



103
517
THS

DENTAL HEALTH AND DIETS
OF ELEMENTARY SCHOOL CHILDREN
IN BERRIEN SPRINGS, MICHIGAN

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Virginia Elizabeth Buck
1945

This is to certify that the

thesis entitled

"Dental Health and Diets of Elementary
School Children in Berrien Springs,
Michigan."

presented by

Virginia Elizabeth Buck

has been accepted towards fulfilment
of the requirements for

M. S. degree in Food & Nutrition

Margaret G. Ohlson
Major professor

Date September 11, 1945

~~81073~~ 129

DENTAL HEALTH AND DIETS OF ELEMENTARY SCHOOL
CHILDREN IN BERRIEN SPRINGS, MICHIGAN

by

Virginia Elizabeth Buck

A THESIS

Submitted to the Graduate School of Michigan
State College of Agriculture and Applied Science
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Foods and Nutrition
School of Home Economics

1945

TABLE OF CONTENTS

	Page
Introduction.....	1
Review of Literature	3
Method	19
Description of Subjects	19
Method of collecting dental data	20
Method of collecting dietary data	21
Method of collecting medical data	22
Method of analyzing data	22
Results and Discussion	23
Dental status of subjects	23
Heights and weights of subjects	25
Diets of subjects	27
Summary	40
Appendix	42
List of Literature Cited	47

ACKNOWLEDGMENT

The writer wishes to acknowledge her grateful appreciation to Mr. H.R. Weine, Superintendent of the Berrien Springs Public Schools, to Miss Mabel Cassell, Director of the Emmanuel Missionary College Training School, and to the children of both schools, whose cooperation made this study possible; to Dr. Fred Wertheimer, who made the dental examinations; to Miss Mary Lewis, who first suggested this study; and to Dr. Margaret A. Ohlson, whose criticisms, suggestions and help have been invaluable.

TABLES

Number	Title	Page
1	Incidence of dental caries in permanent teeth of children by age and sex as reported by different investigators.	4
2	Reports of different investigators as to the diet relationship and dental caries.	8
3	Reports of different investigators as to the inadequacies of American diets.	13
4	The "t" values calculated from incidence of dental caries in <u>Group I</u> and <u>Group II</u> .	24
5	Average heights and weights of boys and girls in <u>Group I</u> .	26
6	Mean intakes of specific nutrients of <u>Group I</u> (by age and sex).	28
7	Mean intakes of specific nutrients of <u>Group II</u> (by age and sex).	30
8	Mean intakes of specific nutrients, of children with less than the average number of caries for their age group, as compared to the mean intakes of all children in the age group.	32
9	Percentage of children, age 6 to 9, below the National Research Council standards for specific nutrients.	34
10	Percentage of children, age 10 to 12, below the National Research Council standards for specific nutrients.	35
11	Percentage of children, age 13 to 15, below the National Research Council standards for specific nutrients.	36

INTRODUCTION

Dental caries is one of the most prevalent diseases of the present time. It is rare, indeed, to find an adolescent child with no decayed teeth, and examinations of men inducted into the armed forces have shown that from 22 to 40 per cent of those rejected were rejected because of tooth and mouth conditions (Editorial, 1941).

Although it is well known that dental caries is common, few observers are agreed as to the cause of dental caries. An examination of the various theories of dental decay (Lynch, D.F., Kettering, C.F., and Gies, W.G., 1939) reveals that there are at least two opposing schools of thought. One group holds to the theory that dental decay is a result of some factor present in or missing from the oral environment. The other group contends that dental decay is the result of poor nutrition. Some of those who believe that dental decay is dependent upon the oral environment contend that the chemical composition of the saliva is the important factor, while others argue that the number of acid-forming bacteria controls the oral environment. Among the exponents of the theories of nutrition are those who emphasize the role of fluorine in prevention of caries. Still others maintain that the amount of carbohydrate, and especially refined

sugars, in the diet is the main factor in control of caries. Still others believe that dental decay is dependent upon the amount of vitamin D in the diet. Finally, there are those who hold to the theory that dental decay can be prevented by a diet which is adequate in all nutrients. However, these various groups as yet have not reached agreement; and so it would not seem ill-advised to investigate further the cause of dental caries.

When repeated dental examinations of children in a certain school in southwestern Michigan revealed that these children were more free from caries than children attending the surrounding schools, it was decided to observe these children and note what differences there might be between them and other children of their age group. As the first investigations revealed the fact that these children were all from one religious sect which laid unusual emphasis upon diet, it was decided to observe especially the diets of the children and to compare them with the diets of other children from the same geographical location. It was hoped that such observations might add to our information concerning the relationship between diet and dental decay. The observations noted are reported in this paper.

REVIEW OF LITERATURE

Knutson, Klein, and Palmer, in 1938, published the results of the dental examination of 4,416 children in Hagerstown, Maryland. Table 1 shows the number of permanent teeth decayed, missing or filled (DMF) per 100 children, by age and sex. The DMF of permanent teeth for boys increased gradually from a rate of 25.2 per 100 children at 6 years of age to 667.8 at 15 years of age. For girls, the corresponding increase was from 33.3 to 619.0.

Table 1 also shows the mean caries rates per 100 children by age and sex found by East (1941) in the examination of 528,842 children. As can be seen by the table, these rates correspond closely to those reported by Knutson, et al.

Studies in England by Rolleston (1943) showed that 49 per cent of 2,096 rural children, age 4 to 14, had an excess of dental caries (4 or more decayed teeth at any period). Rolleston could find no differences between sexes.

Miller (1943), also working in England, found that of British Army recruits (age 18) at enlistment, the average numbers of teeth missing, requiring extraction, requiring filling, filled and sound, were 3.7, 1.2, 2.3, 0.6 and 24.2, respectively.

The studies of Knutson, et al. (1938) and East (1941) show an increase in caries rate with age, and also show an

Table 1. Incidence of dental caries in permanent teeth of children by age and sex as reported by different investigators.

Knutson, Klein, and Palmer (1934) (4,413 children)				East (1941) (522,842 children)				Children in E.M.C. Elementary School* (Group I) (92 children)				Children in Berrien Springs Public School* (Group II) (113 children)			
BOYS				BOYS				BOYS				BOYS			
Age years	DMF/100 children	Age years	Mean caries/100 children	Age years	Mean caries/100 children	Age years	DMF/100 children	Age years	DMF/100 children	Age years	DMF/100 children	Age years	DMF/100 children	Age years	DMF/100 children
6	25.2	6-8	117.0	6-9	167 162	6-9	195 182	6-9	195 182	6-9	195 182	6-9	195 182	6-9	195 182
7	58.4														
8	110.4														
9	178.7	9-11	258.5	10-12	365 156	10-12	521 260	10-12	521 260	10-12	521 260	10-12	521 260	10-12	521 260
10	239.3														
11	275.6														
12	357.2	12-14	420.0	13-15	587 433	13-15	717 379	13-15	717 379	13-15	717 379	13-15	717 379	13-15	717 379
13	398.9														
14	508.5														
15	667.5														
GIRLS				GIRLS				GIRLS				GIRLS			
6	33.3	6-8	131.8	6-9	182 152	6-9	233 176	6-9	233 176	6-9	233 176	6-9	233 176	6-9	233 176
7	86.4														
8	128.1														
9	225.8	9-11	282.5	10-12	283 227	10-12	521 224	10-12	521 224	10-12	521 224	10-12	521 224	10-12	521 224
10	263.7														
11	292.9														
12	374.1	12-14	451.0	13-15	700 472	13-15	738 532	13-15	738 532	13-15	738 532	13-15	738 532	13-15	738 532
13	508.3														
14	537.0														
15	619.0														

* Dental examinations made by Dr. Fred Wertheimer of the Michigan State Department of Public Health (February, 1945).

apparent higher incidence of caries for girls at each chronologic age than for boys. East found, also, that the incidence of caries was greater in latitudes above 40 degrees, in communities where the mean winter temperature is below 30° F., in sections where the number of hours of sunshine per year is less than 2600, and in larger cities.

The effect of the seasons upon the incidence of caries is shown by East (1938), Krpf (1938), and McBeath and Zucker (1938), all of whom reported that there is a higher incidence of caries during the winter and early spring than there is during the summer and autumn.

That economic status has no apparent effect on the incidence of dental caries has been demonstrated in studies by Klein and Palmer (1940) on children in New Jersey and in New York City (1942). In both cases, the total number of permanent teeth, decayed, missing or filled, did not differ significantly between high and low income groups. Miller and Crombie (1939) also found that there was little difference in economic status between a group of 25 children with no caries and a group of 25 children with excess caries.

The study of Miller and Crombie (1939) seemed to indicate that first-born children had less dental caries than later-born children. In their group of 25 caries free children, 15 were eldest children, 4 second and 6 third children, whereas in the group of 25 caries active children, 8 were

eldest children, 4 second, 5 third, and 8 fourth or later. However, in 1943, Berk in a study of 198 5-year-old children concluded that the place of the sibling in the family group is a relatively unimportant factor in the incidence of dental caries in children.

Klein and Palmer (1940) found that the results of an analysis of dental caries in 4,416 elementary school children indicated that brothers and sisters of children susceptible to caries have over twice as many caries in both the permanent and deciduous teeth as do brothers and sisters of immune children.

There seems to be some confusion among authorities as to the effect of infantile rickets on the incidence of dental caries. Eliot, et al. (1943) found in their study that 36 per cent of non-hypoplastic teeth were carious, whereas 50 per cent of hypoplastic teeth were carious. This would indicate a positive relationship between dental caries and rickets. However, Shelling and Anderson (1936) found that the incidence of dental caries in a rachitic group of children was not greater than in a non-rachitic group.

The reports of different investigators as to the relationship of diet to dental caries is noted in Table 2. To control dental caries by dietary means, at least four methods have been suggested. One of these methods has grown out of the discovery that in communities which have a higher amount of flourine in the drinking water, there is a low-

er incidence of dental caries. This has led to the suggestion that drinking water be fortified with 1 p.p.m. of flourine (Dean, et al., 1941; Bibby, 1944).

Dean, et al. (1939) observed that the number of carious teeth per 100 children in communities where the water supply contained 1.7 to 1.8 p.p.m. of flourine was 201 and 205, respectively. In two communities where the water supply was practically free of flourine (0.2 p.p.m.), the corresponding figures were 401 and 633.

These findings have been confirmed by other investigators, including Deatherage (1943) who found fewer caries and a higher rate of teeth with no caries in selectees who had used drinking water containing 0.5-1.0 p.p.m. flourine during the whole of their life or during the first 8 years than in selectees who had used water containing 0 to 0.1 p.p.m. flourine.

Another method advanced for dietary control of caries is to inhibit the consumption of refined sugars and other carbohydrates. In 1936, Jay, et al. reported the results of an experiment in which a group of fifty-one children living in an institution were observed for a period of 17 months. During the first twelve months of the study, while on a low-sugar diet, 13 per cent of the children showed clinical signs of active dental caries. During the following 5 months all of the children received an unrestricted amount of candy. At the

Table 2. Reports of different investigators as to the diet relationship and dental caries.

Investigators	Subjects	Diet of subjects	Dental conditions of subjects
East, B.R. (1938)	159 children	Improved diet	Over 75% reported no new caries; less than 10% had active caries.
	74 children	Institutional diet	Less than 20% reported no new caries; 50% had active caries.
Jay, et al. (1936)	51 children living in an institution	Low-sugar diet	13% showed clinical signs of active caries.
		Unrestricted amount of candy	44% showed evidence of active caries.
Collins, et al. (1942)	388 university students	Average consumption of sugar, 10.5 teaspoonfuls	Caries-free.
		Average consumption of sugar, 18.2 teaspoonfuls	Caries-active.
McBeath and Verlin	Five groups of forty children each	No cod-liver oil	4.50 new carious surfaces per child.
		400 I.U. of vitamin D from cod liver oil	2.48 new carious surfaces per child.
		800 I.U. of vitamin D from cod liver oil	1.65 new carious surfaces per child.
Boyd and Drain (1928)	28 diabetic	Diabetic diet, rich in mineral salts and vitamins	Arrest of dental caries.

end of this time 44 per cent of the group showed evidence of active caries, an increase of 31 per cent.

Bunting (1939) believes that dental caries is determined by the presence in the mouth of specific types of acid producing bacteria, e.g., L. acidophilus, the growth of which is encouraged by sugars and starches in the diet. He, therefore, suggests that "the only practical method for the reduction and elimination of L. acidophilus overgrowth in the mouth is by drastic reduction of sugars and starches in the diet."

Jay (1940) and Collins, et al. (1942) also recommend the reduction of sugars and carbohydrate to prevent dental caries.

Whyte (1943) found that a group of boys, age 6 to 16, receiving for two months a daily supplement of 2 oz. fudge or macaroon bar, had a higher incidence of dental caries than a group of controls receiving no supplement of sweets. As these studies do not take into consideration the fact that 2 oz. of fudge comprises about 250 calories which would undoubtedly replace other food in the diet, they are difficult to analyze; for there is a question as to whether the increase of incidence of caries is due to the added sugar or to other subtracted nutrients.

In France, Dechaume and Cauhepe (1943) reported that of 500 children examined in 1942, 30 per cent had no caries. In 1941, only 17 per cent of the children examined were free from caries. They believed that this apparent anomaly could be

explained by the fact that the diet, though restricted, was alkaline in character, and that cakes and sweets had disappeared.

A third method proposed for dietary control of dental caries is by vitamin D therapy. East (1938) found that when three teaspoonfuls of cod liver oil, or 400 units of vitamin D milk, were added to the diet of children, the rate of caries increase was greatly reduced. McBeath and Zucker (1938) observed that the administration of graded amounts of vitamin D as vitamin D milk resulted in graded caries prevention.

In 1942, McBeath and Verlin published a further study on the role of vitamin D in control of dental caries. In this experiment, five groups of about forty children each were observed during one school year. No changes were made in the diet, except the addition of vitamin D to the milk of four of the groups. During this time, the control group showed an increase of 4.50 new carious surfaces per child. In the group receiving a daily supplement of 400 units from cod liver oil, there were 2.48 new carious surfaces per child. The maximum effect obtained in this study (a reduction to 1.65 new carious tooth surfaces) was shown in the group receiving a daily supplement from cod liver oil of 800 units of vitamin D per child.

Still another method has been suggested for the nutritional control of dental caries; this method insists upon a well-balanced diet containing an optimal amount of all the nutrients which are known to maintain good health in humans. One of the first investigators to note the influence of an optimal diet

upon the teeth was Boyd. In 1928, Boyd and Drain published their first observation of the influence of a diet rich in minerals and vitamins in arresting dental caries in a group of diabetic children. They noted that in a group of 28 well controlled diabetic children, there was no further progress of dental caries, although 82 per cent of the children had shown definitely progressive caries prior to the establishment of the dietary control. Further observations published by Boyd (1940; 1942; 1943; 1944) have confirmed the first reports, and have led him to conclude that the progress of dental caries can be stopped by giving the child an optimal diet.

The conclusions drawn by Boyd have been criticized, because, it is claimed, the arrest of dental caries in the diabetic children was due not to the nutritional value of the diets but to the low amount of carbohydrate in the diets. To answer these criticisms, Boyd (1944) re-analyzed his data in terms of fat versus carbohydrate in the diet. He could find no constant or significant difference in the average rates of progression of caries between two groups of children whose carbohydrate ingestion differed by 100 per cent.

Howe, et al. (1942) observed that a group of children who had received nutritional guidance for a period of over 3 years had 56 per cent fewer cavities than another group who had received no such instruction. The difference was greatest in the 11 to 12 year group (83 per cent fewer cavities) and least in

upon the teeth was Boyd. In 1928, Boyd and Drain published their first observation of the influence of a diet rich in minerals and vitamins in arresting dental caries in a group of diabetic children. They noted that in a group of 28 well controlled diabetic children, there was no further progress of dental caries, although 82 per cent of the children had shown definitely progressive caries prior to the establishment of the dietary control. Further observations published by Boyd (1940; 1942; 1943; 1944) have confirmed the first reports, and have led him to conclude that the progress of dental caries can be stopped by giving the child an optimal diet.

The conclusions drawn by Boyd have been criticized, because, it is claimed, the arrest of dental caries in the diabetic children was due not to the nutritional value of the diets but to the low amount of carbohydrate in the diets. To answer these criticisms, Boyd (1944) re-analyzed his data in terms of fat versus carbohydrate in the diet. He could find no constant or significant difference in the average rates of progression of caries between two groups of children whose carbohydrate ingestion differed by 100 per cent.

Howe, et al. (1942) observed that a group of children who had received nutritional guidance for a period of over 3 years had 56 per cent fewer cavities than another group who had received no such instruction. The difference was greatest in the 11 to 12 year group (83 per cent fewer cavities) and least in

the 6 to 7 year group (27 per cent fewer cavities).

Bowes (1938, 1943) found that in two groups of dental patients, clinic and private, no diet was adequate in all essentials. The greatest number of deficiencies or deviations from desirable standards were shown in the carbohydrate-fat ratio, iron, and vitamins D and B.

Within the past ten years many studies have been made of the dietary habits of American families (Table 3). In 1935, Cowles, in an observation of the winter food consumption of Wisconsin farm families, noted that 26.3 per cent were deficient in calories, 7.0 per cent in protein, 15.6 in calcium, 31.6 in iron, 21.0 in phosphorus, 3.5 in all of these nutrients, and 10.5 in four or more nutrients. The common dietary errors were the use of few vegetables other than white potatoes, small consumption of citrus fruits and almost complete lack of use of whole grain cereals. Many of the families failed to use sufficient milk, but the consumption of meat was very high. The adequacy of the diet was clearly and directly related to the money value of the food eaten. No deficiency in protein, calcium or phosphorus, and little deficiency in calories occurred when as much as \$2.40 per adult male was spent per week. This was due, however, to the large quantity of food consumed, rather than to judicious selection.

Bersook and Halverson (1940), in reporting the nutritional adequacy of the diets of 50 families in Pasadena, California,

Table 3. Reports of different investigators as to the inadequacies of American diets.

Investigators	Subjects	Diets of subjects	Physical conditions of subjects
Cowles (1935)	Wisconsin farm families	26.3% of families deficient in calories; 7.0%, in protein; 31.6% in iron; 15.6%, in calcium; 21.0% in phosphorus.	
Borsook and Halverson (1940)	50 families in Pasadena	12 families deficient in 3 or more nutrients; 18 families had an adequate diet.	Of 56 children under 18 years of age examined, 17 showed no caries. No correlation between high calcium intake and freedom from caries.
Stiebeling (1941)	Farm families	50% had good diets, 25% had fair diets, 25% had poor diets.	
	Village and city families	20% had good diets, 45% had fair diets, 35% had poor diets.	
Milam (1942)	North Carolina	Daily calorie intake of adults was about 2000. Intakes of thiamine and riboflavin about one-half of minimum normal standard. Intakes of calcium and vitamin C about one-half of the normal standard.	Vitamin C intake of blood was found to be below 0.3 mg. per 100 ml. plasma in 61%.
Younts, et al. (1942)	Rural population in middle Tennessee	A moderate to severe deficiency in calorie intake.	A significant and often severe deficiency in body weight.
Hardy, et al. (1943)	7393 children in Chicago	Relatively few had an adequate diet.	Gross physical manifestations suggestive of poor nutrition were exhibited by 60% of children.

found that most of these families spending less than \$2.08 per person per week obtained an inadequate diet. The families generally had adequate intakes of protein, iron and vitamin C. The calcium intake of 21 families was inadequate; only 8 families obtained between 4,000-6,000 I.U. of vitamin A; and approximately one-third of the families were receiving less than the recommended amount of vitamin B₁. As to calories, more families with ample funds for food had an ample caloric intake than those on restricted budgets. Twelve families were found to be deficient in three or more essential items; eighteen families had an adequate diet. The investigators reported that the milk consumption of these Pasadena families was somewhat above the rest of the country, and the fruit and fresh vegetable consumption much higher. They could find no correlation between high calcium intake and freedom from caries, nor was there any correlation between lack of caries and high food expenditure.

A dietary study of 29 boys and 23 girls, 14 to 19 years of age, on a lacto-ovo-vegetarian diet, reported by Foote and Eppright (1940), revealed the following as the average daily intakes: for boys, 3126 calories or 48 calories per kilogram of body weight, 90 gm. protein or 1.4 gm. per kilogram, 1.44 gm. calcium, 1.95 gm. phosphorus, and 0.0182 gm. iron; for girls, 2017 calories or 35 calories per kilogram of body weight, 53 gm. protein or 0.90 gm. per kilogram, 0.79 gm. calcium,

1.01 gm. phosphorus, and 0.0094 gm. iron.

Stiebeling (1941), in reporting the survey conducted by the United States Departments of Agriculture and Labor in 1936-37, points out that of the families studied, 27 per cent had good diets, 38 per cent had fair diets and 35 per cent had poor diets. Fifty per cent of farm families had good diets, 25 per cent fair diets and 25 per cent poor diets; whereas of village and city families, 20 per cent had good diets, 45 per cent had fair diets and 35 per cent had poor diets. Farm families apparently fared better than village or city families because they ate larger quantities of protective foods. Stiebeling's report verifies the observation of other investigators that families which had larger incomes had better diets than those with smaller incomes.

Mack, et al. (1942) made a study of the dietary habits and nutritional status of 147 children of families living in a college community. The results were compared with those for children of an industrial community of lower economic status. The children in the community in which income and educational status of the parents were higher were found to show generally better nutritional status. Although the intake of protective foods varied with income in both communities, intakes of these foods throughout all income groups of the college community were higher than those of the industrial groups.

Milam (1942), in a nutrition survey of a small North Carolina community in 1940-41, found the dietary levels of calories, vitamin B₁, riboflavin, calcium, and vitamin C to be below that

recommended by the National Research Council.

The diets of high school students in New York City, as reported by Wiehl (1942, 1944), show that of 2,000 pupils from low-income families, 21 per cent had less than two-thirds of the standard allowances for calories, 5 per cent for protein, 28 per cent for calcium, 17 per cent for iron, 38 per cent for vitamin A, 14 per cent for vitamin B₁, 25 per cent for riboflavin and 29 per cent for ascorbic acid. The calorie intake for private high school pupils was, on the average, approximately equal to their estimated calorie needs.

Youmans, et al. (1942), working in Tennessee, found the mean intake of calories for boys and girls, age 7 to 9 years, to be 1,726; for boys and girls, age 10 to 12 years, it was 1,855; for boys, age 13 to 15, the mean caloric intake was 2,494; and for girls of the same age, 1,691.

In the spring of 1942, Widdowson and McCance made a survey of the diets of 52 boys in schools in England. The nutritive value of the diets was compared with results obtained from a similar study in 1936-39. It was found that the calorie supply from meat, fats and sugar was lower in 1942 than in the previous study, but the total calorie intake was maintained by an increased consumption of unrationed foods. All diets contained as much protein, Ca, P, Fe, and vitamin B₁ as in the previous study, but the average intakes of animal protein had fallen to between 33 and 47 gm. and vitamin C to between 15

and 17 mg. daily.

A study of the diets of 524 high school girls in Minnesota and Kansas in 1939-40 (Leichsenring, et al., 1943) showed low consumption of eggs, milk and green and yellow vegetables. The observed calorie intakes were less than those recommended by the Committee on Foods and Nutrition of the National Research Council. The protein content of the diet, approximately 70 gm. per day, failed to meet the recommended daily allowance of 80 gm. for girls 13 to 15 years old and 75 gm. for girls of 16 to 20 years. At all ages the intake of Ca, P, and Fe were below the proposed standards. The mean intake of vitamin A appeared to be adequate, but some individuals received much less than the recommended allowance of 5,000 I. U. daily. The intake of vitamin C was variable. No serious deficiency of vitamin B₁ was noted, but the riboflavin intake was probably inadequate.

Hardy, et al. (1943) conducted a survey which extended from January 1939 to August 1941 and included 7,393 children of different national and racial groups and a wide distribution of economic and social conditions in the city of Chicago. The following are the major findings of the survey. Gross physical manifestations suggestive of poor nutrition were exhibited by 60 per cent of the children examined. Ratings of poor general condition varied from 48 per cent at the relief level to 13 per cent at the highest level. The diet patterns of 72 per cent of the children failed to meet a standard of adequacy lower than that recommended by the National Research Council. The diets

of 89 per cent of the Negro children failed to reach the minimum adequate standard. The foods least often lacking were protein foods and those most often lacking, fruits and vegetables. Dietary inadequacies were common at all ages and in no age group were the diets of more than one-third of the children classed as adequate. Inadequate diets occurred in all the socio-economic groups examined; 92 per cent at the lowest level and 41 per cent at the highest.

As can be seen from the above discussion as summarized in Tables 2 and 3, dietary surveys have revealed many deficiencies in the average American diet. Evidences of malnutrition have been reported which confirm the poor dietary habits. Very few investigators have tried to correlate the average diets of American families with their dental health. Those investigators who have reported the effect of diet upon dental decay usually have worked with controlled diets. In the investigation reported in this paper, the usual diets of the elementary school children studied were observed in order to discover whether the dental health could be correlated with the quality of the food ingested.

METHOD

In order to investigate further the relationship of diet to dental caries in children, two groups of elementary children were chosen for observation. Group I consisted of 92 children from the Emmanuel Missionary College Elementary School. The children's ages ranged from 6 years to 15 years. Their school grades ranged from the first through the eighth year. The Emmanuel Missionary College Elementary School is a private school controlled by the Seventh-day Adventist Church. It is situated on the campus of Emmanuel Missionary College, about two miles from the village of Berrien Springs, Michigan. Most of the children attending this elementary school live within five miles of the school. Some of the children live in Berrien Springs, or on outlying farms. Many of the children live in a small residential settlement close to the college campus. The occupations of their parents range from farmers to laborers to college teachers. All of the children come from Seventh-day Adventist homes. As repeated examinations of the teeth of these children have revealed a lower incidence of caries than found in the examinations of the teeth of children in the surrounding area, and as the Seventh-day Adventist families lay stress upon diet, this group was chosen as the experimental group in this study. For clarity, the group of children from the Emmanuel Missionary College Elementary School will be known throughout this paper

as Group I.

The control group, Group II, consisted of 113 children from the Berrien Springs Public School. These children were chosen at random from the school files, but the age, sex, and school grade of each child was matched as closely as possible to the age, sex, and school grade of the children in the experimental group. The Berrien Springs Public School is located within the village of Berrien Springs. Berrien Springs is situated in the southwestern portion of Michigan in the county of Berrien. It is approximately 12 miles from St. Joseph, Michigan, and about 20 miles from South Bend, Indiana. Some of the children observed in this group lived in the village of Berrien Springs, while others lived on surrounding farms. Their parent's occupations were for the most part farmers and laborers, but a few children came from homes of the professional class. No inquiry was made as to the religious affiliations of these families, but it is not believed that there were any Seventh-day Adventist children among this group. This group was chosen as the control group because of its proximity to the Emmanuel Missionary College Elementary School. It was hoped that this would lessen any variations due to the physical environment. Henceforth, the group of children from the Berrien Springs Public School will be known in this paper as Group II.

Method of collecting dental data.--All dental examinations of the children were made on two successive days in February,

1945. The children were examined by Dr. Fred Wertheimer, a dentist from the Michigan State Department of Public Health. The examinations were made by an exploratory tine and, hence, do not show those cavities which are not reached by the tine. At the time of examination, a record was made for each child of the number of deciduous teeth which were decayed or filled, and of the number of permanent teeth erupted, decayed, filled, missing or requiring extraction. This method of dental examination has been the standard procedure of the Michigan State Department of Public Health.

Method of collecting dietary data.--The dietary habits of the children were observed by personal interview with each child. Each child was interviewed once. In order to do this, two months were required, beginning the latter part of January and continuing until the latter part of March, 1945. The children were interviewed singly, during the school hours, at the school, but in a room apart from the regular class. Each child was asked to tell what he had eaten the day before, and the approximate proportions of food. This was recorded by the interviewer as the child was talking. At the same time, the interviewer tried to put the child at ease and to encourage his participation in the interview. If, after recording the diet, it was noticed that one or more of the "basic seven" foods was lacking from the menu, the child was asked to reveal, if possible, when he had last eaten that food. He was also asked specifically about the amount of candy and other sweets which he had consumed re-

cently. Several questions of a more general nature were also asked. The forms used in the interviews are found in the appendix of this report.

It had been planned originally to interview each child twice in this same manner, but as time did not permit, this plan was abandoned. It had also been originally planned to interview the mother of each child, but as a few such interviews did not reveal any additional information beyond that supplied by the child, this plan was discarded as being unnecessary.

Method of collecting medical data.--The height and weight records, as well as the records of past diseases, of the children in Group I were copied from the school's medical reports. In Group II there were no medical records available. For this group the record of past diseases was received from the child at the time of the interview. In Group II the heights and weights of a few of the younger children were measured by the interviewer. It was possible to do this when the interviewer had access to a room in which there were scales and measuring rod.

Methods of analyzing data.--The nutritive values of the diets were calculated by the short method of analysis (Donelson, E.G., and Leichsenring, J.M., 1942). Data were subjected to standard statistical analyses by the methods outlined by Baten (1938).

RESULTS AND DISCUSSION

A comparison of the DMF values for Groups I and II (Table 1) with the values reported by Knutsen, et al. (1938) and those reported by East (1941) shows that the caries incidence for Groups I and II is greater than the previously reported values for all age and sex groups except for girls, 10 to 12 years of age, in Group I. In this group, the DMF per 100 children is 283 ± 227 . The DMF per 100 children for the same age and sex group, as reported by Knutsen, et al. (1938) ranges from 263.7 to 374.1. East (1941) reported the mean caries per 100 children for girls, 9 to 11 years of age, as 282.5. It appears, therefore, that although the dental caries rate is somewhat above average for all the other groups studied, the dental caries rate for girls, 10 to 12 years of age, in Group I is well within the range of data for children of similar economic status, or perhaps even slightly below that range, as reported by Knutsen, et al. (1938) and East (1941).

The mean DMF per 100 children is greater for Group II in each age and sex group than it is for Group I. However, "t" values (Table 4) indicate that the only group in which the dental caries incidence is significantly lower for Group I than for Group II is the group of girls from 10 to 12 years of age. In Group I, the girls of 10 to 12 years of age had a DMF of 283 ± 227 per 100 children. In Group II, the corresponding fi-

gure was 521 ± 224 . The "t" value for these two figures is 3.09; there is less than one chance in a hundred that this is a random result.

Table 4. The "t" values calculated from incidence of dental caries in Group I and Group II.

<u>Age</u>	<u>Degrees of Freedom</u>	<u>"t" values</u>
BOYS		
6-9	37	0.49
10-12	30	1.59
13-15	35	1.58
GIRLS		
6-9	35	0.89
10-12	37	3.09
13-15	32	0.21

It has been established that when boys and girls are growing rapidly there is a greater need for nutrients (Sherman, 1941). Also during rapid growth, there may be competition among the various parts of the body for the nutrients supplied. If not enough nutrients are provided to meet all demands, the more essential tissues tend to develop at the expense of structures less essential to life. Because of this and the fact that all groups of the experimental children showed extensive dental

decay, it was considered wise to investigate the heights and weights of the children studied.

As it was not possible to record the heights and weights of most of the children in Group II, the children in Group I were divided into "low-carries" and "high-carries" groups in order to obtain a similar comparison (Table 5). At 6 to 9 years the "low-carries" group represented all those who had less than 2 carious teeth; the "high-carries" group represented all those with 2 or more carious teeth. At 10 to 12 years, the "low-carries" group was composed of all those with less than 4 carious teeth, whereas the "high-carries" group was composed of those with 4 or more carious teeth. At 13 to 15 years of age, the "low-carries" group represented those with less than 6 carious teeth, and the "high-carries" group represented those with 6 or more carious teeth.

In each age-sex group the mean weight is compared with the ranges for height and weight as found in the Meredith tables. It will be noticed that the average height and weight for each age group is well within the Meredith range, indicating that the children in Group I were growing normally. The heights of these children, however, are toward the top of the range while the weights are near the middle of the range, which would tend to show that these children are tall and thin.

In three age-sex groups the differences in height and weight between the "low-carries" and the "high-carries" groups

Table 5. Average heights and weights of boys and girls in Group I.

	6-9 years			10-12 years			13-15 years		
	No. of children	Height in.	Weight lb.	No. of children	Height in.	Weight lb.	No. of children	Height in.	Weight lb.
Range according to heredity (1943)		44-56	42-81		52-63	60-110		65-70	78-147
Low-carries	9	53.0	66.5	4	56.0	81.0	7	62.5	101.0
High-carries	7	53.0	65.0	4	63.5	100.0	8	66.0	124.0
				GIRLS					
Range according to heredity (1943)		43-56	40-82		55-64	57-108		59-66	68-133
Low-carries	6	51.2	63.0	7	60.0	102.5	6	66.0	107.5
High-carries	7	52.5	60.0	7	65.0	111.0	8	68.5	119.0

is almost negligible. These groups are the boys and girls, 6 to 9 years old, and the girls, 13 to 15 years old. However it will be noticed here, that the "high-carries" groups are slightly larger than the "low-carries" groups. Among the boys, 10 to 12 years of age and 13 to 15 years of age, the "high-carries" groups are definitely much larger than the "low-carries" groups. But in the group of girls, 10 to 12 years of age, the "low-carries" group shows an excess in height and weight over the "high-carries" group.

It is usually considered that an adequate diet will produce better growth than an inadequate diet. If this is true, it would be expected that the taller and heavier children in this study had better diets than the others. But it has also been maintained that an adequate diet will prevent dental carries. If this is true, then it would be expected that the "low-carries" children, who in all age-sex groups but one were the smaller children, would have the better diets. In order to try to understand this apparent anomaly, an analysis of the food intakes of the children studied was necessary.

The mean intakes of specific nutrients for Group I by age and sex are shown in Table 6. It will be observed that in every group the mean number of calories ingested is below the standard set by the National Research Council. The same is true for iron and niacin intakes. In only one group (boys 6 to 9 years of age) is the calcium intake considered adequate,

Age of Subjects	Thiamine mg.	Ribo- flavin mg.	Niacin mg.
--------------------	-----------------	------------------------	---------------

6-9 NRC Sta	1.35±0.40 1.0	2.19±0.67 1.5	9.1±2.6 10
10-12 NRC Sta	1.30±0.33 1.2	2.08±0.87 1.8	8.1±2.5 12
13-15 NRC Sta	1.45±0.46 1.6	1.83±0.65 2.4	9.6±2.9 16

6-9 NRC Sta	1.09±0.20 1.0	1.61±0.33 1.5	7.5±1.9 10
10-12 NRC Sta	1.28±0.38 1.2	1.79±1.08 1.8	7.3±1.8 12
13-15 NRC Sta	1.15±0.34 1.4	1.68±0.78 2.0	7.5±2.4 14

The

*T
Food Com

through courtesy of the Loma Linda

so
in
mean

re-
le-
the
few
us
re

by
d
ars
an
search
ever,
nges-
s in-
uate
the
hree
n in-
vita-
ncil
ns

although it approaches adequacy in the group of girls, 10 to 12 years of age. The intakes of ascorbic acid are adequate in only three age-sex groups; the intakes of thiamine in four groups; and the intakes of riboflavin in four groups. The mean intakes of vitamin A in each group are above the National Research Council standards, however the very large standard deviations indicate that many of the children did not reach the mean intake, while a very few greatly exceeded it. These few children tended to raise the average of the whole group, thus giving a mean that is unrepresentative of the intakes of the group.

The mean intakes of specific nutrients for Group II by age and sex are shown in Table 7. Here, it will be noticed that the mean caloric intake for boys and girls, 6 to 9 years old, is adequate, but for the other age-sex groups, the mean number of calories ingested falls short of the National Research Council standards. A comparison with Group I reveals, however, that in every age-sex group, the mean number of calories ingested by Group II is greater than the mean number of calories ingested by Group I. In Group II the protein intake is adequate in four age-sex groups, the calcium intake in two groups, the iron intake in three groups, the ascorbic acid intake in three groups, the riboflavin intake in five groups and the niacin intake in three groups. As in Group I, the mean intakes of vitamin A for Group II are all above the National Research Council standards, however, here again the large standard deviations

Age of Subjects	Thiamine mg.	Ribo- flavin mg.	Niacin mg.
6-9 NRC Sta	1.58±0.21 1.0	2.32±0.77 1.5	10.9±4.4 10
10-12 NRC Sta	1.47±0.37 1.2	2.26±0.71 1.8	13.8±3.7 12
13-15 NRC Sta	1.33±0.42 1.6	2.48±1.23 2.4	13.0±2.0 16
6-9 NRC Sta	1.43±0.51 1.0	2.21±0.61 1.5	10.2±4.1 10
10-12 NRC Sta	1.26±0.30 1.2	1.87±0.62 1.8	10.8±2.7 12
13-15 NRC Sta	1.29±0.39 1.4	1.96±0.91 2.0	11.3±4.9 14
The			

in-

, the

om

pro-

ser

1

were

3

1,

nu-

r

these

re of

may

np-

on-

as-

a

on-

ts

re

well

indicate that many of the children do not have an adequate intake.

It would seem from tables 6 and 7 that, on the whole, the children from Group II are better fed than the children from Group I. This is especially true in intakes of calories, protein, iron, riboflavin and niacin. The reason for the lesser amount of protein, iron and niacin ingested by the children in Group I may be explained by the fact that the children were mostly non-meat eaters because of religious principles. As meat is one of the main sources of protein, iron and niacin, diets lacking this food would be likely to be low in these nutrients. As the children in Group II in general had better diets it is regrettable that data concerning the growth of these children were not available.

On the other hand, Group I seems to have higher intake of calcium, vitamin A and ascorbic acid than Group II. This may be explained by pointing out that a decrease in meat consumption in Group I probably was accompanied by an increased consumption of fruits and vegetables. Calcium, vitamin A and ascorbic acid have all been shown by experimentation to play a role in tooth formation. The role of these nutrients in controlling dental decay is not as well understood.

In Table 8, the mean intakes of the specific nutrients for all the boys and girls in each age group is noted. Here it will be noted that the mean intake of each nutrient is well

Table 8. for their age group.

	Thiamine mg.	Ribo- flavin mg.	Niacin mg.
Mean intakes for all children	1.38	2.10	9.6
Mean intakes for children with le than 2 cariouste	1.41	1.99	9.6
NRC Standards	1.0	1.5	10
Mean intakes for all children	1.33	1.99	10.2
Mean intakes for children with less than 4 ca- rious teeth	1.32	1.96	9.1
NRC Standards	1.2	1.8	12
Mean intakes for all boys	1.38	2.19	11.5
Mean intakes for boys with less than 6 carious teeth	1.23	1.57	10.0
NRC Standards	1.6	2.4	16
Mean intakes for all girls	1.23	1.84	9.6
Mean intakes for girls with less than 6 carious teeth	1.06	1.61	8.0
NRC Standards	1.4	2.0	14

* Values c

above the standard for boys and girls, 6 to 9 years of age. In the 10 to 12 year old group, the National Research Council standards are met for protein, vitamin A, ascorbic acid, thiamine and riboflavin. In the group of boys, 13 to 15 years old, the National Research Council standard is met for vitamin A only, and the same is true of girls, 13 to 15 years old. These data seem to indicate that as the children grow older, their food intakes become less and less adequate, while their rate of growth becomes more rapid and the incidence of dental caries becomes greater.

Table 8 also shows the mean intakes of the specific nutrients for the "low-carries" groups. In almost every case, these values are lower than the mean intakes for all children; however in each group, the differences in mean intakes is so small that it could well be considered within the range of error for the method used.

Tables 9, 10 and 11 compare the percentage of children in Group I who are below the National Research Council standards for each nutrient with the percentage of children in Group II who are below these standards. As in Tables 6 and 7, these tables again show that on the whole the children in Group II are as well fed, or better fed than the children in Group I; and again, this is especially true in intakes of calories, protein, iron and niacin. However, again, it will be noticed that in several cases there are fewer children in Group I below the National Research Council standards for calcium, vitamin A and

Table 9. Percentage of children, age 6 to 9, below the National Research Council standards for specific nutrients.

		Calories	Protein	Calcium	Iron	Vitamin A I.U.	Ascorbic Acid mg.	Thiamine mg.	Riboflavin mg.	Niacin mg.
NRC Standards		2000	60	1.0	10	5000	60	1.0	1.5	10
BOYS										
Group No.										
I 14	57.1	42.9	35.7	50.0	25.0	30.0	30.0	21.4	7.1	71.4
II 20	35.0	25.0	20.0	25.0	35.0	30.0	30.0	10.0	10.0	50.0
GIRLS										
I 14	71.4	71.4	64.3	72.8	50.0	72.3	72.3	28.6	7.1	92.9
II 13	38.5	23.1	30.0	38.5	30.0	45.2	45.2	23.1	30.0	83.8

Table 10. Percentage of children, age 10 to 12, below the National Research Council standards for specific nutrients.

Calories	Protein	Calcium	Iron	Vitamin A I.U.	Ascorbic Acid mg.	Thiamine mg.	Riboflavin mg.	Niacin mg.
2500	70	1.2	12	4500	75	1.2	1.3	12
BOYS								
Group No.	1	1	1	1	1	1	1	1
I 11	91.9	83.6	72.7	43.6	27.3	33.4	51.5	34.5
II 17	50.8	20.5	70.6	33.5	59.0	41.2	25.5	23.4
GIRLS								
I 17	94.1	73.5	47.1	42.4	45.1	40.9	38.5	37.3
II 17	42.4	27.2	52.5	31.0	44.7	33.5	42.2	40.1

Table 11. Percentages of children, ages 13 to 15, below the RGO standards for specific nutrients

		Calories	Protein	Calcium	Iron	Vitamin A	Isosorbic acid	Thiamine	Riboflavin	Niacin
RGO standards		2500	55	1.4	15	3000	90	1.6	3.4	16

1963

Group	%.	I	II	I	II	I	II	I	II	I	II
I	15	10.0	53.9	73.5	74.9	85.3	90.0	90.0	80.0	100.0	100.0
II	19	94.9	77.9	26.5	25.7	69.4	93.9	10.0	83.2	79.7	79.7

1961

1963

RGO standards		2500	60	1.3	15	3000	90	1.4	3.0	14	
Group	%.	I	II	I	II	I	II	I	II	I	II
I	14	99.9	92.9	91.4	95.9	94.3	97.1	91.4	95.3	100.0	100.0
II	19	99.3	91.1	87.3	83.7	77.3	99.2	79.9	96.6	77.9	77.9

ascorbic acid than in Group II. Between girls of 10 to 12 years of Group I and Group II are found some differences that cannot be noted between the other groups. Here it is observed that Group I has fewer girls below the National Research Council standards in calcium, vitamin A, ascorbic acid, thiamine and riboflavin. This is the only group in which the diets of Group I may be said to be better than those of Group II.

The mean intakes of nutrients observed here may partially explain why the larger children are in the "high-caries" groups. It has been pointed out previously that with a faster rate of growth, there is more competition within the body for food nutrients. It would seem logical, then, to assume that with a similar intake of nutrients, the group of children who were growing faster would be more likely to have a greater rate of dental decay than the slower growing group. The nutrients which in the slower growing child are used to build teeth may be needed in the faster growing child to build bones and muscle.

However, this explanation does not account for the group of girls, age 10 to 12, who had a low incidence of caries and a rapid rate of growth. The analysis of the diets of girls, 10 to 12 years old, in Group I showed that their food intakes were better in calcium and vitamins than the food intakes of the corresponding children in Group II. In no other groups were the differences in diet so striking. It may be assumed from this that when the diet approaches adequacy, an increased rate of

growth may be accompanied with a low incidence of caries.

It would seem from the above discussion that dental caries is not a simple effect which can be attributed to one prevailing cause, but rather the result of a multiplicity of factors among which may be adequacy of diet and rate of growth. This study apparently confirms the observations of Boyd (1940) that as diets more nearly approach adequacy, children grow more rapidly and also have fewer dental caries.

No clear-cut observation could be made as to the effect of carbohydrate upon dental caries from this study. For the most part, the carbohydrate consumption for Group I was greater than for Group II, but this did not hold true in all cases. The number of servings of sweets (sugar, cookies, cake, soft drinks, etc.) per child per day of the "low-caries" group and the "high-caries" group in Group I was computed. In the "low-caries" group the mean number of servings of sweets was 3.0 per child per day. In the "high-caries" group, the mean number of servings was 3.5. This difference does not seem large enough to warrant any conclusion that sweets may increase dental caries.

No correlation could be found between the incidence of dental caries and the intake of vitamin D, but again the data are too few to warrant any conclusion. Thirty-eight per cent of children in the "low-caries" group were known to be receiving vitamin supplements. Forty per cent of the children in the "high-caries" group were known to be receiving vitamin sup-

plements. In each group, approximately one-third of the vitamin supplements were known to be cod liver oil or cod liver oil concentrates. The other supplements were not identified, but in some cases these may have been multiple-vitamin compounds containing vitamin D.

SUMMARY

1. Dental examinations were made of elementary school children in two schools in the same geographical location. The children in Group I had fewer decayed, filled, or missing permanent teeth than the children in Group II. The difference in caries rate, however, was considered significant only for girls, age 10 to 12 years.
2. Heights and weights of "high-caries" children of Group I were generally greater than heights and weights of "low-caries" children. However among girls, 10 to 12 years of age, the heights and weights of "low-caries" children were greater than the heights and weights of "high-caries" children. No data on height and weight were obtained for Group II.
3. Little difference could be found between diets of children in Group I and Group II, or between diets of "low-caries" and "high-caries" children, but it was observed that in all groups most of the diets failed to reach the National Research Council standards of adequacy. However girls, 10 to 12 years of age, in Group I had diets better in calcium, vitamin A, and ascorbic acid than the corresponding children in Group II. This same group also showed fewer children failing to meet the National Research Council standards

for calcium, vitamin A, ascorbic acid, thiamine and riboflavin.

4. An accelerated rate of growth seemed to be accompanied by an increase in dental caries, unless the diet was improved in proportion to rate of growth.
5. No correlations could be found between amounts of carbohydrate, sweets, or vitamin supplements ingested and incidence of dental caries. However, the data were inadequate to conclude that either sweets or vitamin D influence the progress of dental caries.

APPENDIX

HEALTH RECORDS

Name of Child _____ School _____ Date _____

Birth date _____ Age _____ Sex _____ Parent _____

Address _____

Height-Weight Record			Disease Record
Year	Weight	Height	When did child have the following diseases:
			German measles _____ Mumps _____ Chicken Pox _____ Frequency of colds _____ Broken bones _____ Surgery _____ Red measles _____ Influenza _____ Pneumonia _____ infantile _____ Paralysis _____ Rheumatic fever _____ Diphtheria _____ Scarlet fever _____ Small Pox _____ Tuberculosis _____ Meningitis _____ Diarrhea _____ Other _____

How often are dental examinations made of child?

Remarks:-

DIET RECORD : INTERVIEW

Record of All Food That Was Eaten on One Day

Name _____ Date _____ Day _____

School _____

[illegible]

Diet Record : Interview (Cont'd)

If not eaten yesterday, when did you last have the following foods?

Orange or grapefruit, or juice _____

Tomato, or juice _____

Egg _____

Butter or substitute _____ Brand _____

Cheese _____

Milk to drink _____

Leafy vegetables, spec. _____

Meat, fish, chicken _____

Meat substitute, spec. _____

Was any food served yesterday which you did not eat? _____ What
was it? _____ Why didn't you eat it? _____

When did you last have the following:

Ice cream (cones, sundaes, sodas, etc.) _____

Candy _____

Chewing gum _____

Soft drinks (cokes, soda pop, etc., spec.) _____

Coffee _____

Tea _____

Remarks:

FOOD AND DIET HABITS

Name _____ Date _____ School _____

Do you usually eat about the same breakfast? _____ If not, explain

Do you drink milk? _____ Number of glasses per day _____

What foods don't you like?

What foods do you not eat?

What foods do you like especially?

Do you take Cod Liver Oil? _____ Name of preparation and brand _____

Amount daily _____

Do you take other vitamin preparations? _____

Name of preparation and brand _____ Amount daily _____

Where did you eat lunch yesterday? _____

What hour did you get up this morning? _____ Yesterday? _____

What hour did you go to bed last night? _____

How did you spend last summer's vacation?

LIST OF LITERATURE CITED

- Bates, W.D. Elementary Mathematical Statistics. New York: John Wiley & Sons, Inc., 1938, 338 pp.
- Bark, H. 1943. Some factors concerned with the incidence of dental caries in children. Multiple pregnancy, and nutrition during prenatal, postnatal and childhood periods. J. Amer. Dent. Assoc. 30: 1749-1754.
- Bibby, B.G. 1944. Use of fluorine in the prevention of dental caries. I. Rationale and approach. J. Amer. Dent. Assoc. 31: 228-236.
- Borsook, H. and Halverson, W.L. 1940. Nutrition and health in Pasadena. Amer. J. Pub. Health. 30: 895-900.
- Bowes, A. DeP. 1938. Teaching nutrition to dental students at the University of Pennsylvania. J. Amer. Diet. Assoc. 14: 546.
- Bowes, A. DeP. 1943. Dentistry and diet. J. Amer. Dent. Assoc. 30: 1360-1367.
- Boyd, J.D. and Drain, C.L. 1928. The arrest of dental caries in childhood. J. Amer. Med. Assoc. 90: 1867.
- Boyd, J.D. 1940. The role of diet in the control of dentinal caries. J. Amer. Dent. Assoc. 27: 750-756.
- Boyd, J.D. 1942. Nutrition as it affects tooth decay. J. Amer. Diet. Assoc. 18: 211-215.
- Boyd, J.D. 1943. Prevention of dental caries in late childhood and adolescence. J. Amer. Dent. Assoc. 30: 670-680.
- Boyd, J.D. 1943. Long term prevention of tooth decay among diabetic children. Amer. J. Dis. Child. 66: 349-361.
- Boyd, J.D. 1944. The need for betterment of children's diets. J. Amer. Diet. Assoc. 20: 147-149.
- Boyd, J.D. 1944. Dental caries as influenced by fat versus carbohydrate in the diet. Amer. J. Dis. Child. 67: 278-281.
- Bunting, K.W. 1939. Diet and dental caries. N.Y. State J. Med. 39: 18-21. (Nutrition Abst. and Rev. 9: 1054, 1939-1940).
- Collins, K. O., Jensen, A.L. and Becks, H. 1942. Study of

caries-free individuals. 2. Is an optimum diet or a reduced carbohydrate intake required to arrest dental caries? J. Amer. Dent. Assoc. 29: 1169-1178.

- Cowles, M.L. 1935. A study of winter food consumption in Wisconsin farm families. J. Amer. Diet. Assoc. 11: 322-330.
- Dean, H.T., Jay, P., Arnold, F.A. (Jr.), McClure, F.J. and Elvove, E. 1939. Domestic water and dental caries, including certain epidemiological aspects of oral L. acidophilus. Pub. Health Rep. Washington. 54: 862-888. (Nutrition Abst. and Rev. 9: 743, 1939-1940).
- Dean, H.T., Jay, P., Arnold, F.A. (Jr.) and Elvove, E. 1941. Domestic water and dental caries. 1. A dental caries study, including L. acidophilus estimations, of a population severely affected by mottled enamel and which for the past 12 years has used a fluoride-free water. 2. A study of 2,832 white children, aged 12-14 years, of 8 suburban Chicago communities, including Lactobacillus acidophilus studies of 1,761 children. Pub. Health Rep. Washington. 56: 365-381; 761-792. (Nutrition Abst. and Rev. 11: 332, 1941-1942).
- Deatherage, C.F. 1943. Fluoride domestic waters and dental caries experience in 2026 white Illinois selective service men. J. Dent. Res. 22: 129-137. (Nutrition Abst. and Rev. 13: 288, 1943).
- Dechaume and Cauhepe. 1943. La carie dentaire chez l'enfant. Presse med. 51: 236. (Nutrition Abst. and Rev. 14: 388, 1944).
- Donelson, M.G. and Leichsenring, J.M. 1942. Food composition table for short method of dietary analysis. J. Amer. Diet. Assoc. 18: 429-434. Revised 4-1-44.
- Editorial. 1941. Mouth health and military service. J. Am. Dent. Assoc. 28: 624-628.
- East, B.R. 1938. Nutrition and dental caries. Amer. J. Pub. Health. 28: 72-76.
- East, B.R. 1941. Relation of dental caries in city children to sex, age and environment. Amer. J. Dis. Child. 61: 494-517.
- Eliot, M.M., Souther, S.P., Anderson, B.G. and Arnim, S.S. 1934.

A study of the teeth of a group of children previously examined for rickets. Amer. J. Dis. Child. 48: 713-729.

Erpf, S.F. 1938. Dental caries and parodontal disturbances. 2. The seasonal incidence of dental caries. J. Amer. Dent. Assoc. 25: 681-693.

Roote, R. and Eppright, E.S. 1940. A dietary study of boys and girls on a lecto-ovo-vegetarian diet. J. Amer. Diet. Assoc. 16: 222-229.

Hardy, M.C., Spohn, A., Austin, G. McGiffert, S., Mohr, E. and Peterson, A.B. 1943. Nutritional and dietary inadequacies among city children from different socio-economic groups. J. Amer. Diet. Assoc. 19: 173-181.

Howe, P.R., White, R.L. and Elliott, M.D. 1942. The influence of nutritional supervision on dental caries. J. Amer. Dent. Assoc. 29: 38-43.

Jay, P. 1940. The role of sugar in the etiology of dental caries. J. Amer. Dent. Assoc. 27: 393-396.

Jay, P., Hadley, R.P., Bunting, R.W. and Koehne, M. 1936. Observations on relationship of Lactobacillus acidophilus to dental caries in children during experimental feeding of candy. J. Amer. Dent. Assoc. 23: 846-851.

Johnston, R.A. 1943. Adequacy of a diet eaten by children eight to eleven years of age. J. Amer. Diet. Assoc. 19: 416-419.

Klein, H. and Palmer, C.E. 1940. Community economic status and the dental problem of school children. Pub. Health Rep. Washington. 55: 187-205. (Nutrition Abst. and Rev. 10: 209, 1940-1941)

Klein, H. and Palmer, C.E. 1940. Dental caries in brothers and sisters of immune and susceptible children. Milbank Mem. Fund Quart. 18: 67-82.

Klein, H. and Palmer, C.E. 1942. Medical evaluation of nutritional status. 10. Susceptibility to dental caries and family income. Milbank Mem. Fund Quart. 20: 169-177.

Knutson, J.W., Klein, H. and Palmer, C.E. 1938. Studies on dental caries. 8. Relative incidence of caries in the different permanent teeth. J. Amer. Dent. Assoc. 25: 1923-1934.

- Leichsenring, J.M., Donelson, S.G., Deinard, H.H., Pittman, M.S., Coopridge, M. and Haggart, V. 1943. Diets of 524 high school girls. J. Home Econ. 35: 583-586.
- Lynch, D.F., Mettering, C.F. and Gies, W.J. Dental Caries: Findings and Conclusions on its Causes and Control. New York: American Dental Association: Research Commission, 1939, 189 pp.
- Mack, P.B., Smith, J.M., Logan, C.H. and O'Brien, A.T. (with Stewart, A.H. and Dodds, P.) 1942. Mass studies in human nutrition: nutritional status of children in a college community. J. Amer. Diet. Assoc. 18: 69-78.
- McBeath, S.C. and Verlin, W.A. 1942. Further studies on the role of vitamin D in the nutritional control of dental caries in children. J. Amer. Dent. Assoc. 29: 1393-1397.
- McBeath, S.C. and Zucker, T.F. 1938. The role of vitamin D in the control of dental caries in children. J. Nutrition. 15: 547-564.
- Meredith, H.V. 1943. Height-Weight-Age Tables. Iowa Child Welfare Research Station, State University of Iowa.
- Milam, D.F. 1942. A nutrition survey of a small North Carolina community. Amer. J. Pub. Health. 32: 406-412.
- Miller, H.G. and Crombie, D.M.R. 1939. Complete freedom from dental caries. A comparative study of twenty-five children. Lancet. 237: 131-133.
- Miller, R.K.P. 1943. A preliminary survey of the incidence of dental caries in Great Britain. Brit. Dent. J. 74: 286-289. (Nutrition Abst. and Rev. 13: 287, 1943)
- Rolleston, C. 1943. The teeth of school children from the point of view of the school doctor. British J. Child. Dis. 40: 31-35. (Nutrition Abst. and Rev. 13: 287, 1943)
- Shelling, H. and Anderson, G.M. 1936. Relation of rickets and vitamin D to the incidence of dental caries, enamel hypoplasia and malocclusion in children. J. Amer. Dent. Assoc. 23: 840-846.
- Sherman, H.C. Chemistry of Food and Nutrition. 6th ed. chap. XXVI, pp. 470-488. New York: The Macmillan Company, 1941.
- Stiebeling, H.K. 1941. Are we well fed? A report on the diets of families in the United States. U.S. Dept. of Agric. Misc. Publ. 430.

- Whyte, R. 1943. A dietetic, dental and bacteriological study of fifty institutional inmates. Brit. Dent. J. 75: 247-255; 273-281; 301-309. (Nutrition Abst. and Rev. 13: 636, 1944)
- Wiehl, D.G. 1942. Medical evaluation of nutritional status. VII. Diets of high school students of low income families in New York City. Milbank Mem. Fund Quart. 20: 61-82.
- Wiehl, D.G. 1944. Medical evaluation of nutritional status. 15. Caloric intake of high school students in New York City. Milbank Mem. Fund Quart. 22: 5-40.
- Widdowson, E.M. and McCance, R.A. 1942. The war and school-boys' food. Lancet. 243: 689-692.
- Youmans, J.B., Patton, E.W. and Kern, R. 1942. Surveys of the nutrition of populations, description of the population, general methods and procedures, and the findings in respect to the energy principle (calories) in a rural population in middle Tennessee. Amer. J. Pub. Health. 32: 1371-1379; 33: 58-72.

ROOM USE ONLY

ROOM USE ONLY

Mar 10 59

~~XXXXXXXXXX~~

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03082 2542