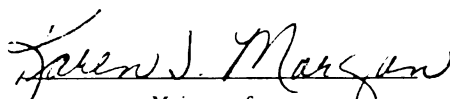


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Food Consumption Patterns
And Dietary Lead Intake
Of Preschool Children
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FOOD CONSUMPTION PATTERNS
AND DIETARY LEAD INTAKE
OF PRESCHOOL CHILDREN

By

Laurie Kathryn Bander

A Thesis

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Food Science and Human Nutrition

1981

ABSTRACT

FOOD CONSUMPTION PATTERNS AND DIETARY LEAD INTAKE OF PRESCHOOL CHILDREN

By

Laurie Kathryn Bander

A nationwide food consumption survey of 371 preschool children between the ages of birth and five years indicated that age had an impact on food consumption patterns, nutrient intakes and dietary lead intake. For the most part, there was a linear relationship between increased food consumption, increased nutrient intake and increased dietary lead intake with increasing age.

In general, the results revealed the children were well nourished as they consumed greater than two-thirds percent of the NRC-RDA for all nutrients except iron. The usage of vitamin/mineral supplements increased the mean intake levels of all vitamins and iron.

The average daily dietary lead intake (48.5 micrograms to 73.9 micrograms) of this sample when partitioned by age group was attributed to frequency of consumption of food items and quantity of foods consumed, as well as the various foods' lead content. To control for variation in amount of food intake by the various aged children, average lead intake per 500 calories and per 500 grams of food consumed was calculated. When these standardized procedures were followed, an equalization in the average daily dietary lead intake values was observed between the age classifications.

to my parents,
for their love and support

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation and gratitude to Dr. Karen J. Morgan for the guidance, generous advice and understanding she gave me throughout my graduate program.

A sincere thank you is extended to Dr. M.E. Zabik for her inspiration, expertise and patience, all of which were essential during this project. I would also like to thank Ms. Jeanne Sowa, Mrs. Cheryl Hall, and Ms. Jean McFadden for the advice and assistance given as members of the guidance committee.

My deepest gratitude is expressed to Tom, who understandingly and patiently supplied me with encouragement, energy, and sometimes the needed desire to achieve my goal.

I am especially thankful to Kathryn Bundy, my office-mate, for her support, unending patience and friendship. Very special gratitude is also due to my roommate Joyce, for her continued encouragement, patience, and 'listening ear' during a trying period.

And finally a note of sincere appreciation is extended to my sisters Barbara and Stephanie, for the contribution of their time and energy in helping to complete this project.

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INTRODUCTION

Dietary practices during infancy and early childhood exert a profound influence on growth and development, both directly through provision of growth-promoting nutrients, and also indirectly as factors affecting lifetime eating habits (Fox et al., 1970). In addition, it is generally agreed by nutritionists that food practices and attitudes established during early years of life affect food choice and, consequently, nutritional status throughout life (Kerrey et al., 1968). However, while nutrition is recognized as an important environmental factor affecting growth, health, and well-being of the young child, little is known about the nutrient requirements or nutrient intakes of this age group (Fryer et al., 1971). Thus, it is essential for nutritionists to develop a better understanding of the food consumption patterns and nutrient intakes of children of all socioeconomic and demographic backgrounds.

The importance of adequate nutrient intake for the preschool child is evident. However, achieving this may not be easy. Few children pass through the preschool years without creating parental concern about their food intake. Unpredictable food habits are common, as likes and

dislikes may change from day to day and week to week. Also, appetites are usually erratic and unpredictable during this period (Kerrey et al., 1968). Another problem is parental dissatisfaction with children's appetite and interest in food. Concerns most frequently expressed are selection of a limited variety of food, dawdling, limited consumption of fruits and vegetables, and consumption of too many sweets and too little meat (Pipes, 1977).

In general, the nutrient requirements do not appreciably change during the preschool years. After a rapid rise in intake of all nutrients during the first nine months of life, reductions can be expected in the intake of some nutrients as increases occur in intakes of others. Overall, during the preschool years there is a decrease in intakes of calcium, phosphorus, iron, and vitamin A because of the omission of iron-fortified infant cereals in the diets, preschooler's reduction in milk intake, and their disinterest in vegetables. Also, during this period children increase their intakes of carbohydrates and fat. Protein intakes may plateau or increase only slightly. Since intakes of vitamin A and ascorbic acid are unrelated to energy intakes, greater ranges of intakes of these nutrients have been noted (Pipes, 1977).

Through the years, several nutritional surveys have been conducted at the local and national levels to determine the adequacy of dietary intakes. Both longitudinal and cross-sectional studies of nutrient and energy intakes

of young children have shown large differences in intakes between individual children of the same age and sex. The results of these dietary intake studies have shown that protein and riboflavin were commonly consumed in excess of recommended allowances (Fryer et al., 1971). The nutrients found least likely to be consumed in recommended amounts were iron and ascorbic acid (Owen et al., 1974).

However, these investigations only covered a limited number of nutrients. The most frequently analyzed nutrients from the diets were calories, protein, vitamin A, ascorbic acid, thiamin, niacin, riboflavin, calcium, and iron. For a more thorough dietary assessment to be made, fiber, cholesterol, sodium, phosphorus, zinc, magnesium, copper, and vitamins B-6 and B-12 levels should also be included in the investigation.

Additionally, dietary assessment of preschool children should also include daily dietary lead intake from food. Recently, it was recognized that childhood lead poisoning is a serious health problem. The margin of safety for adults from lead poisoning is adequate, but the margin of safety for children is small. This discovery prompted the Food and Drug Administration (FDA) to set a goal for lead intake from food, water, and air, to less than 100 micrograms per day for children between the ages of birth and five years (FDA, 1979). Therefore, in light of this, it is essential to monitor the dietary lead intake levels of this age group.

The major purpose of this investigation was to examine the nutritional status of a cross-sectional sample of United State preschool children. The specific objectives were: a) to investigate the food consumption patterns of individuals between the ages of birth and five years; b) to study the nutrient intakes of this sample population on a national scale, and c) to analyze the dietary lead intake associated with the identified food consumption patterns.

REVIEW OF LITERATURE

The study of dietary intakes has been an important part of discovering dietary component intakes and food patterns of preschool children. During the preschool years, food habits, likes and dislikes are established, some of which are transient, many of which form the base for a lifetime of food, and thus, nutrient intake. In the past, many studies have been completed on the food habits of preschool children, and the nutrient composition of their diets have been reported in a variety of ways. However, much of the literature dealt with either small samples of preschool children from limited geographic areas or concentrated on limited nutrient intakes. In this literature review, the results of previously completed research in the areas of food consumption patterns and dietary intakes of preschool children are reported. When reviewing the literature, it was discovered that much attention has been focused on the effect that lead has on children. Therefore, sources of lead in the food supply as well as the health concerns arising from the presence of lead in the food supply are also reviewed.

Food Consumption Patterns

The study of food habits or food consumption patterns encompasses a wide variety of topics ranging from the number

of meals consumed each day to the types of food consumed at those meals or between them. However, one thing is certain, in order to maintain optimal nutrition an individual must consume a diet that contains a variety of foods. Thus, the individual is able to receive an adequate supply of all the nutrients needed to promote a state of well-being (Thiele, 1976).

Metheny and co-workers (1962) investigated the food consumption patterns of 104 Columbus, Ohio preschool children who were enrolled in day-care centers or nursery schools. Complete three-day dietary records of food intake were obtained for 84 percent of the children. The energy value and the content of protein, calcium, iron, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid were computed for the daily food consumed. The diets were classified according to three levels of nutrient content in the average daily food intake: good - met or exceeded full allowance for all nutrients; fair - met at least two-thirds recommendation but fell below full allowance for one or more nutrient; poor - fell below two-thirds of recommended allowance for one or more nutrient. Based on the above classifications, 21 percent of the children had diets evaluated as good; 61 percent had diets that were fair; and 18 percent had diets categorized as poor. All but one child had a vitamin A intake that met the full allowance. Iron was the nutrient least well supplied in the diets, with 54 percent of the children receiving less than the recommended

allowances. For energy, thiamin, and calcium intakes, 42 percent of the diets were below the full recommendations. The full allowances for protein, riboflavin, niacin, and ascorbic acid were met by 89 percent, 95 percent, 97 percent, and 85 percent of the diets, respectively.

An investigation was undertaken by Harrill et al (1972) to determine the consumption patterns at the noon meal and morning snack of 117 preschool children enrolled in the Colorado State University Preschool. The noon meal consisted of a protein-rich food, cooked green or yellow vegetable, another raw vegetable or fruit, milk, bread, and dessert. A min-morning snack - one-half cup of orange-grapefruit juice - was served during each of the four days of the study. The nutrients evaluated in this study included: kilocalories, protein, calcium, iron, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid. The percentage RDA supplied by the mean intakes of calories and the eight nutrients were reported as follows for the noon meal and noon meal plus snack, respectively: kilocalories 28 percent, 30 percent; protein 50 percent, 53 percent; calcium 34 percent, 36 percent; iron 17 percent, 22 percent; vitamin A 102 percent, 108 percent; thiamin 24 percent, 32 percent; riboflavin 60 percent, 62 percent; niacin 43 percent, 46 percent; and ascorbic acid 17 percent, 132 percent. Foods consumed by the children were evaluated in terms of the respective contributions made by each of the food groups to mean caloric and nutrient intakes.

Milk supplied a higher percentage of calories, protein, calcium, and riboflavin than any other food group. The proportion of the caloric and nutrient intake provided by the various food groups reflected, in part, the preferences of the children for certain foods. Sandwiches and toast were consumed a great deal by the children, and bread was one of the better sources of iron, thiamin, and niacin. Except for vitamin A, fruits provided larger amounts of minerals and vitamins than vegetables did. Green vegetables, which are good sources of iron, other minerals and vitamins were not consumed by most children. This decision was made by the child, as green vegetables were made available to them.

As noted in the last study, the consumption of fruits and vegetables by the preschool child may be inadequate. An investigation by Driskell and Price (1974) also indicated this trend of insufficient amounts of fruits and vegetables being consumed. The examination of diets of forty Alabama preschool children revealed 72 percent of the sample failed to consume a serving of a yellow or green vegetable per day. However, 89 percent of the subjects did consume at least one serving of citrus fruit daily. The results of this study are in accordance with those revealed by Owen and co-workers (1969). Of the 585 Mississippi area preschool children involved in the study, 73 percent did not consume a serving of a yellow or green vegetable per day, but 86 percent did consume at least one serving of citrus fruit daily.

Studies pertaining to the preschool childrens frequency of food consumption revealed a definite majority of youngsters consumed four or five meals a day (Litman et al., 1964). Huenemann (1974) pointed out that the current generation are nibblers and that very few preschool children conform to a three-meal-a-day pattern. He noted that for 204 preschool children, food was consumed an average of five to seven times a day.

Eppright and co-workers (1970) examined the diets of 84 preschool children and reported that the frequency of eating changed from infancy through the second and third years and appeared to stabilize in the fourth, fifth, and sixth years. They found that the majority (71.2 percent) of the children ate from four to seven times per day, 20 percent ate less frequently and 10 percent ate more frequently. The most common eating frequency was four to five times per day. This implied that establishing a pattern for meal and snack times appeared to be a developmental characteristic during the preschool years. Children in this study who ate less than four times a day consumed fewer calories and less calcium, protein, iron, and ascorbic acid than the average of other children their age. Moreover, eating more than six times had a favorable effect on the energy, calcium, and ascorbic acid, but not on the iron and protein content of the diet.

A study done by Kerrey et al (1968) suggested that food practices and attitudes established during the early years are believed to affect food choice and, consequently,

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nutritional status throughout life. This study looked at the dietary habits of 38 children during the preschool grades and again during the early elementary school grades. Consumption of fresh fruits and vegetables was low among the preschoolers, and decreased during the elementary years. Only 18 percent of the preschoolers ate a yellow or green vegetable daily, and fruit was consumed once a day by 21 percent of the children. Snacks were consumed by 92 percent of the sample, and most frequently after school and from home supplies. In determining the contribution of these snacks to the total nutrient intake, it was found that 63 percent of the total caloric intake was obtained through snacks, whereas 76 percent of the total protein intake was consumed at mealtime. The eating patterns of these children were fairly constant from preschool to school age, but at the preschool level more snacks were consumed. Again, this implied that practices established with very young children provide the foundation for nutritional status later in childhood. This also underlies the desirability of training children to eat nutritious foods at an early age. Further analysis of the results revealed that the snacking patterns of these two groups were surprisingly similar, thus supporting that the preschool years may be the training ground for the quality of the diet in later life.

The contribution of various food groups to the diet was examined in a study of 3,444 preschool children by Eppright and associates (1969). The food was weighed

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before it was put on the plate, any wastage was also recorded. Protein contributed 24 percent of the calories; fat, 26 percent; and carbohydrate 50 percent. The important contributions by the food groups to the caloric value were milk (10.4 percent), dessert items (10.3 percent), meat (10.1 percent), bread and rolls (10.0 percent), and combination items (9.9 percent).

The Preschool Nutrition Survey of 1968-70 (Owen et al., 1974) provided an overview of descriptive data on nutritional status of a cross-sectional sample of 6,886 preschool children in the United States. Included as part of this investigation was the assessment of food consumption patterns of the sample. In relation to the latter, it was found that age was an important variable in influencing eating patterns. As expected, there was a progressive decrease in the use of dairy foods with increasing age. On the average, most children consumed from one to two cups of milk per day. The decrease in contribution of dairy products to energy, protein, and riboflavin intakes among the children was to some extent offset by increased consumption of other animal proteins, although absolute intakes of energy and of several nutrients remained lower for many (43 percent) of these children. Cereal grains were major contributors of iron and of calories to the children's diets. Fruits contributed progressively more energy and nutrients while vegetables generally contributed less with increasing age. This study also examined the nutrient contribution that convenience foods

made to the diets. In order to summarize some observations concerning the contribution of convenience foods to the diets of the 600 youngsters (nine percent) who used these at least once in two days, the foods were categorized into two groups, those which contained meat and those which didn't. Group A which included frozen meat pot pies, canned beef stews, chili con carne and spaghetti, provided about one-third of the Recommended Dietary Allowance (RDA) for protein, and vitamin A and one-fifth for energy, iron, thiamin, and riboflavin. Group B which included macaroni and cheese and pizzas and provided about one-third of the RDA for protein and one-fifth of the RDA for energy, calcium, vitamin A, thiamin, and riboflavin. Only about one hundred children (one percent) in this study, virtually all four years or older, had significant intakes of convenience foods purchased in so-called "fast-food" establishments. For children who consumed these convenience foods, they contributed about two-thirds of the RDA for protein, one-third of the RDA for energy, iron, thiamin, and riboflavin and one-fifth or less of the RDA for vitamin A, calcium, and ascorbic acid. It wasn't possible to state whether those children who consumed convenience foods, either prepared in the home or in fast-food establishments, did so with regularity or that the use of such foods was distributed evenly throughout the entire pre-school population. It appeared that there was a pattern of use and, therefore, some unidentifiable segment of the population used such foods to an extent which may have

precluded selection of a broader selection of "regular" foods which might have been better balanced nutritionally (Owen et al., 1974).

Nutrient Intakes of Preschool Children

Adequate nutrient intake is recognized as but one of a myriad of environmental factors which influence the young child's genetic potential for physical and mental development (Sims and Morris, 1974). A normal, healthy child grows at a genetically predetermined rate that can be compromised or accelerated by undernutrition, imbalanced nutrient intake, or overnutrition (Pipes, 1977). Evidence of this is the fact that malnutrition of preschool children may lead to depressed growth and impaired intellectual development due to general behavioral unresponsiveness (Cook et al., 1976). For these reasons, in conjunction with the fact that information on dietary intake and nutrient requirements of preschool children has been scarce in the United States (Fryer et al., 1971), the necessity of studying the nutrient intakes of preschool children should be evident.

Overall, during the preschool years there is a decrease in intakes of calcium, phosphorus, iron, and vitamin A with increasing age. This is due to the omission of iron-fortified infant cereals in the diets of children, their reduction in milk intake, and their disinterest in vegetables. During this period children increase their intakes of carbohydrate and fat. Protein intakes may plateau or

increase only slightly. Between three and four years of age there is a slow, steady, and relatively consistent increase in intake of all nutrients (Pipes, 1977). The following research investigations provide further insights into the nutritional status of preschool children and for the most part, provide results that reiterate the above.

The dietary habits and nutrient intakes of 121 birth to five year old children whose parents were attending the University of Minnesota were described by Dierks and Morse (1965). For the entire sample studies, mean total nutrient intakes met or exceeded the RDA in energy, protein, vitamin A, thiamin, riboflavin, niacin, ascorbic acid, and calcium. However, all subjects had mean intakes of iron less than the RDA. In addition, 109 (90 percent) of the participants consumed diets which contained more than 75 percent of the RDA for those nutrients for which there is an established RDA.

Martin (1970) obtained data regarding diets and feeding practices for 100 preschool children between the ages of two and five years from a Head Start program in Des Moines, Iowa in 1968-69. Data was collected using a 24-hour dietary record that had been kept by the child's mother. The mean daily intake of food energy, protein, vitamin A, ascorbic acid, iron, riboflavin, niacin, and thiamin were computed from 24-hour recall records obtained on a school day for each child. Mean values for this group (calculated without supplements which were currently being used by 43 percent of the children) were found to be adequate

for energy, protein, vitamin A, ascorbic acid, riboflavin, niacin, and thiamin, but not iron, when compared to the 1968 RDA's. When nutrient values were calculated with supplements included, it was found that any deficiencies disappeared.

Cook and co-workers (1976) also studied the nutritional status of a group of preschool children enrolled in a Head Start program. However, this study took place in Maine. Food intakes were calculated from consecutive three-day dietary records for 30 preschool children. These dietary records were evaluated for energy, protein, fat, carbohydrate, calcium, phosphorus, iron, vitamin A, ascorbic acid, riboflavin, niacin, and thiamin. An analysis of the food intakes revealed that all children consumed more than two-thirds of the 1974 RDA for protein, phosphorus, vitamin A, niacin, and thiamin. The children had low intakes of iron, calcium, and ascorbic acid (79 percent, 68 percent and 71 percent, respectively). No child had a diet with an energy value below one-third of the recommended allowance.

Sims and Morris (1974) evaluated three 24-hour recall records for each of 163 preschool children. The information obtained from the records was recorded by each child's mother. The nutrients analyzed in this study included kilocalories, protein, calcium, iron, vitamin A, riboflavin, niacin, and ascorbic acid. On the average, all nutrients, except iron, met or exceeded the Recommended Dietary Allowanced. However, for the few children who had intakes below

two-thirds of the RDA for any one nutrient, the most limiting nutrients were iron (16.1 percent of the sample); ascorbic acid (22.0 percent); calcium (10.2 percent); and vitamin A (13.0 percent). All nutrient totals were calculated exclusive of the contribution of vitamin/mineral supplements which 108 children (66 percent) were taking.

Another study involving nutrient intakes of pre-school children was undertaken by Fryer et al (1971). A heterogeneous sample of 3,444 (53 percent male and 47 percent female) preschool children in the twelve states of the North Central Region (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin) took place in the longitudinal study which dealt with dietary intake of food energy, protein, carbohydrate, and fat. Three day food records provided the source for nutrient intakes. For all children, intake of calories, fat, and carbohydrate increased rapidly during the first twelve to eighteen months and then slowly from eighteen to seventy-two months. Again, for all children, protein intake increased rapidly until twelve to eighteen months, leveled off somewhat between eighteen and thirty-six months, and then increased slowly to seventy-two months. Approximately 66 percent of the children received the recommended allowances for calories and at least 90 percent of the allowances for protein. The mean percentage of calories supplied by protein ranged from 15 to 17; by fat 34 to 40;

and by carbohydrate 43 to 50 for all but the youngest age-sex groups.

Fox et al (1971) did further analyses on the diets of these same preschool children in the North Central Region. This study analyzed the calcium, phosphorus, and iron intakes based on three-day dietary records obtained by interviews with each child's mother. Intakes of these three minerals increased rapidly during the early months, phosphorus intakes continued to increase but, at a slower rate throughout the remainder of the preschool period. However, iron intakes declined sharply before the end of the first year and calcium during the second year, followed by a gradual increase in the later preschool period. Calcium and phosphorus intakes compared favorably with the 1968 RDA's in that 82 percent of the sample either met or exceeded the allowances. Iron intakes for the sample however, were low as judged by the RDA's.

For a study of 40 Alabama preschoolers, Driskell and Price (1974) examined 24-hour dietary records. Before the intakes of these children were evaluated, the sample was divided into the following age groups: two years, fifteen subjects; three years, ten; four years, five; and five years, ten. Mean nutrient intakes for kilocalories, protein, calcium, iron, vitamin A, and ascorbic acid were calculated for each age level and compared with the 1968 RDA's. Mean calcium and iron intakes did not meet with recommended allowances at any age. With regard to the other nutrients, the recommended

allowances were met for all those except kilocalories and ascorbic acid. The four-year-olds comprised the only group of individuals that did not meet the recommended allowances for kilocalories, and with respect to ascorbic acid, 40 percent of the total sample fell below the RDA. Similar results were found by Owen and co-workers (1969) in which the dietary intakes of 585 preschool children in Mississippi were analyzed. The nutrient intakes calculated included kilocalories, protein, calcium, iron, vitamin A, and ascorbic acid, and again, calcium, iron, and ascorbic acid values fell below the RDA's for all children. The RDA for the remaining nutrients were met or exceeded by the sample population.

As is evident, there are many contradictory findings regarding the nutrient intakes of preschool children. However, for the most part, it has been well demonstrated that iron, calcium, and ascorbic acid intakes most often fell below the RDA for children between the ages of birth and five years. Further support of this was illustrated in the Health and Nutrition Examination Survey (HANES) (U.S. Dept. HEW, 1977). The survey was conducted between April 1971 and June 1974, and 2,896 children (14 percent of the total sample surveyed) aged birth to five years participated. The nutrient intakes examined in this study included kilocalories, protein, calcium, iron, vitamin A, ascorbic acid, thiamin, riboflavin, and niacin. Based on the standards for HANES dietary intake data, iron was the only nutrient for which the standards were not met.

In terms of most other nutrients for which the National Research Council (NRC) has set an RDA, previous research indicated preschool children were following food consumption patterns which provided them with foods that supplied nutrients to aid them in meeting their respective RDA's for the nutrients analyzed. Previous researchers have only studied a limited number of nutrients, e.g., calories, protein, calcium, phosphorus, vitamin A, iron, thiamin, riboflavin, niacin, and ascorbic acid. However, there were no reported values for the intake of pyridoxine, vitamins B-12 and D, folacin, magnesium or zinc, even though these nutrients have had RDA's assessed (Metheny et al., 1962; Kerry et al., 1968; Patterson, 1971). Not only have these nutrient intakes not been reported, but also the intake of those nutrients for which there is no NRC-RDA, e.g., total fat, total carbohydrate, total sugar, crude fiber, cholesterol, sodium, potassium, and copper, has not been reported.

The previous research investigations are evidence that there are children who receive diets that are inadequate in quantity and/or quality. It has been well documented that all preschool children are at risk for iron deficiency anemia (Pipes, 1977), but in addition, there are other concerns regarding the nutritional status of preschool children. Again, this goes back to the fact that adequate nutrition is recognized as important in promoting normal growth and development of the preschool child (Driskell and Price, 1974). In view of this, it is

not surprising that further investigations should be undertaken regarding the nutritional status of persons birth to five years of age.

Lead Toxicity
and Levels of Intake in Children

Lead poisoning is an important public health problem, with the adverse effects of lead on human health having been recognized for centuries (Goyer and Mahaffey, 1972). Additionally, the toxicity of lead is an appropriate example in environmental pathology for several reasons. Lead, a ubiquitous element, is one of the most useful and abundant metals known to man, and the industrial products containing lead are widely distributed in the environment. Man has been aware of the harmful effects of large amounts of lead for more than two thousand years, but the possible subclinical effects of small amounts of this metal are still not understood (Goyer, 1971). In view of this, it is essential to summarize the problems, concerns and unanswered questions about the health effects of lead in our present-day society.

In the United States, the majority of nonindustrial cases of lead intoxication occurred in children between the ages of one and six years, with the highest incidence between two and three years (Mahaffey, 1977). At present, over 250,000 children per year in the United States are assessed for undue absorption of lead (Mitchell and Aldous, 1974). For these reasons, lead poisoning is now

essentially a disease of childhood, with birth to five year olds comprising the most susceptible population (Barltrop, 1975). Therefore, the recognition of factors, both synergistic and antagonistic, which influence the toxicity of lead are essential for adequate understanding of the sources and effects of environmental lead on young children (Goyer and Mahaffey, 1972).

Children are invariably exposed to lead from a variety of sources. Lead is found in the air they breathe, in the food they eat and in the water they drink (FDA, 1979). However, the major sources of lead for the child population are food, and consequently the diet (Chisolm and Barltrop, 1979).

There are essentially three sources of lead in food. First is the natural background level. This background is present because the ubiquitous distribution of lead in the environment (soil and water) results in its being incorporated into all living organisms, although it has not been established that lead is an essential nutrient for any organism. The remainder of the lead in food is present as a result of human activities, which can be subdivided into (a) pollution of the environment with lead and (b) food processing activities that involve the use of lead (FDA, 1979).

In environmental pollution, lead dust falls out from automobile exhaust or lead smelting operations or lead in run-off water from mining operations may cause additional lead to enter food and feed crops in certain

geographical areas. The previous use of pesticides that contain lead may also have increased levels of lead in certain fruits and vegetables, particularly where the use of such pesticides has been long established, increased levels of lead in the soil may cause further increase in lead in such crops (Chow, 1970).

The most important source of additional lead in the food supply from food processing is the method of packaging and holding food. Foremost among these sources of added lead is the popular "sanitary" or tin can, which is used to package ten to fifteen percent of all food in this country (Damstra, 1977). Thirty-three billion tin cans are used each year to package food, and approximately twenty-five billion more are used annually to package carbonated beverages. The source of the added lead is not the can itself, but the lead solder used in can seams. It is estimated that about twenty percent of the lead in the average daily diet of persons more than one year of age is from canned food, of which approximately two-thirds is from the solder, and the remainder is from the food itself prior to canning. Thus, lead from the tin can solder contributes about fourteen percent of the total lead ingested by humans (Kolbye et al., 1974).

Other less significant sources of added lead in food include migration of lead under normal conditions of use from ceramic glazes, silver plated holloware, porcelain pots and pans, pewter, and fine leaded crystal. Misuse of glazed ceramic ware by storage of acid foods or drinks

for prolonged periods, however, can result in the leaching of relatively large amounts of lead into the food. Very small amounts of lead in food can be traced to food additives that contain low but generally unavoidable levels of lead (FDA, 1979).

Returning to the factors which influence the toxicity of lead, the consideration of antagonisms and synergisms are based on certain assumptions with regard to the metabolism of lead; that is, the daily intake and excretion of lead as well as the movement of lead between various tissues and effects on cells and subcellular organelles (Goyer and Mahaffey, 1972).

As previously stated, the major sources of lead for the child population are food, and consequently the diet. From this, one can accurately conclude that the principle route of entry of lead into the body is oral. Net absorption of lead by the gastrointestinal tract is about five to fifteen percent; the rest is excreted in the feces. Inside the body lead must exist in two forms: a diffusible or mobile form and a non-diffusible or fixed form. Lead must be in a diffusible form in tissues which transport it from one part of the body to another as in red blood cells and plasma, and in organs where lead is transported across cell membranes as in the liver and kidneys. Diffusible lead is sometimes equated with "biologically active" lead but this term may be more appropriately reserved for forms of lead which bind to membranes, enzymes, or other proteins (Berman, 1966).

Another organ important in the metabolism of lead is the liver. It is thought that lead is excreted from the liver in bile, as a portion of ingested lead may be absorbed from the upper gastrointestinal tract, transported across liver cells and excreted into the gut by way of the biliary system (Mahaffey, 1977).

The kidney is the other organ involved in the metabolism of lead. It functions to excrete lead in two ways: by glomerular filtration and transtubular flow. In other organs of the body, lead is nearly completely non-diffusible or bound lead. Over ninety percent of the total amount of lead in the body is in bone. The organs with the least concentration are skeletal or cardiac muscle (Chisolm, 1979).

Although lead poisoning is known to affect a number of essential body functions, these effects have been best documented for the hematopoietic, renal, and central nervous systems. In most instances, the onset of lead poisoning is a slowly progressive process accompanied by a variable continuum of biochemical and clinical manifestations. The severity of these clinical manifestations of lead poisoning depend on both the duration and intensity of exposure (FDA, 1979). The minimal blood lead concentration above which these systems are affected in children is not known (Mahaffey, 1977).

One of the earliest signs of chronic lead poisoning is the occurrence, especially among children, of a microcytic, hypochromic, mildly hemolytic anemia, a type of

anemia characterized by abnormally small red blood cells containing reduced hemoglobin content. This type of anemia results from the interference of lead in specific enzyme systems involved in the synthesis of heme, the iron-containing component of hemoglobin. The development of acute anemia is preceded by increased blood concentrations and urinary excretion of the metabolic precursors of heme. When the body burden of lead is increased, this increase is generally reflected by a concomitant rise in whole blood concentration (Berman, 1966).

Renal damage resulting from acute toxicity includes degeneration of the cell lining of the proximal tubules, varying degrees of cellular necrosis, and decreased reabsorption of amino acids, glucose, and phosphates. Long term exposure of the renal system to lead produces a condition known as chronic lead nephropathy, which is characterized by a slow progressive degeneration of renal tissue with a subsequent decrease in renal function. Chronic nephropathy is occasionally fatal as a result of renal failure (Damstra, 1977).

The most severe form of overt lead toxicity, acute encephalopathy, involves the central nervous system and is characterized by the sudden onset of the accumulation of intercellular fluid in the brain, convulsions, coma, and death as a result of cardiopulmonary arrest. Although the incidence of fatal encephalopathy has decreased markedly over the past twenty years, due to both earlier detection and chelation therapy, in nonfatal cases there are a number

of long-lasting neurological effects. These include gross mental retardation, recurrent seizures, cerebral palsy, behavioral abnormalities such as increased irritability, impaired concept formation, and hyperactivity, and occasionally blindness, loss of power of expression and/or comprehension of language and muscular weakness usually affecting one side of the body. Reduced motor function is the primary effect of lead on the peripheral nervous system, but other symptoms, including loss of feeling in the extremities have also been observed (Mahaffey, 1977).

The clinical effects of lead poisoning in infants and children are well known. However, there is also considerable interest in the subclinical effects of exposure to lead in these groups. Needleman and associates (1979) have suggested that neurophysiological effects such as behavioral and performance defects, may occur in children exposed to lead levels below those required to produce clinical effects. The level of exposure that will produce neurophysiological effects is not yet clearly defined. Therefore, Needleman et al (1979) have suggested that dentene lead levels may be a more useful index of exposure to lead than blood levels because dentene lead levels would reflect long-term integrated lead exposure, whereas blood lead levels would reflect only recent exposure to lead.

Whether exposure to a particular dosage of lead results in overt clinical toxicity or not, may depend on a number of factors both constitutional and environmental which

either enhance or reduce susceptibility to the toxic effects of lead. A number of such factors are: (1) age; (2) season of the year (body temperature, dehydration, ultraviolet light); (3) calcium, phosphorus and vitamin D; (4) iron deficiency; (5) dietary protein; (6) ascorbic acid; (7) nicotinic acid; (8) alcohol; and (9) other heavy metals. The type of factors involved in alteration of vulnerability vary widely, but include dietary and metabolic effects (Mahaffey, 1974). Since very few studies have been performed on human subjects, animals were used to determine the effect of the above factors have on the toxicity of lead. Therefore, some conclusions drawn and reported below, are based in part, on animal studies.

With regard to age, acute lead poisoning is most common in children between the ages of birth and five years (FDA, 1979). There are many reasons why the young might be expected to be more susceptible to lead. First, the greater vulnerability of young growing tissue and greater variation in gastrointestinal acidity or alkalinity to include pH ranges may be more likely to dissolve and hence, increase absorption of lead. Also, shifts of lead into and out of the growing bone of a child may influence biological effects. Children with acute lead intoxications develop lead encephalopathy but encephalopathy in adults is rare except as the result of a very large exposure to lead vapors or organic forms of lead. Also, the greater incidence of lead encephalopathy in the child may reflect inherent sensitivity of the nervous system of the child

to lead. Additionally, it appears that the child has a very low capacity to store lead in an inactive form in the bone (Hardy, 1966).

Clinical lead toxicity is more common among children in summer months (Goyer and Mahaffey, 1972). This is further supported by fact that urinary lead excretion in a person voluntarily ingesting supplemental lead is greater in the summer (Kehoe, 1961). It would seem, therefore, that this phenomenon must result from seasonal metabolic difference. Two explanations cited by Baetjer (1969) included increased vitamin D formation from the sun's ultraviolet irradiation and increased environmental temperature.

The absorption of lead from the gastrointestinal tract as well as the partitioning of lead in various body compartments is thought to be regulated by the same physiological mechanisms which control the metabolism of calcium and phosphorus. This phenomenon is based on the concept that low dietary calcium, phosphorus or both, induced a higher retention of lead in the body in comparison with diets containing higher levels of these minerals. From knowledge gathered thus far, it is presumed that vitamin D enhances gastrointestinal absorption of lead as it does that of calcium (Mahaffey, 1974).

Children with lead poisoning often have iron deficiency anemia and either lead poisoning or iron deficiency results in a microcytic anemia. A synergism between the two conditions has been suspected (Mahaffey, 1977). The mechanisms by which iron and calcium deficiencies enhance

susceptibility to lead have been reported by Six and Goyer (1972). In this study, twenty control rats were fed a diet low in levels of iron and calcium and without added lead. The results revealed a significant increase in bone level of lead as it went from 2.2 micrograms per gram of wet tissue to 10.6 micrograms per gram of wet tissue. There was no elevation of soft tissue lead on the low iron diet and a slight elevation of soft tissue lead on the low calcium diet (2.6 micrograms per gram wet tissue to 4.4 micrograms per gram of wet tissue). When 200 micrograms of lead per milliliter of water was added to the diet, there was an increase in bone lead on a nutritionally adequate diet. The bone lead levels increased from 74 micrograms per gram of wet tissue to 225 micrograms per wet tissue. Soft tissue lead was also increased. On a low iron diet, bone lead tripled in content, but soft tissue lead remained approximately the same as on the nutritionally adequate diet. With the low calcium diet, bone lead was equal to that found in rats fed the low iron diet. However, soft tissue lead was approximately twenty-five to thirty times that seen on either the nutritionally adequate or iron deficient diet. The changes in renal lead content on the low calcium diet were accompanied by indicators of renal dysfunction such as elevated aminoaciduria and increased renal size (Six and Goyer, 1972).

Concerning the other factors mentioned, the data available on how they affect lead toxicity are very limited. Briefly, dietary protein may influence lead intoxication;

large amounts of ascorbic acid in the diet may alleviate symptoms of lead intoxication such as basophilic stippling of erythrocytes; nicotinic acid synthesis from tryptophan may be impaired by lead poisoning; alcoholic persons may be more susceptible to the toxic effects of lead; and cadmium levels may be elevated along with lead in the blood of children with suspected lead poisoning and a possible synergism may exist between these two metals (Goyer and Mahaffey, 1972).

In light of the information available regarding the toxic effects of lead, knowledge of the limiting value for lead intake is essential for the control of lead poisoning in children. Intake has been defined as the amount of lead ingested in the diet and nonfood substances, and the amount retained in respiratory exchange (King, 1971). Based on this definition, the conclusion of a 1971 ad hoc committee that consisted of two physicians and five persons from the Department of Health Education and Welfare, was that the value for a daily permissible total lead intake from all sources for children be three hundred micrograms. This conclusion was based in part on the assumption that ninety percent of ingested lead would be excreted by the child just as it is by the adult. However, further investigations revealed that children have a highly efficient absorption and retention level for ingested lead (FDA, 1980). This discovery caused the Food and Drug Administration to take action, and they have now set a goal to reduce lead intake from all sources - air, water, and food

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to less than one hundred micrograms per day for children between the ages of birth and five years (FDA, 1980).

To reiterate what has been previously stated, there is some, albeit limited, knowledge of lead toxicity studies utilizing human subjects. Two such studies that have been done are as follows. First, Rosen and associates (1980) evaluated dietary lead intake of forty four New York city children between the ages of one and five years. They found that 87 percent of the children had high blood levels of lead, greater than sixty deciliter, and, in addition, these same children had reduced dietary intakes of calcium and vitamin D. Also, increased lead absorption was accompanied by an endogenously produced deficiency in 1,25-dihydroxyvitamin D, the hormonal form of the parent vitamin. Reduction in the serum concentration of this hormone appeared to be a sensitive index of increased levels of lead in the blood.

A study conducted by Ziegler and co-workers (1978) examined the effects of dietary calcium and phosphorus on lead absorption and retention in 107 children between six months and five years. Each child was fed a nutritionally adequate, inadequate, as well as overly-adequate diet, the latter two being adjusted for calcium and phosphorus. Concentrations of lead and of various nutrients in milk and formula were determined. The quantity of each food consumed was recorded. From lead concentrations of the foods and the weights of foods consumed, intakes of lead were calculated. The average lead intake per child was

9.44 micrograms per kilogram of body weight per day, net absorption averaged forty-two percent of intake, and net retention averaged thirty-two percent of intake. Absorption and retention of lead were inversely correlated with calcium intake. Low dietary intakes of calcium, below thirty percent of the RDA, caused increased retention and toxicity of lead. Low dietary intake of phosphorus, again, below thirty percent of the RDA, enhanced the effect of the low calcium diet, whereas low dietary intake of phosphorus alone had little effect. Conversely, high dietary intake of calcium, over one-hundred thirty percent RDA, diminished lead absorption. It was found that calcium and phosphorus acted primarily on intestinal absorption of lead, although low dietary intake of calcium also altered metabolism of lead in bone.

Several studies have been undertaken to investigate the dietary lead intake of young children. However, the information available is very limited. In 1974, the Food and Drug Administration calculated that the dietary lead intake for the two year old, including water, was 115 micrograms per day. Then in 1976, the National Food Processors Association in conjunction with the Can Manufacturers Institute (NFPA-CMI) calculated the dietary lead intake from all food and water for the two year old to be 98 micrograms per day. A follow-up study of two year olds was conducted in 1978-79 by the NFPA-CMI, and the results revealed that dietary lead intake was 57 micrograms per day. In addition, the NFPA-CMI initiated a study that

would utilize dietary information obtained by the Market Research Corporation of America (MPCA) to estimate the daily lead intake from food for infants and young children birth to five years old (n=1204). The data used was from food records kept for fourteen consecutive days. The final results showed a mean intake from food alone to be 50 micrograms per day, and from food and water to be 55 micrograms per day (FDA, 1980). However, the values from this study have been considered somewhat low as no serving sizes were indicated on the food records and consequently, had to be estimated (Elkins, 1981).

Johnson and Skeberdis (1979) conducted a study that examined the lead intake of 154 United States infants age birth through thirteen months. The total food intake of these infants was collected through a four-day dietary record. The results indicated mean dietary lead intake to be 27.6 micrograms per day for birth through five month old infants, and 44.9 micrograms per day for six through eleven month old infants. Further analyses of specific food sources showed that infant formula was the major contributor of lead to the infants diet for the first four to five months. In addition, the largest contribution of lead by baby foods was relatively minor (17 micrograms per day) at eight months. After this age, the relative source of lead from table foods increased, and became the most significant contributor. A final conclusion of this study was that the lead consumption of the infants was proportional to their caloric intake.

Although the margin of safety for adults from lead poisoning from dietary intake is adequate, the margin of safety for children is small. Thus, it is now recognized that infants and young children are at substantially greater risks than adults to lead exposure for the following reasons: (1) blood dyscrasias and neurological effects of lead occur at lower threshold levels in children; (2) due to a greater metabolic rate than adults, children eat and breathe in more lead per unit of body weight and hence are exposed to relatively more lead; (3) at comparable levels of lead intake, infants and young children absorb appreciably greater proportions of lead than do adults; (4) the acute toxic effects of lead in children affect the central nervous system, while in adults the effect is primarily on the peripheral nervous system; (5) on account of pica (compulsive ingestion of things other than normal food), infants and children frequently ingest high levels of lead from nonfood sources (i.e., soil, paint chips, plaster, newsprint, etc.); and (6) there is an increased probability that many children do not receive adequate amounts of dietary calcium and iron, and that this nutritional deficiency results in an increased absorption of lead (FDA, 1979). Therefore, the ultimate preventative goal must be identification and removal of lead in the environment before it enters the child. Accordingly, continued research is necessary to identify sources of lead in diets of children birth to five years, in order to determine if particular segments of this population may

be at risk by exceeding the 100 microgram per day desired,
maximum intake specified by the Food and Drug Administration.

METHODOLOGY

A seven-day dietary record, completed by a representative sample of American families from 48 contiguous states was the source of information for this dietary investigation. In the following pages, an explanation of the diary, as well as the calculations utilized to complete the analyses of the data are presented.

Data Collection

The data used in this investigation was collected by Market Facts of Chicago, Ill. Seven-day food diaries were mailed during the third week of September 1977, to 2,000 of the firms Consumer Market Panel (CMP) II families. Of the initial 61,552 non-institutionalized households belonging to this panel, the sample population used in this study were selected to be representative of households within the United States. The households used were balanced by geographic area, population density, degree of urbanization, family income, and age of panel member. The large number of potential families in CMP II allowed for minimum "previous panel" experience bias to occur. It also allowed for incorporation of new census parameters in panel selection and minimizes within matrix distortion (i.e., age within income, within any one region) (Cala, 1979).

The seven-day food diary, filled out during the week of September 18 to September 24 (Sunday through Saturday), contained spaces for ten menu items each for the morning, mid-day, and evening meal and six menu items for mid-morning, mid-afternoon, and evening snacks. Participants recorded all foods and beverages consumed as well as the amount consumed. Any toppings or additions eaten with each menu item, and the appropriate amounts, were also recorded. Further description for most entries included brand name, type, flavor, and/or method of preparation. Location of where the meal or snack was consumed was also collected. The locations included at home, at school, away from home, and did not eat.

There was also a section at the end of the diary entitled "General Family Information". This section was completed for each member of the family with the personal data requested, i.e., name, age, height, weight, general health, dental history, pregnant or lactating, and any special diet information.

A detailed set of directions were stated in the diary, which included a sample of one day's menu to be used as an accurated example to follow and also to reinforce to the subject the importance of recording every item consumed. For a more detailed description of the seven-day diary used see Cala (1979).

There were 1,550 diaries, of the 2,000 diaries distributed, returned to Market Facts in Chicago. The diaries were

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then sent to Michigan State University where they were sorted and determined to be usable or non-usable. That is, diaries were considered usable if menus for at least four days were recorded. There were 1,494 diaries (approximately 75 percent of the original 2,000 dietary records) which were considered to be usable.

The diaries sent to Michigan State University were accompanied by a basic set of demographic information for each of the original 2,000 families that received diaries. The following facts were included in this information: geographic division and state, country, standard metropolitan statistical area, type of dwelling, ownership, form of residence, income, education level of the panel member and spouse, position of husband, employment status of panel member, household size, age and sex of each family member, marital status, total household income, population density, and degree of urbanization. This information was separated by families who returned the diaries and families who did not, in order to facilitate comparison of socioeconomic data of both groups. This information was analyzed for both groups of usable and non-usable diaries, and then compared with similar statistics for the national population.

The 1,494 diaries received by Michigan State University were separated into families with children between the ages of birth and five years. The total number of families in this category was 244: 146 families had one child between

the ages of birth and five years and 98 families had two or more children within the age range. However, before the total sample was ready to be analyzed, it was necessary to drop the eight children from the sample who were breast-fed. Due to variability of nutrient content of each mother's milk, differences in quantity of milk ingested per feeding (Bond, 1981), and also inaccuracies in recording breast feeding information in the diaries, there was no accurate way to assess what a serving of breast milk was. With the removal of these eight children, the total sample population that was analyzed consisted of children from 238 families: 142 families with one child between birth and five years of age and 96 families had two or more children within this age classification. In total, there were 371 children between the ages of birth and five years in the sample used in this investigation.

After the diaries arrived at Michigan State University, the recorded information was coded to permit computerized analyses to be performed using the Michigan State University Nutrient Data Bank. Eight undergraduate coders were trained to transmit the menu items on the diaries into six-digit food code numbers and two-digit measure codes. (For detailed coding information see Cala, 1979).

Upon completion of the coding, the forms were key-punched and verified by Data Entry, Incorporated of Lansing, Michigan. The information was then put on magnetic tape and returned to Michigan State University for correction

of any coding or keypunching errors. The diaries were thoroughly checked for accuracy for each of the seven days.

This checking revealed numerous errors on the raw data tapes which then had to be edited to the correct code numbers. After this initial editing, a pre-designed program was run to make sure all inaccurate code numbers, measure codes and quantity amounts had been corrected. Once all errors had been corrected, the tapes were then sent to the University of Missouri-Columbia for further analyses.

Data Analyses

The University of Missouri-Columbia provided the computing facilities utilized in the analyses of the sample data. The University of Missouri Computer Network operates on Amdahl 470/V7 (OS/V52 MVS Release 3.8 and NJE Release 3.0) and an IBM 3031 processor (VM/370 Release 6 with BSEPP Release 2). The programming language used to process the sample data was SAS Release 79.4B running under MVS. The computer programs were written by Business and Public Administration Research Center, of Columbia, Missouri.

Before the programs were processed, the sample population was divided into six groups based on the ages of the children. This allowed for the examination of the impact of age on food consumption patterns, nutrient intake, and dietary lead intake for the sample population. The groupings were: less than one year of age; one less than

two years of age; two less than three years of age; three less than four years of age; four less than five years of age; and five years of age. In addition, all analyses were performed on the total sample as well. There was a disproportionate distribution as a result of this classification system: less than one year group contained 38 subjects (10.2 percent of sample); one less than two years, 47 (12.6 percent); two less than three years, 77 (20.8 percent); three less than four years, 73 (19.7 percent); four less than five years, 63 (17.0 percent); and five years, 73 (19.7 percent).

The first program used was a frequency count of the number of times a particular food item was consumed. To facilitate comparison of the usage of the 3,500 foods contained in the MSU Nutrient Data Bank, foods were assigned to one of seventeen food groups. The food groups were: babyfoods; beverages, carbonated and non-carbonated; cereal and cereal products; cheeses and yogurt; combination items; dessert items; eggs; fats, oils, salad dressings and condiments; fruits and vegetables, fresh; fruits, vegetables, and juices, canned; fruit and vegetable juices, fresh and frozen; meats; milk; milk, canned; salted snack foods; soups; and vitamin/mineral supplements. For a complete description of each food group see Appendix I. The number of times an item from each food group was consumed was tabulated. The percent contribution of each food group was calculated for the week's intakes. For example, if eggs were eaten 100 times out of the possible 1,000 food items consumed, its

percent contribution was ten percent.

Following the frequency count, nutrient analyses were completed with the aid of the Michigan State University Nutrient Data Bank. It allows for calculations of a total of 78 dietary components of each food item, in addition to lead. However, only 23 dietary components were selected as being relevant to this study. The 23 which were assessed included: calories, protein, total fat, total carbohydrate, total sugar, cholesterol, fiber, ascorbic acid, thiamin, niacin, riboflavin, vitamins B-6 and B-12, pantothenic acid, vitamin A, iron, calcium, sodium, phosphorus, potassium, magnesium, copper, and zinc.

The first run of this program was for the total pre-school population studied. The program was then altered to compute the dietary intakes for each of the six age group classifications. This program also included the calculation of the percentage of 1980 NRC-RDA for fourteen of the eighteen nutrients which have recommended dietary intake levels. These analyses were done for the intakes of calories, protein, ascorbic acid, thiamin, niacin, riboflavin, vitamins B-6 and B-12, vitamin A, iron calcium, phosphorus, magnesium, and zinc. The dietary intakes of four nutrients (pantothenic acid, copper, sodium, and phosphorus) were compared to the safe and adequate daily intake ranges set by the Food and Nutrition Board (1980).

The dietary intakes for each group and total sample

were analyzed including and excluding vitamin/mineral supplements. These analyses assessed the impact such supplements made on the total intake levels of each of the appropriate vitamin and/or minerals.

To determine the daily dietary lead intake, the Michigan State University Nutrient Data Bank, which contained 3,500 food items including fresh and process foods plus some fast food restaurant items and home recipes, first had to be updated with the lead content of the foods. The lead data used in this study was provided by the National Food Processors Association (FDA, 1980). The protocol and assumptions used by the National Food Processors Association were also used in this investigation. See FDA Docket Number 79N-0200 (FDA, 1980) for a complete and detailed description of this information. For those foods, particularly combination items (e.g., cheeseburger with bun, fish sandwich with and without cheese and bun), in which no lead value was available, but there were lead values for the parts of the whole, the final lead value was based on the sum of the lead per gram weight of each part of the item.

Once this was completed a program was run that allowed for the calculation of average daily dietary lead intake; average daily dietary lead intake based on 500 kilocalories of food eaten, as well as average daily dietary lead intake per 500 grams of food consumed. Since there was a difference in the amount of food eaten by each child, for

example, a one year old generally ate less than a three year old, average daily dietary lead intake based on 500 kilocalories was utilized as a method of standardization. Going one step further than this, while energy measures of food intake reflect physiological need, food selection and consumption are not based solely on this need (Scherwin et al., 1981). Therefore, it was also appropriate to consider the quantity of food consumed in addition to its caloric content. For this reason, average daily dietary lead intake was calculated per 500 grams of food consumed.

Also calculated for the total sample was the average daily dietary lead contribution from 16 of the 17 specified food groups (See Appendix I). Vitamin/mineral supplements were excluded from this analysis, as the lead content of all items in this group was zero. These calculations were based on the lead content of each item, portion sizes and the number of times the food was consumed. The number of children who consumed an item within each food category was also tallied for this assessment.

In addition, a computerized program was used to obtain a least square cubic spline approximation of the average daily dietary lead intakes of the entire preschool sample. The data points were plotted separately, following the procedures of Ahlberg and associates (1967).

The statistical tests utilized in these analyses included one-way and two-way analyses of variance (Young and Veldman, 1977) and SAS General Linear Model (Barr et al., 1976) to determine if significant differences were observed.

When significant differences were found, Duncan's Multiple Range test (Duncan, 1957) was completed to further analyze the values and pinpoint the significant differences.

RESULTS AND DISCUSSION

Three aspects of the impact of age on food consumption patterns of preschool children are reported: the frequency and types of foods consumed during the survey week, the dietary component intakes by the sample population, and dietary lead intake. The data were analyzed for the total sample, as well as six subsequent age classifications.

SAMPLE DESCRIPTION

Of the original 2,000 diaries mailed to Market Facts panel members, 1,494 diaries (75 percent of the original diaries) were completed and found to be in usable form. That is, food was recorded for at least four of the seven survey days. These usable diaries were mailed to Michigan State University where they were sorted so that dietary records for individuals between the ages of birth and five years were available for analysis. Originally, there were 244 diaries containing information of 379 children between the ages of birth and five years. However, the eight children who were breast-fed had to be eliminated from the sample. Due to variability of nutrient content of each mother's milk, differences in quantity of milk ingested per feeding (Bond, 1981) and also to inaccuracies in recording breast feeding information in

the diaries, an accurate nutrient intake assessment could not be made. With the elimination of these eight children, the sample population analyzed consisted of 371 preschool children whose dietary intake information was contained in 238 family diaries. The children were divided into six age classifications, each spanning one year. Table 1 presents the age, sex, and number of children in each age classification.

Table 1. Distribution of preschool children classified by age and sex.

Age Classification	Sex		Total Number of Children
	Male	Female	
< 1	23	15	38
1 < 2	27	20	47
2 < 3	36	41	77
3 < 4	43	30	73
4 < 5	26	37	63
5	38	35	73
Total Sample	193	178	371

As can be seen (Table 1), division by age yielded a disproportionate distribution of the total sample. The less than one year group contained 38 subjects (10.2 percent of sample); one less than two years had 47 subjects (12.6 percent); two less than three years had 77 members

(20.8 percent); three less than four years contained 73 subjects (19.7 percent); four less than five years had 63 members (17.0 percent); and five years contained 73 subjects (19.7 percent). This distribution was in slight disagreement with the 1977 United States preschool population. The following distributions were found for the U.S. preschool population: less than one year 17.1 percent; one less than two years 16.3 percent; two less than three years 16.3 percent; three less than four years 16.0 percent; four less than five years 16.7 percent; and five years 17.6 percent. Also, the national preschool sample was composed of 51 percent males and 49 percent females (United States Department of Commerce, 1979).

The largest group was the two less than three year olds with 77 children; 36 males and 41 females. Following the two less than three year olds were the three less than four years olds and the five year olds. Both classifications contained 73 subjects; however, the sex distribution of the groups varied. There were 43 males and 30 females three less than four years of age, and 38 males and 35 female five year olds. Next, the group consisting of those children four less than five years of age had 63 subjects; 26 males and 37 females. The smallest groups were those with children one less than two years, and less than one year of age. In these two groups, there were 47 subjects; 27 males and 20 females, and 38 subjects; 23 males and 15 females, respectively. The total sample consisted of 193 males (52 percent of sample) and 178

females (48 percent) (Table 1).

An analysis of the demographic data for the preschool children and their families was completed to assure the children's sample was not biased by non-returned diaries. The demographic characteristics which pertained to this sample are indicated in Table 2. Market Facts provided this information for all of the 238 families used in this investigation.

Table 2. Demographic characteristics of sampled families with preschool children.

Characteristics	Percentage Distribution		
	Families Surveyed (n=381)	Families Returning Diaries (n=238)	Families Not Returning Diaries (n=143)
Geographic Location			
New England	5.0	5.5	5.6
Middle Atlantic	15.0	13.4	17.5
E. North Central	20.5	18.9	23.1
W. North Central	8.1	10.5	4.2
South Atlantic	16.5	17.6	14.7
E. South Atlantic	6.3	7.6	4.2
W. South Atlantic	10.2	9.2	11.9
Mountain	5.0	4.6	4.2
Pacific	13.4	12.6	14.7
Education Level			
No School	0.0	0.0	0.0
Elementary	1.6	1.3	2.1
Some High School	12.3	11.8	13.3
High School Graduate	43.0	44.5	40.6
Some College	28.6	24.8	35.0
College Graduate	12.9	16.0	7.7
Post Graduate Degree	1.6	1.7	1.4
Not Specified	0.0	0.0	0.0
Employment Status			
Full-time or Self Employed	23.1	18.9	30.1
Part-time	11.8	11.8	11.9

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Characteristics	Percentage Distribution		
	Families Surveyed (n=381)	Families Returning Diaries (n=238)	Families Not Returning Diaries (n=143)
Not Employed	12.6	10.9	15.4
Homemaker	50.7	57.6	39.2
Not Specified	1.8	0.8	3.5
Marital Status			
Married	92.7	94.1	90.2
Widowed	0.3	0.4	0.0
Divorced	4.7	2.9	7.7
Separated	1.3	1.7	0.7
Single	0.8	0.4	1.4
Not Specified	0.3	0.4	0.0
Household Income			
Up to 3,000	5.2	5.0	5.6
3,000 to 3,999	3.1	2.1	4.9
4,000 to 5,999	6.0	5.5	7.0
6,000 to 7,999	11.0	12.2	9.1
8,000 to 8,999	9.2	7.6	11.9
9,000 to 9,999	18.4	18.9	17.5
10,000 to 11,999	15.5	15.5	15.4
12,000 to 14,999	10.2	10.9	9.1
15,000 to 17,499	12.1	12.6	11.2
17,500 and up	9.2	9.7	8.4
Population Density			
Up to 2,500	17.8	16.4	20.3
2,500 to 49,999	12.6	14.3	9.8
50,000 to 499,999	15.2	16.7	12.6
500,000 to 1,999,999	24.9	23.6	27.3
2,000,000 and up	29.3	29.0	30.1

As shown (Table 2), the sample population used was not unduly biased by those families who had not returned diaries. However, when geographic areas were compared, it was found that more families with children between the ages of birth and five years living in the Middle Atlantic and East North Central regions did not return diaries. Also, a

greater proportion of the surveyed families whose panel member was full-time or self-employed had not returned diaries than had part-time or non-employed individuals.

Table 3 compares the percent United States population with the percent sample population from the divisions of the country. As the table indicates, the sample was balanced with respect to geographic area. There were nine geographic divisions. The largest proportion of the preschool children (18.9 percent) were from the East North Central Area which included Illinois, Indiana, Michigan, Ohio, and Wisconsin. The Mountain area (Montana, Idaho, Wyoming, Nevada, Arizona, New Mexico, Utah, and Colorado) was the least represented for this population (4.6 percent), however, this was expected since this area is not as densely populated as the other eight geographic divisions. The distribution of the sample used in the analysis reported herein was (in descending order): East North Central (18.9 percent), South Atlantic (17.6 percent), Middle Atlantic (13.4 percent), Pacific (12.6 percent), West North Central (10.5 percent), West South Atlantic (9.2 percent), East South Atlantic (7.6 percent), New England (5.5 percent), and as previously reported, Mountain (4.6 percent).

The percentage distribution of the preschool children in relation to population density was relatively similar (Table 2) as it was for income levels. The distribution of this sample was representative of the United States preschool population for population density. Approximately 69 percent of the preschool children population used for

this investigation lived in metropolitan areas, whereas 72 percent of the national preschool population lived in metropolitan areas in 1977 (United States Department of Commerce, 1978). As expected in survey research, there was a low return from the low income households. However, the Ten-State Study research concentrated on the people from low socioeconomic groups, therefore, the research described herein was applicable to the middle income families, as the largest proportion of the sample came from households whose incomes ranged from 15,000 to 17,500 per annum.

Table 3. Percentage distribution of United States children between birth and five years of age and sampled preschool children.

Geographic Location	Percentage Distribution	
	United States	Surveyed Population
New England	6.0	5.5
Middle Atlantic	13.1	13.4
East North Central	18.7	18.9
West North Central	10.8	10.5
South Atlantic	17.0	17.6
East South Central	7.7	7.6
West South Central	8.1	9.2
Mountain	4.2	4.6
Pacific	11.3	12.6

The majority of the children (94 percent) came from households in which the panel member, the mother, was married; whereas only four percent of the children were from single parent households. Almost half (44.5 percent) of the panel members had a high school diploma and 40.8

percent had received some type of higher education. Over half of the mothers (57.6 percent) were full-time homemakers while those who worked on a full-time basis or were self-employed constituted 18.9 percent (Table 2).

For the most part, the sample population utilized in this investigation was fairly representative of the national population. Any differences that were found were not of a magnitude to distort sample findings as being representative of the United States population. In some instances, it was difficult to make a comparison, as the United States Census Bureau uses a breakdown different from the one used in this study. That is, for children between the ages of birth and five years, two classifications are used; under five years and five to nine years (United States Department of Commerce, 1978).

FOOD CONSUMPTION PATTERNS

The consumption frequencies of selected food groups were computed for the total sample as well as for the six subsequent age classifications. In order to determine these consumption frequencies, all food items were assigned to one of seventeen food groups (Appendix I). Every food or beverage item consumed was counted as a single observation. Therefore, the portion size of the food consumed was not a factor in this assessment. After the tally was computed, the percentage contribution of each food group to the total week's diets were calculated.

Food Consumption by the Total Sample

The contribution of each of the seventeen food groups to the total sample's food consumption are indicated in Table 4. Following the tabulation of the food items consumed, a percent calculation was completed to determine the differences in the contribution of each food group to the total sample's food consumption (Table 4). The calculation involved division of the number of observations for the food group, by the total number of food items consumed by the entire sample (36,302).

Milk, homogenized and/or pasteurized, was the most frequently consumed food group by the total sample. That is, milk was consumed as a component of total food intake 16.3 percent of the time by the children of the sample. The food group that consisted of fats, oils, salad dressings, and condiments was consumed by the total sample 15.3 percent of the time, and thus was the second most frequently consumed food group by the total sample (Table 4). It should be noted however, that this food group encompassed many more individual items than any of the other food groups.

The third most frequently consumed food group was cereal and cereal products. This food group was consumed 13.4 percent of the time by the total sample (Table 4). Fruits and vegetables, fresh, were the fourth most popular food group, having been consumed by the total sample 11.0 percent of the time.

The following food groups were the next largest

Table 4. Total number of observations for selected food groups and percentage contribution of each food group to total food consumption for preschool children (n=371).

Food Group	Number of Observations	Percentage Contribution
Babyfoods	1511 ^g	4.2
Beverages, Carbonated and Non-Carbonated	2414 ^f	6.6
Cereal and Cereal Products	4880 ^c	13.4
Cheeses and Yogurt	544 ^j	1.5
Combination Items	816 ^h	2.2
Dessert Items	2828 ^e	7.8
Eggs	627 ⁱ	1.7
Fats, Oils, Salad Dressings and Condiments	5564 ^b	15.3
Fruits and Vegetables, Fresh	3976 ^d	11.0
Fruits, Vegetables and Juices, Canned	1442 ^g	4.0
Fruit and Vegetable Juices Fresh and Frozen	1482 ^g	4.1
Meats	2371 ^f	6.5
Milk, Homogenized and/or Pasteurized	5908 ^a	16.3
Milk, Canned	61 ^m	0.2
Salted Snack Foods	1476 ^g	4.1
Soups	291 ^k	0.8
Vitamin/Mineral Supplements	111 ^l	0.3

^aColumn observations with the same letter are not significantly different ($p < 0.05$) (Siegel, 1956).

contributors in the diets of the total preschool sample: dessert items, 7.8 percent; beverages, carbonated and non-carbonated, 6.6 percent; and meats, 6.5 percent (Table 4). The contribution of the next four food groups to the diets of the sample preschool children was very similar. The percentage contribution of these food groups was: babyfoods, 4.2 percent; fruit and vegetable juices, fresh and frozen, 4.1 percent; salted snack foods, 4.1 percent; and fruits, vegetables and juices, canned, 4.0 percent (Table 4).

The twelfth food group in the ranking was combination items. Foods from this group were consumed 2.2 percent of the time by the total sample. Closely following combination items were the food groups entitled eggs, and cheeses and yogurt. These two groups were consumed 1.7 percent and 1.5 percent, respectively, of the time by the total sample population (Table 4).

The food groups which contributed the least to the diets of the preschool sample included: soups, 0.8 percent; vitamin/mineral supplements, 0.3 percent; and salted snack foods, 0.2 percent.

The results of the research on the foods most frequently consumed by children birth to five years indicated definite differences existed in the frequency of consumption of the food groups analyzed. These differences were further illustrated by a one-sample Chi square statistical test (Siegel, 1956), which was specifically utilized to determine any significant differences among the tallies for each

of the food groups.

For the most part, the results of this investigation support previous research on the prevalence of the consumption of milk, homogenized and/or pasteurized; cereal and cereal products; dessert items; and meats, by children birth to five years of age (Kerrey et al., 1968, Eppright et al., 1969 and Driskell and Price, 1974). However, the results reported herein are not in accordance with prior research regarding the consumption of fresh fruits and vegetables by preschool children. The results of this study revealed that fresh fruits and vegetables were relatively frequently consumed (11.0 percent of the time). The time of year (September) the data used in this investigation was collected may have influenced these results, as many fresh fruits and vegetables were still at their peak. In contrast, Driskell and Price (1974), Kerrey and associates (1968) and Harrill et al (1972) found that children birth to five years of age failed to frequently consume fresh fruits and vegetables. This difference may also be possibly due to the research design employed in the studies. This investigation analyzed data collected from seven-day dietary records, whereas the other studies used the 24-hour dietary recall. A further analysis of the data revealed obvious trends in the consumption of specific food groups at various age intervals

Food Consumption by the Six Age Classifications

The frequency count program was again utilized to identify some of the differences in the frequencies of foods consumed by each age classification. The total sample population (n=371) was divided into the six age classifications, each spanning one year. The computer program tallied each food or beverage item consumed, by all of the children in each of the six age classifications, as an observation in one of the seventeen previously specified food groups (See Appendix I).

For each age classification, percentage contribution was calculated for each food group. This calculation was done by dividing the number of observations of the food group by the total number of observations for the age group. Table 5 presents the percentage contribution of the seventeen food groups to the diets of the preschool children when classified by age.

Overall, the most frequently consumed food items, by all six age classifications were homogenized and/or pasteurized milk; cereal and cereal products; and fresh fruits and vegetables. Homogenized and/or pasteurized milk was a diet component 22.9 percent of the time for children less than one year; 18.9 percent for one less than two year olds; 15.6 percent for children two less than three years; 14.9 percent for three less than four year olds and 15.1 percent and 15.3 percent for children four less than five years and five years, respectively. Cereal and

Table 5 (con't).

Food Group	Age Classification				
	3 < 4 (n=73)		4 < 5 (n=63)		5 (n=73)
	Number of Observations	Percentage Contribution	Number of Observations	Percentage Contribution	Number of Observations
Babyfoods	16	0.2	2	0.0	67
Beverages, Carbonated & Non-Carbonated	457	6.4	422	6.6	569
Cereal & Cereal Products	1030	14.4	894	14.0	1246
Cheeses & Yogurt	105	1.5	77	1.2	149
Combination Items	173	2.4	153	2.4	181
Dessert Items	616	8.6	559	8.7	730
Eggs	114	1.6	100	1.6	123
Fats, Oils, Salad Dressings & Condiments	1254	17.5	1042	16.2	1390
Fruits & Vegetables, Fresh	786	11.0	813	12.7	952
Fruits, Vegetables & Juices, Canned	359	5.0	249	3.9	286
Fruit & Vegetable Juices	319	4.4	290	4.6	303
Fresh & Frozen Meats	489	6.9	462	7.2	630
Milk, Homogenized and/or Pasteurized	1070	14.9	966	15.1	1291
Milk, Canned	1	0.0	5	0.1	0
Salted Snack Foods	293	4.1	297	4.7	399
Soups	60	0.8	46	0.7	73
Vitamin/Mineral Supplements	24	0.3	19	0.3	19
Total	7166	100	6396	100	8408
					100

cereal products and fresh fruits and vegetables contributed less frequently to the diets of children less than one year of age, than to the diets of children in the other five age classifications (4.7 percent and 4.5 percent, respectively). For the remaining age groups, cereal and cereal products were a component of the diet 13.1 percent of the time for children one less than two; 14.0 percent for children two less than three and four less than five; 14.4 percent for children three less than four years; and 14.8 percent for five year olds (Table 5).

Fresh fruits and vegetables contributed similarly to the diets of children one less than two, two less than three, three less than four, four less than five and five years (10.6 percent, 11.7 percent, 11.0 percent, 12.7 percent, and 11.3 percent, respectively). Fats, oils, salad dressings and condiments were also frequently consumed by children in the six age classifications. This was, however, expected, as this food group contained more items than the other groups. Again, children less than one year consumed items from this food group less frequently than children in the other age classifications (5.6 percent).

As expected, babyfoods contributed the greatest percentage (43.6 percent) to the diets of children less than one year. The other main food groups and their percentage contribution were: carbonated and non-carbonated beverages, 3.5 percent; canned fruits, vegetables and juices, 2.8 percent; meats, 2.3 percent; and dessert items, 2.1 percent.

These same four food groups were also among the top contributors to the diets of the other children.

For the five other age classifications, dessert items, meats and carbonated and non-carbonated beverages were the next contributors to the diets of the children in these groups. The percentage contribution of each of these food groups, respectively, were: 7.2 percent, 6.6 percent, and 5.9 percent for children one less than two years; 7.9 percent, 7.7 percent and 6.7 percent for children two less than three; 8.6 percent, 6.9 percent and 6.4 percent for children three less than four years; 8.7 percent, 7.2 percent and 6.6 percent for children four less than five years; and 8.7 percent, 7.5 percent and 6.8 percent for five year old children (Table 5).

The contribution of the remaining food groups varied depending on age classification. The percentage contribution of the next ranking food groups to the diets of children less than one year were: canned milk, 1.8 percent; salted snack foods, 1.5 percent; eggs, 1.4 percent; fresh and frozen fruit and vegetable juices, 1.3 percent; combination items, 0.8 percent; soups, 0.5 percent; cheeses and yogurt, 0.4 percent; and vitamin/mineral supplements, 0.3 percent. Those for children one less than two years were: babyfoods, canned fruits, vegetables and juices, and fresh and frozen fruit and vegetable juices, 4.5 percent each; salted snack foods, 3.6 percent; eggs, 2.8 percent; combination items, 2.0 percent; cheeses and yogurt, 1.8

percent; and canned milk, 0.1 percent (Table 5).

The following food groups were the next largest contributors to the diets of children two less than three years: fresh and frozen fruit and vegetable juices, 4.9 percent; salted snack foods, 4.0 percent; canned fruits, vegetables and juices, 3.6 percent; combination items, 2.8 percent; eggs, 1.8 percent; cheeses and yogurt, 1.7 percent; soups, 0.9 percent; vitamin/mineral supplements, 0.4 percent; babyfoods, 0.1 percent; and canned milk made no contribution.

The remaining food groups which contributed to the diets of children three less than four years included: canned fruits, vegetables and juices, 5.0 percent; fresh and frozen fruit and vegetable juices, 4.4 percent; salted snack foods, 4.1 percent; combination items, 2.4 percent; eggs, 1.6 percent; cheeses and yogurt, 1.5 percent; soups, 0.8 percent; vitamin/mineral supplements, 0.3 percent; babyfoods, 0.2 percent; and again, canned milk made no contribution to the diets of these children (Table 5).

For children four less than five years and five years, the same rank order was observed for the remaining food groups. The percentage contribution of these food groups to the diets of children four less than five years and five years were: salted snack foods, 4.7 percent and 4.8 percent, respectively; fresh and frozen fruit and vegetable juices, 4.6 percent and 3.6 percent, respectively; canned fruits, vegetables and juices, 3.9 percent and 3.4

percent, respectively; combination items, 2.4 percent and 2.1 percent, respectively; eggs, 1.6 percent and 1.5 percent, respectively; cheeses and yogurt, 1.2 percent and 1.8 percent, respectively; soups, 0.7 percent and 1.8 percent, respectively; vitamin/mineral supplements, 0.3 percent and 0.2 percent, respectively; babyfoods, 0.0 percent and 0.8 percent, respectively; and canned milk, 0.1 percent and 0.0 percent, respectively (Table 5).

Thus, as shown in this analysis, the number of times a particular food group was consumed was influenced by age. Definite patterns were observed for the rank order of a few of the food groups as age increased. The occurrences of babyfoods in the diets were less frequent as age increased, while, for the most part, the consumption of cheeses and yogurt, salted snack foods, meats, dessert items, cereal and cereal products, fats, oils, salad dressings and condiments, soups, fruits and vegetables, fresh, and milk, homogenized and/or pasteurized increased with increasing age. The increase in the frequency of consumption of solid foods (e.g. meats, cereal and cereal products, salted snack foods) was expected as the children matured due to the presence of more teeth and greater development of motor patterns (Pipes, 1977).

Overall, the results of the research reported herein revealed an increase in food consumption from birth to five years, and similar consumption patterns for preschool children between the ages of two and five years. The findings of this analysis are in general agreement with results of

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earlier research. As previously stated, this research supports the results of Kerrey and co-workers (1968), Eppright et al (1969) and Driskell and Price (1974), in that the consumption of homogenized and/or pasteurized milk; cereal and cereal products; dessert items; and meats by children birth to five years was prevalent. However, Owen and associates (1974) found a decrease in the consumption of dairy products with increasing age, whereas the results of this analysis revealed an increase in the consumption of dairy products with increasing age. As with the discrepancy between this investigation and previous research (Kerrey et al., 1968, Eppright et al., 1969, and Driskell and Price, 1974) regarding the consumption of fresh fruits and vegetables, a possible explanation for the disagreement with dairy product consumption may be in the different methods employed to collect the data.

NUTRIENT ANALYSES

After having examined the food frequencies of the sample population, the data were analyzed to determine the average daily intakes and percentages NRC-RDA of 23 dietary components obtained by the sample. The components which were assessed included: calories, protein, total fat, total carbohydrate, total sugar, cholesterol, fiber, ascorbic acid, thiamin, niacin, riboflavin, vitamins B-6 and B-12, pantothenic acid, vitamin A, iron, calcium, sodium, phosphorus,

potassium, magnesium, copper, and zinc. This analysis was performed for the total sample as well as for the six subsequent age classifications. In addition, this analysis was done including and excluding vitamin/mineral supplements in an attempt to determine the impact these supplements had on the dietary component intakes of this pre-school sample.

Nutrient Analysis of the Total Sample

The data were assessed to determine the adequacy of dietary intakes of 23 components, by the total sample, regardless of age. This investigation also examined the proportion of calories obtained from carbohydrate, protein and fat. Additionally, the percentage of subjects whose dietary intakes fell below 100 percent, 66 percent and 33 percent NRC-RDA for one to seven days during the survey week was also examined. The results of these assessments are reported with vitamin/mineral supplements included and excluded in the calculations.

Proportion of Calories

The proportion of calories obtained from total carbohydrate, complex carbohydrate, total sugar, protein and fat are presented in Tables 6 and 7. It has been recommended that 50 to 55 percent of calories be obtained from carbohydrate, with 40 to 45 percent of caloric intake coming from complex carbohydrate (Food and Nutrition Board, 1980). The

caloric contribution from fat has been suggested to be 30 to 35 percent of calories, while protein should contribute 12 to 15 percent (Food and Nutrition Board, 1980). For this sample population, 50 percent of the calories consumed were obtained from carbohydrate; this proportion was at the lower end of the recommended range. The contribution of fat to the diets was just slightly higher than suggested, as 36 percent of calories was obtained from fat. Protein contributed 14 percent of the calories, which was within the recommended range.

Table 6. Distribution of calories from carbohydrate, protein and fat in the diets of preschool children (n=371).

Macronutrient	Percentage of Total Calories
Carbohydrate	50
Protein	14
Fat	36

The distribution of complex carbohydrate and total sugar to caloric consumption was different from that recommended (Table 7). A much lower percentage of caloric intake was obtained from the consumption of complex carbohydrate (25 percent) than recommended (40 to 45 percent). Total sugar intake, 25 percent of the total caloric intake, was greater than normally recommended (10 percent).

Table 7. Proportion of calories obtained from complex carbohydrate and total sugar by the preschool children (n=371).

Component	Percentage Distribution	
	Complex Carbohydrate	Total Sugar
Calories	25	25

Nutrient Intakes

The mean nutrient intakes and percentages NRC-RDA for the total sample are indicated in Table 8. Average figures indicated an adequate diet was consumed by the total sample for calories, protein, ascorbic acid, thiamin, niacin, riboflavin, vitamin B-6 and B-12, vitamin A, calcium phosphorus, and magnesium. Those nutrients which showed less than average intake levels of 100 percent NRC-RDA included iron and zinc. Iron was the least adequately consumed, with 88 percent of the NRC-RDA being obtained from the diets, on the average, of this preschool sample. The average zinc intake appeared to be fairly adequate, as 92 percent NRC-RDA was met.

In 1980, the Food and Nutrition Board (1980) set Estimated Safe and Adequate Daily Dietary Intake (ESADDI) Ranges for several vitamins and minerals. These ranges are compared with the average daily intakes of this sample for pantothenic acid, copper, sodium and potassium in Table 9. The intakes of pantothenic acid, copper and potassium appeared to be adequate, as values were within the recommended ranges. The intake level for sodium was greater than recommended.

Table 8. Average daily nutrient intakes of the preschool children sample population (n=371).

Dietary Component	Total Sample		Avg %RDA
	Avg Intake	SD	
Calories	1528	675	112
Total Protein, g	55	24	229
Total Fat, g	63	31	
Total Carbohydrate, g	191	87	
Total Sugar, g	96	50	
Cholesterol, mg	238	139	
Crude Fiber, g	2.4	1.5	
Ascorbic Acid, mg	91	65	213
Thiamin, mg	1.10	1.14	155
Niacin, mg	13.30	7.00	156
Riboflavin, mg	1.70	0.89	205
Vitamin B-6, μg	1012	456	107
Vitamin B-12, μg	3.89	3.57	191
Vitamin A, IU	4694	3521	223
Pantothenic Acid, μg	3310	1654	
Iron, mg	10.6	5.8	88
Calcium, mg	894	479	123
Phosphorus, mg	1058	480	152
Sodium, mg	2055	998	
Potassium, mg	2092	995	
Magnesium, mg	201	112	138
Copper, μg	1093	723	
Zinc, mg	8.0	5.6	92

Additionally, table salt usage cannot be assured to have been accurately reported in this type of dietary survey methodology. Thus, the average sodium intakes reported herein, basically, represent that obtained from food only. Therefore, these average intake values are well in excess of the recommended sodium intake.

Table 9. Comparison of average daily intakes by preschool children of selected vitamins and minerals with their Estimated Safe and Adequate Daily Dietary Intake Ranges¹.

Nutrient	Mean Intake	ESADDI Range
Pantothenic Acid, μg	3310	2,000 - 3,000
Copper, μg	1093	500 - 1,500
Sodium, mg	2055	115 - 950
Potassium, mg	1058	350 - 1,500

¹Food and Nutrition Board, 1980.

Recognizing the shortcomings of the NRC-RDA's for research (Hegsted, 1972), i.e., generally higher levels than required by most individuals and variations of levels of intake from day to day, but also acknowledging their usefulness as guides, data were assessed in a manner which allowed evaluation of day to day variability of intake and various levels of requirement. That is, the proportion of the sample whose nutrient intakes were above 100 percent, 66 percent and 33 percent NRC-RDA for all seven days surveyed were determined. This program also permitted the percentage of preschool children whose nutrient intakes fell below 100, 66 and 33 percent NRC-RDA for one to seven days to be calculated. A detailed presentation of this information is in Tables 10-12.

Very few of this total sample had obtained 100 percent NRD-RDA for all seven survey days for the thirteen nutrients

Table 10. Percentage of U.S. preschool children birth to five years (n=371) whose daily nutrient intake always was above 100% NRC-RDA as well as the percentage of preschool children whose nutrient intake fell below 100% of the NRC-RDA for 1 to 7 days.

Dietary Component	Met 100% NRC-RDA	Number of Days Below 100% NRC-RDA							
		1		2		3		4	
		%	Cum %	%	Cum %	%	Cum %	%	Cum %
<u>Macro:</u>									
Calories	16.2	13.0	83.8	9.7	70.8	11.9	61.1	11.9	49.2
Protein	73.5	16.2	26.5	5.2	10.3	2.1	5.1	1.8	3.0
<u>Vitamins:</u>									
Vitamin C	24.9	17.3	75.1	12.9	57.8	15.5	44.9	11.4	31.4
Thiamin	33.5	26.8	66.5	16.5	39.7	12.9	23.2	6.0	10.4
Niacin	18.1	20.0	81.9	22.2	61.9	16.2	39.7	12.4	23.5
Riboflavin	72.4	18.7	27.6	5.1	8.9	1.6	3.8	1.4	2.2
Vitamin B-6	8.7	10.8	90.3	20.3	79.5	11.1	69.2	16.7	58.1
Vitamin B-12	32.2	12.4	67.8	14.9	45.4	12.9	30.5	7.6	17.6
Vitamin A	34.6	25.9	65.4	14.1	39.5	10.0	25.4	7.0	15.4
<u>Minerals:</u>									
Iron	6.2	5.4	93.8	7.9	88.4	16.4	80.5	8.7	74.1
Calcium	17.6	15.4	82.4	11.3	67.0	10.0	55.7	13.5	45.7
Phosphorus	34.6	16.7	65.4	14.9	48.7	13.0	33.8	8.9	20.8
Magnesium	20.0	13.2	80.0	14.1	66.8	7.8	52.7	14.4	44.9
Zinc	3.5	4.9	96.5	4.0	91.6	6.0	87.6	11.6	81.6

Table 10 (con't).

Dietary Component	Number of Days Below 100% NRC-RDA					
	5			6		
	%	Cum %	%	Cum %	%	%
<u>Macro:</u>						
Calories	12.2	37.3	13.5	25.1	11.6	
Protein	0.8	2.2	0.6	1.4	0.8	
<u>Vitamins:</u>						
Vitamin C	8.6	20.0	8.7	11.4	2.7	
Thiamin	3.8	4.3	0.5	0.5	0.0	
Niacin	7.6	11.1	2.1	3.5	1.4	
Riboflavin	0.3	0.8	0.5	0.5	0.0	
Vitamin B-6	15.4	41.1	14.4	26.0	11.6	
Vitamin B-12	3.2	10.0	4.9	6.8	1.9	
Vitamin A	3.8	8.4	3.5	4.6	1.1	
<u>Minerals:</u>						
Iron	10.8	65.4	18.9	54.6	35.7	
Calcium	13.3	32.2	7.5	18.9	11.4	
Phosphorus	6.5	11.9	3.2	5.4	2.2	
Magnesium	13.2	30.5	11.1	17.3	6.2	
Zinc	18.9	70.0	23.5	51.1	27.6	

Table 11. Percentage of U.S. preschool children birth to five years (n=371) whose daily nutrient intake always was above 66% NRC-RDA as well as the percentage of preschool children whose intake was below 66% NRC-RDA.

Table 11. Percentage of U.S. preschool children birth to five years (n=371) whose daily nutrient intake always was above 66% NRC-RDA as well as the percentage of preschool children whose nutrient intake fell below 66% of the NRC-RDA for 1 to 7 days.

Dietary Component	Met 66% NRC-RDA	Number of Days Below 66% NRC-RDA							
		1		2		3		4	
		%	Cum %	%	Cum %	%	Cum %	%	Cum %
<u>Macro:</u>									
Calories	54.3	19.7	45.7	8.4	26.0	9.5	17.6	4.0	8.1
Protein	89.2	8.4	10.8	0.8	2.4	0.2	1.6	0.0	1.4
<u>Vitamins:</u>									
Vitamin C	36.5	23.2	63.5	18.4	40.3	9.7	21.9	5.7	12.2
Thiamin	88.1	9.7	11.6	1.1	1.9	0.5	0.8	0.3	0.3
Niacin	60.8	25.1	39.2	9.0	14.1	3.2	5.1	1.6	1.9
Riboflavin	93.8	4.6	6.2	1.6	1.6	0.0	0.0	0.0	0.0
Vitamin B-6	30.5	18.1	69.5	15.7	51.4	14.9	35.7	11.3	20.8
Vitamin B-12	57.6	22.1	42.4	10.0	20.3	4.6	10.3	2.5	5.7
Vitamin A	61.6	22.2	38.4	8.4	16.2	2.9	7.8	2.2	4.9
<u>Minerals:</u>									
Iron	20.0	14.4	80.0	6.0	65.6	10.2	51.6	10.3	41.4
Calcium	44.3	17.3	55.7	14.9	38.4	7.3	23.5	7.0	16.2
Phosphorus	69.2	17.6	30.8	5.1	13.2	3.8	8.1	2.4	4.3
Magnesium	49.7	18.4	50.3	13.8	31.9	9.7	18.1	4.6	8.4
Zinc	16.8	12.4	83.2	13.8	70.8	11.9	57.0	15.1	45.1

Table 11 (con't).

Dietary Component	Number of Days Below 66% NRC-RDA				
	5		6		7
	%	Cum %	%	Cum %	%
<u>Macro:</u>					
Calories	2.5	4.1	0.5	1.6	1.1
Protein	0.3	1.4	0.3	1.1	0.8
<u>Vitamins:</u>					
Vitamin C	3.5	6.5	1.6	3.0	1.4
Thiamin	0.0	0.0	0.0	0.0	0.0
Niacin	0.3	0.3	0.0	0.0	0.0
Riboflavin	0.0	0.0	0.0	0.0	0.0
Vitamin B-6	3.5	9.5	4.1	6.0	1.9
Vitamin B-12	1.6	3.2	0.8	1.6	0.8
Vitamin A	1.3	2.7	0.9	1.4	0.5
<u>Minerals:</u>					
Iron	10.0	31.1	9.2	21.1	11.9
Calcium	5.7	9.2	2.7	3.5	0.8
Phosphorus	0.8	1.9	0.6	1.1	0.5
Magnesium	1.9	3.8	1.1	1.9	0.8
Zinc	14.6	30.0	9.4	15.4	6.0

Table 12. Percentage of U.S preschool children birth to five years (n=371) whose daily nutrient intake always was above 33% NRC-RDA as well as the percentage of preschool children whose nutrient intake fell below 33% of the NRC-RDA for 1 to 7 days.

Dietary Component	Met 33% NRC-RDA	Number of Days Below 33% NRC-RDA							
		1		2		3		4	
		%	Cum %	%	Cum %	%	Cum %	%	Cum %
<u>Macro:</u>									
Calories	91.1	7.0	8.9	1.9	0.0	1.1	0.0	0.0	1.1
Protein	96.2	2.4	3.8	0.3	1.4	0.3	1.1	0.0	1.1
<u>Vitamins:</u>									
Vitamin C	67.6	20.2	32.4	6.2	12.2	3.3	6.0	1.6	2.7
Thiamin	98.6	1.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Niacin	96.2	3.5	3.8	0.0	0.3	0.0	0.3	0.3	0.3
Riboflavin	98.6	1.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Vitamin B-6	77.3	15.7	22.7	3.8	7.0	1.6	3.2	0.2	1.6
Vitamin B-12	84.0	10.0	16.0	3.3	6.0	0.7	2.7	0.3	1.4
Vitamin A	89.7	6.8	10.3	1.6	3.5	1.4	1.9	0.0	0.5
<u>Minerals:</u>									
Iron	67.6	16.2	32.4	7.5	16.2	3.3	8.7	2.4	5.4
Calcium	78.1	12.7	21.9	4.6	9.2	3.0	4.6	0.8	1.6
Phosphorus	93.2	4.9	6.8	1.1	1.9	0.0	0.8	0.0	0.8
Magnesium	83.7	9.5	12.7	1.6	3.2	0.8	1.6	0.0	0.8
Zinc	67.0	19.8	33.0	7.5	13.2	2.5	5.7	1.0	3.2

Table 12 (con't).

Dietary Component	Number of Days Below 33% NRC-RDA				
	5		6		7
	%	Cum %	%	Cum %	%
<u>Macro:</u>					
Calories	0.3	1.1	0.0	0.8	0.8
Protein	0.0	0.8	0.0	0.8	0.8
<u>Vitamins:</u>					
Vitamin C	0.3	1.1	0.3	0.8	0.5
Thiamin	0.0	0.0	0.0	0.0	0.0
Niacin	0.0	0.0	0.0	0.0	0.0
Riboflavin	0.0	0.0	0.0	0.0	0.0
Vitamin B-6	0.6	1.4	0.3	0.8	0.5
Vitamin B-12	0.6	1.1	0.0	0.5	0.5
Vitamin A	0.0	0.5	0.0	0.5	0.5
<u>Minerals:</u>					
Iron	1.6	3.0	1.1	1.4	0.3
Calcium	0.3	0.8	0.0	0.5	0.5
Phosphorus	0.3	0.8	0.0	0.5	0.5
Magnesium	0.0	0.8	0.3	0.8	0.5
Zinc	1.4	2.2	0.3	0.8	0.5

examined by this method (Table 10). Protein was consumed at the 100 percent NRC-RDA level on all seven surveyed days by the greatest percentage of the sample; 73.5 percent. Close behind protein was riboflavin which was consumed at the 100 percent NRC-RDA level by 72.4 percent of the sample. Iron and zinc were consumed at the 100 percent NRC-RDA level for all seven survey days by a small percentage of the sample; 6.2 percent and 3.5 percent, respectively. In addition, the largest percentage of subjects whose diets fell below 100 percent NRC-RDA for all seven surveyed days was exhibited in the intake of both iron and zinc; 35.7 percent of this sample had diets which provided less than 100 percent of the NRC-RDA for iron for all seven days surveyed, and 27.6 percent of the sample had diets which were below 100 percent of the NRC-RDA for zinc.

When two-thirds NRC-RDA was used as the standard of dietary intake adequacy, the nutrient profile analyses appeared to be improved (Table 11). However, a small percentage of the preschool children consumed calories (1.1 percent), protein (0.8 percent), vitamin C (1.4 percent), vitamins B-6 and B-12 (1.9 percent and 0.8 percent, respectively), vitamin A (0.5 percent), calcium (0.8 percent), phosphorus (0.5 percent), magnesium (0.8 percent) and zinc (6.0 percent) in less than adequate (i.e., less than 66 percent NRC-RDA) amounts for all seven days. A greater percentage of the sample, 11.9 percent failed to consume

adequate amounts of iron for all seven days. From Table 12 it can be seen that for the nutrients vitamin C, vitamins B-6 and B-12, iron and zinc there may be some concern since for these nutrients there were a few children who failed to obtain 33 percent NRC-RDA for five out of the seven days surveyed.

To summarize, even though the average daily nutrient intakes of the preschool sample appeared to be adequate, several nutrients were consumed in levels less than desirable by individual people. This inadequate intake appeared to be particularly evident for the intakes of zinc, iron, vitamin B-6, calcium and magnesium.

For the most part, the results reported herein support the results of previous research. Martin (1970), Cook and co-workers (1976), Sims and Morris (1974), Fox and associates (1971), Driskell and Price (1974) and Owen et al (1969) all reported low iron intake for preschool children. In addition, mean dietary intake levels for ascorbic acid and vitamin A were found to be below 100 percent of the recommended level by Cook and co-workers (1976), Sims and Morris (1974) and Owen et al (1969).

As was clearly pointed out in the Review of Literature section, there are many contradictory findings regarding the nutrient intakes of preschool children. Additionally, previous research has dealt with a limited number of nutrients, and very few researchers have looked at zinc, vitamin B-6 and magnesium intakes. However, for the most part, it has been well documented that iron, calcium and ascorbic

acid intakes most often fell below the RDA for children between the ages of birth and five years. The results of this investigation revealed similar findings.

Impact of Dietary Supplements on Nutrient Intakes of the Total Sample

Approximately thirty percent (111 subjects) of this preschool population used vitamin/mineral supplements at least once during the survey week. Poly Vi Flor Drops, Tri Vi Flor Drops and Iron Drops for Children were the supplements most frequently used by children less than one year of age. However, with increasing age, an increased frequency in the consumption of chewable multiple vitamins, chewable multiple vitamins plus iron and chewable vitamin C was observed. In light of this, the analyses described in the previous section were recalculated to include all vitamin/mineral supplements taken by the sample population.

The impact of vitamin/mineral supplements on the nutrient intake levels of this preschool population is indicated in Table 13. The use of vitamin/mineral supplements increased the average daily intakes for all vitamins and minerals except sodium, potassium and zinc. However, the increased intake levels of calcium, phosphorus and copper were so slight that they were not increased to more adequate percentages NRC-RDA.

Again, to further investigate the adequacy of the diets when dietary supplements were included in the calculations, the data were analyzed to determine the proportion of the

subjects whose nutrient intakes were always above 100 percent, 66 percent and 33 percent NRC-RDA for all seven days surveyed (Tables 14-16). Very few of these preschool children consumed 100 percent NRC-RDA of the thirteen nutrients assessed for all seven days. However, comparison of this data with the analyses without vitamin/mineral supplements (Tables 10-12), revealed that when vitamin/mineral supplements were included in the diets, the nutrient profiles of the subjects appeared to improve. Greater proportions of the sample met 100 percent NRC-RDA for vitamin C, thiamin, niacin, riboflavin, vitamins B-6 and B-12, vitamin A and iron. The vitamin/mineral supplements appeared to improve the profile of vitamin intake more than that of mineral intake. However, less than one-third of the subjects still did not meet 100 percent NRC-RDA for vitamin C, niacin and vitamins B-6 and B-12. The percentage of subjects who met 100 percent NRC-RDA for iron increased from 6.2 percent without vitamin/mineral supplements to 10.8 percent with the inclusion of vitamin/mineral supplements. Zinc intake, on the other hand, was not improved when vitamin/mineral supplements were included in the calculations, indicating zinc was not included in the supplement preparations.

When two-thirds NRC-RDA was used as the standard of dietary intake adequacy, the nutrient profile appeared to improve. Again, this was mainly evident for vitamin C, thiamin, niacin, riboflavin, vitamins B-6 and B-12,

Table 1

Dietary

Calori
Total
Total
Total
Total
Choles
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Thiam
Niaci
Ribof
Vitam
Vitam
Vitam
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Table 13. Average daily nutrient intakes obtained from food and vitamin/mineral supplement consumption by preschool children (n=371)

Dietary Component	Total Sample		Avg %RDA
	Avg Intake	SD	
Calories	1528	675	112
Total Protein, g	55	24	229
Total Fat, g	63	31	
Total Carbohydrate, g	191	87	
Total Sugar, g	96	50	
Cholesterol, mg	238	139	
Crude Fiber, g	2.4	1.5	
Ascorbic Acid, mg	118	116	274
Thiamin, mg	1.28	1.27	191
Niacin, mg	15.61	8.81	193
Riboflavin, mg	1.91	1.03	240
Vitamin B-6, μ g	1198	678	125
Vitamin B-12, μ g	4.50	3.90	220
Vitamin A, IU	5213	3747	247
Pantothenic Acid, μ g	3489	1897	
Iron, mg	11.8	7.0	98
Calcium, mg	896	478	123
Phosphorus, mg	1059	480	152
Sodium, mg	2055	998	
Potassium, mg	2092	995	
Magnesium, mg	201	112	138
Copper, μ g	1092	723	
Zinc, mg	8.0	5.6	92

vitamin A and iron. At least one-half of the sample consumed diets adequate in thiamin, niacin, riboflavin, vitamin B-12, vitamin A and phosphorus. The mineral profile of these subjects improved very little when dietary supplements were included in the analyses. In fact, the only mineral which was consumed adequately (66 percent) by a greater percentage of the sample was iron.

The greatest differences were observed with regard to

Table 14. Percentage of U.S preschool children birth to five years (n=371) whose daily nutrient intake always was above 100% NRC-RDA as well as the percentage of preschool children whose nutrient intake fell below 100% of the NRC-RDA for 1 to 7 days when vitamin/mineral supplements were used.

Dietary Component	Met 100% NRC-RDA	Number of Days Below 100% NRC-RDA							
		1		2		3		4	
		%	Cum %	%	Cum %	%	Cum %	%	Cum %
<u>Macro:</u>									
Calories	16.2	13.0	83.8	9.7	70.8	11.9	61.1	11.6	49.2
Protein	73.5	16.2	26.5	5.2	10.3	1.9	5.1	1.0	3.2
<u>Vitamins:</u>									
Vitamin C	32.4	19.2	67.6	11.9	48.4	12.5	36.5	7.8	24.0
Thiamin	40.8	25.4	59.2	15.7	33.8	9.5	18.1	5.4	8.6
Niacin	25.1	23.6	74.9	19.1	51.3	13.3	32.2	9.7	18.9
Riboflavin	75.1	14.6	24.9	5.7	7.3	0.3	1.6	0.8	1.3
Vitamin B-6	17.8	13.8	82.2	9.8	68.4	11.3	58.6	13.0	47.3
Vitamin B-12	40.8	19.7	59.2	13.8	39.5	11.1	25.7	6.0	14.6
Vitamin A	40.5	27.1	59.5	11.1	32.4	8.6	21.3	5.9	12.7
<u>Minerals:</u>									
Iron	10.8	7.9	89.2	8.1	81.3	5.1	73.2	8.1	68.1
Calcium	17.6	15.4	82.4	11.6	67.0	9.7	55.4	13.5	45.7
Phosphorus	34.9	16.5	65.1	14.8	48.6	13.0	33.8	8.6	20.8
Magnesium	20.0	13.2	80.0	14.1	66.8	7.8	52.7	14.1	44.9
Zinc	3.5	4.9	96.5	4.0	91.6	6.0	87.6	11.6	81.6

Table 14 (con't)

Dietary Component	Number of Days Below 100% NRC-RDA					
	5			6		
	%	Cum %	%	Cum %	%	%
<u>Macro:</u>						
Calories	12.5	37.6	13.5	25.1	11.6	
Protein	0.9	2.2	0.5	1.3	0.8	
<u>Vitamins:</u>						
Vitamin C	7.8	16.2	6.2	8.4	2.2	
Thiamin	2.7	3.2	0.5	0.5	0.0	
Niacin	6.9	9.2	1.0	2.3	1.3	
Riboflavin	0.0	0.5	0.5	0.5	0.0	
Vitamin B-6	13.5	34.3	12.7	20.8	8.1	
Vitamin B-12	3.2	8.6	4.3	5.4	1.1	
Vitamin A	2.8	6.8	3.5	4.0	0.5	
<u>Minerals:</u>						
Iron	10.5	60.0	17.9	49.5	31.6	
Calcium	13.3	32.2	7.6	18.9	11.3	
Phosphorus	6.8	12.2	3.2	5.4	2.2	
Magnesium	13.5	30.8	11.1	17.2	6.2	
Zinc	18.9	70.0	23.5	51.1	27.6	

Table 15. Percentage of U.S. preschool children birth to five years (n=371) whose daily nutrient intake always was above 66% NRC-RDA as well as the percentage of preschool children whose nutrient intake fell below 66% of the NRC-RDA for 1 to 7 days when vitamin/mineral supplements were used.

Dietary Component	Met 66% NRC-RDA	Number of Days Below 66% NRC-RDA							
		1		2		3		4	
		%	Cum %	%	Cum %	%	Cum %	%	Cum %
<u>Macro:</u>									
Calories	54.3	19.8	45.7	8.3	25.9	9.5	17.6	3.8	8.1
Protein	88.9	8.8	11.1	0.7	2.3	0.3	1.6	0.0	1.3
<u>Vitamins:</u>									
Vitamin C	43.2	23.6	56.8	15.4	33.2	7.8	17.8	4.9	10.0
Thiamin	89.7	9.0	10.3	0.8	1.3	0.2	0.5	0.3	0.3
Niacin	66.5	22.7	33.5	6.5	10.8	3.0	4.3	1.3	1.3
Riboflavin	94.3	4.4	5.7	1.3	1.3	0.0	0.0	0.0	0.0
Vitamin B-6	38.1	18.1	61.9	14.3	43.8	11.7	29.5	9.7	17.8
Vitamin B-12	63.8	17.8	36.2	9.8	18.4	4.3	8.6	2.1	4.3
Vitamin A	65.7	20.3	34.3	8.1	14.0	1.9	5.9	1.8	4.0
<u>Minerals:</u>									
Iron	21.5	15.7	74.9	12.4	59.2	9.5	46.8	9.5	37.3
Calcium	44.3	17.3	55.7	14.9	38.4	7.6	23.5	6.4	15.9
Phosphorus	69.2	17.6	30.8	5.1	13.2	3.8	8.1	2.1	4.3
Magnesium	49.7	18.4	50.3	13.8	31.9	9.5	18.1	4.8	8.6
Zinc	16.8	12.4	83.2	13.8	70.8	11.9	57.0	15.1	45.1

Table 15 (con't).

Dietary Component	Number of Days Below 66% NRC-RDA					
	5		6		7	
	%	Cum %	%	Cum %	%	%
<u>Macro:</u>						
Calories	2.7	4.3	0.5	1.6	1.1	1.1
Protein	0.2	1.3	0.3	1.1	0.8	0.8
<u>Vitamins:</u>						
Vitamin C	2.7	5.1	1.3	2.4	1.1	1.1
Thiamin	0.0	0.0	0.0	0.0	0.0	0.0
Niacin	0.0	0.0	0.0	0.0	0.0	0.0
Riboflavin	0.0	0.0	0.0	0.0	0.0	0.0
Vitamin B-6	3.2	8.1	3.6	4.9	1.3	1.3
Vitamin B-12	0.6	2.2	0.8	1.6	0.8	0.8
Vitamin A	1.4	2.2	0.5	0.8	0.3	0.3
<u>Minerals:</u>						
Iron	14.4	27.8	2.3	13.4	11.1	11.1
Calcium	6.0	9.5	2.7	3.5	0.8	0.8
Phosphorus	1.1	2.2	0.6	1.1	0.5	0.5
Magnesium	1.9	3.8	1.1	1.9	0.8	0.8
Zinc	14.6	30.0	9.4	15.7	6.0	6.0

Table 16. Percentage of U.S. preschool children birth to five years (n=371) whose daily nutrient intake always was above 33% NRC-RDA as well as the percentage of preschool children whose nutrient intake fell below 33% of the NRC-RDA for 1 to 7 days when vitamin/mineral supplements were used.

Dietary Component	Met 33% NRC-RDA	Number of Days Below 33% NRC-RDA							
		1		2		3		4	
		%	Cum %	%	Cum %	%	Cum %	%	Cum %
<u>Macro:</u>									
Calories	90.8	7.3	9.2	0.8	1.9	0.0	1.1	0.0	1.1
Protein	96.0	2.7	4.0	0.2	1.3	0.3	1.1	0.0	1.1
<u>Vitamins:</u>									
Vitamin C	71.9	18.1	28.1	5.3	10.0	2.8	4.7	1.1	1.9
Thiamin	98.4	1.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Niacin	96.5	3.2	3.5	0.0	0.3	0.3	0.3	0.0	0.0
Riboflavin	98.4	1.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Vitamin B-6	79.5	14.3	20.5	3.8	6.2	1.1	2.4	0.5	1.3
Vitamin B-12	86.2	8.7	13.8	3.2	5.1	1.1	1.9	0.3	0.8
Vitamin A	90.8	6.2	9.2	1.7	3.0	1.0	1.3	0.0	0.3
<u>Minerals:</u>									
Iron	69.7	15.2	30.3	7.3	15.1	2.9	7.8	1.9	4.9
Calcium	78.1	12.7	21.9	4.6	9.2	3.0	4.6	0.8	1.6
Phosphorus	93.2	4.9	6.8	1.1	1.9	0.0	0.8	0.0	0.8
Magnesium	87.3	9.5	12.7	1.6	3.2	0.8	1.6	0.0	0.8
Zinc	67.0	19.8	33.0	7.5	13.2	2.5	5.7	1.0	3.2

Table 16 (con't)

Dietary Component	Number of Days Below 33% NRC-RDA					
	5		6		7	
	%	Cum %	%	Cum %	%	%
<u>Macro:</u>						
Calories	0.3	1.1	0.0	0.8	0.8	0.8
Protein	0.0	0.8	0.0	0.8	0.8	0.8
<u>Vitamins:</u>						
Vitamin C	0.3	0.8	0.2	0.5	0.3	0.3
Thiamin	0.0	0.0	0.0	0.0	0.0	0.0
Niacin	0.0	0.0	0.0	0.0	0.0	0.0
Riboflavin	0.0	0.0	0.0	0.0	0.0	0.0
Vitamin B-6	0.3	0.8	0.2	0.5	0.3	0.3
Vitamin B-12	0.0	0.5	0.0	0.5	0.5	0.5
Vitamin A	0.0	0.3	0.0	0.3	0.3	0.3
<u>Minerals:</u>						
Iron	1.7	3.0	1.0	1.3	0.3	0.3
Calcium	0.3	0.8	0.0	0.5	0.5	0.5
Phosphorus	0.3	0.8	0.0	0.5	0.5	0.5
Magnesium	0.0	0.8	0.3	0.8	0.5	0.5
Zinc	1.4	2.2	0.3	0.8	0.5	0.5

mineral profiles when 33 percent NRC-RDA was used as the standard of dietary intake adequacy. When vitamin/mineral supplements were included in the nutrient intakes, at least two-thirds of the sample met 33 percent of the NRC-RDA for all minerals. However, when vitamin/mineral supplements were included in the calculations, iron was the only mineral for which a greater percentage of the sample met 33 percent of the NRC-RDA (69.7 percent) (Table 16). In comparison, without vitamin/mineral supplements, 67.6 percent of the preschool sample met 33 percent of the NRC-RDA for iron (Table 12).

In summary, the mean intakes of all vitamins were raised by the inclusion of vitamin/mineral supplements in the calculations. The only mineral which showed an increase in the mean intake level when vitamin/mineral supplements were included in the calculations, was iron.

Nutrient Analysis of the Six Age Classifications

To learn the impact of age on nutrient intake levels, the sample was divided into the six previously mentioned age classifications, and the average daily intake levels for each were calculated.

Nutrient Intakes of the Six Age Classifications

The mean nutrient intakes and percentage NRC-RDA obtained from foods consumed by the preschool children classified by age are indicated in Table 17. Age made a significant difference in the average intake levels of a majority of the nutrients. For all dietary components except cholesterol, thiamin, niacin, riboflavin, vitamin A, pantothenic acid, iron and calcium, there was a progressive increase in mean intake with increasing age. This reflects increasing food intake with increasing age. Mean dietary intake levels of thiamin, niacin, riboflavin, vitamin A, iron and calcium declined after one year of age, and for the most part, showed a steady rise after the initial decline.

The mean percentages NRC-RDA for the nutrient intakes are also presented in Table 17. As shown, for each age classification, the majority of the nutrients had been consumed at levels greater than 100 percent NRC-RDA. A closer look at this revealed the following: for children less than one year and four less than five years, at least 100 percent NRC-RDA was met for all dietary components; at least 100 percent NRC-RDA was obtained by children one less than two years for all dietary components except calories (96 percent), vitamin B-6 (93 percent) and iron (58 percent); preschoolers two less than three years, on the average, met at least 100 percent NRC-RDA for all nutrients except iron (73 percent); again, iron was the only nutrient consumed below 100 percent

Table 17. Average daily nutrient intakes of preschool children classified by age (n=371).

Dietary Component	Age Classification					
	< 1 (n=38)		1 < 2 (n=47)		2 < 3 (n=77)	
	Mean	SD	%RDA	Mean	SD	%RDA
Calories	950 ^e	706	104 ^a	1255 ^d	488	96 ^a
Total Protein, g	38 ^d	26	216 ^{ab}	49 ^c	20	214 ^{ab}
Total Fat, g	37 ^e	34		52 ^c	23	
Total Carb, g	118 ^d	82		152 ^{de}	58	
Total Sugar, g	49 ^c	49		74 ^c	35	
Cholesterol, mg	135 ^c	138		243 ^{cd}	144	
Crude Fiber, g	1.6 ^{cd}	1.5		1.9 ^d	1.0	
Ascorbic Acid, mg	69 ^b	55	197 ^a	78 ^{ab}	49	173 ^a
Thiamin, mg	0.87 ^a	0.54	243 ^a	0.83 ^c	0.32	132 ^b
Niacin, mg	15.63 ^{bc}	15.28	368 ^a	9.75 ^{bc}	4.14	117 ^b
Riboflavin, mg	1.70 ^d	0.89	366 ^a	1.50 ^{cd}	0.59	200 ^b
Vitamin B-6, g	680 ^b	414	129 ^a	840 ^b	356	93 ^{bc}
Vitamin B-12, g	2.82 ^{ab}	1.74	248 ^a	3.19 ^b	1.42	160 ^a
Vitamin A, IU	4988 ^{ab}	3998	263 ^a	3618 ^b	2289	181 ^a
Pantothenic Acid, g	3257 ^b	2562		3037 ^b	1372	2999 ^b
Iron, mg	14.0 ^a	11.1	100 ^{ab}	8.7 ^c	4.7	58 ^d
Calcium, mg	1032 ^b	609	205 ^a	853 ^b	410	106 ^b
Phosphorus, mg	903 ^e	566	269 ^a	961 ^d	393	120 ^b
Sodium, mg	890 ^e	985		1690 ^c	857	
Potassium, mg	1746 ^c	1080		1824 ^c	798	
Magnesium, mg	156 ^c	109	234 ^a	166 ^{bc}	69	111 ^b
Copper, g	737 ^{ab}	613		942 ^{ab}	610	
Zinc, mg	7.6 ^{ab}	8.9	164 ^a	8.2 ^{ab}	7.8	82 ^b

^aRow means with the same letter are not significantly different ($p < 0.05$) (Duncan, 1957).

Table 17. Average daily nutrient intakes of preschool children classified by age (n=371).

Dietary Component	Age Classification									
	<1 (n=38)			1 < 2 (n=47)			2 < 3 (n=77)			%RDA
	Mean	SD	%RDA	Mean	SD	%RDA	Mean	SD	%RDA	
Calories	950 ^e	706	104 ^a	1255 ^d	488	96 ^a	1438 ^{cd}	470	127 ^a	
Total Protein, g	38 ^d	26	216 ^{ab}	49 ^c	20	214 ^{ab}	52 ^{bc}	19	259 ^a	
Total Fat, g	37 ^e	34		52 ^{de}	23		59 ^{cd}	23		
Total Carb, g	118 ^e	82		152 ^c	58		179 ^b	62		
Total Sugar, g	49 ^c	49		74 ^b	35		95 ^b	41		
Cholesterol, mg	135 ^{cd}	138		243 ^{cd}	144		225 ^{bc}	126		
Crude Fiber, g	1.6 ^b	1.5		1.9 ^b	1.0		2.2 ^b	1.1		
Ascorbic Acid, mg	69 ^b	55	197 ^a	78 ^{ab}	49	173 ^a	93 ^{ab}	70	240 ^a	
Thiamin, mg	0.87 ^b	0.54	243 ^a	0.83 ^c	0.32	132 ^b	0.96 ^{bc}	0.35	162 ^b	
Niacin, mg	15.63 ^{bc}	15.28	368 ^a	9.75 ^{bc}	4.14	117 ^b	12.05 ^c	4.08	155 ^b	
Riboflavin, mg	1.70 ^d	0.89	366 ^a	1.50 ^{cd}	0.59	200 ^b	1.49 ^{bc}	0.62	207 ^a	
Vitamin B-6, g	680 ^b	414	129 ^a	840 ^{cd}	356	93 ^{bc}	985 ^b	359	126 ^{abc}	
Vitamin B-12, g	2.82 ^{ab}	1.74	248 ^a	3.19 ^b	1.42	160 ^b	3.46 ^b	1.94	195 ^a	
Vitamin A, IU	4988 ^{ab}	3998	263 ^a	3618 ^b	2289	181 ^a	4127 ^b	2109	240 ^a	
Pantothenic Acid, g	3257 ^b	2562		3037 ^b	1372		2999 ^b	1363		
Iron, mg	14.0 ^a	11.1	100 ^{ab}	8.7 ^c	4.7	58 ^d	9.5 ^{bc}	4.0	73 ^{cd}	
Calcium, mg	1032 ^{ab}	609	205 ^a	853 ^b	410	106 ^b	780 ^c	400	113 ^b	
Phosphorus, mg	903 ^b	566	269 ^a	961 ^d	393	120 ^b	972 ^{cd}	379	141 ^b	
Sodium, mg	890 ^e	985		1690 ^c	857		1994 ^{bc}	707		
Potassium, mg	1746 ^c	1080		1824 ^c	798		1947 ^{bc}	778		
Magnesium, mg	156 ^c	109	234 ^a	166 ^{bc}	69	111 ^b	187 ^{bc}	86	146 ^b	
Copper, g	737 ^{ab}	613		942 ^{ab}	610		994 ^b	530		
Zinc, mg	7.6 ^{ab}	8.9	164 ^a	8.2 ^{ab}	7.8	82 ^b	6.9 ^b	2.7	81 ^b	

^aRow means with the same letter are not significantly different (p < 0.05) (Duncan, 1957).

Table 17 (con't).

Dietary Component	Age Classification							
	3 < 4 (n=73)				4 < 5 (n=63)			
	Mean	SD	%RDA		Mean	SD	%RDA	
								5 (n=73)
Calories	1584 ^{bc}	653	122 ^a		1680 ^b	553	100 ^a	1915 ^a
Total Protein, g	55 ^{bc}	20	240 ^{ab}		59 ^b	21	198 ^b	69 ^a
Total Fat, g	65 ^{bc}	30			69 ^{ab}	24		80 ^a
Total Carb, g	201 ^{bc}	84			212 ^a	77		239 ^a
Total Sugar, g	105 ^b	50			109 ^b	51		114 ^a
Cholesterol, mg	239 ^{abc}	116			245 ^{ab}	98		296 ^a
Crude Fiber, g	2.4 ^{abc}	1.4			2.7 ^{ab}	1.5		2.9 ^a
Ascorbic Acid, mg	94 ^{ab}	59	207 ^a		100 ^a	64	222 ^a	98 ^a
Thiamin, mg	1.13 ^{ab}	1.05	144 ^b		1.39 ^{ab}	2.33	151 ^b	1.24 ^a
Niacin, mg	12.73 ^{bc}	4.92	122 ^b		14.35 ^{ab}	5.14	129 ^b	15.38 ^a
Riboflavin, mg	1.63 ^b	0.70	173 ^{ab}		1.85 ^{ab}	1.20	177 ^b	2.02 ^{ab}
Vitamin B-6, g	1020 ^b	437	113 ^{abc}		1131 ^b	480	87 ^b	1215 ^a
Vitamin B-12, g	3.59 ^b	2.15	179 ^a		3.37 ^b	1.75	149 ^c	5.68 ^a
Vitamin A, IU	4587	2906	229 ^a		4677	2322	187 ^a	5952
Pantothenic Acid, g	3122 ^b	1259			3532 ^{ab}	1535		3839 ^{ab}
Iron, mg	9.5 ^{bc}	3.4	63 ^d		10.6 ^{bc}	4.2	106 ^a	12.5 ^a
Calcium, mg	832 ^b	347	104 ^b		905 ^{abc}	428	113 ^b	1035 ^a
Phosphorus, mg	1082 ^{bc}	397	128 ^b		1121 ^{ab}	444	140	1272 ^a
Sodium, mg	2212 ^{bc}	892			2338 ^{ab}	824		2557 ^a
Potassium, mg	2007 ^{bc}	848			2271 ^{ab}	1031		2528 ^a
Magnesium, mg	203 ^b	117	135 ^b		224 ^b	134	112 ^b	241 ^a
Copper, g	1047 ^{ab}	600	84 ^b		1181 ^{ab}	692		1448 ^a
Zinc, mg	8.4 ^{ab}	7.0			7.8 ^{ab}	3.0	7.8 ^b	9.2 ^a

^aRow means with the same letter are not significantly different ($p < 0.05$) (Duncan, 1957).

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NRC-RDA for children three less than four years; and for children five years of age, riboflavin (93 percent NRC-RDA was the only nutrient whose average intake level was below 100 percent NRC-RDA.

The results of this investigation generally illustrate findings similar to those previously reported. Overall, during the preschool years there is a decreased intake of calcium, phosphorus, iron and vitamin A, and a steady increase in protein, carbohydrate and fat with increasing age (Pipes, 1977). For the most part, these trends were observed for this preschool sample population. There was a steady increase in the intakes of protein, carbohydrate and fat with increasing age, however, vitamin A, calcium and iron intakes, after an initial decline, rose between the ages of three and five years, while phosphorus intake increased with increasing age.

Impact of Dietary Supplements on Nutrient Intakes of the Six Age Classifications

Since approximately thirty percent of this preschool sample took some kind of vitamin/mineral supplement at least once during the survey week, it was deemed important to determine the impact of these supplements on the nutrient intakes of this preschool population classified by age (Table 18). Further analysis of the six age classifications revealed vitamin/mineral supplements were consumed by 24 percent of the children less than one year of age; 26 percent of the children one less than two years of age; 36

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percent of the children two less than three years of age; 33 percent of the children three less than four years of age; 30 percent of the children four less than five years of age; and 26 percent of the children five years of age.

As previously discussed, age had a definite impact on the intake of the macronutrients. This did not change, nor was it expected to, when vitamin/mineral supplements were included in the analyses. However, the average intakes of vitamins and minerals were affected by the usage of dietary supplements. The mean intake of all vitamins, regardless of age classification, was raised by the inclusion of vitamin/mineral supplements in the calculations, and consequently, the percentage NRC-RDA was also raised. Additionally, the mean percentage NRC-RDA for all vitamins was at least 100 percent for all age classifications.

The inclusion of vitamin/mineral supplements in the analyses did not appreciably affect the average daily intakes of the minerals examined (Table 18). In fact, iron was the only mineral which had an appreciable increase in mean intake with the inclusion of vitamin/mineral supplements. The increase which was observed was applicable to all age classifications.

Thus, when vitamin/mineral supplements were taken into consideration, an increase in the mean intake levels of all vitamins was noted. However, iron was the only mineral for which an increase in mean intake was observed when vitamin/mineral supplements were included in the calculations.

Table 18. Average daily nutrient intakes obtained from food and vitamin/mineral consumption by the preschool children classified by age (n=371).

^aRow means with the same letter are not significantly different ($p < 0.05$) (Duncan, 1957).

DIETARY LEAD INTAKE

In recent years, there has been much concern generated from the scientific community regarding the lead intake of young children. Previous research in this area revealed that lead intake levels, once thought to be acceptable, were in fact, unacceptable. This prompted the Food and Drug Administration to establish a long range goal that lead intake from food, water and air, by children birth to five years of age, not exceed 100 micrograms per day (FDA, 1979). Whether or not the 100 microgram total lead intake per day for young children is a justifiable goal has received little attention from the scientific community.

In view of this, the data collected on the preschool sample were fully examined to determine the average daily dietary lead intake, and food sources that contributed to this intake. This analysis was performed for the total sample as well as for the six age classifications. In addition, to control for the amount of food consumed by the various age groups, average lead intake per 500 calories consumed was studied. However, while energy measures of food intake reflect physiological need, food selection and consumption are not based solely on this need. It is therefore more appropriate to consider the quantity of food rather than its caloric content (Scherwin, et al., 1981). For this reason, average daily dietary lead intake per 500 grams of food consumed was also analyzed.

Dietary Lead Intake for the Total Sample

As indicated in Table 19, average daily dietary lead intake for this preschool sample was 62.0 micrograms. Analysis of the total sample also revealed average daily lead intake from food eaten was 21.4 micrograms per 500 calories consumed and 20.6 micrograms per 500 grams consumed (Table 19).

Table 19. Average daily total lead intake, per 500 calories and per 500 grams of food consumed for the sample preschool children (n=371).

Dietary Lead Intake	Lead Contribution (μg)	
	Mean	SD
Daily	62.0	29.6
Per 500 Calories	21.4	6.3
Per 500 Grams	20.6	5.3

The lead distribution of the total sample is plotted in Figure 1. The average daily dietary lead intake for these preschool children ranged from five micrograms per day to 229 micrograms per day. The greatest percentage of the children had a mean dietary lead intake of 45 and 57 micrograms per day (22.4 percent and 16.7 percent, respectively). Further analysis of the distribution of the sample revealed that of the 371 children, 33 (8.9 percent) had a mean lead intake level of greater than 100 micrograms per day from food alone. Of these 33 children, 31 were between the ages

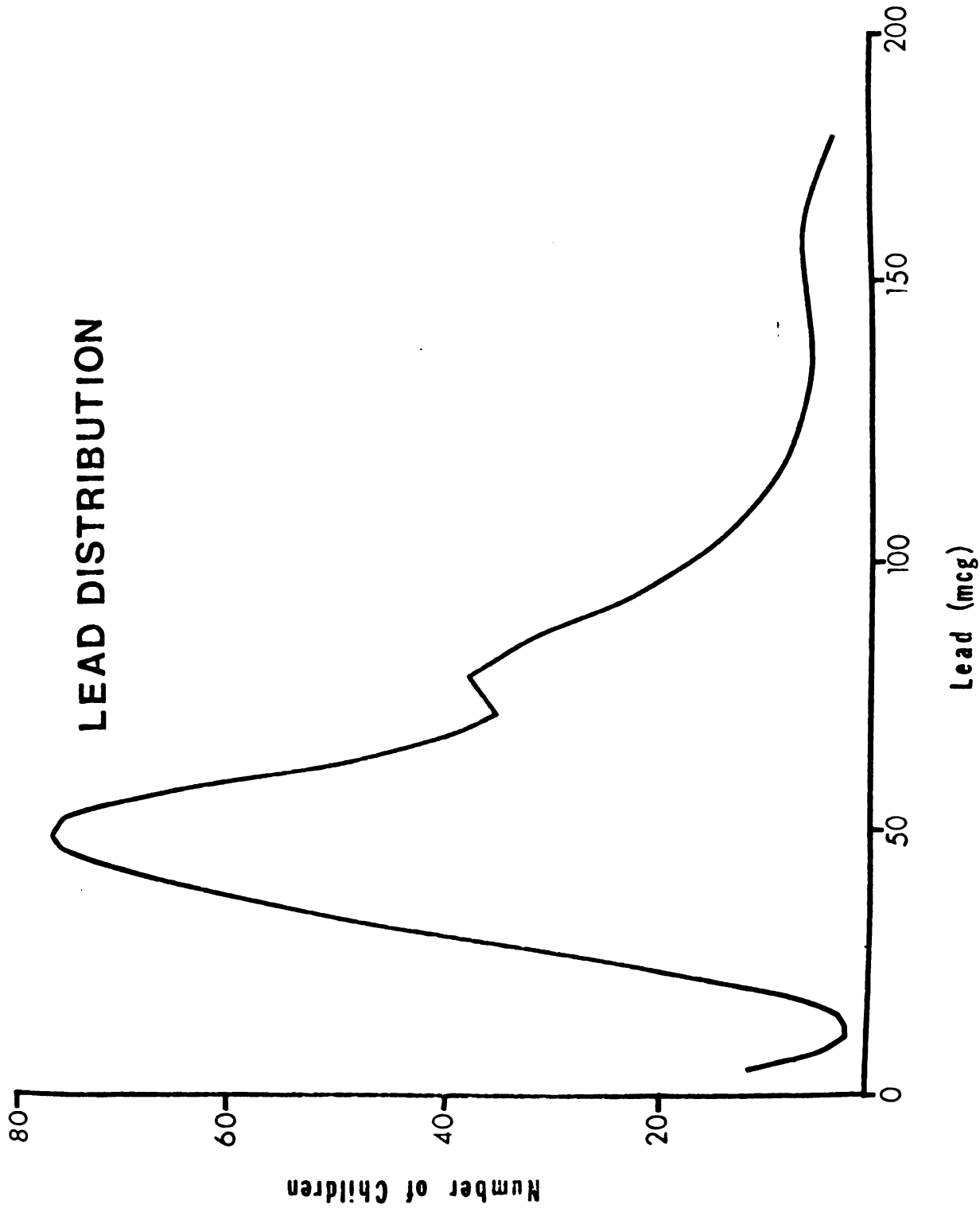


Figure 1. Spline distribution of average daily dietary lead intake of preschool children (n=371).

of four and five years, and the other two children were under one year of age.

In light of the fact that there were children who had a mean lead intake which exceeded 100 micrograms per day from food alone, the dietary intakes of these children were examined to determine if unusual food consumption patterns existed. This examination revealed that the types of foods consumed by the 33 children were not exceptionally high in lead; however, the quantity of food consumed was greater than that consumed by the remaining children in the sample.

Table 20 presents the total grams of food consumed by these 33 children, as well as their mean lead intake. These values are all much greater than the average values for the other children in the sample. Therefore, this analysis also served as justification for examining average daily dietary lead intake per 500 grams of food consumed. As will be seen later, differences that existed between age classifications when average daily dietary lead intake was assessed were lessened when average daily dietary lead intake was calculated per 500 grams of food consumed.

The food sources and their percentage contribution to the average lead intake of this preschool sample are indicated in Table 21. As shown in this table, canned fruits, vegetables and juices and combination items were the food groups which contributed the greatest percentage of lead to the average daily intake of the children (23.8 percent and

Table 20 Average daily dietary lead intake and total grams of food consumed for children who exceeded 100 micrograms of lead per day (n=33)

Child	Average Lead Intake (μg)	Grams of Food Consumed
1	234.1	4034.5
2	231.8	3951.7
3	219.1	3544.4
4	193.0	3181.1
5	188.2	3180.1
6	179.4	3093.1
7	177.3	2876.4
8	169.5	2798.2
9	163.7	2687.3
10	160.6	2601.7
11	155.8	2565.6
12	155.2	2624.5
13	149.3	2458.9
14	148.0	2680.0
15	147.8	2281.1
16	146.7	2377.2
17	140.2	2567.0
18	135.6	2935.1
19	134.8	2549.1
20	129.3	2444.1
21	122.6	2645.6
22	122.2	2452.4
23	121.3	2521.4
24	120.9	2372.8
25	116.8	2502.0
26	115.6	2219.0
27	112.1	2059.5
28	111.0	2201.8
29	105.2	2087.3
30	103.7	2071.6
31	101.3	2016.0
32	101.8	2068.2
33	101.4	2198.7
Remaining Sample*	53.8	1452.5

*Average values for 338 children.

Table 21. Percentage contribution of selected food groups to the average daily dietary lead intake of the preschool sample (n=371).

Food Group	Lead Contribution (μ g)		Percentage Contribution
	Mean	SD	
Babyfoods	11.9 ^c	13.6	1.8
Beverages, Carbonated and Non-Carbonated	4.3 ^f	2.9	3.5
Cereal and Cereal Products	7.8 ^d	4.0	7.3
Cheeses and Yogurt	1.7 ^g	1.0	1.0
Combination Items	16.4 ^b	18.4	12.0
Dessert Items	3.6 ^f	2.8	3.3
Eggs	10.7 ^d	4.1	7.3
Fats, Oils, Salad Dressings and Condiments	1.4 ^g	1.0	1.3
Fruits and Vegetables, Fresh	7.4 ^{de}	1.0	6.9
Fruits, Vegetables and Juices, Canned	27.6 ^a	25.1	23.8
Fruit and Vegetable Juices, Fresh and Frozen	12.8 ^{cd}	8.7	9.4
Meats	6.2 ^e	5.6	5.5
Milk, Homogenized and/or Pasteurized	9.5 ^d	6.6	9.2
Milk, Canned	13.0 ^{cd}	29.7	0.4
Salted Snack Foods	1.4 ^g	1.7	1.2
Soups	13.0 ^{cd}	6.2	5.8

^a Row means with the same letter are not significantly different ($p < 0.05$) (Duncan, 1957).

12.5 percent, respectively). The food groups which were the next largest contributors to average lead intake included: fresh and frozen fruit and vegetable juices, 9.4 percent; and homogenized and/or pasteurized milk, 9.2 percent. Cereal and cereal products and eggs (7.3 percent each); fresh fruits and vegetables (6.9 percent); soups (5.9 percent); and meats (5.5 percent) were the food groups which contributed moderately to the average lead intake. The other food groups which contributed to the mean lead intake included: carbonated and non-carbonated beverages (3.5 percent); dessert items (3.3 percent); babyfoods (1.8 percent); fats, oils, salad dressings and condiments (1.3 percent); salted snack foods (1.2 percent); and canned milk (0.4 percent). Not surprisingly, further analysis of the food groups revealed that the top contributors to the average lead intake of the sample were also the ones composed of foods that were relatively high in lead content.

Table 22 presents the number of children who consumed items from each food group, the total number of times foods from each group were consumed and the mean lead contribution of each food group to the children's lead intake. From this table, it can be seen that the mean lead contribution calculated for each food group was dependent on the number of children who consumed foods from the group, the total number of times foods from each group were consumed as well as the lead content of the individual food items. For example, fats, oils, salad dressings and condiments were consumed

Table 22. Average dietary lead contribution by specified food groups based on the number of children who consumed foods within each group and the total number of observations.

Food Group	Number of Children Consuming	Number of Observations	Mean (μg)	SD (μg)
Babyfoods	57	1511	11.9	13.6
Beverages, Carbonated and Non-Carbonated	316	2414	4.3	2.9
Cereal and Cereal Products	355	4880	7.8	4.0
Cheeses and Yogurt	225	544	1.7	1.0
Combination Items	291	816	16.4	18.4
Dessert Items	345	2828	3.6	2.8
Eggs	260	627	10.7	4.1
Fats, Oils, Salad Dressings and Condiments	352	5564	1.4	1.0
Fruits and Vegetables, Fresh	355	3976	7.4	1.0
Fruits, Vegetables, and Juices, Canned	327	1442	27.6	25.1
Fruit and Vegetable Juices, Fresh and Frozen	280	1482	12.8	8.7
Meats	337	2371	6.2	5.6
Milk, Homogenized and/or Pasteurized	368	5908	9.5	6.6
Milk, Canned	12	61	13.0	29.7
Salted Snack Foods	308	1476	1.4	1.7
Soups	163	291	13.0	6.2

5,564 times by 352 children; however, the mean lead contribution from this group was only 1.4 micrograms. The implication, and correctly so, was that the lead content of items within this group was relatively low. Canned milk, on the other hand, was consumed 61 times by 12 children and the mean lead contribution was 13.0 micrograms. Again, this finding correctly illustrated that canned milk had a high lead content. Similar correlations are evident for the remaining food groups (Table 22).

Dietary Lead Intake for the Six Age Classifications

Having established that the average daily dietary lead intake for this preschool sample was 62.0 micrograms, it was deemed important to investigate possible changes in dietary lead intake with increasing maturity. Again, the six previously mentioned age classifications were utilized for this assessment.

From Table 23, it can be seen that there was a progressive increase in average daily dietary lead intake with increasing age. The range for the average lead intake from food was from 48.5 micrograms per day for children less than one year of age to 73.9 micrograms per day for children five years of age. For children one less than two years and two less than three years, the average daily dietary lead intake was similar (54.8 micrograms per day and 55.6 micrograms per day, respectively). An even more similar average daily dietary lead intake level was observed

for children three less than four years and four less than five years. The average dietary lead intake for children three less than four years was 65.0 micrograms, whereas for children four less than five years, average daily dietary lead intake was 65.1 micrograms.

Table 23. Average daily dietary lead intake values by age classification for children birth to five years (n=371).

Age Classification	n	Average Lead Intake (μ g)	
		Mean	SD
< 1	38	48.5 ^c	37.6
1 < 2	47	54.8 ^{bc}	20.8
2 < 3	77	55.6 ^{bc}	21.6
3 < 4	73	65.0 ^{ab}	29.4
4 < 5	63	65.1 ^{ab}	28.6
5	73	73.9 ^a	33.2

^aRow means with the same letter are not significantly different ($p < 0.05$) (Duncan, 1957).

The linear relationship between increasing age and increased average dietary lead intake was expected. In most instances, one can assume that more food is consumed by a child as he matures. Therefore, with this increased food consumption, it would be expected that greater amounts of lead would enter into the body. In an attempt to control for the various amounts of food consumed by the different age classifications, average daily dietary lead intake for

this preschool sample was standardized per 500 calories of food consumed.

Further analysis of average daily dietary lead intake per 500 calories consumed indicated no set pattern existed. For children one less than two years, two less than three years and three less than four years, average daily dietary lead intake per 500 calories consumed was 23.5 micrograms, 22.0 micrograms and 22.5 micrograms, respectively.

Table 24. Average daily dietary lead intake by age classification for children birth to five years (n=371), standardized per 500 calories consumed.

Age Classification	n	Standardized Lead Intake (μ g)	
		Mean	SD
< 1	38	17.4 ^c	9.3
1 < 2	47	23.5 ^a	7.8
2 < 3	77	22.0 ^{ab}	5.3
3 < 4	73	22.5 ^a	5.7
4 < 5	63	21.8 ^{ab}	5.6
5	73	19.9 ^d	4.5

^aRow means with the same letter are not significantly different ($p < 0.05$) (Duncan, 1957).

As previously stated, while energy measures of food intake reflect physiological need, food selection and consumption are not based solely on this need, (Scherwin et al., 1981). Therefore, it was more appropriate to assess average daily dietary lead intake per 500 grams of food consumed. Again, as illustrated in Table 25, children less

Table 25. Average daily dietary lead intake by age classification for children birth to five years (n=371), standardized per 500 grams of food consumed.

Age Classification	n	Standardized Lead Intake (μ g)	
		Mean	SD
< 1	38	16.2 ^b	6.8
1 < 2	47	20.6 ^a	5.5
2 < 3	77	20.4 ^a	4.3
3 < 4	73	21.9 ^a	5.2
4 < 5	63	20.7 ^a	4.2
5	73	21.9 ^a	5.3

^aRow means with the same letter are not significantly different ($p < 0.05$) (Duncan, 1957).

than one year had the lowest average daily dietary lead intake per 500 grams of food consumed (16.2 micrograms). For the remaining age classifications, the results were very similar. Additionally, a test for statistical differences (Duncan, 1957) indicated that for children one less than two; two less than three; three less than four; four less than five; and five years of age, there were no statistical differences in average daily dietary lead intake per 500 grams of food consumed. The average daily dietary lead intake per 500 grams of food consumed for children two less than three was 20.4 micrograms; for children one less than two, 20.6 micrograms; for children four less than five, 20.7 micrograms; and for children three less than four and five year olds, 21.9 micrograms. Therefore, when quantity of food was controlled for

in this assessment, differences in the average daily dietary lead intake of the age classifications became very slight, except for the less than one year olds.

The results of this analysis revealed average daily dietary lead intake to be lower than that found by previous researchers. Several of these previous investigations also included the lead found in water in the calculations, however, the results of these studies were still very different from the results reported herein. In 1974, the Food and Drug Administration calculated that the dietary lead intake for the two year old, including water, was 115 micrograms per day. Two years later, the National Food Processors Association (NFPA) in conjunction with the Can Manufacturers Institute (CMI) calculated the dietary lead intake from all food and water for the two year old to be 98 micrograms per day. A follow-up study of two year olds was conducted in 1978-79 by the NFPA-CMI, and the results revealed that dietary lead intake from food alone, was 57 micrograms per day. In comparison, the results of this investigation indicated that average daily dietary lead intake for the two year old was 55.6 micrograms. This was very close to the 1978-79 study, indicating that the lead content of foods may be lower and analytical methods used to determine the lead content may possibly be more refined than in previous years.

In addition, an analysis of the daily lead intake of children birth to five years was conducted by the NFPA-CMI.

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The data used was from food records kept for fourteen consecutive days. The final results showed a mean intake from food alone to be 50.0 micrograms per day. However, this value has been considered somewhat low as portion sizes were not recorded in the food records, and therefore, they were estimated when the lead intake analyses were made (Elkins, 1981). In light of this, an accurate comparison can not be made with the results obtained in this investigation.

SUMMARY AND CONCLUSIONS

A nationwide food consumption survey of 371 preschool children between the ages of birth and five years indicated that age had an impact on food consumption patterns, nutrient intakes and dietary lead intake. The sample population used was balanced by geographic location, population density, income, degree of urbanization and age of the mother to be indicative of the national population. Meal locations and food items consumed during third week of September 1977 were reported in seven day dietary records. These food diaries contained spaces for recording all foods and beverages consumed at three main meal periods and three snacking periods during the day. Information was obtained pertaining to the amount eaten plus the type, brand or flavor of the food item. Spaces also were included to indicate where the meal was eaten; at home, at school, away from home (not including school) or was not eaten. These data were collected by Market Facts of Chicago, Illinois. The food diaries were then sent to Michigan State University where they were coded for computer analyses. The MSU Nutrient Data Bank, which contains approximately 3,500 food items, was used for determining the nutrient intakes and dietary lead intake of this sample population.

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To examine the impact of age on food consumption patterns, nutrient intakes and dietary lead intake, the sample population was partitioned by six age classifications, each spanning one year. There was a disproportionate distribution as a result of this classification system: less than one year group contained 38 subjects (10.2 percent of the sample); one less than two years, 47 (12.6 percent); two less than three years, 77 (20.8 percent); three less than four years, 73 (19.7 percent); four less than five years, 63 (17.0 percent); and five years, 73 (19.7 percent).

Three aspects of the impact of age on food consumption patterns of preschool children were investigated: the frequency and types of foods consumed during the survey week, the dietary component intakes by the sample population, and dietary lead intake. In addition, the impact of vitamin/mineral supplements on nutrient intakes was reported. The data were analyzed for the total sample, as well as the six subsequent age classifications.

The results of the food consumption survey revealed that homogenized and/or pasteurized milk was most frequently consumed by the total sample. The food group that consisted of fats, oils, salad dressings and condiments was the second most frequently consumed food group, followed by cereal and cereal products and fresh fruits and vegetables.

An analysis of the six age classifications indicated that the number of times a particular food group was consumed was influenced by age. Definite patterns were

observed for the rank order of a few of the food groups as age increased. Homogenized and/or pasteurized milk was most frequently consumed by children in all age groups, while the occurrences of babyfoods in the diets were less frequent as age increased, and, for the most part, the consumption of cheeses and yogurt; cereal and cereal products; fats, oils, salad dressings and condiments; soups; and fresh fruits and vegetables increased with increasing age. The increase in the frequency of consumption of solid foods (e.g., meats, cereal and cereal products) was expected as the children matured due to the presence of more teeth and greater development of motor patterns.

The nutrient analyses of these food consumption patterns revealed that age had a definite impact on dietary component intakes. For the total sample, all nutrients except iron and zinc, were, on the average, consumed in amounts that exceeded 100 percent of the NRC-RDA. When nutrient intakes were assessed in a manner that allowed evaluation of day to day variability, the results revealed that the children were well nourished as they consumed greater than two-thirds percent of the NRC-RDA for all nutrients except iron. For a majority of the dietary components, age made a significant difference in the average intake levels. For all dietary components except cholesterol, thiamin, niacin, riboflavin, vitamin A, pantothenic acid, iron and calcium, there was a progressive increase in mean intake with increasing age. This reflects increasing food intake

with increasing age. Mean dietary intake levels of thiamin, niacin, riboflavin, vitamin A, iron and calcium declined between the ages of one and two years, but for the most part, showed a steady rise after the initial decline.

When vitamin/mineral supplements were included in the analysis, the average intakes of vitamins and minerals were affected. The mean intake of all vitamins, regardless of age classification, was raised by the inclusion of vitamin/mineral supplements in the calculations, and consequently, the percentage NRC-RDA was also raised. The inclusion of vitamin/mineral supplements in the analyses did not appreciably affect the average dietary intakes of the minerals examined. In fact, iron was the only mineral which had an appreciable increase in mean intake with the inclusion of vitamin/mineral supplements.

The dietary lead intake analysis was performed for the total sample, as well as for the six age classifications. In addition, to control for variation in amount of food intake by the various aged children, average lead intake per 500 calories and per 500 grams of food consumed was calculated. Analysis of the total sample revealed average daily dietary lead intake from foods eaten was 62.0 micrograms, 21.4 micrograms per 500 calories consumed and 20.6 micrograms per 500 grams consumed. The food groups which were the largest contributors to average lead intake were canned fruits, vegetables and juices, and combination items. This was attributed to frequency of consumption of these

foods, as well as their lead content.

When average daily dietary lead intake was assessed for each age classification, a progressive increase in the level of intake was observed with increasing age. However, this linear relationship was no longer evident when average daily lead intake was examined per 500 calories. The average lead intake per 500 calories was lower for older children, indicating that older children did indeed consume more food, however, the lead content of the foods eaten was not as concentrated. The average daily dietary lead intake per 500 grams revealed very similar results for the age groups, and any differences that existed in the average lead intake of the age classifications were lessened with this assessment.

Further investigations might include a more indepth analysis of the data in relation to the socioeconomic and demographic characteristics of the children; employment status of the mother; age of the parents or the number and age of siblings. Utilizing the children's personal data provided in the diary, another analysis might include a comparison of the food consumption patterns of obese and non-obese preschool children. Another interesting study would be to complete a similar survey within the next two years to investigate the changes in the children's food consumption patterns and dietary lead intake with maturity. Also, recognizing the serious health implications of excess dietary lead intake, it would be beneficial to conduct

a similar survey every two or three years to determine where the United States preschool population stands with regard to the Food and Drug Administration's long range dietary lead intake goal.

APPENDIX

APPENDIX I

Food Items in the 17 Food Groups Used in the Analyses

Food Group	Foods Within the Groups
Babyfoods	Strained Foods Junior Foods Infant Formulas Infant Cereals
Beverages, Carbonated and Non-Carbonated	Cola Drinks Lemonade Powdered Drink Mixes Water
Cereal and Cereal Products	All Breads All Crackers All Sandwich Buns All Cereals
Cheeses and Yogurt	All Varieties
Combination Items	All Salads All Sandwiches Pizza Ravioli, Spaghetti
Dessert Items	All Cakes All Cookies All Pies All Puddings, Custards
Eggs	All Varieties
Fats, Oils, Salad Dressings and Condiments	All Varieties

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APPENDIX I (con't)

Food Group	Foods Within the Groups
Fruits and Vegetables, Fresh	All Varieties
Fruits, Vegetables and Juices, Canned	All Varieties
Fruit and Vegetables Juices, Fresh and Frozen	All Varieties
Meats	Red Meats Poultry Fish
Milk, Homogenized and/or Pasteurized	Plain Chocolate Malted Milk
Milk, Canned	Evaporated Sweetened Condensed Whipped Topping
Salted Snack Foods	Nuts and Seeds Potato Chips Popcorn Pretzels
Soups	All Varieties
Vitamin/Mineral Supplements	All Varieties

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