' sample using the results of the adjusted calibrator solutions as outlined in Table 2. The equation generated was the log of $X=Y-88.51/-14.32$.
- 7) The value of X was calculated by taking the antilog of X.
- 8) The percent bound value was multiplied by the dilution factor (100 divided by the amount of patient serum [e.g., if the serum sample was 5 μ l, the equation was:

$100/5 \mu\text{l} = 20$)).

- 9) The value of X was plotted against the new percent bound value calculated in step 8 to obtain the amount of ferritin in the sample.

Table 3 contains the results of the above procedure on two blood samples. Averages for the three tubes with the same amount of patient's serum were calculated and placed in Table 3. If the value for one of the three tubes varied widely from the other two values, the two similar values were averaged. If there was no similar reading for the triplicate tubes, the word "erratic" was reported in the table. Appendix E contains the raw data of these calculations.

Table 3. Ferritin levels for small amounts of serum using the altered Ferritin Double Antibody procedure.

Amount	Sample #1	Sample #2
5 μl	16.3 ng/ml	erratic
10 μl	erratic	22.7 ng/ml
15 μl	13.5 ng/ml	22.6 ng/ml
20 μl	12.8 ng/ml	25.4 ng/ml
25 μl	22.4 ng/ml	erratic
30 μl	23.6 ng/ml	erratic
35 μl	17.2 ng/ml	36.8 ng/ml

The ferritin values for the study participants were calculated using the same procedure above. The blood analysis was conducted at a separate time with a different calibration kit, so a separate logarithm curvilinear line was calculated ($Y = X^{-98/-14.5}$). Y represented the new

ferritin level and X represented the percent bound value. The results in Table 3 indicated that the ferritin values were not exact; however, regardless of sample size the results obtained were similar to the actual values.

Statistical Analysis

The following statistical tests were conducted for each program separately and for the total group collectively.

- 1) Paired t-tests were conducted between the scores on nutrition knowledge tests taken at the beginning to the study (program enrollment) and the nutrition knowledge test taken six months later.
- 2) Paired t-tests were conducted between dietary components (protein, calcium, iron, vitamin C, and vitamin A) consumed prior to study enrollment and dietary components consumed six months later.
- 3) Paired t-tests were conducted between hematocrit levels taken prior to study enrollment and hematocrit levels six months later.
- 4) Paired t-tests were conducted between ferritin levels taken prior to study enrollment and ferritin levels six months later.
- 5) Correlation of nutrition knowledge scores with each of the five dietary components (protein, calcium, iron, vitamin C, and vitamin A) were conducted.

- 6) Correlation of nutrition knowledge scores with hematocrit levels were conducted.
- 7) Correlation of nutrition knowledge scores with relative ferritin levels were conducted.
- 8) Correlation of each of the dietary components (protein, calcium, iron, vitamin C, and vitamin A) with hematocrit levels were conducted.
- 9) Correlation of each of the dietary components (protein, calcium, iron, vitamin C, and vitamin A) with relative ferritin levels were conducted.
- 10) Group t-tests for hematocrit levels, knowledge scores, and dietary components when separated by the discrete variables "taking nutrition classes in high school," "taking nutrition classes in college," and "participating in other food programs" were conducted.
- 11) Group t-tests between the nutrition knowledge postprogram scores for those receiving a preprogram test versus those that received a postprogram test only were conducted.
- 12) Correlations of demographic data (age, income, family size, previous nutrition education sessions, and individual income [income divided by family size]) with the dependent variables of hematocrit levels, ferritin levels, dietary components, and nutrition knowledge scores were conducted.
- 13) Regression analyses using nutrition knowledge scores,

hematocrit levels, relative ferritin levels, and dietary intake components as the dependent variables, and nutrition knowledge scores, hematocrit levels, relative ferritin levels, dietary components, family size, income, individual income, vitamin supplementation, years of education, participating in food programs, and taking nutrition classes in high school or college as the independent variables were conducted on each other.

- 14) One-way analysis of variance was calculated among the EFNEP, WIC, and control groups for several nutrients, hematocrit, and nutrition knowledge scores.
- 15) An analysis of covariance was conducted with "years of formal education" as a covariate with "nutrition knowledge score."
- 16) Item analysis, item discrimination, item difficulty, and item effectiveness were calculated on each test question of the nutrition knowledge test.

CHAPTER IV

RESULTS AND DISCUSSION

Undernutrition of iron and protein can have irreversible health effects such as increased rates of infection, low growth rates in children, and delayed motor and cognitive development (Galler, 1987; Soemantri et al., 1985). The purpose of this study was to determine the impact of participation in the Expanded Food and Nutrition Education Program (EFNEP) and Women, Infants, and Children Supplemental Food Program (WIC) by iron status, nutrition knowledge, and dietary behavior. The specific objectives were to: 1) determine the impact of participation in the EFNEP program on iron status as assessed by hematocrit and ferritin values; 2) determine the effect of nutrition knowledge on hematocrit and ferritin values for both WIC and EFNEP program participants; and 3) determine the effect of dietary behavior on hematocrit and ferritin values for both WIC and EFNEP participants.

Description of the Study Population

All study participants were enrolled in the study between December 1989 and June 1991. The WIC population had a high dropout rate, with 42 of the original 155 participants completing the study. All 26 EFNEP participants and 23 of the 28 control families completed the study.

The characteristics of the study population served as independent variables in the research. Nutrition knowledge test scores, hematocrit levels, relative ferritin levels, and the five nutrients also served as independent variables when used as predictive variables on each other as dependent variables. The results presented in Appendix A describe the population according to age distribution for the children, usage of vitamin and mineral supplements, family size, income level, and years of formal education. The results have been separated by program participation. The control participants had a higher mean education level. The EFNEP participants had higher mean family size.

The characteristics of this study population differ somewhat from other data reported in the literature. DelTredici et al. (1988) reported the mean income for a California EFNEP group as $\$567 \pm 186$ per month. The EFNEP participants in this study had a $\$1045 \pm 332$ monthly income (and a mean individual income [income/family size] of $\$225$). The authors also reported a family size of 4.5 ± 1.6 if the father was present or 3.4 ± 1.4 if the father was not present compared to 5.0 ± 1.44 for the EFNEP participants in this study. Chipman and Kendall (1989) reported the mean income for a Colorado EFNEP group as $\$315$ per month, and that 66% were participants in the Food Stamp Program, and 30% also participated in the WIC program. Torisky et al. (1989) reported 71% participated in the Food

Stamp Program and 68% in the WIC program, with an average monthly income of \$579. Twelve percent of the EFNEP participants in this study were participants in the Food Stamp Program and none were participating in the WIC program due to the study design. The participants in this study had a higher income, slightly larger family size, and participated less frequently in other food programs than did those in other reported studies.

Nutrition Knowledge Test Results

Each study participant or guardian of the study participant took a 21-question multiple-choice nutrition knowledge test at preprogram enrollment and six months later. Internal consistency of the test was calculated prior to this study on ten graduates of the programs with a split-half reliability. A similar number of correct responses were scored on the odd-numbered questions as on the even-numbered questions. The test contained face validity, as program graduates felt the test covered material that was taught, even if they missed questions.

The number and percentage of study participants who answered questions correctly were tallied by program and by question in Table 4. The results of separating the test scores into ranges of correct responses (Table 5) revealed that the WIC participants had a high proportion scoring less than 52% correctly on the pre- and posttests, the

Table 4. Percent of study participants answering each question correctly, tallied by program.

Question	WIC		EFNEP		WIC-C		EFNEP-C		COMPCSITE	
	pre	post	pre	post	pre	post	pre	post	pre	post
1	16(38)	36(85)	17(65)	23(89)	19(83)	18(78)	19(83)	18(78)	71(62)	95(98)
2	23(55)	41(98)	23(89)	24(92)	23(100)	23(100)	23(100)	23(100)	92(81)	111(97)
3	9(21)	24(57)	17(65)	17(65)	15(65)	16(70)	15(65)	16(70)	55(49)	73(64)
4	19(45)	28(67)	15(58)	19(73)	23(100)	23(100)	23(100)	23(100)	80(70)	93(82)
5	20(48)	33(79)	23(89)	25(96)	21(91)	21(91)	21(91)	21(91)	85(75)	100(93)
6	7(17)	16(38)	10(39)	13(50)	17(74)	14(61)	17(74)	14(61)	51(45)	57(50)
7	11(25)	24(57)	15(58)	16(62)	13(57)	13(57)	13(57)	13(57)	52(46)	66(58)
8	23(55)	39(93)	25(100)	23(89)	22(96)	23(100)	22(96)	23(100)	93(82)	108(95)
9	21(50)	41(98)	26(100)	24(92)	22(96)	22(96)	22(96)	22(96)	91(80)	109(96)
10	23(55)	40(95)	23(89)	26(100)	20(87)	23(100)	20(87)	23(100)	86(75)	112(98)
11	13(31)	22(52)	16(62)	15(58)	16(70)	14(61)	16(70)	14(61)	61(54)	64(57)
12	22(52)	39(93)	20(77)	20(77)	20(87)	20(87)	20(87)	20(87)	82(72)	99(87)
13	23(55)	42(100)	19(73)	24(92)	21(91)	23(100)	21(91)	23(100)	84(74)	112(98)
14	19(45)	38(91)	19(73)	24(92)	20(87)	23(100)	20(87)	23(100)	78(68)	18(95)
15	6(14)	19(45)	7(27)	12(46)	12(52)	10(44)	12(52)	10(44)	37(33)	51(45)
16	9(21)	17(41)	9(35)	14(54)	14(61)	17(74)	14(61)	17(74)	46(40)	65(57)
17	16(38)	28(67)	15(58)	17(65)	19(83)	16(70)	19(83)	16(70)	69(61)	77(68)
18	21(50)	36(86)	24(92)	26(100)	23(100)	22(96)	23(100)	22(96)	91(80)	106(93)
19	9(21)	15(36)	9(35)	6(23)	6(26)	10(44)	6(26)	10(44)	30(26)	41(36)
20	15(36)	27(64)	19(73)	21(81)	19(83)	19(83)	19(83)	19(83)	72(63)	86(75)
21	15(36)	25(65)	17(65)	17(65)	18(78)	18(78)	18(78)	18(78)	63(50)	73(66)
n	24	42	26	26	23	23	23	23	114	114

Note: Numbers in parentheses () are percentages

EFNEP participants had a high proportion scoring less than 52% correctly on the pretest with most of the participants scoring between 52% and 76% on the posttest, and the control participants had a higher proportion scoring higher than 76% correctly on both the pretest and posttest.

To determine if taking a pretest had an effect on posttest scores, approximately half of the WIC participants were administered both a pretest and posttest while the other half received only a posttest. There was no significant difference on the posttest score between the 24 WIC participants that took both a pretest and posttest and the 18 WIC participants taking only a posttest. This was

Table 5. Nutrition knowledge test scores, tallied by program.

Score	WIC		EFNEP		WIC-C		EFNEP-C		COMPOSITE	
	pre	post	pre	post	pre	post	pre	post	pre	post
7 and less	-	-	2(8)	-	-	-	-	-	2(2)	-
8 to 11	4(17)	3(7)	2(8)	1(4)	-	-	-	-	6(6)	4(4)
12 to 16	13(54)	25(60)	14(54)	16(62)	12(52)	9(39)	12(52)	9(39)	51(53)	59(52)
17 to 21	7(29)	14(33)	8(31)	9(35)	11(48)	14(61)	11(48)	14(61)	37(40)	51(44)
mean	14.2 a*	15.5 b*	14.2 c**	15.6 d**	16.7	16.9	16.7	16.9	15.5	15.5
std dev	3.27	2.89	3.77	2.79	1.97	2.42	1.97	2.42	3.11	2.78
range	8-20	8-21	4-21	10-21	13-20	12-21	13-20	12-21	4-21	8-21
n	24	42	26	26	23	23	23	23	96	114

Note: Numbers in parentheses () are percentages.

Numbers followed by an "a" differ significantly from those followed by a "b,"

numbers followed by a "c" differ significantly from those followed by a "d."

* significant at $p = .003$ level

** significant at $p = .039$ level

std dev = standard deviation

assessed by a significance of $p = 0.20$ when a group t-test was conducted. When years of formal education (control groups with 12.8 years, WIC with 12.02, and EFNEP with 12.00 years) were considered as a covariate with nutrition knowledge scores, there were no significant differences among the groups observed with an analysis of covariance.

The calculations of difficulty level, index of discrimination, and efficiency level on postnutrition knowledge scores (Table 6) indicated questions 3, 6, 11, 15, 16, 17, 19, 20, and 21 were the best discriminators of the moderately difficult questions with high efficiency scores. The pretest calculations (Table 7) indicated questions 4, 11, 14, 15, 16, 17, 20, and 21 were the best discriminators of the moderately difficult questions with high efficiency scores. The difficulty index indicated

Table 6. Index of discrimination, efficiency level, and difficulty level calculations for the postprogram nutrition knowledge test items.

Question	CH	CL	PH	PL	D	P	Maximum Level	E
1	20	15	0.91	0.68	0.23	0.73 m	0.54	0.42
2	22	22	1.00	1.00	0.00	0.92 e	0.16	0.00
3	19	4	0.86	0.18	0.68*	0.48 m	0.96	0.71
4	22	11	1.00	0.50	0.50	0.69 m	0.62	0.81
5	22	19	1.00	0.86	0.14	0.85 e	0.30	0.47
6	20	7	0.91	0.32	0.59*	0.56 m	0.88	0.67
7	16	10	0.73	0.45	0.28	0.54 m	0.92	0.30r
8	22	19	1.00	0.86	0.14	0.85 e	0.30	0.47
9	22	18	1.00	0.82	0.18	0.83 e	0.34	0.53
10	22	22	1.00	1.00	0.00	0.92 e	0.16	0.00r
11	22	8	1.00	0.36	0.64*	0.63 m	0.74	0.86
12	19	20	0.86	0.91	-0.05	0.81 e	0.38	0.00r
13	22	21	1.00	0.95	0.05	0.89 e	0.22	0.23r
14	22	17	1.00	0.77	0.23	0.81 e	0.38	0.61
15	21	3	0.95	0.14	0.81*	0.50 m	1.00	0.81
16	22	4	1.00	0.18	0.82*	0.54 m	0.92	0.89
17	21	8	0.95	0.36	0.59*	0.60 m	0.80	0.74
18	22	15	1.00	0.68	0.32	0.77 m	0.46	0.69
19	17	5	0.77	0.23	0.54*	0.46 m	0.92	0.59
20	22	7	1.00	0.32	0.68*	0.61 m	0.78	0.87
21	18	5	0.82	0.23	0.59*	0.48 m	0.96	0.61

Note: 22 were in the high scoring group, 22 were in the low scoring group, CH = correct responses for the high scoring group, CL = correct responses for the low scoring group, PH = proportion of correct responses for the high scoring group, PL = proportion of correct responses for the low scoring group, D = index of discrimination, P = difficulty level, m = moderate difficulty (p between 2 & 8), e = easy difficulty level (p > 8), * = best discriminating questions, r = refining needed, E = efficiency of item. Question #12 had the only negative index of discrimination.

that 13 of the questions were moderately difficult (approximately two thirds of the questions) and 8 were

Table 7. Index of discrimination, efficiency level, and difficulty level calculations for the preprogram nutrition knowledge test items.

Question	CH	CL	PH	PL	D	P	Maximum Level	E
1	17	17	0.77	0.65	0.12	0.71 m	0.58	0.21r
2	22	19	1.00	0.73	0.27	0.85 e	0.30	0.90
3	16	6	0.73	0.23	0.50	0.45 m	0.90	0.56
4	21	13	0.95	0.50	0.45*	0.71 m	0.58	0.78
5	22	18	1.00	0.69	0.31	0.83 e	0.34	0.91
6	21	6	0.95	0.23	0.72	0.56 m	0.88	0.82
7	16	6	0.73	0.23	0.50	0.45 m	0.90	0.56
8	22	20	1.00	0.77	0.23	0.88 e	0.24	0.96
9	22	21	1.00	0.81	0.19	0.89 e	0.22	0.86
10	22	23	1.00	0.88	0.12	0.94 e	0.12	1.00
11	20	8	0.91	0.31	0.60*	0.58 m	0.84	0.71
12	22	21	1.00	0.81	0.19	0.89 e	0.22	0.86
13	22	18	1.00	0.69	0.31	0.83 e	0.34	0.91
14	22	14	1.00	0.54	0.46*	0.75 m	0.50	0.92
15	15	5	0.68	0.19	0.49*	0.42 m	0.16	3.06
16	20	5	0.91	0.19	0.72*	0.52 m	0.96	0.75
17	21	14	0.95	0.54	0.41*	0.73 m	0.54	0.76
18	22	22	1.00	0.85	0.15	0.92 e	0.16	0.94
19	11	5	0.50	0.19	0.31	0.33 m	0.66	0.51
20	22	15	1.00	0.58	0.42*	0.77 m	0.46	0.91
21	21	13	0.95	0.50	0.45*	0.71 m	0.58	0.78

Note: 22 were in the high scoring group, 26 were in the low scoring group, CH = correct responses for the high scoring group, CL = correct responses for the low scoring group, PH = proportion of correct responses for the high scoring group, PL = proportion of correct responses for the low scoring group, D = index of discrimination, * = best discriminating question, P = difficulty level, m = moderate difficulty (p between 2 & 8), e = easy difficulty level (p < 8), r = refinement needed, E = efficiency of item.

rated as easy questions. The easy questions did not prove to be good discriminators between low and high scoring groups.

The efficiency of several test questions (efficiency = index of discrimination divided by the maximum value of the index of discrimination) was calculated. The ability to consider both the index of discrimination (the proportion correctly responding to a question from a low scoring group subtracted from the proportion of correct responses from the high scoring group) and the difficulty level (maximum index of discrimination) revealed that questions #1, 7, 10, 12, and 13 need revising if the test is used again.

Paired T-Tests

Paired t-tests were calculated for all study participants and for a subgroup of participants not taking vitamin supplements on hematocrit level, relative ferritin levels, nutritional knowledge scores, and several nutrient components. The paired t-tests were separated by program and tallied in Tables 8 and 9. When the paired t-tests for all study participants were calculated, the WIC participants had a significant increase in nutrition knowledge score (14.2 ± 3.27 to 15.5 ± 2.89) and protein intake ($274 \pm 121\%$ RDA to $343 \pm 125\%$ RDA) at the follow-up visit. The EFNEP participants had a significant increase in nutrition knowledge score (14.2 ± 3.77 to 15.6 ± 2.79) and hematocrit level ($38.5 \pm 3.78\%$ to $40.7\% \pm 2.13$). The WIC control group had a significant decrease in relative ferritin ($209 \pm 36 \mu\text{g/l}$ to $85 \pm 81 \mu\text{g/l}$), and the EFNEP

Table 8. Paired t-tests on hematocrit, relative ferritin, nutrition knowledge scores, and several nutrients for study participants.

Program	Variable	Mean	N	p	Ave % pt. change
WIC	pre vit A post vit A	226±230% RDA 240±236% RDA	42	0.809	0.686
EFNEP	pre vit A post vit A	253±206% RDA 280±203% RDA	26	0.606	1.070
WIC-C	pre vit A post vit A	188±160% RDA 135±136% RDA	23	0.234	0.206
EFNEP-C	pre vit A post vit A	195±225% RDA 203±163% RDA	23	0.877	1.110
Composite	pre vit A post vit A	218±210% RDA 220±201% RDA	114	0.944	0.762
WIC	pre calc post calc	105±47% RDA 122±49% RDA	42	0.074*	0.384
EFNEP	pre calc post calc	107±59% RDA 142±96	26	0.036**	0.401
WIC-C	pre calc post calc	106±52% RDA 96±48% RDA	23	0.377	0.148
EFNEP-C	pre calc post calc	102±49% RDA 106±55%	23	0.740	0.233
Composite	pre calc post calc	105±50% RDA 118±65% RDA	114	0.037**	0.310
WIC	pre prot post prot	274±121% RDA 343±125% RDA	42	0.010***	0.543
EFNEP	pre prot post prot	131±41% RDA 156±46% RDA	26	0.023**	0.317
WIC-C	pre prot post prot	132±72% RDA 115±32	23	0.273	0.049
EFNEP-C	pre prot post prot	257±112% RDA 296±111% RDA	23	0.151	0.348
Composite	pre prot	209±117% RDA	114	0.003***	0.352

Table 8 continued

Program	Variable	Mean	N	p	Ave % pt. change
WIC	pre iron post iron	74±42% RDA 115±145% RDA	42	0.070*	0.654
EFNEP	pre iron post iron	63±26% RDA 77±32% RDA	26	0.068*	0.468
WIC-C	pre iron post iron	58±19% RDA 60±20% RDA	23	0.846	0.125
EFNEP-C	pre iron post iron	59±20% RDA 77±25% RDA	23	0.001***	0.447
Composite	pre iron post iron	65±31% RDA 82±92% RDA	114	0.010***	0.463
WIC	pre vit C post vit C	147±124% RDA 184±142% RDA	42	0.224	1.500
EFNEP	pre vit C post vit C	202±156% RDA 245±149% RDA	26	0.327	2.580
WIC-C	pre vit C post vit C	151±177% RDA 177±162% RDA	23	0.540	1.000
EFNEP-C	pre vit C post vit C	115±84% RDA 201±155% RDA	23	0.030**	2.340
Composite	pre vit C post vit C	154±139% RDA 200±150% RDA	114	0.014**	1.818
WIC	pre Hct post Hct	36.4±2.2% 37.1±2.3%	42	0.149	0.019
EFNEP	pre Hct post Hct	38.5±3.5% 40.7±2.2%	26	0.001***	0.064
WIC-C	pre Hct post Hct	40.2±2.3% 40.3±2.4%	23	0.937	0.000
EFNEP-C	pre Hct post Hct	37.1±2.1% 37.0±2.4%	23	0.817	0.002
Composite	pre Hct post Hct	38.1±3.0% 38.8±2.4%	144	0.006	0.021

Table 8 continued

Program	Variable	Mean	N	p	Ave % pt. change
WIC	pre know sc	14.2±3.3	24	0.003**	0.114
	post know sc	15.5±2.7			
EFNEP	pre know sc	14.2±3.8	26	0.039**	0.211
	post know sc	15.6±2.8			
WIC-C	pre know sc	16.7±2.0	23	0.611	0.017
	post know sc	16.9±2.4			
EFNEP-C	pre know sc	16.7±2.0	23	0.611	0.017
	post know sc	16.9±2.4			
Composite	pre know sc	15.3±3.1	96	0.002***	0.094
	post know sc	16.2±1.8			
WIC	pre rel fer	76±58 µg/l	13	0.716	0.956
	post rel fer	85±49 µg/l			
EFNEP	pre rel fer	128±121 µg/l	23	0.644	0.511
	post rel fer	114±88 µg/l			
WIC-C	pre rel fer	209±223 µg/l	16	0.023**	0.235
	post rel fer	85±81 µg/l			
EFNEP-C	pre rel fer	124±135 µg/l	35	0.576	0.470
	post rel fer	104±91 µg/l			
Composite	pre rel fer	136±151 µg/l	87	0.494	0.487
	post rel fer	99±81 µg/l			

Note: vit C = vitamin C intake, vit A = vitamin A intake, calc = calcium intake, prot = protein intake, rel fer = relative ferritin, * = significant at p = .10 level, ** = significant at p = .05 level, *** = significant at p = .01 level, Ave % pt change = Average percent point change

Table 9. Paired t-tests on hematocrit, relative ferritin, nutrition knowledge scores, and several nutrients for study participants not taking vitamin supplements.

Program	Variable	Mean	N	p	Ave % pt. change
WIC	pre vit A post vit A	219±230% RDA 260±256	34	0.506	0.863
EFNEP	pre vit A post vit A	289±215% RDA 257±193% RDA	20	0.575	0.818
WIC-C	pre vit A post vit A	201±167% RDA 145±144% RDA	20	0.272	0.209
EFNEP-C	pre vit A post vit A	218±241% RDA 200±151% RDA	19	0.776	0.766
Composite	pre vit A post vit A	230±216% RDA 223±205% RDA	93	0.797	0.693
WIC	pre calc post calc	102±44% RDA 124±45% RDA	34	0.035**	0.453
EFNEP	pre calc post calc	102±60% RDA 139±104% RDA	20	0.089*	0.448
WIC-C	pre calc post calc	112±51% RDA 101±47% RDA	20	0.340	0.150
EFNEP-C	pre calc post calc	105±51% RDA 109±60% RDA	19	0.797	0.245
Composite	pre calc post calc	105±50% RDA 119±66% RDA	93	0.052*	0.344
WIC	pre prot post prot	268±116% RDA 348±115% RDA	34	0.005***	0.612
EFNEP	pre prot post prot	123±39% RDA 151±45% RDA	20	0.031**	0.368
WIC-C	pre prot post prot	140±73% RDA 115±34% RDA	20	0.158	0.039
EFNEP-C	pre prot post prot	272±109% RDA 296±122% RDA	19	0.402	0.166
Composite	pre prot	210±116% RDA	93	0.007***	0.328

Table 9 continued

Program	Variable	Mean	N	p	Ave % pt. change
WIC	pre iron post iron	80±44% RDA 124±158% RDA	34	0.105	0.689
EFNEP	pre iron post iron	62±27% RDA 78±34% RDA	20	0.056*	0.543
WIC-C	pre iron post iron	59±16% RDA 59±21% RDA	20	1.0	0.053
EFNEP-C	pre iron post iron	62±17% RDA 80±25% RDA	19	0.005***	0.371
Composite	pre iron post iron	68±32% RDA 91±101% RDA	93	0.022**	1.583
WIC	pre vit C post vit C	160±129% RDA 200±149% RDA	34	0.286	1.583
EFNEP	pre vit C post vit C	204±146% RDA 238±125% RDA	20	0.421	1.616
WIC-C	pre vit C post vit C	153±188% RDA 155±115% RDA	20	0.979	0.999
EFNEP-C	pre vit C post vit C	129±86% RDA 187±142% RDA	19	0.132	1.830
Composite	pre vit C post vit C	162±140% RDA 196±137% RDA	93	0.090	1.515
WIC	pre Hct post Hct	36.5±2.2% 37.1±2.3%	34	0.182	0.016
EFNEP	pre Hct post Hct	38.5±3.8% 40.4±2.1%	20	0.006***	0.058
WIC-C	pre Hct post Hct	40.5±2.3% 40.5±2.5%	20	0.969	0.001
EFNEP-C	pre Hct post Hct	37.0±1.6% 37.5±2.1%	19	0.272	0.015
Composite	pre Hct post Hct	37.9±2.9% 38.6±2.8%	93	0.005***	0.022

Table 9 continued

Program	Variable	Mean	N	p	Ave % pt. change
WIC	pre know sc	14.0±3.1	19	0.016**	0.110
	post know sc	15.2±2.5			
EFNEP	pre know sc	14.6±3.3	20	0.052*	0.122
	post know sc	15.7±2.6			
WIC-C	pre know sc	16.7±2.1	20	0.750	0.013
	post know sc	16.9±2.6			
EFNEP-C	pre know sc	16.8±2.1	19	0.640	0.017
	post know sc	17.0±2.4			
Composite	pre know sc	15.5±2.9	78	0.007***	0.066
	post know sc	16.9±2.4			
WIC	pre rel fer	75±50 µg/l	18	0.720	1.200
	post rel fer	68±49 µg/l			
EFNEP	pre rel fer	129±138 µg/l	17	0.355	0.485
	post rel fer	97±58 µg/l			
WIC-C	pre rel fer	240±236 µg/l	13	0.009***	0.632
	post rel fer	73±81 µg/l			
EFNEP-C	pre rel fer	142±154 µg/l	11	0.530	0.402
	post rel fer	112±98 µg/l			
Composite	pre rel fer	139±159 µg/l	59	0.008***	0.442
	post rel fer	95±71 µg/l			

Note: vit C = vitamin C intake, vit A = vitamin A intake, calc = calcium intake, prot = protein intake, rel fer = relative ferritin, * = significant at p = .10, ** = significant at p = .05 level, *** = significant at p = .01 level. Ave % pt change = Average percent point change.

control group had a significant increase in dietary iron intakes ($59 \pm 20\%$ of RDA to $77 \pm 25\%$ of RDA). The paired t-test calculations for the subgroup of participants not taking vitamin supplements, which could be a subgroup with a different emphasis on nutrition, indicated the WIC participants had a significant increase in dietary protein intake ($268 \pm 116\%$ of RDA to $348 \pm 115\%$ of RDA), and EFNEP participants had a significant increase in hematocrit ($38.5 \pm 3.8\%$ to $40.4 \pm 2.1\%$). The preprogram value of 38.5 ± 3.78 was above the CDC cut-off value for low hematocrit ("low normal"), and an increase within an already normal range is impressive. The WIC-control participants had a significant decrease in relative ferritin ($240 \pm 236 \mu\text{g/l}$ to $73 \pm 81 \mu\text{g/l}$), and the EFNEP-control group had a significant increase in dietary iron intake ($62 \pm 17\%$ of RDA to $80 \pm 25\%$ of RDA).

In this study, the WIC participants did not have a significant increase in hematocrit level at the postprogram evaluation above the preprogram hematocrit level (36.4 ± 2.17 at preprogram and 37.1 ± 2.34 at postprogram evaluation). Rush et al. (1988a) in the "Review of Past Studies" of the WIC program summarized that most evidence indicated that the WIC program had led to a decreased incidence of anemia in late infancy and early childhood. "However, the issue warrants a great deal more attention" (Rush et al., 1988a, p. 409).

EFNEP has previously evaluated its effectiveness by reporting changes in dietary behavior. Torisky et al. (1989) reported that by the end of the study on Virginia EFNEP participants, they scored 100% on meeting the basic four food group dietary guidelines. DelTredici et al. (1988) reported a significant improvement in dietary behavior which was attributed to increased intakes of milk, protein, and fruit/vegetable groups.

In this study there were only a few significant differences in nutrient intake before and after study participation. At the $p = 0.05$ level there were significant differences between preprogram and postprogram levels for calcium and protein in the EFNEP program. This study did not make dietary comparisons to food groupings, as in previous studies; yet differences between nutrient intakes would be similar to improvements in consuming the basic four food groups. The increase in nutrition knowledge scores indicates the nutrition education components of the Utah EFNEP program are effective. The increase in hematocrit levels indicates an improved iron status (indicative of health/nutritional status) for EFNEP participants.

The significant differences noted from the paired t-test calculations for the control groups were 1) the WIC-control children had a decrease in relative ferritin ($p=0.023$); and 2) the EFNEP-control women had a significant

increase in dietary iron ($p=0.001$). There was no increase for either control group in nutrition knowledge score, which may be due to their higher initial test scores, or to the lack of their participation in nutrition education sessions during this study period. The increase in dietary iron might have been influenced positively due to study involvement; yet, the children of the study participants (WIC-control participants) did not show a similar increase.

Percentage of the Study Population That
Did Not Meet 67% and 100% of the
RDA for Several Nutrients

The frequency of study participants consuming less than 67% and less than 100% of the RDA for vitamin A, vitamin C, calcium, iron, and protein were tallied for each separate program in Tables 10, 11, 12, 13, and 14. The frequency of dietary iron intake at less than 67% and 100% of the RDA for all participants was the highest of all nutrients (62% preprogram and 42% postprogram were below 67% of the RDA and 91% preprogram, and 80% postprogram were below 100% of the RDA). The frequency of dietary protein intake for the total population that was below 67% and 100% of the RDA was the lowest of all the nutrients studied (5% preprogram and 4% postprogram were below 67% of the RDA, and 18% preprogram and 10% postprogram below 100% of the RDA). The mean intake of nutrients for this study

Table 10. Percentage of WIC study participants who were below 67% and 100% of the 1989 RDA for several vitamins and minerals.

Nutrient	<67% RDA	<100% RDA	mean intake	mean intake % RDA	range intake % RDA
Vitamin A					
preprogram	3 (7)	7 (17)	904 R.E.	226	30-999
postprogram	3 (7)	10 (24)	960 R.E.	240	21-997
Vitamin C					
preprogram	16 (38)	21 (50)	59 mg	147	20-587
postprogram	6 (14)	15 (36)	74 mg	184	36-601
Calcium					
preprogram	11 (24)	21 (50)	840 mg	105	24-218
postprogram	5 (12)	10 (24)	976 mg	122	39-271
Iron					
preprogram	22 (57)	36 (86)	7.4 mg	74	22-217
postprogram	13 (33)	27 (64)	11.5 mg	115	30-806
Protein					
preprogram	1 (2)	2 (5)	44 gm	274	41-554
postprogram	1 (2)	1 (2)	55 gm	343	61-713

Note: Numbers in parentheses () are percentages
R.E. = Retinol Equivalent

Table 11. Percentage of EFNEP study participants who were below 67% and 100% of the 1989 RDA for several vitamins and minerals.

Nutrient	<67% RDA	<100% RDA	mean intake	mean intake % RDA	range intake % RDA
Vitamin A					
preprogram	5 (19)	9 (35)	2024 R.E.	253	23-648
postprogram	4 (15)	5 (19)	2240 R.E.	280	8-616
Vitamin C					
preprogram	8 (31)	8 (31)	121 mg	202	7-496
postprogram	3 (12)	3 (12)	147 mg	245	58-674
Calcium					
preprogram	7 (27)	13 (50)	856 mg	107	27-276
postprogram	7 (27)	8 (31)	1136 mg	142	23-459
Iron					
preprogram	13 (50)	23 (89)	9.5 mg	63	16-107
postprogram	11 (42)	22 (85)	11.6 mg	77	40-195
Protein					
preprogram	1 (4)	5 (19)	65 gm	131	33-231
postprogram	1 (4)	1 (4)	78 gm	156	60-260

Note: Numbers in parentheses () are percentages
R.E. = Retinol Equivalent

Table 12. Percentage of WIC-Control study participants who were below 67% and 100% of the 1989 RDA for several vitamins and minerals.

Nutrient	<67% RDA	<100% RDA	mean intake	mean intake % RDA	range intake % RDA
Vitamin A					
preprogram	5 (22)	7 (30)	752 R.E.	188	37-587
postprogram	7 (30)	13 (57)	540 R.E.	135	26-687
Vitamin C					
preprogram	10 (44)	14 (61)	60 mg	151	10-683
postprogram	6 (26)	9 (39)	71 mg	177	10-727
Calcium					
preprogram	6 (26)	10 (44)	848 mg	106	17-247
postprogram	8 (35)	12 (52)	768 mg	96	28-183
Iron					
preprogram	17 (74)	22 (96)	5.8 mg	58	31-105
postprogram	15 (65)	23 (100)	6.0 mg	60	10-98
Protein					
pre program	3 (13)	7 (30)	21 gm	132	42-401
postprogram	2 (9)	6 (26)	128 gm	115	44-174

Note: Numbers in parentheses () are percentages
R.E. = Retinol Equivalent

Table 13. Percentage of EFNEP-Control study participants who were below 67% and 100% of the 1989 RDA for several vitamins and minerals.

Nutrient	<67% RDA	<100% RDA	mean intake	mean intake % RDA	range intake % RDA
<hr/>					
Vitamin A					
preprogram	5 (22)	6 (26)	1560 R.E.	195	23-942
postprogram	3 (13)	7 (30)	1624 R.E.	203	23-942
Vitamin C					
preprogram	7 (30)	13 (56)	69 mg	115	9-280
postprogram	3 (13)	8 (39)	121 mg	201	40-618
Calcium					
preprogram	6 (26)	12 (52)	816 mg	102	37-231
postprogram	3 (13)	13 (57)	848 mg	106	30-256
Iron					
preprogram	15 (65)	23 (100)	8.9 mg	59	19-98
postprogram	8 (35)	19 (83)	11.6 mg	77	38-131
Protein					
preprogram	1 (4)	1 (4)	129 gm	257	81-512
postprogram	-	-	148 gm	296	148-590

Note: Numbers in parentheses () are percentages
R.E. = Retinol Equivalent

Table 14. Percentage of the total study participants who were below 67% and 100% of the RDA for several vitamins and minerals.

Nutrient	<67% RDA	<100% RDA	mean intake	mean intake % RDA	range intake % RDA
Vitamin A					
preprogram	18 (16)	28 (25)	774 R.E.	129	23-999
postprogram	14 (12)	39 (34)	876 R.E.	146	8-997
Vitamin C					
preprogram	38 (33)	56 (49)	51 mg	101	7-683
postprogram	17 (15)	35 (31)	77 mg	153	10-727
Calcium					
preprogram	29 (25)	56 (49)	768 mg	96	17-276
postprogram	22 (19)	43 (38)	856 mg	107	23-459
Iron					
preprogram	71 (62)	104 (91)	7.2 mg	58	16-217
postprogram	48 (42)	91 (80)	9.1 mg	73	10-806
Protein					
preprogram	6 (5)	18 (16)	64 gm	195	33-554
postprogram	4 (4)	10 (9)	77 gm	232	44-713

Note: Numbers in parentheses () are percentages
R.E. = Retinol Equivalent

population was compared to the Nationwide Food Consumption Survey - Continuing Survey of Food Intake by Individuals (CSFII) (USDA, 1985). The CSFII 1985 data were compared to the 1980 Recommended Dietary Allowances (RDAs), but were adjusted to the 1989 RDAs for comparison purposes for this study.

The WIC children in this study had higher dietary intakes of vitamin A and protein, lower dietary intakes of vitamin C, and similar dietary intakes of calcium and iron when compared to the children in the CSFII. The EFNEP women in this study had higher dietary intakes of vitamin A, vitamin C, and calcium, and similar dietary intakes of iron and protein when compared to the women in the CSFII. This comparison and the analysis of variance calculations to determine differences between programs in hematocrit, nutrition knowledge scores, years of education, family size, relative ferritin levels, and dietary nutrients are summarized in Table 15. There was no significant difference between programs for preprogram and postprogram nutrition knowledge scores when the covariates of "years of formal education" and "nutrition knowledge scores" were entered into an analysis of covariance.

When comparing the data of WIC participants to previous literature on dietary intake, there were differences for each nutrient, yet the trends for low dietary intakes are similar. Smith et al. (1986) reported

Table 15. Analysis of variance calculated among the programs for several nutrients, hematocrit, and knowledge scores for participants not taking vitamin supplements.

Variable	WIC	EFNEP	WIC-C	EFNEP-C	TOTAL	CSFII
years education	12.02 a ±1.58 (7-16)	12.0 a ±1.57 (6-13)	13.8 b ±1.51 (12-16)	13.8 b ±1.51 (12-16)	12.73 ±1.76 (6-16)	
family size	3.95 b ±1.03 (2-6)	5.0 a ±1.44 (3-8)	3.96 b ±1.02 (2-5)	3.96 b ±1.02 (2-5)	4.19 ±1.20 (2-8)	
pre nutr know sc	14.2 a ±3.27 (8-20)	14.2 a ±3.77 (4-21)	16.7 b ±1.97 (13-20)	16.7 b ±1.97 (13-20)	15.5 ±3.11 (4-21)	
post nutr know sc	15.5 a ±2.89 (8-21)	15.6 ±2.79 (10-21)	16.9 b ±2.42 (12-21)	16.9 b ±2.42 (12-21)	15.5 ±2.78 (8-21)	
pre Hct	36.4 ±2.17 (32-42)	38.5 ±3.78 (31-47)	40.2 ±2.31 (34-45)	37.1 ±1.64 (32-41)	38.0 ±3.66 (31-47)	
post Hct	37.1 ±2.34 (32-43)	40.7 ±2.13 (36-46)	40.3 ±2.49 (37-46)	37.0 ±2.05 (31-41)	38.0 ±3.11 (31-46)	
pre rel ferritin	76.2 a ±50 (12-356)	127.9 ±138 (13-540)	208.5 b ±236 (22-795)	84.3 ±153 (5-945)	84 (8-792)	
post rel ferritin	85.6 ±49 (20-289)	113.7 ±59 (14-358)	84.3 ±81 (5-945)	124.2 ±98 (8-468)	64 (5-945)	
pre vit A %RDA	219 ±230 (30-999)	289 ±215 (23-648)	201 ±167 (37-587)	218 ±241 (23-942)	218 (23-999)	ch-185
post vit A %RDA	260 b ±256 (21-997)	257 b ±193 (8-616)	145 a ±144 (26-687)	200 b ±151 (23-942)	220 (8-997)	w-124
pre vit C %RDA	160 ±129 (20-587)	204 ±146 (7-496)	153 ±188 (10-683)	129 ±86 (9-280)	154 (7-683)	ch-221
post vit C %RDA	200 ±148 (36-601)	238 ±125 (58-674)	155 ±115 (10-727)	187 ±142 (40-618)	200 (10-727)	w-132
pre calc %RDA	102 ±44 (24-218)	102 ±60 (27-276)	112 ±51 (17-247)	105 ±51 (37-231)	105 (17-276)	ch-109

Table 15 continued

Variable	WIC	EFNEP WIC-C	EFNEP-C	TOTAL CSFII	
post calc %RDA	124 ±45 (39-271)	139 ±104 (23-459)	101 ±47 (28-183)	109 ±60 (30-256)	118 (23-459) w-79
pre iron %RDA	80 ±44 (22-217)	62 ±27 (16-107)	59 ±16 (31-105)	62 ±17 (19-98)	65 (16-217) ch-80
post iron %RDA	124 a ±158 (30-806)	78 b ±34 (40-195)	59 b ±21 (10-98)	80 b ±25 (38-131)	86 (10-806) w-78
pre prot %RDA	268 ±116 (41-554)	123 ±39 (33-231)	140 ±73 (42-401)	272 ±109 (81-512)	209 (33-554) ch-240
post prot %RDA	348 ±115 (61-713)	151 ±45 (60-260)	115 ±34 (44-174)	296 ±12 (148-590)	245 (44-713) w-139

Note: Numbers in parentheses () are ranges. Numbers followed by an "a" differ significantly from those followed by a "b" for that variable. CSFII = Continuing Survey of Food Intake for Individuals - 1985, , Hct = hematocrit, vit A = vitamin A, vit C = vitamin C, calc = calcium, prot = protein, nutr = nutrition, know = knowledge, sc = score, rel ferritin = relative ferritin, %RDA = percent dietary intake of the recommended dietary allowance, ch = child value of CSFII, w = woman value of CSFII.

44% of the participants were consuming less vitamin A, 23% with less vitamin C, 40% with less calcium, 44% with less iron, and 32% with less protein than the RDA. In this study, 24% of the WIC participants consumed less than 100% of the RDA for vitamin A at postprogram evaluation, 36% with less vitamin C, 24% with less calcium, 64% with less iron, and 2% with less protein than the RDA. These figures cause reason for concern, yet improvement from preprogram values are encouraging (Tables 10-15).

Mean Values and the Frequencies of Hematocrit
and Relative Ferritin

The mean value and the frequency were calculated for both hematocrit and relative ferritin levels. They are summarized in Tables 16 and 17. The frequencies and means were separated by program for both preprogram values and postprogram values. Two WIC children (5%) were below the 34% cut-off level for low hematocrit at their preprogram evaluation. One WIC child (2%) was below the 34% cut-off value at the postprogram evaluation. Eight EFNEP women (31%) were below the 37% cut-off value for hematocrit for women at the preprogram evaluation, and one (4%) was below the 37% value at the postprogram evaluation. Six EFNEP-control women (26%) had low hematocrit levels at preprogram evaluation, and eight (34%) had low hematocrit levels at postprogram evaluation. Relative ferritin values of less than 20 $\mu\text{g/l}$, representing low iron stores, were found in three (9%) WIC children preprogram and in one (3%) of the participants postprogram. Two (8%) of the EFNEP women participants preprogram and one (4%) of the participants postprogram had relative ferritin values of $<20 \mu\text{g/l}$. None of the WIC-control children preprogram and three (15%) of the participants postprogram had relative ferritin values of $<20 \mu\text{g/l}$. Three (18%) EFNEP-control women participants preprogram and four (21%) participants postprogram had relative ferritin levels $<20 \mu\text{g/l}$.

Table 16. Hematocrit values of study subjects, tallied by program.

Hct	WIC		EFNEP		WIC-C		EFNEP-C		COMPOSITE	
	pre	post	pre	post	pre	post	pre	post	pre	post
31	-	-	1(4)	-	-	-	-	1(4)	1(1)	1(1)
32	2(5)	1(2)	-	-	-	-	1(4)	-	3(3)	1(1)
33	-	-	-	-	-	-	1(4)	-	1(1)	-
34	5(12)	4(9)	1(4)	-	1(4)	-	-	3(13)	7(6)	7(6)
35	7(17)	6(14)	4(15)	-	-	-	2(9)	3(13)	13(11)	9(8)
36	4(9)	8(19)	2(8)	1(4)	-	-	2(9)	1(4)	8(7)	10(9)
37	9(21)	6(14)	2(8)	-	-	2(9)	7(30)	2(9)	18(16)	10(9)
38	10(24)	8(19)	2(8)	3(11)	2(9)	3(13)	4(17)	6(26)	18(16)	20(18)
39	1(2)	2(5)	4(15)	3(11)	5(22)	5(22)	4(17)	4(17)	14(12)	14(12)
40	3(7)	3(7)	3(11)	5(19)	5(22)	6(26)	1(4)	2(9)	12(10)	16(14)
41	-	1(2)	1(4)	4(15)	2(9)	1(4)	1(4)	1(4)	4(4)	7(6)
42	1(2)	2(5)	1(4)	6(23)	4(17)	2(9)	-	-	6(5)	10(9)
43	-	1(2)	4(15)	1(4)	2(9)	3(13)	-	-	6(5)	2(2)
44	-	-	-	2(8)	1(4)	-	-	-	1(1)	5(4)
45	-	-	-	-	1(4)	-	-	-	1(1)	-
46	-	-	-	1(4)	-	1(4)	-	-	-	2(2)
47	-	-	1(4)	-	-	-	-	-	1(1)	-
mean	36.4	37.1	38.5 a*	40.7 b*	40.2	40.3	37.1	37.0	38.0	38.0
std dev.	2.17	2.34	3.78	2.13	2.31	2.49	1.64	2.05	3.66	3.11
range	32-42	32-43	31-47	36-46	34-45	37-46	32-41	31-41	31-47	31-45
n	42	42	26	26	23	23	23	23	114	114

Note: Numbers in parentheses () are percentages

The number followed by an "a" differs significantly from the number followed by a "b."

*significant at $p = .001$ level

std dev = standard deviation

Table 17. Relative ferritin values of study subjects, tallied by program.

Relative Ferritin ug/l	WIC		EFNEP		WIC-C		EFNEP-C		CCOMPOSITE	
	pre	post	pre	post	pre	post	pre	post	pre	post
<20	3(9)	1(3)	2(8)	1(4)	-	3(15)	3(18)	4(21)	8(9)	9(10)
21 - 50	8(25)	8(27)	1(4)	4(17)	4(25)	7(35)	3(18)	4(21)	16(18)	23(25)
51 - 100	9(29)	15(50)	11(46)	9(38)	4(25)	3(15)	5(29)	5(25)	29(32)	32(34)
101 - 150	7(22)	3(10)	4(17)	2(8)	2(13)	3(15)	1(6)	2(11)	14(16)	10(10)
151 - 200	3(9)	1(3)	3(13)	3(13)	-	-	2(12)	1(5)	8(9)	5(5)
201 - 250	-	1(3)	1(4)	3(13)	1(5)	3(15)	-	2(11)	3(3)	9(10)
251 - 300	-	1(3)	-	1(4)	1(5)	-	1(5)	-	1(1)	2(2)
301 - 350	1(3)	-	-	-	1(5)	-	-	1(5)	2(2)	1(1)
>351	1(3)	-	2(8)	1(4)	3(15)	1(5)	2(12)	-	8(9)	2(2)
mean	76.2 a	85.4	127.9	113.7	203.5 a*	84.3b*	124.2	104.3	84.0	64.0
std dev.	50	49	138	59	35	81	154	98	129	117
range	12-356	20-269	13-540	14-358	22-792	5-945	8-468	11-308	8-792	5-945
n	32	30	24	24	15	20	17	19	89	93

Note: Numbers in parentheses () are percentages.

The number followed by an "a" differs significantly from the number followed by a "b."

*significant at $p = .023$ level.

std dev = standard deviation

Yip et al. (1987b) reported a declining prevalence of anemia in childhood, which the data of this study reinforced. Although this may appear encouraging, the point discussed by Stockman (1987) was that only 25 - 30% of low income individuals take advantage of the WIC program; thus, the real prevalence of anemia is unknown and should be considered seriously. The possibility that those with greatest concern for the health of their children

participate in WIC would indicate that the incidence of anemia in childhood is higher than the Centers for Disease Control (CDC) suggest. Most anemia statistics gathered by the CDC on children are collected from the WIC program.

The percentage of women with hematocrits less than 37%, the CDC cut-off value for anemia, was high (31% for EFNEP women and 26% for EFNEP-control women at preprogram evaluation). The mean hematocrit levels for EFNEP participants increased by the end of the study, yet it fell slightly for the EFNEP-control women. This was in agreement with Kris-Etherton (1986) and Tilgner and Schiller (1990) who reported a high incidence of anemia in healthy athletic and nonathletic women. It is thought that the high incidence of low hematocrit levels is due to a decreased dietary iron intake, which may be compounded by the desire for thinness, or to a higher rate of hemolysis and gastrointestinal loss due to strenuous exercise.

Correlation Analysis

Correlations were calculated among the postprogram nutrition knowledge scores, dietary iron intake, and hematocrit levels to determine any causal relation in knowledge score to behavior and to health (Table 18). The only correlation above 0.23 was that of the postprogram dietary iron intake with postprogram hematocrit level in the EFNEP-control participants of 0.507.

Table 18. Correlations of nutrition knowledge scores, iron intake, and hematocrit, reported by program.

Program	Variables	p
WIC	2nd knowledge score & 2nd iron intake	-0.189
	2nd knowledge score & 2nd hematocrit	+0.087
	2nd iron intake & 2nd hematocrit	-0.151
EFNEP	2nd knowledge score & 2nd iron intake	+0.248
	2nd knowledge score & 2nd hematocrit	+0.158
	2nd iron intake & 2nd hematocrit	-0.138
WIC Control	2nd knowledge score & 2nd iron intake	+0.129
	2nd knowledge score & 2nd hematocrit	-0.226
	2nd iron intake & 2nd hematocrit	+0.073
EFNEP Control	2nd knowledge score & 2nd iron intake	+0.018
	2nd knowledge score & 2nd hematocrit	-0.171
	2nd iron intake & 2nd hematocrit	+0.507*

* Significant at $p = 0.05$ level. No other correlations were significant.

Pearson correlations were calculated between several dependent and independent variables. Those close to or greater than 0.2 are recorded in Table 19. Correlations of "income" with "dietary iron intake," "income" with "dietary vitamin C intake," and "years of education" with "nutrition knowledge scores" appear repeatedly with different programs. This finding was not surprising, as high iron foods and high vitamin C foods are generally more expensive to purchase. Those with the highest level of education would be expected to score high on a test since they are experienced test takers.

Iron intake does not correlate to hematocrit level in a straight line relationship because iron absorption

Table 19. Correlations of independent variables.

Program	Variables	p
WIC	income & 2nd iron intake	+0.7155**
	income & 1st vitamin C intake	+0.4655**
	family size & 1st vitamin C intake	+0.3575*
	family size & 2nd knowledge score	+0.3499*
	individual income & 2nd iron intake	+0.7390**
	individual income & 1st vit. C intake	+0.5006**
EFNEP	years education & 2nd knowledge score	+0.4442*
	family size and 2nd knowledge score	+0.4379*
	years ed. & 2nd relative ferritin	-0.4457*
WIC Control	years education & 1st relative ferritin	+0.5367*
EFNEP Control	income & 1st vitamin C intake	+0.5107*
	individual income & 1st vit C intake	-0.6091**

Pearson correlations were used.

* Significant at p = 0.05 level

** Significant at p = 0.01 level

decreases as iron stores increase (Green et al., 1968).

The cut-off value for a low hematocrit as outlined by CDC is less than or equal to 37 for adults and 34 for children. Correlations between iron intake and hematocrit level were conducted for only those participants with a hematocrit of 37 or less (there were too few with less than a 34 hematocrit for children), and they are reported in Table 20. Only preprogram hematocrit levels and dietary iron intake showed a significant correlation in the WIC group. Preprogram hematocrit and protein intake were significant in the WIC and EFNEP-control groups. The same correlations were conducted for participants not taking vitamin or mineral supplements, and results are reported in Table 21. Again, the WIC program had a significant correlation between preprogram hematocrit level and dietary iron

intake. The WIC and EFNEP control groups had significant preprogram hematocrit and dietary protein intake.

Table 20. Correlations for study participants with a hematocrit of 37 or less.

Program	N	Variables	R ²	p
WIC	27	pre Hct & pre protein	0.376	0.027*
		pre Hct & pre iron	0.314	0.050*
EFNEP-C	9	pre Hct & pre protein	0.719	0.014*
		pre Hct & pre iron	0.749	0.010**
Composite	46	pre iron & pre vitamin C	0.329	0.013*
		pre vitamin A & pre vitamin C	0.261	0.040*

Note: protein, iron, vitamin A & vitamin C are dietary intakes of these nutrients, Hct = hematocrit, pre = preprogram, * = significant at p = 0.05, ** = significant at p = 0.01, EFNEP-C = EFNEP-control group.

Table 21. Correlations for study participants not taking vitamin supplements and with a hematocrit of 37 or less.

Program	N	Variables	R ²	p
WIC	21	pre Hct & pre protein	0.540	0.006**
		pre Hct & pre iron	0.381	0.044*
		post iron & post protein	0.396	0.042*
		post vit A & post vit C	0.505	0.012*
EFNEP-C	7	pre Hct & pre protein	0.641	0.060

Note: vit A = vitamin A, vit C = vitamin C. Protein, iron, vit A, vit C are dietary intakes of these nutrients. Hct = hematocrit, pre = preprogram, post = postprogram, * = significant at p = 0.05, ** = significant at p = 0.01, EFNEP-C = EFNEP-Control group.

Grouped T-Tests for Hematocrit, Nutrition Knowledge
Scores and Five Nutrients when Separated by the
Discrete Variables of "Taking Nutrition Classes"
and "Participating in Food Programs"

Grouped t-tests were calculated to determine if taking nutrition classes in high school or college, or if participation in other supplemental food programs had an effect on hematocrit level, relative ferritin level, nutrition knowledge score, or dietary intake of various nutrients. Table 22 lists the variables that show a significant difference between those who had participated in nutrition classes or in food programs and those who had not participated. Hematocrit, nutrition knowledge scores, vitamin A intake, and relative ferritin values were the variables that showed a significant difference between those that did and those that did not participate in nutrition classes or food programs. The results indicate that nutrition classes in college do have a positive effect on iron status and nutrition knowledge. Participating in federal food programs was associated with lower mean nutrition knowledge scores and lower relative ferritin levels. Participation in high school nutrition classes was associated with lower hematocrit levels and lower vitamin A intakes. This negative finding is a concern, and the different results between high school and college nutrition classes could be attributed to the level of difficulty

between the two curricula. Based on these data findings, participation in nutrition classes in college or high school or even earlier should be encouraged.

Regression Analysis

Regression analyses were conducted to determine effective predictor variables for the dependent variables of hematocrit, relative ferritin levels, nutrition knowledge scores, and several nutrient components. Table 23 lists the significant predictor variables, as separated by program. Income level and participation in nutrition classes in high school or college were the best predictors for dietary intake of several nutrients, while years of education, participation in nutrition classes in college, and preprogram nutrition knowledge score were the best predictors for the nutrition knowledge score. The best predictor for the postprogram hematocrit level was preprogram hematocrit level (except for the WIC participants, for whom the best predictor was participation in nutrition classes in high school). Table 24 is part of Table 23 reformatted to emphasize the effect income and nutrition classes in high school or college had on nutrient intake and nutrition knowledge scores. These data would suggest improved dietary intake and improved health are associated with participating in nutrition classes in college and high school.

Table 22. Grouped t-tests for hematocrit levels, nutrition knowledge scores and several nutrients when separated by the discrete variables "taking nutrition classes in high school," "taking nutrition classes in college," and "participating in other food programs."

Discrete Variable	Program	Dependent Variable	Mean	T-value	p
Nutr. H.S. No (n = 31) Yes (n = 11)	WIC	pre Hct pre Hct	36.9% 34.9%	3.35	0.0003
Nutr. H.S. No (n = 21) Yes (n = 5)	EFNEP	post Vit A post vit A	324% RDA 91% RDA	4.6	0.000
Nutr. College No (n = 37) Yes (n = 5)	WIC	pre Hct pre Hct	36.1% 38.6%	-2.39	0.064
Nutr. College No (n = 12) Yes (n = 11)	WIC-C	pre know score pre know score	15.83 17.55	-2.23	0.041
Nutr. College No (n = 12) Yes (n = 11)	EFNEP-C	pre know score pre know score	15.83 17.55	2.23	0.041
Food Program No (n = 35) Yes (n = 7)F	WIC	pre know score pre know score	14.90 10.75	3.2	0.021
Food Program No (n = 35) Yes (n = 7)	WIC	post know score post know score	15.49 12.57	3.48	0.004
Food Program No (n = 22) Yes (n = 4)	EFNEP	post rel fer post rel fer	123 ug/l 67 ug/l	2.63	0.015

Note: nutr. H.S. = nutrition classes in high school, nutr. college = nutrition in college, food program = participating in federal food programs, know score = total knowledge score, rel fer = relative ferritin, Hct = hematocrit, WIC-C = WIC control, EFNEP-C = EFNEP control.

Table 23. Regression analysis calculations showing significance.

Program	Dep Variable	Ind Variable	R ²	p
WIC	post know sc	pre know sc	0.67	0.0000
		+pre Hct	0.76	0.0000
WIC	post rel fer.	family size	0.45	0.0120
		+nutr H.S.	0.65	0.0052
WIC	post iron	ind income	0.55	0.0000
WIC	post vit C	family size	0.13	0.0201
WIC	pre vit C	ind income	0.25	0.0000
WIC	pre prot	nutr H.S.	0.24	0.0154
		+food prog	0.43	0.0029
		+vit supp	0.54	0.0011
WIC	pre iron	family size	0.22	0.0193
WIC	pre vit A	years ed	0.19	0.0342
WIC	pre Hct	nutr H.S.	0.43	0.0005
		+nutr coll	0.57	0.0002
EFNEP	post know sc	pre know sc	0.27	0.0068
EFNEP	post vit C	ind income	0.21	0.0196
EFNEP	post vit A	nutr H.S.	0.21	0.0171
		+nutr coll	0.37	0.0048
EFNEP	post calc	pre calc	0.31	0.0031
EFNEP	post Hct	pre Hct	0.33	0.0020
EFNEP	post rel fer	post know sc	0.27	0.0108
EFNEP	pre prot	vit supp	0.15	0.0448
EFNEP	pre know sc	years ed	0.20	0.0230
WIC-C	post know sc	pre know sc	0.35	0.0029
WIC-C	post prot	nutr H.S.	0.24	0.0170
WIC-C	post calc	nutr H.S.	0.31	0.0059
		+pre calc	0.55	0.0004
WIC-C	post Hct	pre Hct	0.37	0.0019
WIC-C	post rel fer	nutr H.S.	0.37	0.0044
WIC-C	pre vit A	nutr coll	0.21	0.0281
		+ vit supp	0.38	0.0089

Table 23 continued

Program	Dep Variable	Ind Variable	R ²	p
WIC-C	pre know sc	nutr coll	0.197	0.0337
WIC-C	pre rel fer	years ed	0.29	0.0321
EFNEP-C	post know sc	pre know sc	0.35	0.0029
EFNEP-C	post prot	nutr H.S.	0.63	0.0000
		+pre prot	0.72	0.0000
EFNEP-C	post iron	nutr H.S.	0.23	0.0233
EFNEP-C	post calc	nutr H.S.	0.77	0.0000
EFNEP-C	post Hct	vit supp	0.25	0.0179
		+pre Hct	0.51	0.0012
EFNEP-C	pre vit C	ind income	0.37	0.0020
EFNEP-C	pre know sc	nutr coll	0.21	0.0303
COMPOSITE	post prot	EFNEP part	0.11	0.0003
COMPOSITE	post iron	ind income	0.48	0.0000
COMPOSITE	post know sc	year ed	0.15	0.0000
		+nutr coll	0.20	0.0000
		+family size	0.23	0.0000
COMPOSITE	post Hct	EFNEP part	0.19	0.0000
		+nutr coll	0.28	0.0000
COMPOSITE	pre prot	EFNEP part	0.13	0.0001
COMPOSITE	pre know sc	nutr coll	0.17	0.0000
		+years ed	0.23	0.0000

Note: know sc = nutrition knowledge score, prot = protein intake, calc = calcium intake, vit A = vitamin A intake, vit C = vitamin C intake, iron = iron intake, rel fer = relative ferritin, Hct = hematocrit, vit supp = vitamin supplementation, ind income = individual income, years ed = years of education, nutr H.S. = nutrition classes in high school, nutr coll = nutrition classes in college, food prog = food program participation.

Table 24. Regression analysis outlined with income level and nutrition classes as predictor variables.

Predictor Variable	Program	Dep Variable	R ²	p
Individual Income	WIC	post iron	0.55	0.0000
"	WIC	pre vit C	0.25	0.0000
"	EFNEP	post vit C	0.21	0.0196
"	EFNEP-C	pre vit C	0.37	0.0020
"	Composite	post iron	0.48	0.0000
Nutrition High School	WIC	pre prot	0.24	0.0154
"	WIC	pre Hct	0.43	0.0005
"	EFNEP	pre vit A	0.21	0.0171
"	WIC-C	post prot	0.24	0.0170
"	WIC-C	post calc	0.31	0.0054
"	WIC-C	post Rel Fer	0.37	0.0044
"	EFNEP-C	post prot	0.63	0.0000
"	EFNEP-C	post iron	0.23	0.0233
"	EFNEP-C	post calc	0.77	0.0000
Nutrition College	WIC-C	pre vit A	0.21	0.0281
"	WIC-C	pre know sc	0.197	0.0337
"	EFNEP-C	pre know sc	0.21	0.0303
"	Composite	pre know sc	0.17	0.0000

Note: EFNEP-C = EFNEP control group, WIC-C = WIC control group, calc = calcium intake, prot = protein intake, vit A = vitamin A intake, vit C = vitamin C intake, know sc = nutrition knowledge score.

Since the relationship between iron intake and hematocrit level is not a straight line relationship as discussed previously (Green et al., 1968), study participants with a hematocrit of 37 or less were selected for a regression analysis. With hematocrit level as the dependent variable the only significant predictor variables were dietary iron intake in the EFNEP-control group ($R^2 = 0.561$) and dietary protein intake for the entire study group ($R^2 = 0.1387$ and $p = 0.0276$).

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Nutrition Knowledge

Nutrition knowledge test scores for the Women, Infants, and Children Supplemental Food Program (WIC) participants increased significantly from preprogram to postprogram (14.2 ± 3.27 to 15.5 ± 2.89) when analyzed by paired t-tests. The Expanded Food and Nutrition Education Program (EFNEP) participants also showed a significant improvement in nutrition knowledge test score from preprogram to postprogram (14.2 ± 3.77 to 15.6 ± 2.79) when analyzed by paired t-tests. The control participants did not have an increase in nutrition knowledge score in paired t-test analysis; yet, their preprogram scores were significantly higher than the WIC and EFNEP preprogram scores, a probable result of their higher level of formal education. This was recognized as a limitation of the study and an analysis of covariance with level of formal education and knowledge test scores as covariables revealed there was no difference among the WIC, EFNEP, and control participants for preprogram knowledge scores.

The results of this study can be interpreted favorably for both the WIC and EFNEP programs. The participants in this study were less isolated, more sophisticated, better educated, more discriminating, and more self-motivated than

earlier EFNEP participants, but they were similar to the EFNEP participants reported by Chipman and Kendall (1989). They would be expected to score higher on a posttest evaluation. This did not occur in this study's control participants (those not receiving nutrition education). The nutrition education programs for both the EFNEP and WIC participants were effective in increasing the participants' knowledge about practical nutrient information that is essential to optimal health.

Hematocrit Levels

The hematocrit levels for the EFNEP participants showed a significant increase from preprogram (38.5 ± 3.78) to postprogram (40.7 ± 2.13) when analyzed by paired t-tests. The mean preprogram value of 38.5 ± 3.78 was above the cut-off value for low hematocrit (termed "low normal"), and an increase within an already normal range is impressive. An analysis of variance was conducted on the difference scores of hematocrit level from preprogram to postprogram. There was a significant difference in hematocrit level for EFNEP participants from the WIC and control participants ($F = 0.0018$).

The change in hematocrit values for WIC participants was not significant (mean of 36.4 ± 2.17 at preprogram to 37.1 ± 2.34 at postprogram) when analyzed by paired t-tests. The hematocrit values for the control groups

remained unchanged.

Participation in the EFNEP program appeared to improve iron status by increasing mean hematocrit levels from a "low normal" level to a "normal" level. These findings should be considered when allocating money for nutrition education programs. The EFNEP program (the program with more emphasis on nutrition education accompanied by hands-on training) appears to be superior in increasing iron status over the WIC program (the program with emphasis on nutrition education and food supplements). The difficult task of defining motivation for program participation needs to be considered and studied. WIC participants often, on informal questioning, reported the food supplements as the incentive to participate in the program. The EFNEP participants, however, stated an interest in self-improvement and better health. Enrollment of participants in both programs simultaneously could prove synergistic in improving nutrition knowledge levels and iron status in program participants.

Dietary Nutrients

The mean intake of vitamin A, vitamin C, calcium, and protein were above the RDA at preprogram evaluation and postprogram evaluation (Table 8); yet, the percentage of individual participants who consumed less than 67% of the RDA (Table 14) was high, similar to the Continuing Survey

of Food Intake by Individuals 1985 study data (16% for vitamin A, 33% for vitamin C, 25% for calcium, and 5% for protein at preprogram evaluation; 12% for vitamin A, 15% for vitamin C, 19% for calcium, and 4% for protein at postprogram evaluation). The mean value of all nutrients reported in Table 8 may represent a false "high" since a few individuals consumed as high as 999% of the RDA.

Iron intake was a concern when examining mean values of dietary iron for each program (58 - 74% of the RDA), as shown in Table 8, or when observing that 62% of the participants consumed less than 67% of the RDA (Table 14).

There was a significant increase in dietary protein in the WIC program, for calcium and protein in the EFNEP program, and for iron in the EFNEP-control group between preprogram and postprogram evaluation when analyzed by paired t-tests. The proportion of WIC and EFNEP participants that consumed less than 67% of the RDA of a nutrient (any of the five) decreased from preprogram evaluation to postprogram evaluation. It was impressive that those at highest risk for nutrient deficiencies improved their dietary intake after participation in these programs. Control participants at highest risk for nutrient deficiencies (< 67% RDA) did not show the same trends for dietary improvement.

Effect of Nutrition Education Sessions
in High School or College and Income
Level on Dietary Intake and
Nutrition Knowledge Scores

Grouped t-tests were conducted between study participants who took nutrition classes in high school and those who did not, between study participants who took nutrition classes in college and those who did not, and between study participants who enrolled in other food programs (e.g., food stamps) and those who did not. The results reported in Table 22 indicate participating in nutrition education in college had a positive effect on iron status and nutrition knowledge scores. Participating in nutrition classes in high school and in other food programs had a negative effect on hematocrit, nutrition knowledge scores, and vitamin A intake. The differences between the nutrition curriculum in college and high school could account for the frequency of exposure and detail of information. The Utah State Board of Education does not have a nutrition curriculum for secondary schools. In contrast, the nutrition courses taught in Utah at the college level are curriculum outlined in detail for 10-15 weeks. These data show that more emphasis on nutrition curriculum in high school or earlier could provide important benefits.

Limitations

- 1) The control group in this study had a higher education level, which may have altered nutrition knowledge test scores. Yet, when using years of formal education as a covariate with nutrition knowledge test scores, there was no significant difference among the groups.
- 2) Dietary intake values were calculated on a 24-hour dietary recall, checked against a food frequency. This limits the validity of individual analysis, but is accepted for groups of people.
- 3) The income level of this study population was higher than income level of WIC and EFNEP participants reported in previous studies.

Recommendations

- 1) This study should be conducted on a larger sample size (having the clinics' personnel collect the data to help decrease the problems of the high dropout rates).
- 2) The study should be conducted with accurate ferritin values (obtain permission from local clinics for a larger blood sample).
- 3) The data of this study could be expanded by including information on the amount of iron enhancers and iron inhibitors in the diets.
- 4) This study should be conducted on high school students versus college students who have standardized

nutrition curricula.

- 5) This study should be conducted when different methods of education are used (monitor the class topics, method of instruction, and follow-up procedures).

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APPENDICES

APPENDIX A: Study Participant Characteristics

Table A.1. Age distribution for WIC and WIC control study participants.

Age in years	WIC		WIC-Control		COMPOSITE	
	pre	post	pre	post	pre	post
1	8(19)	3(7)	3(13)	-	11(17)	3(5)
2	11(26)	12(29)	6(26)	7(30)	17(26)	19(29)
3	18(43)	13(31)	9(39)	4(17)	27(42)	17(26)
4	5(12)	13(31)	5(22)	7(30)	10(15)	20(31)
5	-	1(2)	-	5(22)	-	6(9)
mean	2.47	2.93	2.70	3.43	2.55	3.11
range	1 - 4	1 - 5	1 - 4	1 - 5	1 - 4	1 - 5
n	42	42	23	23	65	65

Note: Numbers in parentheses () are percentages.

Table A.2. Study participants categorized by family size and tallied by program.

Family Size	WIC	EFNEP	WIC-C	EFNEP-C	COMPOSITE
2	2 (5)	-	1 (4)	1 (4)	4 (4)
3	14 (33)	4 (15)	9 (39)	9 (39)	36 (31)
4	13 (31)	7 (27)	3 (13)	3 (13)	26 (23)
5	10 (24)	6 (23)	10 (44)	10 (13)	7 (6)
6	3 (7)	4 (15)	-	-	7 (6)
7	-	4 (15)	-	-	4 (4)
8	-	1 (4)	-	-	1 (1)
mean	3.95 b* ±1.03	5.0 a* ±1.44	3.96 b* ±1.02	3.96 b* ±1.02	4.19 ±1.20
range	2-6	3-8	2-5	2-5	2-8
n	42	26	23	23	114

Note: Numbers in parentheses () are percentages.
 Numbers followed by an "a" differ significantly from those followed by a "b."
 * significant at = p. 001 level

Table A.3. Study participants categorized by monthly income and tallied by program.

Income dollars per month	WIC	EFNEP	WIC-C	EFNEP-C	TOTAL
less than 100	1 (2)	-	-	-	1 (.8)
101-200	1 (2)	-	-	-	1 (.8)
201-300	1 (2)	-	-	-	1 (.8)
301-400	3 (7)	-	-	-	3 (3)
401-500	5 (12)	3 (12)	3 (13)	3 (13)	14 (12)
501-600	-	3 (12)	3 (13)	3 (13)	9 (8)
601-700	1 (2)	-	-	-	1 (.8)
701-800	1 (2)	-	-	-	1 (.8)
801-900	4 (9)	2 (8)	2 (9)	2 (9)	10 (9)
901-1000	5 (12)	-	-	-	5 (4)
1001-1100	1 (2)	5 (19)	1 (4)	1 (4)	8 (7)
1101-1200	3 (7)	2 (8)	3 (13)	3 (13)	11 (10)
1201-1300	2 (5)	-	-	-	2 (2)
1301-1400	1 (2)	11 (42)	11 (48)	11 (48)	34 (30)
1401-1500	2 (5)	-	-	-	2 (2)
1501-1600	1 (2)	-	-	-	1 (.8)
1601-1700	1 (2)	-	-	-	1 (.8)
1701-1800	2 (5)	-	-	-	2 (2)
1801-1900	2 (5)	-	-	-	2 (2)
1901-2000	2 (5)	-	-	-	2 (2)
2001-2100	1 (2)	-	-	-	1 (.8)
2101-2200	1 (2)	-	-	-	1 (.8)
2201-2300	1 (2)	-	-	-	1 (.8)
mean	1297 ±1476	1045 ±332	1052 ±355	1052 ±355	1140 ±938
range	89-2226	438-1339	438-1339	438-1339	89-2226
mean individual income (income/family size)	351.4	224.6	279.2	279.2	293.3
n	42	26	23	23	114

Note: Numbers in parentheses () are percentages.

Table A.4. Study participants categorized by years of formal education and tallied by program.

Years of Education	WIC	EFNEP	WIC-C	EFNEP-C	COMPOSITE
6	-	1 (4)	-	-	1 (1)
7	1 (2)	-	-	-	1 (1)
8	1 (2)	-	-	-	1 (1)
9	-	1 (4)	-	-	1 (1)
10	3 (7)	1 (4)	-	-	4 (4)
11	2 (5)	1 (4)	-	-	3 (3)
12	26 (62)	10 (38)	1 (4)	1 (4)	38 (33)
13	4 (9)	12 (46)	15 (65)	15 (65)	46 (40)
14	3 (7)	-	2 (9)	2 (9)	7 (6)
15	-	-	-	-	-
16+	2 (5)	-	5 (22)	5 (22)	12 (11)
mean	12.02a* ±1.58	12.00a* ±1.57	13.80b* ±1.51	13.80b* ±1.51	12.73 ±1.76
range	7-16	6-13	12-18	12-18	6-18
n	42	26	23	23	114

Note: Numbers in parentheses () are percentages.
 Numbers followed by an "a" differ significantly from those followed by a "b."
 * significant at p = .0000 level

Table A.5. Percent of study participants who were taking vitamin supplements, participated in other federal food programs, or took a nutrition class in high school or college.

Category	WIC		EFNEP		WIC-C		EFNEP-C		COMPOSITE	
	pre	post	pre	post	pre	post	pre	post	pre	post
Vitamin Supplement	8(19)	11(26)	6(23)	5(19)	3(13)	4(17)	4(17)	4(17)	21(18)	21(21)
Food Programs	7(17)	7(17)	3(12)	3(12)	1(4)	1(4)	1(4)	1(4)	12(11)	12(11)
Nutrition in High School	11(26)	11(26)	5(19)	5(19)	2(9)	2(9)	2(9)	2(9)	20(18)	20(18)
Nutrition in college	5(12)	5(12)	2(8)	2(8)	11(48)	11(48)	11(48)	11(48)	29(25)	29(25)
n	42	42	26	26	23	23	23	23	114	114

Note: Numbers in parentheses () are percentages.

APPENDIX B: Data Collection Forms and Consent Form

NUTRITION KNOWLEDGE

NAME: _____

Revised 10-30-90

NUMBER: _____

DATE: _____

Select the correct answer to the following questions by marking a letter in the space provided.

_____ 1. What is the best buy for low-fat protein?

- a. Boneless, skinless chicken breasts at \$2.49 a pound.
- b. Chicken nuggets 6 for \$1.75.
- c. Whole chicken at 49 cents a pound and skin it at home.

_____ 2. The best source of Iron is:

- a. Old rusty nails
- b. Yogurt
- c. Broccoli
- d. Eggs

_____ 3. A food which is a good source of Vitamin A is:

- a. Pineapple
- b. Broccoli
- c. Whole Wheat Bread
- d. Chicken lean

_____ 4. The following information is found on food labels. Which food has the most Protein per calorie?

	<u>gm protein</u>	<u>calories</u>
a. Split pea soup	1	22
b. Bacon	1	82
c. Oatmeal	1	28
d. Corn	1	30

_____ 5. Protein is important to the human body because:

- a. It prevents heart attacks.
- b. Builds and repairs cells.
- c. Speeds up how fast you digest food.
- d. Reduces blood clotting time.

_____ 6. A good source of Vitamin C is:

- a. Potato
- b. Rice
- c. Bread
- d. Milk
- e. Sunshine

_____ 7. From the list below the best source for calcium is:

- a. Beans or Legumes
- b. Tomatoes
- c. Eggs
- d. Rice

_____ 8. Which of the following lists contain the Basic 4 food groups?

a. Nuts and seeds
Fruits and Vegetables
Meat, Poultry, Fish, Beans
Milk and Cheese c. Milk and Cheese
Breads and Cereals
Fats and Sweets
Fruits and Vegetables | <ul style="list-style-type: none"> b. Milk and Cheese
Breads and Cereals
Meat, Poultry, Fish, Beans
Fruits and Vegetables d. Fruits
Vegetables
Meat, Poultry, Fish, Beans
Milk and Cheese. |
|---|--|

_____ 9. A most Nutritious food is one that:

- a. Is low in nutrients and high in calories.
- b. Has a lot of calories or energy.
- c. Is high in nutrients and low in calories.
- d. Contains a large amount of protein.

_____ 10. Which of the following foods would have the most calories?

	<u>grms carbohydrate</u>	<u>grms protein</u>	<u>grms fat</u>
a. Skim milk (1 cup)	12	8	0
b. French Fries (15 pieces)	15	2	15
c. Hot Dog without a Bun (1)	1	6	10
d. Cantaloupe (2/3 melon)	30	0	0

_____ 11. When adding fat or sugar to a food, the nutrient value per calorie is:

- a. Increased.
- b. Decreased.
- c. Not changed.

- _____ 12. When purchasing a beverage, the most nutritious is:
- a. Fruit juice
 - b. Fruit drink
 - c. Fruit juice with vitamin C.
 - d. Light Beer
 - d. Diet pop
- _____ 13. Which of the following foods would provide the most protein for your money
a. 16 oz bag dry pinto beans Price \$1.29 Servings per container 12 Serving size 1/2 C Nutrients per serving Calories.....96 Protein.....8 gms CHO.....16 gms Fat.....tr	b. 16 oz can pinto beans Price 69 cents Servings per container 4 Serving size 1/2 C Nutrients per serving Calories.....123 Protein.....8 gm CHO.....16 gm Fat.....3 gm
- _____ 14. Eating foods with complex carbohydrates and fiber has beneficial effects, these include:
- a. Helping prevent certain types of cancer (especially if high in vitamin A and vitamin C)
 - b. Helping control diabetes
 - c. Helping prevent colon problems
 - d. All of the above
- _____ 15. Pinto Beans are high in iron. Which food should be included with the meal to increase the iron absorption?
- a. Hammer and nails
 - b. Milk
 - c. Tomatoes
 - d. Carrots
- _____ 16. Pinto beans are high in protein. Which food should be added to make a complete protein?
- a. Orange juice
 - b. Corn tortilla
 - c. Brocoli

- _____ 17. Mrs. Jones is 7 months pregnant and has noticed she needs to take rapid breaths to get enough oxygen (air). If the baby is not pushing on the lungs, this condition could possibly be helped if she ate more foods high in:
- a. Vitamin A
 - b. Vitamin C
 - c. Iron
 - d. Calcium
- _____ 18. Jane at age 22 wants to decrease her risk for osteoporosis, since her grandmother just had a broken hip. She has increased her diet in:
- a. Vitamin A
 - b. Calcium
 - c. Vitamin C
 - d. Iron
- _____ 19. Jerry has noticed that his gums bleed when he brushes his teeth. His bruises and scratches also take a long time to heal. He should try increasing his diet in:
- a. Vitamin C
 - b. Vitamin D
 - c. Fluoride
 - d. Calcium
- _____ 20. Jessie has noticed she has trouble driving at nighttime because her eyes do not adjust to dark. The doctor diagnosed her condition as nightblindness and told her to increase her diet in:
- a. Vitamin D
 - b. Vitamin C
 - c. Vitamin A
 - d. Niacin
- _____ 21. Hot foods should be kept hot and cold foods should be kept cold to:
- a. Preserve nutrients
 - b. Avoid food poisoning
 - c. To keep a person busy

PARTICIPATION AND CONSENT FORM
Nutrition Education Project

Name: _____
 Social Security # _____
 Birth Date: _____
 County Computer # _____

"The Effect of Nutrition Knowledge on Hematocrit Values"

Informed consent to participate in a Utah State University Research project conducted by staff from USU Extension and Women, Infant, Children Supplemental Food Program (WIC).

I _____ understand that as a participant in this project:

- 1) I will provide a written diet history (the WIC 24 hour diet recall) on my child at the beginning of the research project and 6 months later. (These are the usual time frames this is done for the EFNEP and WIC programs and will be part of the WIC recertification procedure.)
- 2) I will provide a written medical history on my child at the beginning of the research project. This is the standard WIC medical history form.
- 3) I will allow a trained person to take a finger prick blood sample on my child at the start of the study and at a 6 month follow-up screening (the usual scheduled certification appointment). This is the normal procedure for WIC enrollment.
- 4) I will answer a questionnaire on nutrition at the beginning of the study and at a 6 month follow-up (certification appointment).
- 5) I will attend the nutrition lessons presented through EFNEP or WIC while my child is participating in the study.

In return for my participation I understand I will have access to all my child's data including the dietary evaluations and blood chemistry data.

I understand I or my child am free to withdraw our participation in this project at any time and the walk in no way jeopardizes my child's continued participation in the WIC or EFNEP program.

I understand there are no expected risks to my child involved due to our participation in this project.

Any questions relating to the procedures used in this project will be answered by Nedra Christensen (484-9374) or Becky Low (468-3181).

 Guardian Signature

 Date

 Witness

 Date

 Date of Location

CHILD

FIRST VISIT

Name _____

Address _____

Phone # _____

Child's Name _____

Child's Age _____

Child's Ht _____ %ile _____

Wt _____ %ile _____

Hct _____

Family size _____

Income/Mon _____

Previous Nutrition Classes _____

Last Level of Education Completed _____

Ethnic Origin _____

Enrolled in EFNEP Y N

Enrolled in other Government Food Programs _____

RETURN VISIT

Ht _____ %ile _____

Wt _____ %ile _____

Hct _____

Family size _____

Income level _____

Name _____

Address _____

Phone Number _____

Income Level (Please check one of the following)

☐ Under \$438 per month	☐ \$889 - 1038 per month
☐ \$439 - 588 per month	☐ \$1039 - 1188 per month
☐ \$589 - 738 per month	☐ \$1189 - 1338 per month
☐ \$739 - 888 per month	☐ \$1339 and over per month

Total number on individuals living in household _____

Please circle the last grade of formal education completed

None 1 2 3 4 5 6 7 8 9 10 11 12 some college

BS Degree Graduate Degree

List any type and number of nutrition classes recieved in the past.

UTAH DEPARTMENT OF HEALTH
FAMILY HEALTH SERVICES DIVISION
NUTRITION HISTORY - TEENS AND ADULTS BASIC FOUR

DIRECTIONS		LAST 24 HOUR OR TYPICAL DIETARY INTAKE			
1. Circle food eaten. 2. Please fill in the number of times eaten daily OR weekly, not both. 3. Circle the typical amount eaten. 4. If you eat more than a listed amount circle +		Example: <u>oatmeal</u> <u>2 1/2</u> <u>1C</u> <u>2 1/2</u> <u>milk</u> <u>1C</u>			
		MORNING			
FOODS EATEN	#	O	#	WEEKLY	USUAL SERVING SIZE
Example: <u>orange</u> <u>grapefruit</u>				<u>3</u>	<u>1/2</u> <u>1</u> <u>2</u> +
CALCIUM					
PROTEIN					
VITAD					
Milk (2%, whole, skim, Choc.)					1/2c 1c 2c +
Cheese					1/2oz 1oz 2oz +
Yogurt, Pudding					1/2c 1c 2c +
Ice-cream, cottage cheese					1/2c 1c 2c +
PROTEIN					
IRON					
Eggs					1 2 3 +
Chicken, Fish, Turkey					1oz 2oz 3oz +
*Beef, Ham, Pork					1oz 2oz 3oz +
Hot Dogs, Luncheon Meat, Bologna					1 2 3 +
Peanut Butter					1T 2T 3T +
*Dried Beans, Nuts					
Dried Peas, Tofu					1/2c 1c 2c +
Burrito, Taco, Tamales					1 2 3 +
VIT C					
Citrus Juice, WTC Juice					1/2c 1c 2c +
Oranges, Grapefruits					1/2 1 2 +
Cabbage, Cauliflower					1/2c 1c 2c +
VIT A and C					
*Broccoli					1/2c 1c 2c +
VIT A					
*Spinach, Kale, Greens, Carrots, Sweet Potatoes, Squash					1/2c 1c 2c +
Apples, Cantaloupe					1/2c 1c 2c +
OTHER VEGETABLES & FRUITS					
Corn, Peas, Green Beans, Lettuce, Potato, Tomato					1/2c 1c 2c +
Apples, Bananas, Pears					1/2c 1c 2c +
Other Fruit Juices					1/2c 1c 2c +
BREADS					
IRON					
Bread, Tortillas					1/2 1 2 +
Crackers, Granola, Soda					
Muffins, Pancakes, Biscuits					1 2 3 +
Noodles, Rice, Macaroni					
Spaghetti, Ramen Noodles					1/2c 1c 2c +
*Cereals - WTC					1/2c 3/4c 1c +
Cereals - Non-WTC					1/2c 3/4c 1c +
Coffee, Tea, Cola Drinks					1/2c 1c 2c +
Soda Pop, Koolaid, Tang					1/2c 1c 2c +
Cookies, Cake, Candy, Pie					1 2 3 +
Potato Chips, Snack Chips					1/2c 1c 2c +
Jelly, Jam, Sugar					1 tsp 2 tsp 3 tsp +
Butter, Margarine					1 tsp 2 tsp 3 tsp +
OTHER FOODS EATEN AND NOT LISTED ABOVE					
* Foods high in iron					

CARE PLAN (Office Use Only)

NUTRIENT SUMMARY OFFICE USE ONLY (Circle numbers for which the total is less than recommended)					
NUTRIENT	RECOMMENDED SERVING				TALLY TOTAL
	Teen	Atx	SP	PP	
MILK 1 c milk, yogurt, pudding OR 1-1/2 oz cheese OR 2 c cottage cheese, ice cream		5-6	4	4-5	3
MEAT/PROTEIN 2 oz meat OR 2 eggs OR 4 T P. Butter OR 1 c. legumes		3	3	3	3
WTC 3 oz meat OR 1/4 c. legumes OR 3/4 c. WTC cereal		4	4	4	4
VITAMIN C 1/2 c juice (WTC citrus) OR 1/2 Orange, grapefruit OR 1/2 c broccoli		2	2	3	3
VITAMIN A 1/2 c cooked 1 c raw		1	1	1	3-4 1-2
OTHER FRUIT VEGETABLES 1/2 c servings		2	2	2	2
GRAIN/BREADS 1 slice bread OR 1 oz dry cereal OR 1/2 c cooked cereal/pasta, OR Crackers: 6 saltine/3 graham		4	4	4	4

Staff Signature & Title _____ Date ____/____/____

Client's Name _____

Staff signature & Title _____ Date ____/____/____

(PLEASE COMPLETE OTHER SIDE)

UTAH STATE WIC PROGRAM
Pregnancy & Medical Interview

Date _____ Name _____ Doctor's Name _____
 Birthdate _____ Age _____ Date of last period (LMP) _____
 Age at start of menstruation _____
 What month did you start prenatal care _____ Prenatal Classes Attended? Yes/No
 Pre-pregnancy weight _____ Total Wt Gain/Loss During Pregnancy _____

Do you Have: (Please circle)

Headaches	Persistent Nausea/ Vomiting	Problems Seeing	Gestational Diabetes
Dizziness	Swelling	Toxemia or Pre-eclampsia	Spotting or Hemorrhaging
Stomach or Intestinal Problems	Vitamin/Mineral Deficiencies	Tuberculosis	Cancer
Chronic Infections	Diabetes	Heart Disease	Kidney Disease
Liver Disease	Lung Disease	Thyroid Disease	High Blood Pressure
Food Allergies	Anemia	Family History of Genetic Disorders	Mental Retardation
Venereal Disease	HIV Positive		Hepatitis

CURRENT PREGNANCY	PREVIOUS PREGNANCIES																																	
<div style="text-align: right; margin-bottom: 5px;">YES NO</div> Are you expecting twins/triplets? _____	Date last pregnancy ended _____ (include miscarriages, etc.)																																	
Do you plan to breastfeed? _____	Total number of previous pregnancies _____ (include miscarriages)																																	
Do you smoke? How much? _____	Average pounds weight gain _____																																	
Do you drink alcohol? How much? _____	Have you ever had the following:																																	
Do you use drugs/medication? What kind? _____	<table style="width: 100%; border: none;"> <thead> <tr> <th></th> <th style="text-align: center;">YES</th> <th style="text-align: center;">NO</th> </tr> </thead> <tbody> <tr> <td>Infant death?</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>Premature Birth?</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>Weight? _____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>Infant with birth defect?</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>What kind? _____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>Two or more miscarriages? or</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>Abortions?</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>Stillborns?</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>Infants born under 5-1/2 lbs?</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>Other problems? _____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> </tbody> </table>		YES	NO	Infant death?	_____	_____	Premature Birth?	_____	_____	Weight? _____	_____	_____	Infant with birth defect?	_____	_____	What kind? _____	_____	_____	Two or more miscarriages? or	_____	_____	Abortions?	_____	_____	Stillborns?	_____	_____	Infants born under 5-1/2 lbs?	_____	_____	Other problems? _____	_____	_____
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Infants born under 5-1/2 lbs?	_____	_____																																
Other problems? _____	_____	_____																																
<div style="border: 1px solid black; padding: 2px;"> Office Use Only Breastfeeding encouraged? _____ EDC/ADC _____ Prenatal Vitamins Recommended? _____ </div>																																		

Your signature indicates consent for use of this information to determine WIC eligibility.

Client Signature _____

CPA/Nutritionist/Title _____

UTAH STATE WIC PROGRAM

CHILD'S MEDICAL HISTORY

TODAY'S DATE _____
 PARENT/GUARDIAN _____
 CHILD'S NAME _____ BIRTHDATE _____
 DOCTOR'S NAME _____

MEDICAL HISTORY

DOES YOUR CHILD HAVE: (Please Circle)

Frequent diarrhea	Chronic Constipation	Growth Problems (Failure to Thrive)
Food Allergies	Vomiting	Swallowing Problems
Dental Cavities or Problems	Stomach or Intestinal Problems	Birth Defects
Down Syndrome	Cerebral Palsy	Mental Retardation
PKU	Diabetes	Celiac Disease
Heart Disease	High Blood Pressure	Kidney Disease
Liver Disease	Thyroid Problems	Wilson's Disease
Maple Syrup Urine Disease	Cystic Fibrosis	Colic
Cancer	Hepatitis	HIV+

HAVE ANY FAMILY MEMBERS HAD ANY OF THE ABOVE? Yes ____ No ____

IF YES, PLEASE INDICATE WHICH: _____

ARE YOUR CHILD'S IMMUNIZATIONS CURRENT? YES ____ NO ____

DOES YOUR CHILD GET FREQUENT INFECTIONS? (Ear, tonsillitis, sore throat, bronchitis, etc.)

YES ____ NO ____ EXPLAIN _____

LIST ANY MEDICATIONS YOUR CHILD IS TAKING: _____

Your signature indicates consent to use this information to determine WIC eligibility. All information will be kept confidential.

Parent's Signature: _____

Nutritionist/CPA Signature _____

(PLEASE COMPLETE OTHER SIDE)

**Statement of the PI to the IRB for Proposed
Research Involving Human Subjects**

Proposal Title The Effect of Nutrition Knowledge & Behavior on Hematocrit Values.

Principal Investigator* Nedra K. Christensen Dept. NFS UMC 3700 Ext. 346-474-9374

Student Researcher _____ Dept. _____ UMC _____ Ext. _____

- A. Human subjects will participate in this research and be asked to do the following: provide a written dietary history, medical history, take a pre and post test (quiz) and have a finger-prick hematocrit (Hct) value.
- B. The potential benefits to be gained from the proposed research are: covering where the emphasis on improving health (Hct) is placed OR should be placed (e.g. nutrition education, or actual food supplements) in these two federal programs.
- C. The risk(s) to the rights and welfare of human subjects involved are: the minimal risks associated with a finger stick blood sample.
- D. The following safeguards/measures to mitigate/minimize the identified risks will be taken: County Health Dept. procedures will be utilized (e.g. clean equipment between each subject, new lancets, gloved employees, alcohol swabs, etc for each new participant).
- E. The informed consent procedures for subjects will be as follows: (Explain procedures to be followed and attach an example of the informed consent instrument) Each participant will be told that participation is voluntary and will follow the federal program protocols - see attached consent form.
- F. The following measures regarding confidentiality of subjects will be taken: All reports will be done by participant number (not name). Raw data will not be distributed.
- G. Other: (If, in your opinion no, or minimal, risk to subjects exists, please explain in this section) _____

Nedra K. Christensen
Principal Investigator Signature*

Student Researcher Signature

* A student researcher should name his/her advisor or chairman as the principal investigator. Both are required to sign this form.

APPENDIX C: Standards for Anemia and Blood Collection

(Permission to reprint granted orally by

Don Johnson, Utah Department of Health,

WIC Director, March 16, 1993)

TABLE 1. ANEMIA STANDARDS ADJUSTED FOR ALTITUDE

1. The following chart should be used to determine nutritional risk and WIC eligibility. Values less than the cut-off are required to designate nutritional risk.
2. Please note the following:
 * Hemoglobin and hematocrit levels indicating risk adjust with altitude change. The altitude for your clinic specified on the following page should be applied for all clients seen in the clinic.

Hematocrit, % *	Altitude (Feet)			
Age of Individuals	0-2999	3000-4999	5000-6999	7000 or more
Less than 6 months		No Standards		
6 - 23 months	33%	34%	35%	36%
2 - 4 years 11 months	34%	35%	36%	37%
Breastfeeding and Post Partum Women	36%	37%	38%	39%
Pregnant Women				
1st Trimester	35%	36%	37%	38%
2nd Trimester	32%	33%	34%	35%
3rd Trimester	33%	34%	35%	36%

Hemoglobin, mg%	Altitude (Feet)			
Age of Individuals	0-2999	3000-4999	5000-6999	7000 or more
Less than 6 months		No Standards		
6 - 23 months	11.0 gms	11.3 gms	11.7 gms	12.0 gms
2 - 4 years 11 months	11.2 gms	11.5 gms	11.9 gms	12.2 gms
Breastfeeding and Post Partum Women	12.0 gms	12.3 gms	12.7 gms	13.0 gms
Pregnant Women				
1st Trimester	11.5 gms	11.8 gms	12.2 gms	12.5 gms
2nd Trimester	10.5 gms	10.8 gms	11.2 gms	11.5 gms
3rd Trimester	11.0 gms	11.3 gms	11.7 gms	12.0 gms

* Centers for Disease Control, Criteria for Anemia in Children and Childbearing-Aged Women. MMWR 38: 401 - 404, 1989

Nutrition During Pregnancy. Subcommittee on Dietary Intake and Nutrient Supplements During Pregnancy. Food and Nutrition Board, National Academy of Sciences, Washington D.C., 1990.

TABLE 2.

DISTRICT, CLINIC AND ALTITUDE TABLE

Clinic		Altitude (Feet)
<u>Bear River District Health Department</u>		
21001	Logan	4526
21002	Brigham City	4220
21003	Tremonton	4320
21004	Randolph	6442
<u>Central Utah District Health Department</u>		
24001	Nephi	5119
24002	Delta	4650
24003	Manti	5800
24004	Richfield	5303
24005	Junction	6000
24006	Loa	7020
24007	Fillmore	5061
24013	Mt. Pleasant	5700
<u>Davis County Health Department</u>		
22201	Farmington	4231
<u>Family Health Services</u>		
All Clinics	Salt Lake City	4366
<u>Salt Lake City/County Health Department</u>		
All Clinics	Salt Lake City	4366
<u>Salt Lake Indian Health Care Center</u>		
31000	Salt Lake City	4366
<u>Southeastern District Health Department</u>		
27000	Price	5567
27002	Castledale	5660
27003	Moab	4000
27004	Blanding	6000
27014	Monticello	7050
<u>Southwest Utah District Health Department</u>		
25001	St. George	2880
25007	Hurricane	3279
25008	Hilldale	5200
25011	Enterprise	6000
25012	Nevada	1600
25002	Cedar City	5800
25003	Kanab	4925
25004	Panguitch	6670
25005	Escalante	5258
25006	Tropic	6400
25009	Antimony	6300
25101	Beaver	5895

DISTRICT, CLINIC AND ALTITUDE TABLE

<u>Clinic</u>	<u>Altitude (Feet)</u>
<u>Summit City-County Health Department</u>	
28001 Coalville	5300
Kamas	6500
Park City	7000
<u>Tooele County Health Department</u>	
22401 Tooele	4900
22402 Wendover	4240
<u>Uintah Basin District Health Department</u>	
26101 Vernal	5331
26102 Roosevelt	5280
26112 Duchesne	5515
26109 Manila	6295
<u>U of U Teen Mom Child Clinic</u>	
22601 Salt Lake City	4366
<u>City-County Health Department of Utah County</u>	
29001 Provo	4553
29002 Orem	4553
<u>Utah Rural Development Corporation</u>	
30002 Provo	4553
<u>Ute Indian Tribe</u>	
26001 Ft. Duchesne	5331
<u>Wasatch-City-County Health Department</u>	
23101 Heber City	5593
<u>Weber-Morgan District Health Department</u>	
22101 Ogden	4370
22103 Spanish	4370
22102 Morgan	5068

The information in this activity is important, regardless of whether or not it is your job responsibility to perform the hematocrit test. Understanding hematocrit procedures will help you answer related client questions and help you follow-up results of the test more effectively.

TEST PROCEDURES

In order to be useful as an indicator of nutritional status, the hematocrit test must be accurately performed, recorded and compared with appropriate standards.

EQUIPMENT

Locate the centrifuge in your clinic. Have a staff member lift the cover and then the inside lid which seals in the hematocrit tubes. Find the grooves for holding tubes and the scale used to read results. Inhead hematocrit readers are not to be used. Hematocrit Reader cards are required. The centrifuge must be kept calibrated and in good working condition to assure accurate results. Check with the nutritionist regarding its maintenance schedule.

Locate other equipment listed in the Materials and Supplies list on Page 6.

GUIDANCE ON THE HANDLING OF BODY FLUIDS IN THE WIC PROGRAM

WIC programs should be following your agency's or health department's policy on the handling of body fluids.

The Utah State Department of Health's recommendation is to follow the Center for Disease Control's (CDC's) "Universal Precautions" for the Prevention of Transmission of H.I.V. Hepatitis B Virus, and other Bloodborne Pathogens in Health Care Settings published in the Morbidity and Mortality Weekly Report, June 24, 1988.

A copy of this report, which is available from the Utah Department of Health, Bureau of Epidemiology, is included as an appendix to this module. If you have any questions you can call or write. Their telephone number is 538-6191.

TECHNIQUE

- (1) Put on disposable gloves (recommended to protect against possible contact with AIDS or hepatitis-infected blood), or wash hands in hot, soapy water (as per health department policy).
- (2) Prepare equipment ahead to speed procedure: unwrap bandaid, lancet (or secure sterile blade to Autolet) and gauze pad, moisten cotton ball with alcohol, secure 2 hematocrit tubes.
- (3) Explain to client and/or parent why you are doing the test and how it will be done. Example: The hematocrit test is done to measure the amount of red blood cells, and thus, the amount of iron in your blood. Low levels of iron in the blood can affect the health of you and your child and may even affect growth. It is easy to measure and if low, easy to correct by adding more high iron foods to your diet. I will take a few drops of blood from your finger and fill two glass tubes. Then, I'll put the tubes in this machine, which spins very fast and separates the red blood cells from the liquid part of the blood.

- (4) If a child, grasp the client's entire hand and select either the middle or fourth (ring) finger for drawing blood. See Figure 1. For infants, it may be easier to draw blood from the big toe or heel. See "Skin Puncture of Infants" (p. 13-14) and helpful hints for increasing blood flow (on p. 12) before doing this procedure.

Figure 1. Position for Puncturing Finger to Draw Blood

- (5) Wipe clean the finger or toe with a cotton ball wet with alcohol and dry thoroughly before you puncture it (you may use a sterile gauze pad for this). Blood will not well up and form a drop at the puncture site of a moist finger.
- (6) Grasp the lancet between the thumb and forefinger of your right hand. (If you are left handed, the directions for which hand to use should be reversed.)
- (7) Grasp the patient's finger between the fingers and the thumb of your left hand. Your fingers can be on top of the patient's finger with your thumb supporting his finger (fig. 2), or the thumb can be on top of the patient's finger with your fingers supporting his finger (fig. 3).

Fig. 2

Fig. 3

- (3) Hold the patient's finger firmly with one hand and make a swift, deep puncture with the lancet halfway between the center of the ball of the finger and its side using a 10 to 20° angle. It is not recommended to take blood from the fingertip.

- (9) The cut should be made across the fingerprints to produce a large round drop of blood. (fig. 4)

- (10) Throw away the blade or lancet in a closed container with a tight fitting lid. Wipe away the first drop of blood with a clean gauze pad (it may be contaminated with tissue fluids).

Figure 5. Filling the Hematocrit Tube With Blood.

- (11) A gentle squeeze and release action may be applied to obtain the blood. Avoid tightly squeezing the client's finger since this may cause blood and tissue fluid to mix which will affect the accuracy of the test. If the blood does not flow freely, you'll need to puncture the finger toe or heel again.
- (12) As soon as the second drop of blood appears, place the tube next to the blood and fill it up to the black line on the tube (2/3 full). If using tubes without marked lines, fill tubes 2/3 to 3/4 full. It helps to hold tubes downward.
- (13) Fill a second tube the same way. Do not change the volume of blood in the tube by using cotton balls or kleenex to draw the blood out. This changes the fluid balance.
- (14) Ask the client/parent to press the gauze pad or cotton ball tightly on the finger, toe or heel to stop the blood flow. Place a bandaid around it.
- (15) Stick one end of the tube in the clay and twist gently to seal. Greatly roll the hematocrit tube between your index and thumb several times in order to mix the blood and anti-coagulant well. Hematocrit tubes break easily.
- (16) Open the cover of the centrifuge and place the tubes in the numbered channels with the clay ends to the outside of the rack. The tubes should be placed opposite each other to balance the machine. If you only have one tube of blood, balance it with a tube filled with water. As many as twenty tubes can be put in simultaneously. If you are including blood samples from more than one client, be sure to write down each client's name and the number of the channels containing their blood.
- (17) Lock the cover over the tubes and close the lid. The length of time to set the timer varies with different centrifuges depending on the rotations per minute (RPM's). Check with the

nutritionist and your equipment guide concerning the clinic's equipment. Ideally, the centrifuge would be labelled with this information.

- (18) When the centrifuge has completely stopped spinning, remove the tubes. Red blood cells should be "packed" at the bottom of the tube and clearly separate from the upper layer of plasma.

Figure 6. Blood Sample After Centrifuging

- 19) Read the levels, as soon as possible, using a separate Hematocrit Reader-card. Place the tube vertically on the chart with the bottom edge of the red blood cells just touching the '0' percent line. Slide the tube along the chart until the top edge of the plasma intersects the 100 percent line. The height of the red cell layer is then read as a percent of total blood volume.

NOTE: If you cannot read the tubes immediately, place them upright (with red cells on the bottom) to delay mixing of packed red blood cells with plasma. Tubes should be read within 5-10 minutes.

- (20) Record client name and results on appropriate sheets, including the cert. form, depending on your agency's procedures. If results of the two tubes do not agree to within 2 percentage points, e.g., 31% 34%, repeat entire procedure. If they do agree to within 2 percentage points, then average the values and record the value as a whole number or as a one half fraction e.g., 31 and 33% average to 32% and 31%, and 32% average to 31.5%. Caution - when using the reader card, read only full percentage points. DO NOT read half points. Half points should only be derived from averaging of two tubes. You should never record hemato-crit values in, anything other than whole or half percentage points.

Figure 7. How to Read the Hematocrit

- (21) Also note and record variation in plasma color: milky white (indicates fat in plasma¹); red (indicates hemolysis, or broken red blood cells usually a technique problem); or yellow/orange (indicates possible hepatitis; clean the work area and your hands well). Refer abnormalities to the nutritionist.
- (22) You will be working closely with the C.P.A. or nutritionist in your clinic in order to understand each of the above steps, and then to perform each of the above steps on WIC clients.

HELPFUL HINTS

If the client has cold/pale hands, seems nervous, or you did not get sufficient blood the first time:

- (1) Increase blood circulation to the hand by a) having the client open and close their hand with their arm dangling to the side; b) rubbing their hand between your two hands; or c) having the client hold their hand under warm water for a few minutes.
- (2) Prick the finger with their arm and hand hanging at their side.
- (3) "Milk" the upper arm down to the hand. **DO NOT SQUEEZE THE FINGER**, as this will force tissue fluid to come out and dilute the sample.
- (4) If you can only obtain one sample, fill the other tube with water, seal, and place opposite the sample in the centrifuge to balance the machine.

If Screening a Very Young Child:

- (1) Ask the parent to hold the child on their lap, holding the arms and/or knees firmly. A squirming child can be braced between the parent's knees. If necessary, the mother can brace the child's shoulders with one arm, and use the other to turn the child's head toward her.
- (2) Explain to the child that the stick will be the only part that will hurt. Show the child the tube and touch the finger with the tube to show that it doesn't hurt.
- (3) Have the child hold the bandaid and tell him it will be his, when it's all over.
- (4) Prick very quickly.
- (5) Make sure to give the child positive comment.
- (6) You may choose to draw a smiley face on the bandaid, make a rabbit with a long bandaid and cotton, or tell the child to "watch what happens to the magic straw."

¹ Fat may be normal in the plasma if the client has recently eaten (within 6 hours) a high-fat meal. Presence of fat in plasma following a low-fat meal or on an empty stomach may be abnormal, and the client should be referred to his/her health care provider.

GUIDELINES FOR HEEL STICKS IN INFANT

Figure 3. Proper Positioning For Heel Sticks

SKIN PUNCTURE OF INFANTS

1. Choose the site (foot that is not edematous or swollen).
2. Warm the area for 3 minutes (increased blood flow to the area sevenfold).
3. Properly cleanse the area (one of the complications of an improperly cleansed area is infection).
4. Wipe dry (the presence of alcohol will quickly hemolyze blood).
5. Make the puncture in one continuous, deliberate motion, with the lancet held perpendicular to the puncture site following the four guidelines listed below.
6. Wipe away first drop (it may be contaminated with tissue fluids).
7. Ease, and reapply pressure of thumb or forefingers as drops of blood form.
8. Fill two (2) capillary tubes with blood and proceed as with hematocrit instructions for children and adults.

FOUR GUIDELINES SHOULD BE FOLLOWED WHEN PERFORMING HEEL PUNCTURES IN INFANTS TO AVOID PUNCTURING THE HEEL BONE AND POSSIBLE RISK OF OSTEOCHONDritis AND SEPSIS

Figure 9. Location for Heel Puncture

1. Punctures should be made on the most medial or lateral portions of the plantar or flat surface of the heel.
2. Punctures should not be made on the posterior curvature of heel...
3. Punctures should not be made deeper than 2.4 millimeters.
4. Punctures should not be made through previous puncture sites because hidden infection may be present.

RESOLVING POSSIBLE PROBLEMS

If the Hematocrit Tubes Break During Centrifugation:

- (1) Make sure centrifuge top is fastened down tight and even.
- (2) Check gaskets for breaks and clay deposits.
- (3) Make sure the tubes are positioned right in the centrifuge.
- (4) See if there is glass present in the machine from past breaks and remove it.

If Blood Spins Out During Centrifugation:

- (1) Check gaskets.
- (2) Inspect clay; it may be dirty, dry, etc. Use new clay.
- (3) Make sure to twist tubes before removing them from the clay. Do this twice if necessary.

If Readings on Hematocrit Tubes Differ More Than 2%:

- (1) Check finger-stick for leaving alcohol on finger, or squeezing finger too hard (milking).
- (2) Check blood in tubes for bubbles. This occurs when there is not a steady flow of blood and the tube is tipped or removed from the finger, allowing air to enter.
- (3) See if one tube leaked and the other did not.
- (4) Did you leave tubes more than 15 minutes before reading, after centrifuge had stopped spinning? Repeat the test.

- (5) Did you use the READERCARD correctly on both readings? a) the zero line should be aligned with the point at which the red blood cells rest against the top of the clay; b) the 100% line should be aligned with the top of the plasma. Make sure you are looking directly down at the tube when you decide what the percent of red blood cells is (looking at an angle may vary your reading 2-5%).
- (6) Are plasma portions faintly red? If so, hemolysis (where red blood cells break up and leak into the plasma) occurred. This is usually a technique problem.

SOURCES OF ERROR

- (1) Excess squeezing or pressure of finger or toe. This causes tissue fluid to come out and may dilute the sample.
- (2) Failure to wipe off the first drop of blood. The first drop of blood may be mixed with alcohol or may contain broken red blood cells and extra plasma.
- (3) Centrifuge out of calibration. This affects speed and time. Usually results in falsely high hematocrit.
- (4) Rubbing fingers over the sealant to fill in the holes. This leaves oil in the sealant and can result in a poor seal and leakage of red blood cells.
- (5) Worn rubber gasket of centrifuge. This may result in breakage of tubes and red blood cell leakage.
- (6) Air bubbles in sample (that do not "spin out" when centrifuged; small air spaces will probably spin out and not affect the hematocrit).
- (7) Over or under filling tubes.
- (8) Not balancing tubes in the centrifuge.
- (9) Not running centrifuge for correct duration. Know maximum packing time of the centrifuge in your clinic. (See Nutrition Assessment & Equipment Manual to determine maximum packing time.)
- (10) Failure to record names and centrifuge channels when spinning blood samples of more than one client simultaneously. Result may be incorrectly assigned.
- (11) Reading the sample incorrectly. Plasma layer should not be included in the reading, etc.
- (12) Recording errors. Common errors include recording hematocrit results in the hemoglobin box on the CERT form or failing to record a decimal value.

NOTE: Hemoglobin values (if used) are to be recorded to 1 decimal position.

ACTIVITY 3

COMPARING TEST RESULTS TO STANDARDS

OBJECTIVES

Knowledge

- (1) Clinical Assistant (CA) will be able to list WIC Program standards used to define normal and abnormal hematocrit values.
- (2) CA will be able to describe what the hematocrit test tells us.

Application

- (1) CA will explain the purpose and procedure of the hematocrit test to eight applicants/participants (or their parents) without error: two infants, two children, two pregnant women, two lactating women.
- (2) CA will demonstrate recommended techniques for performing the hematocrit test for these eight applicants/participants (if a job responsibility) (including local health department's policy on handling blood).
- (3) CA will determine if these eight applicants/participants are at risk for anemia.
- (4) CA will accurately explain results of the hematocrit test to these eight applicants/participants.

MATERIALS AND SUPPLIES

- (1) Utah State WIC Program Nutritional Assessment and Equipment Manual
- (2) Utah State Plan of Program Operations and Administration Section B (P & P manual)
- (3) Utah State WIC Protocols on Anemia and Dietary Iron

GLOSSARY

NHANES II: The Second National Health and Nutrition Examination Survey, conducted in 1977-78 by the U.S. Public Health Service within the Department of Health and Human Services. The purpose of the survey was to assess the health and nutrient intakes of a population sample of 20,000 people, on the basis of a 24-hour dietary recall and extensive physical, anthropometric and biochemical analyses of health status.

Standards: Criteria used to determine the normality, adequacy, or accuracy of a value.

ELIGIBILITY CRITERIA

The Utah State WIC Program utilizes the hematocrit value as an essential component of certification, primarily to determine program eligibility. It provides a valuable indicator for the client's risk of iron deficiency anemia and a basis for nutrition counseling.

The Utah WIC Program has established cut off levels for interpreting hematocrit and hemoglobin values based on the centers for Disease Control's (CDC) criteria for anemia in children and women, adjusted to clinic altitude (see Tables 1 & 2 on pp 3 A-C) CDC's criteria were published in the Morbidity and Mortality Weekly Report, June 9, 1989, portions of which are excerpted below.

The reference values established by CDC for children and nonpregnant women are derived from the most current nationally representative sample - the second National Health and Nutrition Examination survey, 1976-1980 (NHANES II). Because representative data are not yet available for pregnant women, anemia reference values are based on the most current clinical studies available.

Anemia Cutoffs for Children

Because hematologic values change as children grow older, it is necessary to use age-specific criteria for diagnosing anemia in children. The CDC hemoglobin and hematocrit cutoffs represent the age-specific fifth percentile values for "healthy persons" from NHANES II (excluding persons who were likely to have iron deficiency based on multiple iron biochemical measures).

The Utah Program has adopted CDC's hematocrit cutoffs for infants and children, adjusted for clinic altitude. Infants and children with hemoglobin or hematocrit values less than the figures given below and at risk for anemia and are eligible for WIC.

Altitude Feet

	0-2999	3000-4999	5000-6999	7000 or more
<u>Hematocrit %</u>				
6 mos-23 mos	33%	34%	35%	36%
2-5 years of age	34%	35%	36%	37%
<u>Hematocrit mg%</u>				
6 mos-23 mos	11.0gm	11.3gm	11.7gm	12.0gm
2-5 years of age	11.2	11.5gm	11.9gm	12.2gm

Anemia Cutoffs During Pregnancy

During a normal pregnancy, a woman's hematologic values change substantially (discussed later in this module). For women with adequate iron nutrition, Hb and HCT values start to decline during the early part of the first trimester, reach a low point near the end of the second trimester, then gradually rise during the third trimester. Because of the change of Hb and HCT during pregnancy, anemia must be characterized according to the specific stage of pregnancy.

CDC has established anemia cutoffs for each of the three trimesters of pregnancy, based on data from four European studies of healthy iron supplemented women. To establish criteria for eligibility. The Utah WIC Program adjusted CDC's figures for the second and third trimesters of pregnancy and for nonpregnant women to various altitude levels. Utah's eligibility cutoff for the first trimester are based on the fifth percentile of normal at 8 weeks gestation which varies slightly from CDC's first trimester value. (From Dietary Intake and Nutrient Supplements: Iron Nutrition During Pregnancy, In Nutrition During Pregnancy, Institute of Medicine, National Academy Press, 1990.

A woman qualifies for WIC on the basis of anemia if her hematologic values are less than the following:

	<u>Altitude Feet</u>			
	0-2999	3000-4999	5000-6999	7000 or more
<u>Hematocrit %</u>				
1st Trimester	35%	36%	37%	38%
2nd Trimester	32%	33%	34%	35%
3rd Trimester	33%	34%	35%	36%
Breastfeeding or Postpartum	36%	37%	38%	39%
<u>Hematocrit mg%</u>				
1st Trimester	11.5gm	11.8gm	12.2gm	12.5gm
2nd Trimester	10.5gm	10.8gm	11.2gm	11.5gm
3rd Trimester	11.0gm	11.3gm	11.7gm	12.0gm
Breastfeeding or Postpartum	12.0gm	12.3gm	12.7gm	13.0gm

Utah's WIC eligibility cut off for infants and children represent a level where at least half of the infants and children who qualify for a low hematocrit will increase their hematocrit values during a six month certification period. This increase indicates that iron stores in the body were low, and the low hematocrit was most likely due to an inadequate intake of dietary iron. Please note that WIC eligibility criteria for a low hematocrit only suggests that the client is at risk for having or developing iron deficiency anemia. WIC clinic procedures are screening tests only, and do not allow one to make a diagnosis of iron deficiency anemia. Hematocrit values in the population are normally distributed. A low hematocrit value may be normal for some people. The low hematocrit value means that the person has a greater chance of iron deficiency anemia. However, all clients meeting the low hematocrit criteria should be counseled according to the anemia and dietary protocols. If a low hematocrit does not respond to increased dietary iron, the client should receive further dietary assessment and counseling and perhaps medical referral.

STOP HERE and read the Utah State WIC Protocols on Anemia and Dietary Iron. (Subject: Iron-Women, Infants & Children.
Subject: Anemia, Iron Deficiency - Infant and Children)

TABLE 5. THE CDC NON-PREGNANT AND PRENATAL
HEMATOLOGICAL CUT-OFFS BY TRIMESTER

<u>Status</u>	<u>Hgb (gm%)</u>	<u>Hct (%)</u>
Non-pregnant	<12.0	<36
1st trimester	<11.0	<33
2nd trimester	<10.5	<32
3rd trimester	<11.0	<33

3. Altitude

The body normally adjusts to changes in altitude by increasing hemoglobin and hematocrit values. This is because the lower oxygen concentration in the air at higher altitudes stimulates the production of red blood cells. In other words, when there is less oxygen available to a person, she/he needs more red blood cells and hemoglobin to carry that oxygen to the cells of the body. This means that a low hematocrit is more likely to indicate anemia for a person living at a high altitude than at sea level. In other words, we expect to see higher hematocrits in people living at high elevations.

In FY 1991, Utah began adjusting eligibility criteria based on clinic altitude. These adjustments are applied to Table I on p 3A.

TABLE 6. THE REVISED CDC ALTITUDE ADJUSTMENTS
FOR HEMATOLOGICAL INTERPRETATION.

<u>Altitude (ft)</u>	<u>Hgb (gm%)</u>	<u>Hct (%)</u>
0-2999	0.0	0.0
3000-4999	+0.3	+1.0
5000-6999	+0.7	+2.0
7000+	+1.0	+3.0

Some clinics serve participants who actually live in a different area (e.g. Teen Mom, PKU Clinics). Please note that the altitude level used to determine eligibility for a participant is that given in Table II (pp 3B-C) for the clinic area in which he/she lives. For example, if a client lives in Summit County and attends the Teen Mom Clinic, use the altitude level given for Summit County to determine WIC eligibility.

3. Smoking

Smoking also results in higher hematocrits. This effect similar to that at high altitudes. The body increases red blood cell production because the cells need to receive more oxygen. The influence of smoking on hemoglobin and hematocrit levels has also been addressed by CDC, as presented in the following table.

Table 7

THE CDC SMOKING ADJUSTMENTS FOR HEMATOLOGICAL INTERPRETATION³

	<u>Hgb (gm%)</u>	<u>Hct (%)</u>
Non-smoker	0.0	0.0
1/2 - 1 pack per day smoker	+0.3	+1.0
1 - 2 pack per day smoker	+0.5	+1.5
2 + pack per day smoker	+0.7	+2.0

Information presented in the above table can be applied to assessment and counseling recommendations regarding the client's hematological status and not for eligibility determination.

For example, a pregnant woman who smokes 1 pack per day (ppd) and has a 35% hematocrit is at higher risk for anemia than a pregnant woman with a 35% hematocrit who does not smoke. When the hematocrit value of the smoker is adjusted, it can be interpreted as 33.5, (because the 1 ppd smoker's hematocrit is 1.5 percent higher than it would be if she didn't smoke). She is, therefore, actually more anemic than is apparent.

SUMMARY

Because it is more sensitive to the factors influencing hematocrit values, the information presented here is more appropriate for counseling purposes than the WIC eligibility criteria. You will notice that the hematocrit tends to change as a child ages, and hematocrit decreases as a pregnancy progresses. Altitude influences hematocrit values in any case. As altitude or smoking increases, so does the observed hematocrit value. There is no guidance given on the additive effect of smoking and altitude at this point.

LIMITATIONS

Please note that WIC eligibility criteria for a low hematocrit only suggest that the client is at risk for having or developing iron deficiency anemia. However, all clients meeting the low hematocrit criteria should be counseled according to the anemia and dietary protocols.

³ Increase in blood value associated with smoking.

APPENDIX D: Ferritin Double Antibody Procedure

(Permission to reprint granted orally by

Kristine Guzman, March 15, 1993)

FERRITIN

is a double-antibody ^{125}I radioimmunoassay designed for the quantitative measurement of ferritin in serum or plasma. It is intended strictly for *in vitro* use as an aid in the diagnosis of iron deficiency and iron overload.

Catalog Numbers: **KFED1** (100 tubes) **KFED2** (200 tubes) **KFED5** (500 tubes).

The 100-tube kit contains not more than 2.5 microcuries (93 kilobecquerels) of radioactive ^{125}I -ferritin; the 200-tube kit contains not more than 5 microcuries (185 kilobecquerels); and the 500-tube kit contains not more than 12.5 microcuries (463 kilobecquerels).

Summary and Explanation of the Test

The ferritin molecule consists of a protein shell (MW 450,000) and a core of iron. High concentrations are found in liver cells and in erythrocyte recycling centers (RE cells) of the liver, spleen and bone marrow. In these tissues ferritin serves as the body's principal storehouse for surplus iron, protecting against the toxic effects of excess and maintaining a readily mobilized reserve for erythropoiesis. Ferritin is also present in human plasma where its concentration is normally a satisfactory index of body iron stores as measured by quantitative phlebotomy, iron absorption studies, liver biopsy and the microscopic examination of bone marrow aspirates for stainable iron deposits.

This relationship with iron stores can be seen in the pattern of serum ferritin values under a variety of physiological and pathological conditions. For individuals in good health the median level, slightly elevated at birth, reaches a low of about 30 ng/mL at six months, with the increase to adult levels taking place after puberty. In males, the median level continues to climb—from about 70 ng/mL at age eighteen to almost 200 ng/mL twenty-five years later—whereas in females there is a plateau at 35 or 40 ng/mL throughout the childbearing years and a sharp increase thereafter. For adults in good health, the serum ferritin level has been variously reported to range from 20 (± 10) up to 300 (± 100) ng/mL for men, and 10 (± 5) up to 150 (± 50) ng/mL for women. Concentrations below 10 or 15 ng/mL are typical of uncomplicated iron deficiency anemia. For iron overload, values over 300 or 400 ng/mL are the rule, with levels in the 1000–5000 ng/mL range common in full-blown cases of hemochromatosis.

Clinical applications of the serum ferritin assay have been extensively reviewed. It has important roles to play in the diagnosis of iron deficiency and excess, and in the management of conditions and treatments posing a threat to iron balance. It has proved a valuable aid in discriminating iron deficiency anemia from anemias due to other causes and in exposing the disappearance of iron reserves before the onset of anemia. Serial determinations have been employed to monitor, noninvasively, the progressive erosion of iron stores during pregnancy and in patients undergoing regular dialysis treatment. Both in company with other routine blood tests and on its own, the ferritin assay has been used to screen for iron deficiency in a variety of populations, ranging from blood donors to unselected hospital patients. It is also valuable in screening for precirrhotic hemochromatosis and other forms of iron overload and in monitoring patients who are receiving regular blood transfusions or iron replacement therapy and thus in danger of accumulating excessive iron stores.

Although iron depletion appears to be the only condition associated with reductions in the serum ferritin level, increases are observed not only in the presence of increased iron stores but also in several other situations, including liver disorders, inflammatory conditions, leukemia, Hodgkin's disease and certain other malignancies. Here, increased levels may reflect the escape of ferritin from damaged liver cells, impaired clearance of ferritin from the plasma, synthesis of ferritin by tumor cells, or an expansion of the iron storage compartment induced by ineffective erythropoiesis. Inflammation tends to raise the ferritin level, while lowering the serum iron concentration, by stimulating increased ferritin production in RE cells, using iron that would otherwise be released to plasma transport proteins. In this condition and others, the correlation between iron stores and circulating ferritin continues to hold, but with a shift towards higher values—necessitating an adjustment in the normal range if the ferritin assay is still to be used for distinguishing normal from depleted iron reserves.

2 • Double Antibody Ferritin

Principle of the Procedure

In the Double Antibody Ferritin procedure, ^{125}I -labeled ferritin competes with ferritin in the patient sample for sites on ferritin-specific antibody. After incubation for a fixed time, separation of bound from free is achieved by the PEG-accelerated double-antibody method. The tube is then counted in a gamma counter, the counts being inversely related to the amount of ferritin present in the patient sample.

Procedure	The calibration curve requires a total incubation time of just 1 hour at 37°C. An experienced technician with proper equipment can prepare a calibration curve and 20 patient samples for counting in 2 hours, using less than 1/2 hour of bench time. Reagents are color coded for ease of addition. The assay can also be performed at room temperature, using a 3-hour incubation.
Separation	Separation is by a single-reagent Precipitating Solution consisting of second antibody and dilute PEG. This method has been shown to yield more consistent and reproducible results than other liquid-phase techniques. The flocculation reaction is complete in just minutes at room temperature; the precipitate packs to a firm and easily visible pellet; and nonspecific binding is at least as low as in separations employing second antibody alone.
Data Reduction	Conventional RIA techniques of calculation and quality control are applicable. The assay has been optimized for linearity in a logit-log representation throughout the range of its calibrators.
Calibration	The kit is equipped with protein-based standards having ferritin values ranging from 10 to 1000 ng/mL. The assay is standardized in terms of the World Health Organization's First International Standard for Ferritin (human liver) for Immunoassay, number 80/602. The calibrators are supplied in liquid form, ready to use.
Counts	The tracer has a high specific activity, with total counts of approximately 40,000 cpm at iodination. Maximum binding is approximately 45%. Nonspecific binding and patient blanks are negligible.
Precision	CVs are low and uniform, and no 'end-of-run' effect has been observed in assays involving up to 250 tubes. The procedure can detect as little as 6 ng/mL.
Specificity	The antiserum is highly specific for ferritin, with very low crossreactivity to other compounds that might be present in patient samples. Neither bilirubin nor hemolysis has any effect on the assay.
Accuracy	Extensive recovery experiments have shown that the assay is accurate over a broad range of values. Its accuracy has been further verified in a patient comparison study against another well-established ferritin radioimmunoassay.
Expected Values	The recommended normal ranges of 11 - 120 ng/mL for women and 25 - 400 ng/mL for men are in substantial agreement with modern reference methods.

Specimen Collection

The patient need not be fasting, and no special preparations are necessary. Collect blood by venipuncture into plain, heparinized or EDTA tubes, avoiding hemolysis and noting the time of collection, and separate the serum or plasma from the cells. The procedure calls for 100 μL of serum per assay tube. Lipemic samples and sample contaminated with radioactivity are unsuitable for use.

The samples may be stored refrigerated at 2-8°C for seven days or for longer periods of time if frozen at -20°C. But be sure to aliquot the sample before freezing to avoid repeated freeze-thaw cycles. Before assay, allow the samples to come to room temperature and mix by *gentle* swirling or inversion.

Materials Supplied—Initial Preparation

■ **Precautions:** Before opening the kit, review the paragraphs on safety, printed on the inside front cover, as they relate to the safe handling and disposal of reagents containing radioactivity, human serum-derived material and sodium azide.

- 1 **Ferritin Antiserum** FED1, 5FED1†
One vial (two vials*) of lyophilized ferritin antiserum. Reconstitute each vial by adding 10 mL (50 mL†) distilled water. Store refrigerated: stable at 2–8°C for at least 30 days after reconstitution. *Color:* blue.
- 2 **[¹²⁵I] Ferritin** FED2
One vial (two vials*, five vials†) containing 10 mL of iodinated ferritin in liquid form, ready to use. Store refrigerated: stable at 2–8°C for at least 30 days after opening, or until the expiration date marked on the vial. *Do not freeze.* *Color:* red.
- 3 **Ferritin Calibrators** FED3–9
One set (two sets†) of seven vials, labeled A through G, of ferritin calibrators in a protein base. The zero calibrator vial A contains 6.0 mL; the remaining vials B through G each contain 2.0 mL. Store refrigerated: stable at 2–8°C for at least 30 days after opening.
The calibrators contain 0, 10, 25, 100, 200, 500 and 1000 nanograms of ferritin per milliliter (ng/mL) in terms of the WHO 1st IS 80/602. Intermediate calibration points can be obtained by mixing calibrators in suitable proportions.
- 4 **Precipitating Solution** NF6, 5NF6†
One vial (two vials*†) of Precipitating Solution, containing goat anti-rabbit gamma globulin (GARGG) and dilute polyethylene glycol (PEG) in saline. The Precipitating Solution is supplied in liquid form, ready to use. Each vial contains 110 mL (260 mL†). Store refrigerated: stable at 2–8°C for at least 30 days after opening, or until the expiration date marked on the vial. Since a fine precipitate may form after refrigeration, the Precipitating Solution should be thoroughly mixed before use, without foaming.

* Pertains to the 200-tube KFED2 kit.

† Pertains to the 500-tube KFED5 kit.

Materials Required But Not Provided

- Gamma counter
- Centrifuge—preferably refrigerated and capable of 3000×g

Reagent Preparation:

- Distilled or deionized water
- Pipets: 10 mL

Radioimmunoassay:

- Plain 12×75mm polypropylene tubes—available from DPC
- Micropipets, 100 μ L and 1.0 mL. For the 100 μ L reagent additions a reliable repeating dispenser (Nichiryo, Eppendorf or equivalent) is recommended. A syringe-style dispenser (Nichiryo, Eppendorf or equivalent) accurate to within ± 0.1 mL is recommended for the 1.0 mL addition of Precipitating Solution.
- Vortex mixer
- Water bath capable of maintaining 37°C—required for the basic 1-hour procedure. (The assay may also be performed using a 3-hour, room-temperature incubation.) Note that neither an oven nor a heat block is suitable.
- Foam decanting rack—available from DPC
- A bi-level protein based set of ferritin controls is available from DPC (catalog number: FEC01-2).

4 • Double Antibody Ferritin

Radioimmunoassay Procedure

All components except the Precipitating Solution must be at room temperature prior to use.

- 1 Label eighteen tubes in duplicate: T (total counts), NSB (nonspecific binding), A (maximum binding) and B through G. Label additional tubes, also in duplicate, for serum samples and controls.

Calibrator	ng/mL
A(MB)	0
B	10
C	25
D	100
E	200
F	500
G	1000

- 2 Pipet 100 μ L of the zero calibrator A into the NSB and A tubes, and 100 μ L of each of the remaining calibrators B through G into correspondingly labeled tubes. Pipet 100 μ L of each patient sample (serum or plasma) and each control into the tubes prepared. High samples should be diluted with the zero calibrator.
- 3 Add 100 μ L of [125 I] Ferritin to all tubes.
A repeating dispenser of the Nichiryo or Eppendorf type is recommended for this step and for the addition of antiserum at step 4. Remove the T tubes for counting at step 9; they require no further processing. All tubes should be red.
- 4 Add 100 μ L of Ferritin Antiserum to all tubes except the NSB and T tubes. Vortex.
All tubes except the NSB and T tubes should be purple. Mixing should cause a visible vortex in the tubes. Multiple-tube rack mixers have been found unsuitable.
- 5 Incubate for 1 hour at 37°C.
The assay may also be performed using a 3-hour, room-temperature incubation.
- 6 Add 1.0 mL of well-mixed, cold Precipitating Solution to all tubes. Vortex.
The Precipitating Solution should be thoroughly mixed just prior to use. For the 1.0 mL reagent addition a repeating dispenser of the Nichiryo or Eppendorf type may be employed. All tubes except the T tubes should be blue.
- 7 Centrifuge for 15 minutes at 3000 $\times$ g.
The use of a refrigerated centrifuge is desirable but not essential.
- 8 Decant (or aspirate) the supernatant, retaining the precipitate for counting.
Using a foam decanting rack, gently tap the tubes on absorbent paper, and blot the rims, to remove residual droplets.
- 9 Count each tube for 1 minute.

Calculation of Results

To calculate ferritin concentrations from a logit-log representation of the calibration curve, first calculate for each pair of tubes the average NSB-corrected counts per minute:

$$\text{Net Counts} = \text{Average CPM} \text{ minus } \text{Average NSB CPM}$$

Then determine the binding of each pair of tubes as a percent of maximum binding (MB), with the NSB-corrected counts of the A tubes taken as 100%:

$$\text{Percent Bound} = \frac{\text{Net Counts}}{\text{Net MB Counts}} \times 100$$

Using the logit-log graph paper provided with the kit, plot Percent Bound on the vertical axis against Concentration on the horizontal axis for each of the calibrators B through G, and draw a straight line approximating the path of these six points. Ferritin concentrations for the unknowns may then be estimated from the line by interpolation.

Although other approaches are acceptable, data reduction by the logit-log method just described has certain advantages in this context—for example, in allowing easier recognition of deviant calibration points—since the Double Antibody Ferritin procedure has been optimized for linearity in that representation.

Example: The figures tabulated below are for illustration only and should not be used to calculate results from another assay.

Tube	Duplicate CPM	Average CPM	Net CPM	Percent Bound	Ferritin ng/mL
T	37,648 37,667	37,653			
NSB	918 916	917	0		
A(MB)	17,873 17,811	17,842	16,925	100.0%	0
B	15,816 16,193	16,005	15,088	89.1%	10
C	14,252 14,230	14,241	13,324	78.7%	25
D	8,998 9,148	9,073	8,156	48.2%	100
E	6,410 6,469	6,440	5,523	32.6%	200
F	3,851 3,827	3,839	2,922	17.3%	500
G	2,446 2,418	2,432	1,515	9.0%	1000
Unknowns:					
X1	12,204 12,234	12,219	11,302	66.8%	45
X2	7,321 7,233	7,277	6,360	37.6%	159
X3	4,356 4,103	4,230	3,313	19.6%	407

Quality Control Parameters:
20% Intercept = 396 ng/mL

T = 37,658 cpm
50% Intercept = 94 ng/mL

%NSB = 2.4%
80% Intercept = 22 ng/mL

%MB = 45%

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Quality Control

Record Keeping: It is good laboratory practice to record for each assay the lot numbers and reconstitution dates of the components used.

Sample Handling: The instructions for handling and storing patient samples and components should be carefully observed. Dilute high patient serum samples with the zero calibrator prior to assay. All samples, including the calibrators and controls, should be assayed in duplicate. It is important to use a disposable-tip micropipet, changing the tip between samples, in order to avoid carryover contamination. Pairs of control tubes may be spaced throughout the assay to help verify the absence of significant drift. Inspect the results for agreement within tube pairs, and take care to avoid carryover from sample to sample.

Controls: Controls or serum pools with low, intermediate and high ferritin concentrations should routinely be assayed as unknowns, and the results charted from day to day as described in J.O. Westgard et al, "A multi-rule chart for quality control" *Clinical Chemistry* 27 (1981) 493-501. See also *Scandinavian Journal of Clinical and Laboratory Investigation* 44 (1984) Suppl 171 and 172. Repeat samples are a valuable additional tool for monitoring interassay precision.

Centrifugation: The procedure calls for centrifuging at 3000×g for 15 minutes. A high-speed, refrigerated centrifuge is desirable but not essential. Use the formulas below to calculate the acceleration of your centrifuge at a given speed, or the speed (in revolutions per minute) required to achieve a desired g force.

$$g \text{ force} = 28.35 \times (\text{rpm}/1000)^2 \times \text{radius [inches]} \quad \text{rpm} = 187.7 \sqrt{\frac{g \text{ force}}{\text{radius [inches]}}}$$

Data Reduction: It is good practice to construct a graph of the calibration curve as a visual check on the appropriateness of the transformation used, even where the calculation of results is handled by computer. See further S.E. Davis et al, "Radioimmunoassay data processing with a small programmable calculator" *Journal of Immunoassay* 1 (1980) 15-25; and R.A. Dudley et al, "Guidelines for immunoassay data reduction" *Clinical Chemistry* 31 (1985) 1264-71.

Q. C. Parameters: We recommend keeping track of these performance measures:

- T = Total Counts (as counts per minute)
- %NSB = $100 \times (\text{Average NSB Counts} - \text{Total Counts})$
- %MB = $100 \times [(\text{Average MB Counts} - \text{Average NSB Counts}) - \text{Total Counts}]$

And the 20, 50 and 80 percent "intercepts" where

- 20% = Ferritin Concentration at 20 Percent Bound, etc.

Performance Characteristics

In the sections below, ferritin results are expressed as nanograms of ferritin per milliliter (ng/mL). The assay has been standardized in terms of the World Health Organizations First International Standard for Ferritin for Immunoassay number 80/602.

Sensitivity

Forty zero calibrator (maximum binding) tubes were processed in a single assay, along with a set of nonzero calibrators and controls. Mean and standard deviation were calculated for the counts per minute of the forty zero tubes. Then, from a standard curve prepared by the logit-log technique and using this mean as the zero point, the apparent ferritin concentration was determined at increasing standard deviations from the mean.

Mean ± SD of 40 MB tubes	Mean minus	% B/B ₀	Apparent Concentration	Approximate Sensitivity
14,811 ± 269	1SD	93.2%	1.3	6 ng/mL
	2SD	96.4%	3.9	
	3SD	94.6%	6.2	

The detection limit for 'minimal detectable dose' of an assay is commonly defined as the apparent concentration two standard deviations below the counts at maximum binding or as the concentration at 95% B/B₀. By the more conservative definition, the Double Antibody Ferritin assay has a detection limit of approximately 6 ng/mL.

Precision

The reliability of the Double Antibody Ferritin procedure was assessed by examining its reproducibility on samples selected to represent a range of ferritin levels.

Intraassay: Statistics were calculated for each of three samples from the results of twenty-two pairs of tubes in a single assay.

Sample	Mean	SD	CV
1	12	0.9	7.5%
2	39	1.3	4.6%
3	130	3.5	2.7%

Interassay: Statistics were calculated for each of five samples from the results of pairs of tubes in n different assays.

Sample	Mean	SD	CV	n
1	13	1.4	10.8%	51
2	43	2.4	5.6%	51
3	131	5.7	4.4%	32
4	143	6.4	4.5%	50
5	328	22.1	6.7%	35

Kinetics

To determine the effect of employing incubation times other than 1 hour, as specified on page 4, assays were set up in parallel, using incubations of 30 minutes, 1, 2 and 3 hours, all at 37°C. Various quality control performance measures were monitored, including: nonspecific binding and maximum binding (percent of total counts); the correlation coefficient (ρ) of the logit-log line; the assay CV, based on the binding of the replicates; the sensitivity of the assay (concentration at 95% B/B₀ and at two standard deviations from the counts per minute at zero binding); the 20, 50 and 80 percent intercepts (ng/mL); and the binding of the calibrators (% B/B₀). In addition, several samples were assayed as unknowns in each of the assays.

Parameter	30 min	1 hour	2 hours	3 hours
Total Counts	36,398 cpm	36,710 cpm	36,779 cpm	36,620 cpm
% NSB	1.5%	1.9%	2.2%	3.6%
% MB	41%	44%	45%	44%
ρ	-0.9992	-0.9991	-0.9994	-0.9994
Assay CV	1.6%	1.9%	1.3%	2.1%
Sensitivity: (-2SD)	1.7 ng/mL	1.4 ng/mL	1.4 ng/mL	0.85 ng/mL
(95% B/B ₀)	4.3	4.2	3.3	4.0
Intercepts:				
20% B/B ₀	536 ng/mL	515 ng/mL	457 ng/mL	439 ng/mL
50% B/B ₀	128	112	99	94
80% B/B ₀	28	24	22	20
Calibrators:				
B-10 ng/mL	91%	90%	89%	89%
C-25	82%	80%	78%	77%
D-100	55%	52%	50%	49%
E-200	40%	37%	34%	34%
F-500	23%	21%	19%	19%
G-1000	14%	13%	11%	10%
Controls:				
1	40 ng/mL	38 ng/mL	37 ng/mL	35 ng/mL
2	69	63	66	63
3	285	295	277	280
Samples:				
1	22 ng/mL	21 ng/mL	22 ng/mL	23 ng/mL
2	32	32	30	27
3	43	39	39	36
4	60	51	53	49
5	66	61	63	61
6	75	69	72	67
7	82	80	77	73
8	188	170	158	152
9	227	206	187	164
10	838	730	718	639

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Drift

To determine whether there is any position effect due to delays in the addition of reagents or decanting, pairs of tubes were spaced throughout a long assay for each of six samples. The results show no significant position (or "end-of-run") effect even in assays of more than 250 tubes.

Sample	Tubes 9 - 20	Tubes 95 - 106	Tubes 169 - 180	Tubes 243 - 254
1	11	12	9	12
2	34	37	38	34
3	40	36	42	40
4	121	121	120	121
5	131	127	128	126
6	286	280	275	284

Specificity

The antiserum is highly specific for liver ferritin. When different forms of ferritin found in the human body were tested, both HeLa ferritin and Heart ferritin showed crossreactivities of less than 1% in the Double Antibody Ferritin procedure.

Effect of Bilirubin and Hemolysis

To simulate severe icterus, six serum samples were spiked with 20 mg/dL of bilirubin. In another experiment, to simulate mild, moderate and severe hemolysis, six serum samples were spiked with 10, 15 and 30 μ L/mL of packed red blood cells. All samples were assayed both spiked and unspiked by the Double Antibody Ferritin procedure with the following results.

Sample	Bilirubin		Sample	Packed Red Blood Cells μ L/mL			
	Unspiked	20 mg/dL		Unspiked	10	15	30
1	36	38	1	15	17	18	23
2	112	122	2	38	43	44	46
3	136	137	3	63	67	71	72
4	208	224	4	118	123	123	119
5	230	242	5	172	174	171	173
6	296	286	6	228	225	226	224

The results show that neither severe icterus (bilirubin up to 20 mg/dL) nor gross hemolysis has any effect on the Double Antibody Ferritin procedure.

Protein Effect

To simulate various protein concentrations, experiments were performed in which 2.0 mL aliquots of a human serum pool were freeze-dried and then reconstituted with various volumes of water. Each reconstituted aliquot was then assayed by the Double Antibody Ferritin procedure. Note that aliquots reconstituted with half the original volume represent an extremely high protein concentration, in the order of 14 g/dL. These results indicate that even wide variations in protein have relatively little effect on the Double Antibody Ferritin assay.

Experiment	Reconstitution	Protein Concentration	O Observed	E Expected	% O/E
1	1.0 mL	2.00x ~ 14.0 g/dL	283	260	109%
	1.3	1.50x ~ 10.5	207	195	106%
	2.0	1.00x ~ 7.0	130	—	(100%)
	3.0	0.67x ~ 4.7	98	87	113%
2	1.0 mL	2.00x ~ 14.0 g/dL	382	432	88%
	1.3	1.50x ~ 10.5	326	324	101%
	2.0	1.00x ~ 7.0	216	—	(100%)
	3.0	0.67x ~ 4.7	168	145	116%

Effect of Anticoagulants

To determine whether anticoagulants interfere with the assay, blood was collected from 10 volunteers into plain, heparinized and EDTA vacutainer tubes. All samples were assayed by the Double Antibody Ferritin procedure. The results were subjected to linear regression analysis.

(Heparin) = 1.06 (Serum) + 0.65	r = 1.000	Means:
(EDTA) = 1.01 (Serum) - 0.08	r = 1.000	Serum 79 ng/mL
n = 10		Heparin: 74 ng/mL
		EDTA: 78 ng/mL

The results show that heparinized and EDTA plasma yield virtually the same results as serum in the Double Antibody Ferritin procedure.

Parallelism

Four patient serum samples were assayed both undiluted and diluted with the zero calibrator. The observed and expected values are presented below in ng/mL.

Sample	Dilution	O Observed	E Expected	% O/E	Sample	Dilution	O Observed	E Expected	% O/E
1	4 in 4 (undiluted)	142			3	4 in 4 (undiluted)	596		
	3 in 4	107	107	100%		3 in 4	422	447	94%
	2 in 4	69	71	97%		2 in 4	285	298	96%
	1 in 4	32	36	89%		1 in 4	139	149	93%
2	4 in 4 (undiluted)	382			4	4 in 4 (undiluted)	838		
	3 in 4	278	287	97%		3 in 4	594	629	94%
	2 in 4	178	191	93%		2 in 4	382	419	91%
	1 in 4	84	96	88%		1 in 4	196	210	93%

Spiking Recovery

Three spiking solutions were made using the zero calibrator as diluent. The solutions (A, B and C) were made to represent 1000, 2000 and 4000 ng/mL, respectively. The spiking solutions were diluted in the zero calibrator and assayed by the Double Antibody Ferritin procedure.

Spiking Solution	Dilution	O Observed	E Expected	% O/E
A	1 in 4	250	250	100%
B	1 in 10	199	200	100%
C	1 in 20	203	200	102%

50 μ L of each of these solutions was spiked into 0.950 mL aliquots of each of four different patient serum samples, for a spiking ratio of 1 to 19, leaving the serum matrix of the spiked samples relatively intact. These spiked samples were then assayed by the Double Antibody Ferritin procedure. To calculate expected values, 95% of the unspiked value was added to 5% of the spiking solution concentration (50, 100 and 200 ng/mL, respectively).

Sample	Spiking Solution	O Observed	E Expected	% O/E	Sample	Spiking Solution	O Observed	E Expected	% O/E
1	—	146			3	—	230		
	A	178	189	94%		A	259	269	96%
	B	222	239	93%		B	309	319	97%
	C	323	339	95%		C	405	419	97%
2	—	229			4	—	255		
	A	265	268	99%		A	289	292	99%
	B	318	318	100%		B	347	342	101%
	C	389	418	93%		C	413	442	93%

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Method Comparison

Fifty patient serum samples were assayed by the Double Antibody Ferritin procedure and by another commercially available ferritin radioimmunoassay kit (Kit A). Linear regression analysis of the data shows good correlation between these methods.

$$\begin{array}{ll} \text{(DPC)} = 0.98 \text{ (Kit A)} - 3.6 \text{ ng/mL} & \text{Means:} \\ r = 0.990 & \text{DPC: 91 ng/mL} \\ & \text{Kit A: 95 ng/mL} \end{array}$$

In addition, the 1-hour, 37°C and the 3-hour, room-temperature procedures were compared on 100 samples with the following results.

$$\begin{array}{ll} \text{(1 hr 37°C)} = 1.02 \text{ (3 hr RT)} - 6 \text{ ng/mL} & \text{Means:} \\ r = 0.9956 & \text{3 hr RT: 154 ng/mL} \\ & \text{1 hr 37°C: 161 ng/mL} \end{array}$$

Expected Values

A normal range study was performed in which 120 samples from adult volunteers in good health were assayed by the Double Antibody Ferritin procedure. The results are summarized in the table below.

	Median	Central 95%	n
Males	105 ng/mL	25 - 400	52
Females	33 ng/mL	11 - 120	58

The normal range limits suggested by this study should be regarded as *guidelines only*. Because of differences which may exist between laboratories and locales with respect to population, diet, laboratory technique and selection of reference groups, it is important for each laboratory to establish by similar means the appropriateness of adopting the normal ranges suggested by this study. For further discussion, see the section Summary and Explanation of the Test.

In a further study, samples from 29 patients with iron deficiency anemia were assayed by the Double Antibody Ferritin procedure. Diagnosis of iron deficiency was based on laboratory findings: decreased iron (Fe) and iron-binding capacity (TIBC), and/or decreased mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH). It is not known whether the patients had "uncomplicated" iron-deficiency anemia. Ferritin results for the twenty-four females in this study ranged from undetectable to 15 ng/mL; 79 percent were below 10 ng/mL. The five males had ferritin results ranging from undetectable to 16 ng/mL, with all but one less than 7 ng/mL.

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Technical Assistance: If questions arise concerning the Double Antibody Ferritin reagents, or for further advice on technique, data reduction, quality control or expected values, please contact DPC's Technical Services department.

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Outside the United States, contact your National Distributor.

Double Antibody Ferritin is manufactured by EURO/DPC Ltd. and distributed in the United States by DPC.

Manufactured under a Quality System (ISO 9002/EN29002/BS 5750 part II) approved by the British Standards Institute.

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G 059

June 28, 1991

APPENDIX E: Adjusted Ferritin Double Antibody Procedure
for Small Samples

Table A.6. Adjusted ferritin double antibody for small samples.

Sample	Raw Data CPM	Net CPM	Dilution	Dilution Factor	Percent Bound	Log X	10 ¹	Results
1	26674	26224			230.46	-9.9077	0.00	0.00
2	26584	26134			229.67	-9.8525	0.00	0.00
3	512	62			0.54	6.1478	1405318.96	0.00
4	388	-62			-0.54	6.2239	1674453.68	0.00
5	4272	3822			33.59	3.8403	6922.77	0.00
6	8424	7974			70.08	1.2922	19.60	0.00
7	10002	9552			83.94	0.3238	2.11	0.00
8	10472	10022			88.07	0.0354	1.08	0.00
9	6454	6004			52.76	2.5012	317.10	0.00
10	3128	2678			23.53	4.5423	34861.63	0.00
11	9755	9305			81.77	0.4754	2.99	0.00
12	9278	8828			77.58	0.7681	5.86	0.00
13	7843	7393			64.97	1.6488	44.54	0.00
14	9074	8624			75.79	0.8933	7.82	0.00
15	8445	7995			70.26	1.2793	19.03	0.00
16	7732	7282			64.00	1.7169	52.11	0.00
17	4823	4373			38.43	3.5021	3177.95	0.00
18	5029	4579			40.24	3.3757	2375.27	0.00
19	3131	2681			23.56	4.5405	34714.15	0.00
20	3432	2982			26.21	4.3558	22687.38	0.00
21	1367	917			8.06	5.6231	419822.12	0.00
22	1981	1531			13.45	5.2463	176301.63	0.00
23	1011	561			4.93	5.8415	694289.97	0.00
24	1216	766			6.73	5.7157	519676.80	0.00
25	11829	11379	5	20	100.00	-0.7974	0.16	3.19
26	10624	10174	5	20	89.41	-0.0579	0.88	17.50
27	10723	10273	5	20	90.28	-0.1187	0.76	15.22
28	10248	9798	10	10	86.11	0.1728	1.49	14.89
29	10823	10373	10	10	91.16	-0.1800	0.66	6.61
30	7451	7001	10	10	61.53	1.8893	77.51	775.07
31	9994	9544	15	6.67	83.87	0.3287	2.13	14.21
32	10352	9902	15	6.67	87.02	0.1090	1.29	8.57

Table A.6 continued

33	10063	9613	15	6.67	84.48	0.2864	1.93	12.89
34	9861	9411	20	5	82.70	0.4103	2.57	12.86
35	9761	9311	20	5	81.83	0.4717	2.96	14.81
36	9977	9527	20	5	83.72	0.3391	2.18	10.92
37	9291	8841	25	4	77.70	0.7601	5.76	23.03
38	9918	9468	25	4	83.21	0.3754	2.37	9.49
39	9327	8877	25	4	78.01	0.7380	5.47	21.88
40	9090	8640	30	3.33	75.93	0.8835	7.65	25.49
41	9203	8753	30	3.33	76.92	0.8141	6.52	21.73
42	1464	1014	30	3.33	8.91	5.5635	366047.01	#####
43	9263	8813	35	2.86	77.45	0.7773	5.99	17.11
44	9253	8803	35	2.86	77.36	0.7835	6.07	17.35
45	8377	7927	35	2.86	69.66	1.3211	20.94	59.84
46	6784	6334	100	1	55.66	2.2987	198.92	198.92
47	6219	5769	100	1	50.70	2.6454	441.99	441.99
48	6736	6286	100	1	55.24	2.3281	212.88	212.88
49	9319	8869	5	20	77.94	0.7430	5.53	110.66
50	4614	4164	5	20	36.59	3.6304	4269.69	85393.79
51	3086	2636	5	20	23.17	4.5681	36993.28	739865.68
52	9913	9463	10	10	83.16	0.3784	2.39	23.90
53	9989	9539	10	10	83.83	0.3318	2.15	21.47
54	8723	8273	10	10	72.70	1.1087	12.84	128.45
55	10148	9698	15	6.67	85.23	0.2342	1.71	11.43
56	9380	8930	15	6.67	78.48	0.7055	5.08	33.84
57	8349	7899	15	6.67	69.42	1.3382	21.79	145.26
58	9221	8771	20	5	77.08	0.8031	6.35	31.77
59	972	522	20	5	4.59	5.8655	733626.50	#####
60	9581	9131	20	5	80.24	0.5822	3.82	19.10
61	481	31	25	4	0.27	6.1668	1468248.16	#####
62	7981	7531	25	4	66.18	1.5641	36.65	146.60
63	9583	9133	25	4	80.26	0.5809	3.81	15.24
64	8451	8001	30	3.33	70.31	1.2756	18.86	62.88
65	6664	6214	30	3.33	54.61	2.3723	235.68	785.60
66	7791	7341	30	3.33	64.51	1.6807	47.94	159.80
67	8691	8241	35	2.86	72.42	1.1284	13.44	38.40
68	8783	8333	35	2.86	73.23	1.0719	11.80	33.72
69	2299	1849	35	2.86	16.25	5.0511	112486.70	321390.58
70	6068	5618	100	1	40.27	2.7381	547.12	547.12
71	6083	5633	100	1	49.50	2.7289	535.65	535.65
72	5770	5320	100	1	46.75	2.9210	833.61	833.61

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1975-1976	Internship Program, New England Deaconess Hospital, Boston, Massachusetts.
1976	Clinical Dietitian, New England Deaconess Hospital, Boston, Massachusetts.
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1980-1984	Nutrition Coordinator, Diabetes Research and Training Center, Vanderbilt University.
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Honors and Activities

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Coordinator of Semiannual Nutrition Workshops for public health dietitians and nurses September 1985 - September 1988

Speaker, Alabama's Annual Diabetes Association Meeting, "Update on Diet", October 1983

Speaker, Tennessee Annual Diabetes Association Meeting, "Diet Adherence" and "Fiber", May 1982

Chairman, Council on Practice Division of Education, Nashville District Dietetic Association, 1981-82

Chairman, Council on Practice Division of Community Nutrition, Nashville District Dietetic Association, 1982-83 and 1983-84

Co-Chairman of Workshop, "Nutritional Counseling for the Home Health Nurse", 1982

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Publications

Srinivasan, V., Christensen, N.K., Wyse, B.W., Hansen, R.G.: Pantothenic Acid Nutritional Status in the Elderly - Institutionalized and Non-institutionalized. American Journal of Clinical Nutrition 34: 1736-1742, September 1981.

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