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Dental Caries Experience Among Selected Population Groups in the State of Oregon

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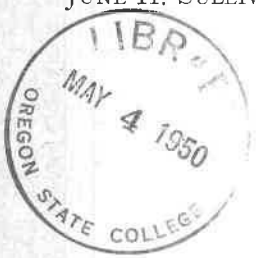

Agricultural Experiment Station, School of Home Economics.
Oregon State College, Corvallis, and the
Bureau of Human Nutrition and Home Economics,
United States Department of Agriculture,
United States Public Health Service, and the
Western Regional Research Group,
Cooperating

FOREWORD

In 1945, the Extension Women's Council of Oregon was instrumental in obtaining a grant of $20,000 from the Oregon Legislature for a two-year period for a study on the relationship between nutrition and dental caries. In 1947 the Legislature appropriated a second grant of $20,000 and in 1949 a third grant of $15,000 for the continuation of this research.

This money was allocated to the School of Home Economics at Oregon State College with the specification that the research be done under the direction of the Department of Foods and Nutrition.

In October 1948, it was found that the research program at Oregon State College could be enlarged greatly because of Federal cooperation. Of money appropriated, $40,000 was allocated to the Western Region for a study of the nutritional status of population groups in selected areas of the West. The states concerned in this study are: Oregon, Washington, California, Montana, Idaho, Colorado, Utah, Arizona, and New Mexico.

Wm. A. Schoenfeld

Dean and Director of Agriculture

Acknowledgments

Appreciation is expressed to the members of the Dental Advisory Committee, Dr. Harold J. Noyes, Dean, University of Oregon Dental School, Dr. O. T. Wherry, member of the Oregon State Board of Health, and Dr. E. R. Abbett, representative of the Oregon State Dental Association, for their helpful suggestions and criticisms in the planning of these studies and the interpretation of the results.

This investigation was made possible through appropriations by the Oregon State Legislature in 1945 and 1947 for research under the direction of the Department of Foods and Nutrition, School of Home Economics. The Extension Women's Council of the State of Oregon was instrumental in obtaining the fund. This study was also a part of the Western Regional Research Project on the Nutritional Status of Population Groups in Selected Areas of Oregon with the cooperation of the Oregon Agricultural Experiment Station. It was financed in part from funds appropriated under the Research and Marketing Act of 1946. The cooperation and assistance of the Bureau of Human Nutrition and Home Economics, U. S. Department of Agriculture, and the U. S. Public Health Service are acknowledged.

Part of the material contained in this publication appeared originally in the *Journal of Dental Research*, and part in *Oral Surgery, Oral Medicine, and Oral Pathology*.

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INTRODUCTION

The value of the epidemiological method as a tool in studying dental caries and some of the factors which may have an influence on the prevalence and incidence rates of the disease has been greatly enhanced during the past decade by investigations among population groups of different racial, national, and geographic backgrounds. From numerous reports on this subject in the literature, valuable data have been presented which, when they are put together, tend to create a pattern which reveals some of the characteristics peculiar to dental caries attack and also some of the factors which do or may have a bearing on caries resistance. Studies on caries experience conducted among the same age groups of people living in different geographic areas of the United States revealed that there are wide differences in the attack rates of the disease among them. As an explanation for this variability, the effect of several extrinsic and intrinsic factors on dental caries experience has been analyzed.

In a recent report[1] on caries prevalence (decayed and missing teeth) among draftees from all the states, it was pointed out that the State of Oregon occupied the fifth highest position among the forty-eight states. In view of this fact, and because there were no detailed data available concerning the dental condition of the people of the State of Oregon, a number of studies were undertaken for the purpose of finding the caries experience among selected groups of people and also some of the possible etiological factors which influence it.

These studies, which are described in the present publication, were divided into three phases: (1) the incidence of dental caries among freshman students at Oregon State College, (2) geographic variations of dental caries in Oregon, and (3) dental caries among institutionalized children.

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I. THE INCIDENCE OF DENTAL CARIES AMONG FRESHMAN STUDENTS AT OREGON STATE COLLEGE

The subjects of this part of the investigation were freshman students of Oregon State College who, according to the registrar's records, were residents of the State and did not serve in the Armed Services during the last war. The purpose of eliminating nonresidents and veterans was to have as homogeneous a group as possible.

The dental examination was done by means of mouth mirror and explorers in good, natural light combined with a dental spotlight. Posterior bite-wing radiographs were taken of each student. An illuminator and magnifying glass were employed for viewing the radiographs. Pits and fissures were listed as carious if the explorer caught and only when a carious lesion was actually found by careful examination. Observations were not made for third molars. All missing teeth were assumed to have been lost because of extensive caries, except in a few cases where the subject upon questioning stated other reasons, for example, lost by accident or congenitally missing. In these instances, the missing teeth were not listed. All students were examined by one of us (D.M.H.), and this fact adds more uniformity to the collected material, as the method of examination was the same for all the subjects.

The following items were recorded on the dental examination form: (1) number of teeth which had been filled; (2) number of missing teeth; (3) number of teeth indicated for extraction because of extensive caries; (4) number of cavities indicated for filling detected by explorer, and (5) number of cavities indicated for filling detected by radiographs.

The dental caries experience was measured by counting the number of filled teeth, missing teeth because of caries, teeth indicated for extraction, and teeth with untreated dental caries indicated for filling. The term "DMF" (Decayed, Missing, Filled) was used to designate past and present caries experience for teeth and tooth surfaces.

Findings

The sex and age distributions of the 582 freshman students examined are given in Table 1. There are more women than men in all age groups. Most of the students fell within the 18-years-old group. In the age group 17 and under, only one student was sixteen, while in the age group 20 and over, most of the students were

Table 1. NUMBER OF FRESHMAN STUDENTS AT OREGON STATE COLLEGE GIVEN DENTAL EXAMINATION, BY SPECIFIED AGE AND SEX GROUPS

Freshman students	Age last birthday				All ages
	17 years and under	18 years	19 years	20 years and over	
Men	13	172	39	11	235
Women	21	214	82	30	347
Both sexes	34	386	121	41	582

20 years old with only a few above this age. All of the counties of the State of Oregon except Grant and Wallowa were represented in the sample. Counties such as Multnomah, Marion, Benton, and Linn, where larger cities and towns are located, had a greater number of students attending Oregon State College. Four of the 582 students were found caries-free.

The data given in Table 2 provide information as to the dental caries experience (DMF) in terms of teeth and tooth surfaces per student. As can be seen, the average number of DMF teeth and tooth surfaces increases with the chronological age of the student.

Table 2. NUMBER OF DMF PERMANENT TEETH AND TOOTH SURFACES BY SPECIFIED AGE GROUPS OF 582 FRESHMAN STUDENTS AT OREGON STATE COLLEGE. RATES ARE EXPRESSED PER STUDENT

Permanent teeth	Age last birthday				All ages
	17 years and under	18 years	19 years	20 years and over	
	Average	*Average*	*Average*	*Average*	*Average*
Number of DMF teeth	13.00	14.28	14.50	14.68	14.12
Number of DMF surfaces	28.71	33.51	36.02	35.37	33.40

The average number of DMF teeth of the 17-year-old student was 13.0 and increased to 14.7 at the age of 20 years. The number of tooth surfaces increased from an average of 28.7 at the age of 17 to approximately 36.0 at the age of 20 years.

In order to be able to compare these data with the findings of surveys conducted in other parts of the country, it was necessary to eliminate the carious lesions detected by means of bite-wing radiographs which have contributed to the DMF teeth rates reported. Table 3 shows the numbers of DMF teeth, exclusive of carious lesions detected by radiographs, of freshman students at Oregon State College as compared with high school students from Hagerstown, Md., San Francisco, and New York City.[2] On this basis, the 17-year-old student at Oregon State College had an average of 12.2

Table 3. COMPARISON OF AVERAGE NUMBER OF DMF TEETH PER PERSON BY SPECIFIED AGE GROUPS IN OREGON,* HAGERSTOWN, MD., SAN FRANCISCO, AND NEW YORK CITY

Locality	Age last birthday			
	17 years	18 years	19 years	20 years
	Average	*Average*	*Average*	*Average*
Oregon	12.24	13.51	13.93	14.24
Hagerstown, Md.	7.73	8.72	9.25	.....
San Francisco	7.7	8.3	.....	.....
New York City	7.99	8.69	6.94	.....

* To make the foregoing comparison, it was necessary to determine the DMF teeth exclusive of the carious lesions detected by posterior bite-wing radiographs.

DMF teeth while his counterpart in Hagerstown, San Francisco, and New York City had an average of approximately 8.0 DMF teeth. A similar difference was also observed in the other age groups.

There are reports in the literature [3 4] showing that girls have higher dental caries experience rates than boys of the same chronological age. This is also demonstrated in Table 4. The 582 fresh-

Table 4. NUMBER OF DMF PERMANENT TEETH AND TOOTH SURFACES BY SPECIFIED AGE AND SEX GROUPS OF 582 FRESHMAN STUDENTS AT OREGON STATE COLLEGE. RATES ARE EXPRESSED PER STUDENT

Permanent teeth	Age last birthday				All ages
	17 years and under	18 years	19 years	20 years and over	
	Average	*Average*	*Average*	*Average*	*Average*
Men					
DMF teeth	13.00	14.07	13.51	13.82	13.60
DMF surfaces	28.23	32.88	33.05	32.36	31.63
Women					
DMF teeth	13.00	14.45	14.96	15.00	14.35
DMF surfaces	29.00	34.01	37.43	36.47	34.23

man students were divided according to sex and age distribution, and their DMF teeth and tooth surfaces were calculated. It is evident from this table that in all age groups the dental caries experience of the women was higher than that of men. This does not mean that females are more susceptible to the disease than males. It has been shown[5] that this phenomenon is due to the fact that the teeth of girls erupt earlier than those of boys and therefore they are exposed longer to the factors which influence the occurrence of the disease.

Table 5 gives a picture of the past and present caries experience of the subjects by specified age and sex groups. Although women experienced higher DMF teeth and tooth surfaces than men (as was shown in Table 4), their mouths, nevertheless, were in better condition. In general, they had fewer missing teeth, fewer teeth requiring extraction, and fewer open cavities requiring filling. This is rather

Table 5. NUMBER OF FILLED TEETH, EXTRACTED TEETH, TEETH REQUIRING EXTRACTION, AND CAVITIES REQUIRING FILLING OF 582 FRESHMAN STUDENTS OF OREGON STATE COLLEGE. RATES ARE EXPRESSED PER STUDENT BY SPECIFIED AGE AND SEX GROUPS

Permanent teeth	Age last birthday				All ages
	17 years and under	18 years	19 years	20 years and over	
	Average	*Average*	*Average*	*Average*	*Average*
Men					
Filled	8.77	10.19	10.56	9.18	9.68
Extracted	.46	.66	.72	1.82	.92
Requiring extraction	0.00	.10	.05	.18	.08
Cavities requiring filling	7.46	6.72	5.13	5.18	6.12
Women					
Filled	10.57	11.71	12.05	11.73	11.52
Extracted	.43	.57	1.18	1.23	.85
Requiring extraction	.10	.03	.02	.10	.06
Cavities requiring filling	4.71	5.11	4.49	4.37	4.67

difficult to explain on the basis that women are more conscious of the significance of dental health. Presumably, it is because women take better care of their teeth for esthetic reasons. Klein and Palmer,[6] after studying the dental status of school children of forty communities in New Jersey, concluded that the economic status of the community in which the children lived did not affect the incidence of dental caries, but that, on the other hand, it influenced the amount of dental service given to the individual. The more prosperous the community was, the greater the amount of dental care received. This means that more teeth are saved by fillings and less are neglected to such an extent as to require extraction. As has been shown in Table 3, the high school children in Hagerstown, Md., had a lower rate of DMF teeth than freshman students at Oregon State College. On the other hand, the students at Oregon State College showed fewer teeth missing and also fewer teeth requiring extraction than their counterparts in Hagerstown, Md.[7] (Table 6). This difference can probably be attributed to the better economic status of the families

Table 6. NUMBER OF MISSING TEETH AND TEETH REQUIRING EXTRACTIONS AMONG 582 FRESHMAN STUDENTS AT OREGON STATE COLLEGE AND 1,841 HIGH SCHOOL CHILDREN AT HAGERSTOWN, MD. RATES ARE EXPRESSED PER SUBJECT BY SPECIFIED AGE GROUPS

Permanent teeth	Age last birthday			
	17 years	18 years	19 years	20 years
	Average	*Average*	*Average*	*Average*
Oregon				
Missing	0.45	0.62	0.95	1.53
Extraction indicated	.05	.07	.04	.14
Hagerstown, Md.				
Missing	1.27	1.80	2.78	.....
Extraction indicated	.15	.21	.16	.....

from which the college students come. At the same time, such factors as better understanding of the importance of dental health and better distribution of dentists throughout the state may have influenced it.

From previous reports,[8 9 10] the importance of including radiographs in the dental examination as a diagnostic tool for the detection of carious lesions has been demonstrated. Table 7 shows the total

Table 7. COMPARISON OF CAVITIES REQUIRING FILLING DETECTED BY MEANS OF CLINICAL AND X-RAY EXAMINATIONS OF 582 FRESHMAN STUDENTS AT OREGON STATE COLLEGE. RATES ARE EXPRESSED PER STUDENT

	Cavities
Average total number	5.50
Average number detected by explorer	3.83
Average number detected by radiograph	1.67
Per cent detected by radiograph	30.36

number of cavities per student requiring filling as well as the number of cavities which were detected by explorer and by the taking of posterior bite-wing radiographs. On the average, there are 5.5 cavities per student requiring filling. Of these, 3.8 were found by using the explorer alone, and 1.7 by taking posterior bite-wing radiographs. In other words, 30.4 per cent of the cavities requiring filling would have been missed if posterior bite-wing radiographs had not been taken. This is significant, although the number of cavities which could be missed if bite-wing radiographs are not included in the examination may fluctuate considerably, depending on the ability of the examiner as well as the time devoted for each examination.

One of the aims of this study was to try to find variations in the caries experience of students coming from the different geographic regions of the State with the thought of further local investigation. For this purpose the State of Oregon was divided into six geographic areas (Figure 1): Coast, Willamette Valley, Blue Mountains, Southern Oregon, Columbia Basin, and Central Oregon. Statistical treatment of the data* revealed that the students from the Coast region showed a high and those from the Central Oregon region a low dental caries experience.

* Appreciation is expressed to Dr. Jerome Li, Department of Mathematics, Oregon State College, for his suggestion of using the analysis of variance in the treatment of the data.

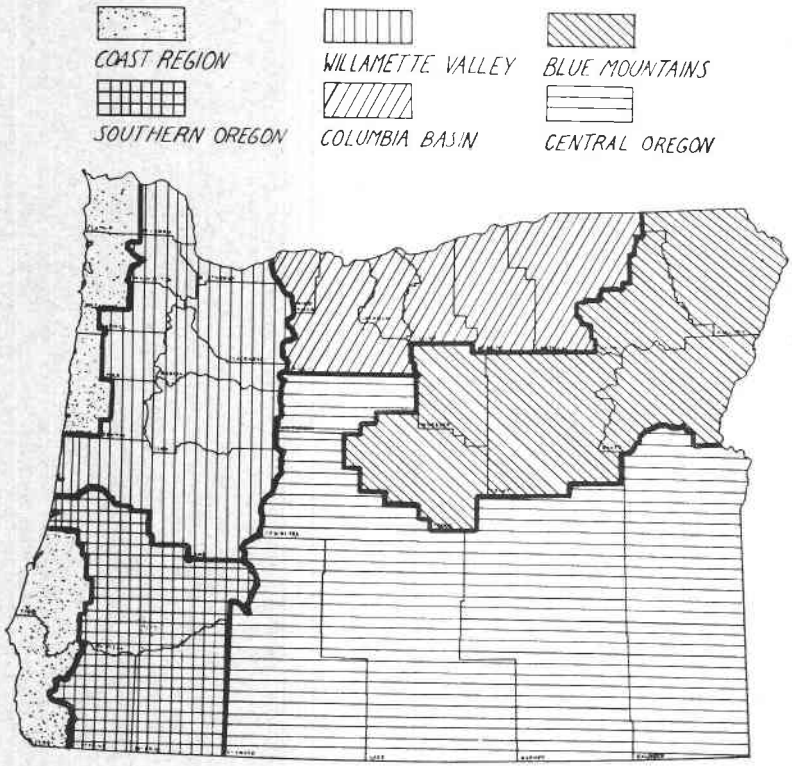

Figure 1. Geographic Division of the State of Oregon.

2. GEOGRAPHIC VARIATIONS OF DENTAL CARIES IN OREGON

On the basis of the above described preliminary investigation on the caries experience of freshman students, a local study was undertaken in the Coast and Central Oregon regions which aimed to find the dental caries attack rate of a selected group of people of these areas, and also to consider some of the environmental factors which may have influenced it.

Dental examinations were conducted in two counties in each of the geographic areas. In the Coast region the counties of Clatsop and Coos were investigated, and in the Central Oregon region the counties of Deschutes and Klamath. These counties were selected on the basis of their better local health facilities and organization, and also because they were more densely populated as compared with the other counties within the two regions.

The subjects of the investigation were white school children 14, 15, and 16 years of age. In order to have a homogeneous group, the dental examination was given only to those children who were native born and reared. A child was classified as native born and reared if, during the first eight years of his life, no breaks occurred in continuity of residence within his native county which totaled more than one month in any one calendar year, and also if after his eighth birthday and up to the time of the examination he was not absent from the county for a length of time which totaled more than three months in any calendar year. Children meeting the above requirements were examined from almost all of the schools in each one of the four counties visited. A public health nurse made the contacts with the schools and explained to the staff the purpose of the investigation. The eligibility of the subjects was determined in the classroom. Those of the children who met the requirements were given a slip for their parents to sign, as the parental consent was necessary for the examination. At the time of the examination the child was again questioned regarding previous residence. Arrangements as to the number of children and time of examination for each day were also made by the public health nurse. The total number of children examined in any one day was not more than twenty-four, and on the average a period of fifteen minutes was spent for each child.

The dental examination was done by means of mouth mirror and explorers in front of a small window in a trailer. The dental spotlight was used for auxiliary light. Posterior bite-wing radiographs, one for each side, were taken of most of the children. The

dental findings were called out to a dental assistant who made appropriate markings on a dental record. Items for which observations were made included: (1) number of filled teeth; (2) number of missing teeth; (3) number of carious teeth indicated for filling; (4) number of carious teeth indicated for extraction; (5) number of carious surfaces indicated for filling detected by clinical examination, and (6) number of carious surfaces indicated for filling detected by radiographs. A separate record was set up for observations of cases of hypoplasia.

All examinations were made by one examiner (D.M.H.), a fact which adds uniformity to the collected data, as the method employed for the examination of all the subjects was the same.

The carious lesions recorded were those which can be usually observed on a careful clinical examination. A grayish white or white spot on the enamel was considered a carious lesion if the explorer caught when passed lightly over the surface. Pits and fissures were listed as carious if the explorer caught and only when upon careful examination a carious lesion was actually found. Observations were not made for third molars and deciduous teeth, a few of which were encountered. All missing teeth were assumed to have been lost because of extensive caries except in a few cases where the subject upon questioning stated other reasons—for example, lost by accident or extracted because of orthodontic treatment. In these instances, the missing teeth were not listed.

The dental caries experience was measured by counting the number of filled teeth, missing teeth because of caries, teeth indicated for extraction, and teeth with untreated dental caries indicated for filling. The symbol "DMF" was used to designate past and present caries experience for teeth and tooth surfaces.

Table 8. PERCENTAGE OF NATIVE BORN AND REARED SCHOOL CHILDREN ELIGIBLE FOR EXAMINATION AND PERCENTAGE EXAMINED BY SEX IN THE THREE AGE GROUPS COMBINED

County	Eligible			Examined		
	Boys	Girls	Both sexes	Boys	Girls	Both sexes
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Coast						
Clatsop	32	27	29	55	59	57
Coos	34	34	34	68	66	67
Central Oregon						
Deschutes	22	27	24	39	65	53
Klamath	24	24	24	61	64	62

Findings

The material presented in Table 8 gives the percentage of the total number of school children, by sex, in the three combined age groups of the four counties under investigation who met the standards set for eligibility in the examination, and also the percentage of the eligible ones examined. As can be seen, the percentage of children eligible for examination is rather similar in the four counties. Furthermore, the number of eligible children of both sexes given the examination is well over 50 per cent of the total in all the counties with the exception of boys in Deschutes County. These two factors greatly strengthen the homogeneity of the subject population and the significance of the findings.

The total number of children examined was 741. Their distribution by age, sex, county, and geographic region is given in Table 9.

Table 9. AGE AND SEX DISTRIBUTION OF 741 NATIVE BORN AND REARED SCHOOL CHILDREN EXAMINED IN TWO GEOGRAPHIC REGIONS OF OREGON

County	Age last birthday			
	14 years	15 years	16 years	All ages
COAST				
Clatsop				
Boys	37	23	32	92
Girls	35	30	20	85
Both sexes	72	53	52	177
Coos				
Boys	47	55	27	129
Girls	46	34	33	113
Both sexes	93	89	60	242
CENTRAL OREGON				
Deschutes				
Boys	11	10	16	37
Girls	25	23	23	71
Both sexes	36	33	39	108
Klamath				
Boys	36	37	29	102
Girls	39	42	31	112
Both sexes	75	79	60	214
BOTH REGIONS				
Boys	131	125	104	360
Girls	145	129	107	381
Both sexes	276	254	211	741

The number of subjects by sex in all age groups was about evenly divided in the counties of Clatsop, Coos, and Klamath. In Deschutes County the ratio of girls to boys was 2 to 1.

The data shown in Table 10 reveal the dental caries experience (DMF) in terms of teeth and tooth surfaces per child by specified age groups. The figures given in this table and subsequent tables are exclusive of the carious lesions detected by posterior bite-wing radio-

Table 10. NUMBER OF DMF PERMANENT TEETH AND TOOTH SURFACES OF 741 NATIVE BORN AND REARED SCHOOL CHILDREN BY SPECIFIED AGE GROUPS IN TWO GEOGRAPHIC REGIONS OF OREGON. RATES ARE EXPRESSED PER CHILD

County	Age last birthday			
	14 years	15 years	16 years	All ages
	Average	*Average*	*Average*	*Average*
COAST				
Clatsop				
DMF teeth	13.3	15.1	15.3	14.4
DMF surfaces	30.1	35.8	36.4	33.6
Coos				
DMF teeth	11.1	13.6	13.9	12.7
DMF surfaces	24.0	30.6	30.7	28.1
CENTRAL OREGON				
Deschutes				
DMF teeth	9.6	12.0	12.3	11.3
DMF surfaces	21.4	25.5	28.2	25.1
Klamath				
DMF teeth	7.5	9.6	10.0	9.0
DMF surfaces	15.2	19.2	20.7	18.2

graphs. The average number of DMF teeth and tooth surfaces increases simultaneously with the chronological age of the subjects. This is a characteristic peculiar to dental caries attack and has been found to vary with different population groups depending on several extrinsic and intrinsic factors.

As can be seen from the table, the dental caries experience of the subjects in all age groups varied from county to county. The average number of DMF teeth of the 14-year-old child in Clatsop County was 13.3 while his counterpart in Coos County was 11.1, a difference of 2 DMF teeth. The same difference was observed in the 14-year-old children between the counties of Deschutes and Klamath of the Central Oregon region. On the other hand, a difference of 1.7 DMF teeth was observed between the rates of all ages of Clatsop and Coos counties, while the difference in the counties of Deschutes and Klamath between the rates of all ages rises to 2.3 DMF teeth. Moreover, if we take the DMF teeth rate of the 14-year-old in Clatsop County of the Coast region, which was 13.3, and compare it with that of his counterpart in Klamath County of the Central Oregon region, which was 7.5, we observe a difference of 5.8 DMF teeth. A similar difference is observed in the remaining two age groups of these two counties. The same wide variability in the number of DMF tooth surfaces is also present among the school children of the two geographic regions.

The following number of children were found to be caries-free in the four counties: Clatsop, none; Coos, 3; Deschutes, 3; and Klamath, 8.

From all the foregoing findings it is shown that a difference of varying degree exists in the incidence of dental caries among school children in two geographic areas of the State of Oregon. The more pronounced disparity is observed between Clatsop County of the Coast region and Klamath County of the Central Oregon region. The DMF teeth rate of all ages of every county was compared with that of each one of the other three and the difference was found to be statistically significant. The difference in the combined rates of all ages between the two regions (3.7 DMF teeth) was also statistically significant.

In order to compare the data of this investigation with the findings of surveys conducted in other parts of the county, Table 11 was

Table 11. COMPARISON OF AVERAGE NUMBER OF DMF TEETH PER PERSON BY SPECIFIED AGE GROUPS OF FOUR COUNTIES IN OREGON, HAGERSTOWN, MD., SAN FRANCISCO, AND NEW YORK CITY*

Locality	Age last birthday		
	14 years	15 years	16 years
	Average	*Average*	*Average*
Clatsop, Oregon	13.3	15.1	15.3
Coos, Oregon	11.1	13.6	13.9
Deschutes, Oregon	9.6	12.0	12.3
Klamath, Oregon	7.5	9.6	10.0
Hagerstown, Md.	5.6	6.6	7.2
San Francisco	5.6	6.5	7.2
New York City	5.8	6.9	7.4

* History of previous residence of the children was not taken into account for eligibility in the examination in Hagerstown, Md., San Francisco, and New York City.

prepared. As can be seen, the average number of DMF teeth of the school children of all age groups in Clatsop County, Oregon, was more than twice as much as that of the school children of the same age groups in Hagerstown, Maryland, San Francisco, and New York City.[2] Progressively smaller differences were noted between the other three counties of Oregon and the three places mentioned, the least one being of that in Klamath County where, on the average, a difference of more than two DMF teeth was observed. However, it should be remembered that for the children examined in the three other localities of the country no standards were set regarding history of previous residence.

The relationship between sex and caries prevalence has been pointed out in the past during studies of different population groups.[3 4] The DMF teeth and tooth surfaces of the 741 school children were calculated by age and sex in the four counties under investigation and the rates are shown in Table 12. It is apparent from this table that in general boys experience a lower rate of attack than girls of the same chronological age. This trend has been at-

Table 12. Number of DMF Permanent Teeth and Tooth Surfaces of 741 Native Born and Reared School Children by Specified Age and Sex Groups in Two Geographic Regions of Oregon. Rates Are Expressed per Child

County	Age last birthday							
	Boys				Girls			
	14 years	15 years	16 years	All ages	14 years	15 years	16 years	All ages
	Average	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*
Coast								
Clatsop								
DMF teeth	12.3	12.7	15.6	13.5	14.2	17.0	15.0	15.4
DMF surfaces	28.7	27.3	37.0	31.2	31.5	42.3	35.4	36.2
Coos								
DMF teeth	10.4	13.3	13.5	12.3	11.7	14.1	14.2	13.2
DMF surfaces	21.5	29.5	27.6	26.2	26.5	32.3	33.2	30.2
Central Oregon								
Deschutes								
DMF teeth	7.4	10.0	10.3	9.3	10.6	12.9	13.7	12.3
DMF surfaces	17.0	23.0	23.0	21.2	23.3	26.7	31.5	27.1
Klamath								
DMF teeth	6.3	9.9	10.1	8.7	8.6	9.2	10.0	9.2
DMF surfaces	13.0	20.6	20.3	17.9	17.2	17.9	21.0	18.5

Table 13. Dental Caries Experience of 741 Native Born and Reared School Children in Two Geographic Regions of Oregon. Rates Are Expressed per Child by Specified Age and Sex Groups

County	Age last birthday							
	Boys				Girls			
	14 years	15 years	16 years	All ages	14 years	15 years	16 years	All ages
	Average	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*
COAST								
Clatsop								
Filled	7.2	7.4	9.8	8.2	9.9	11.9	10.7	10.8
Missing	0.7	1.0	1.1	0.9	0.8	1.7	1.0	1.2
Extraction indicated	0.2	0.3	0.5	0.3	0.1	0.2	0.1	0.2
Filling indicated	6.2	5.3	6.6	6.1	5.2	6.2	5.8	5.7
Surfaces indicated for filling	9.3	7.5	9.3	8.8	7.5	8.4	8.6	8.1
Coos								
Filled	4.6	7.7	6.3	6.3	6.6	9.5	9.1	8.2
Missing	0.6	0.7	1.0	0.7	0.6	1.0	1.0	0.8
Extraction indicated	0.3	0.3	0.2	0.3	0.3	0.1	0.2	0.2
Filling indicated	6.1	6.6	7.5	6.6	6.8	6.0	5.9	6.3
Surfaces indicated for filling	8.6	9.5	10.3	9.3	9.5	8.5	8.8	9.0
CENTRAL OREGON								
Deschutes								
Filled	3.4	6.6	7.1	5.9	7.8	9.9	8.6	8.7
Missing	0.7	1.0	1.1	0.9	0.8	0.9	1.2	1.0
Extraction indicated	0.3	0.2	0.1	0.2	0.2	0.0	0.1	0.1
Filling indicated	3.7	3.5	3.1	3.4	2.9	3.7	5.0	3.9
Surfaces indicated for filling	5.5	4.5	4.4	4.7	3.8	4.5	7.1	5.1
Klamath								
Filled	2.4	5.5	4.2	4.0	4.9	5.0	4.8	4.9
Missing	0.8	1.1	0.8	0.9	0.6	0.6	1.0	0.7
Extraction indicated	0.2	0.2	0.1	0.1	0.2	0.1	0.5	0.3
Filling indicated	3.6	4.4	6.0	4.5	3.9	4.3	4.5	4.3
Surfaces indicated for filling	5.0	6.3	9.1	6.6	5.7	6.1	6.1	6.0

tributed to differences in post-eruptive tooth age between boys and girls[5]—that is, the teeth of girls in general erupt earlier than those of boys and hence are exposed longer to the factors responsible for the occurrence of the carious lesions.

Another point of interest which was observed from this table is a tendency in both sexes for a considerable increase in rate of caries experience between ages 14 to 15 as compared with that of age groups 15 to 16. Although a single examination does not show when dental caries occurred, this phenomenon can possibly be explained as due to the increased susceptibility to dental caries during the period of early adolescence. Such an increase can be measured accurately in longitudinal studies of individual cases carried over a period of years, because when large numbers of children are considered, a smooth curve is usually obtained which obliterates the peaks of caries activity. Previous studies by Hanke,[11] Noyes,[12] and Massler[13] have also shown a rapid rise in the formation of cavities during the early teen ages. It is generally agreed by these investigators that the increased susceptibility is associated with the adolescent phase of rapid growth which precedes puberty and constitutes a problem of special clinical consideration. The data presented in Table 12 seem to confirm this observation.

A detailed presentation of the four items comprising the dental caries experience of the subjects by specified age and sex groups is given in Table 13. The teeth of girls have received better care, although, as was shown in Table 12, they have experienced higher rates of DMF teeth and tooth surfaces than the boys. In girls, generally, the number of missing teeth and teeth requiring extraction because of extensive caries is similar to that of boys; at the same time the number of carious teeth and tooth surfaces requiring filling is less. This means that girls give earlier attention to their dental needs and, therefore, more teeth are saved by fillings. The only explanation that can be offered is that girls generally are more conscious of their dental needs for esthetic reasons.

Another observation of special interest in the two regions is the degree of dental care which had been received by the children of the four counties. Although the subjects of Clatsop County had higher rates of caries experience than those of Coos County, they nevertheless showed fewer carious teeth and tooth surfaces requiring filling, whereas the opposite would have been expected. Similarly, the children of Deschutes County who experienced higher rates of caries attack showed fewer carious teeth and tooth surfaces in need of filling than were observed among those children of Klamath County with lower rates.

Table 14. COMPARISON OF CARIOUS SURFACES REQUIRING FILLING DETECTED BY MEANS OF CLINICAL AND X-RAY EXAMINATIONS OF 505 NATIVE BORN AND REARED SCHOOL CHILDREN IN TWO GEOGRAPHIC REGIONS OF OREGON. RATES ARE EXPRESSED PER CHILD

	Carious surfaces
Average total number	9.9
Average number detected by explorer	7.4
Average number detected by radiograph	2.5
Per cent detected by radiograph	25.3

Of the 741 children examined, posterior bite-wing radiographs, one for each side, were taken of 505 of them. Table 14 shows that on the average each child had 9.9 carious surfaces which needed filling. Of those, 7.4 were detected by explorer alone and 2.5 by taking posterior bite-wing radiographs. In other words, 25.3 per cent of the carious surfaces requiring filling would have been missed if radiographic examination had not been included. This percentage seems high, but the practicability of including radiographic examinations in epidemiological surveys on dental caries for the purpose of determining the dental status of population groups can be questioned. It has been shown in previous studies[10] [14] that radiographs, in addition to a careful examination by mirror and explorer, do not materially change the results of such surveys.

As a part of the dental examination of the school children observations for cases of enamel hypoplasia were included. It has been reported in the literature of recent years[15] that hypoplasia is not restricted to certain geographic locations, as mottled enamel is, but is ubiquitous in its occurrence and also, because of its high incidence, constitutes a public health problem which needs further study. Sterling[16] found an incidence of 2.5 per cent among Negro school children. Sarnat and Schour[15] stated that enamel hypoplasia occurs in approximately 5 per cent of the school children of Chicago. Mellanby[17] examined children of Finnish Lapps and reported hypoplastic lesions in 3.9 per cent of them. Brucker[18] placed its incidence at 4 per cent among school children in Newark, New Jersey. In the present investigation of 741 school children no cases of enamel hypoplasia were observed. For this, no explanations can be advanced at the present time.

The data presented in this part of the investigation supply another link to the chain of epidemiological studies on dental caries among selected population groups. In most of the epidemiological studies on dental caries of school children in different parts of the country, no attempt was made to set up standards relative to pre-

vious residence of the subject population for eligibility in the examination. Notable exceptions are the studies of the fluorine-dental caries relationship[19 20 21] where only those children continuously exposed (native born and reared) to the common water supply were examined. In the present investigation we followed closely the procedure employed in the above-mentioned studies, and the examination was given only to those children who were classified as native born and reared. The main difference was that in this study the whole county was considered as the place of residence, while in the studies of fluoride domestic water and the prevalence of dental caries, the unit of residence was the city. The classification of school children as native born and reared on a county basis has some apparent shortcomings which are excluded when the city is considered as residence. Nevertheless, because of the elimination of the "circulation factor" to a certain degree, the findings obtained have a greater significance as compared with those of investigations where no consideration was given to the subject's previous residence. This is particularly true in the case of the states of the Pacific Coast where the current of westward migration in the last few years was considerable. Studies like the present one offer better possibilities for clarification of the role played by some of the environmental and other factors in caries attack and resistance.

The findings of the present study reveal that the magnitude of the dental caries problem among school children living in two geographic areas of the same state varies considerably. From a public health point of view this fact seems to indicate that it is highly advisable and necessary to do further research in all the parts of the state with the thought of finding the prevalence of the disease in different geographic regions. As a result of such an investigation, areas of high rates of caries attack should be considered first for the application of preventive and corrective measures that are deemed necessary. Particularly this is true in view of the fact that existing facilities and personnel for public health dentistry are not adequate in most of the cases. Moreover, such an investigation will serve as a basis for appraising from time to time the effectiveness of the preventive and corrective measures which are used.

In an attempt to find an explanation for the differences in caries experience observed among the subjects examined, the following three factors were considered for investigation in each one of the four counties: (1) fluorine content and total hardness of the public water supplies, (2) ratio of dentists to population, and (3) climatological data.

1. Public water supplies

For the determination of the fluorine content and total hardness of the drinking waters of the four counties under investigation, a list of all the public water supplies currently in use throughout each one of the counties was secured from the Oregon State Board of Health. These water supplies fell into three categories: owned by cities, owned by water districts, and privately owned. From a total number of 75 public water supplies which were in operation in the four counties during the time of the examination, determinations for fluorine content and total hardness were made in 51 of them. This number represents two-thirds of all the public water supplies used by the different communities in the two geographic regions and includes the four county seats, almost all the towns, and several of the smaller communities of any appreciable size. On this basis, by far the greatest part of the population of each county consumed water from sources which have been investigated.

A single water sample collected at the time of the dental examination or shortly after was used in determining the fluorine content and total hardness of the public water supplies investigated.* The data presented in Table 15 give the location, source, amount of fluorine, calcium, magnesium, iron, and total hardness of each one of the communal waters analyzed in the four counties of two geographic regions of Oregon. As can be seen, the sources of all the public water supplies of the Coast region are surface waters, whereas ground waters prevail among those of the Central Oregon region. In general, the waters from the four counties showed no substantial differences in the content of constituents for which chemical analyses were made. The amount of fluorine present in the public water supplies of both geographic regions is negligible. Furthermore, on the basis of the figures on total hardness presented, almost all of the waters are classified as "soft,"[22] although there were marked differences in the calcium content and the total hardness in some of the water samples analyzed.

Inasmuch as satisfactory conclusions cannot be drawn regarding the dental caries experience of a population group and its relationship to the amount of fluorine or total hardness of the water based on a single sample collected at the time of the examination, a retroactive investigation of the public water supplies was undertaken. This was done in an attempt to find whether any changes in the source or

* The fluorine content was determined by means of color standards, W. A. Taylor and Co., Baltimore, Md. Calculations for total hardness were made according to "Standard Method for the Examination of Water and Sewage." American Public Health Association, 9th Ed., New York, 1946, p. 23. Miss June H. Sullivan performed the water analyses.

Table 15. Analyses of 51 Public Water Supplies in Four Counties of Oregon

Public water supply	Source of water supply	Fluoride (F)	Calcium (Ca)	Magnesium (Mg)	Iron (Fe)	Total hardness as $CaCO_3$
		Ppm	*Ppm*	*Ppm*	*Ppm*	*Ppm*
Coast Region						
Clatsop						
Arch Cape	Creek	0.0	2.8	4.1	0.00	24
Astoria	Creek	0.1	2.2	1.9	0.28	14
Brownsmead	Creek	0.1	3.3	0.5	0.06	10
Cannon Beach*	Spring	0.0	4.5	2.7	0.00	22
Clifton	Creek-River	0.0	4.4	2.1	0.00	19
Gearhart	River	†	†	†	†	†
Hammond	Creek-River	‡	‡	‡	‡	‡
Knappa	Creek	0.2	5.4	2.0	0.05	22
Rainbow Water System	Creek	0.0	2.3	1.4	0.10	11
Seaside	River	0.0	1.7	1.2	0.03	9
Svensen*	Creek	0.0	1.6	1.8	0.06	11
Warrenton	Creek-River	0.0	1.4	1.6	0.05	10
Wauna	River	0.0	14.5	3.7	0.11	52
Wave Crest	Creek	0.0	4.7	3.2	0.11	25
Westport Mill	Creek	0.0	1.4	1.5	0.00	10
Young's River*	Creek	0.0	4.5	1.0	0.17	16
Coos						
Bandon	Creek-Spring	0.0	1.1	1.8	0.08	10
Coos Bay	Creek-Spring	0.0	13.3	1.6	0.00	40
North Bend	Creek-Spring	0.0	13.3	1.6	0.00	40
Coquille	Creek	0.0	2.1	2.2	0.09	14
Eastside*	Creek-Spring	§	§	§	§	§
Empire	Lake	0.0	3.9	1.3	0.21	15
Myrtle Point	Spring-River	0.0	9.9	5.2	1.24	48
Powers	Spring-River	0.0	7.4	1.9	0.03	26
Sandford Heights*	Creek	‖	‖	‖	‖	‖

Table 15. Analyses of 51 Public Water Supplies in Four Counties of Oregon—*Continued*

Public water supply	Source of water supply	Fluoride (F)	Calcium (Ca)	Magnesium (Mg)	Iron (Fe)	Total hardness as $CaCO_3$
Central Oregon Region		*Ppm*	*Ppm*	*Ppm*	*Ppm*	*Ppm*
Deschutes						
Bend	Creek-Spring	0.2	3.0	1.4	0.00	13
Redmond	River	0.1	2.3	2.4	0.12	16
Shevlin*	Deep well	0.0	3.2	2.3	0.02	17
Sisters	Creek	0.2	4.4	1.8	0.00	18
Terrebonne	Deep well	0.0	26.3	17.5	0.00	138
Klamath						
Bly Water Company	Deep well	0.0	12.7	6.5	0.00	58
Cascade Summit	Creek	0.0	2.3	0.4	0.00	7
Chiloquin*	Deep well	0.0	2.0	1.8	0.00	12
Crater Lake National Park	Creek-Spring	0.0	4.3	0.7	0.05	14
Crescent Lake	Spring	0.1	6.7	2.0	0.00	25
Ellingson's Mill*	Well	0.0	35.0	30.0	0.02	211
Fairhaven Heights	Deep well	0.0	13.8	2.3	0.00	44
Gilchrist Timber Co.	Deep wells	0.0	3.4	2.1	0.00	17
Klamath Agency	Spring	0.2	3.0	1.5	0.00	14
Klamath Falls	Deep wells	0.0	9.5	4.2	0.02	41
Klamath View Auto Courts	Deep well	0.0	17.5	9.5	0.00	83
Lake O' Woods	Lake	0.0	3.6	0.7	0.02	12
Malin	Deep wells	0.0	24.2	21.0	0.00	147
Merrill*	Deep well	0.0	7.6	4.6	0.00	38
Modoc Point	Deep well	0.0	12.5	6.0	0.00	56
Smith Lumber Co.*	Deep well	0.1	21.0	3.5	0.00	67
Sprague River*	Deep wells	0.0	16.8	17.5	0.04	114
Stewart Lenox	Deep wells	0.0	41.4	8.0	0.00	136
Weyerhaeuser Mill	Deep well	0.0	10.7	1.7	0.02	34
Weyerhaeuser Camp No. 4	Deep well	0.0	11.1	7.8	0.00	60
Weyerhaeuser Camp No. 6	Deep well	0.0	8.3	3.1	0.05	34

* See: Changes in the Water Supplies (1932-1948).
† Supplied by Seaside.
‡ Supplied by Warrenton.
§ Supplied by Coos Bay-North Bend.
‖ Supplied by Coquille.

physical set-up of the public water supplies under consideration had occurred within the life period (1932-1948) of the population groups given a dental examination.

In general, the results of the investigation into the histories of the public water supplies, as far as could be ascertained, did not reveal evidence of extensive alterations of such nature. In only a few small communities changes in the source of the communal waters have been noted and these are listed below.

A point of particular consideration was to inquire whether or not a softening plant is or had been in operation in any one of the communal water supplies, since it is known that this lowers considerably the fluorine content and total hardness of the water.[20 21] The information gathered on this point did not disclose that such a treatment was applied to the water supplies at any period during the lifetime of the subjects examined.

Changes in the Water Supplies (1932-1948)

CLATSOP COUNTY: 1. CANNON BEACH, about 1938 a new spring was added to the source of the water supply. 2. SVENSEN, from 1932 to 1938 water from various wells was used. In 1939 as the community expanded all the wells were abandoned and the present source of water was installed. 3. YOUNG'S RIVER, the present source of water was put in operation in 1939. Prior to this year the community used individual sources of water which included wells, springs, and creeks.

COOS COUNTY: 1. EASTSIDE, from 1932 to 1939 there was no public water supply in this community. Individual wells were used as sources of drinking water. 2. SANDFORD HEIGHTS, during the period 1932-1939 the source of water supply was springs.

DESCHUTES COUNTY: 1. SHEVLIN, prior to 1942 the source of the water supply was a spring, but it was changed to deep well because the lumber company which owned the water supply moved to a new location.

KLAMATH COUNTY: 1. CHILOQUIN, prior to 1940 the source of the water supply was a river. ELLINGSON'S MILL, in 1944 one well was abandoned as a source of water because it dried up. 3. MERRILL, in 1939 a new deep well was added and the one formerly used was abandoned because of inadequate flow. 4. SMITH LUMBER CO., the mill started operating in 1941. From that time up to March 1946, when the present deep well was drilled, a deep well from the Kalpine Plywood mill served as the source of drinking water. 5. SPRAGUE RIVER, one deep well was used as the source of drinking water up to 1938 when it was abandoned. The present source consists of two deep wells which were put into operation, one in 1939 and the other in 1941.

2. Ratio of dentists to population

The extent of dental services available in the four counties is presented in the form of dentist-population ratios of two widely separated years within the lifetime of the subjects examined. These ratios have been computed for each county on the basis of the esti-

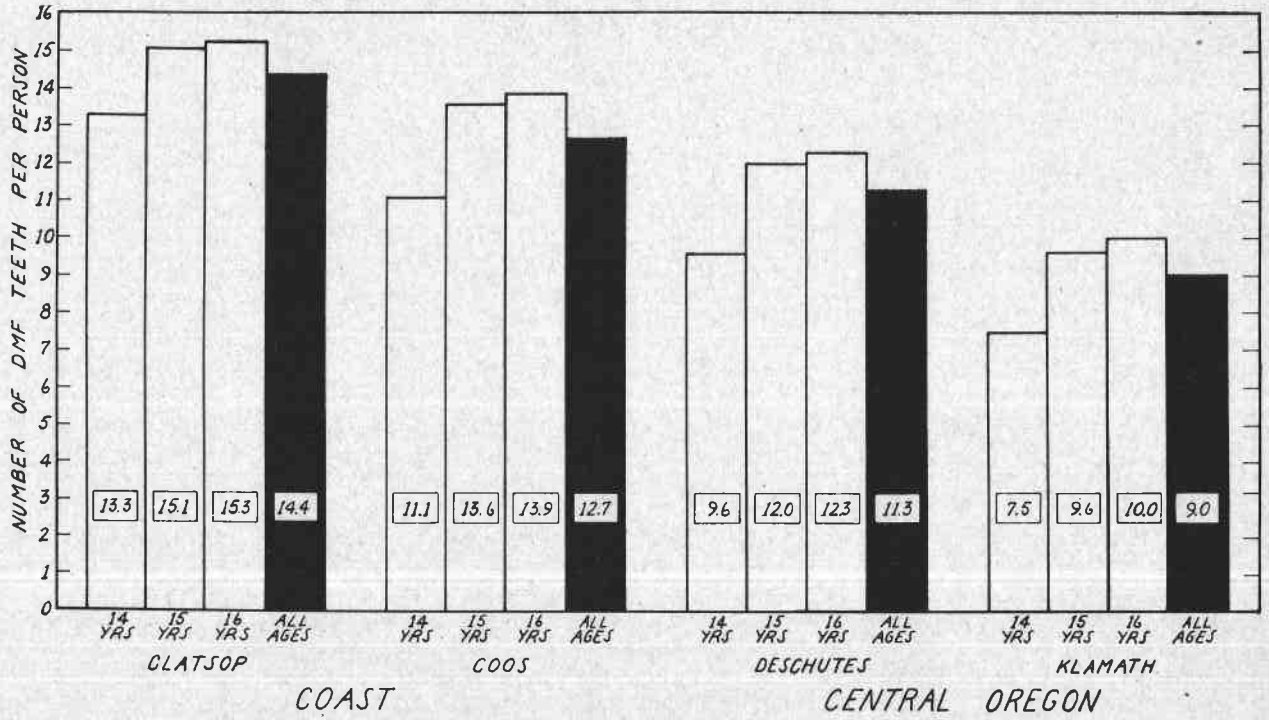

Figure 2. Dental Caries Experience of 741 School Children Ages 14, 15, and 16 in Four Counties of Oregon.

mated population and the number of practicing dentists during the years of 1940 and 1945.[23] In general, the information given in Table 16, supplemented by Figure 2, shows that a small dentist-population ratio does not necessarily decrease the prevalence of caries and, conversely, a large ratio does not tend to increase it. This tendency is particularly illustrated in the cases of Clatsop and Klamath counties.

Table 16. RATIO OF DENTISTS TO POPULATION FOR THE YEARS 1940 AND 1945 IN FOUR COUNTIES OF OREGON

County	Estimated population†	Number of dentists‡	Ratio
COAST			
Clatsop			
1940	24,786	16	1:1,549
1945	27,416	19*	1:1,443
Coos			
1940	32,568	16	1:2,036
1945	24,918	17*	1:1,466
CENTRAL OREGON			
Deschutes			
1940	18,728	15	1:1,249
1945	19,862	12*	1:1,655
Klamath			
1940	40,699	20	1:2,035
1945	40,132	16*	1:2,508

† The estimated population for 1940 was taken from the Twentieth Biennial Report, State Board of Health of Oregon.
‡ The number of dentists practicing in each county during 1940 was obtained from Dr. L. Boire, President, Oregon State Board of Dental Examiners.
* Based on 1947 register of dentists.

Table 17. SUMMARY OF CLIMATOLOGICAL DATA* (PERIOD 1932-1947) AND RANGE OF ALTITUDE OF TWO GEOGRAPHIC REGIONS OF OREGON

	Coast		Central Oregon	
	Clatsop County	Coos County	Deschutes County	Klamath County
Average number of clear days per year†	111	135	144	164
Average number of partly cloudy days per year†	109	74	96	94
Average number of cloudy days per year†	145	156	125	107
Range of altitude‡	5′ to 75′	9′ to 300′	2,870′ to 4,650′	4,065′ to 4,760′

* From U. S. Department of Commerce, Weather Bureau: Climatological Data, Oregon Section.
† Number of observation stations: Clatsop 4; Coos 5; Deschutes 3; Klamath 8.
‡ Based on elevations of the communities within each county.

3. Climatological data

A summary of the climatological data as well as the range of altitude for each one of the four counties is presented in Table 17. The average number of clear, partly cloudy, and cloudy days per year was calculated on the basis of information for the period 1932-1947 contained in the annual reports of the Weather Bureau, Oregon Section. It is evident from this table that, in general, the counties of the Coast region are characterized by fewer hours of sunshine than the counties of the Central Oregon region. The more pronounced variation in the condition of the sky is observed between the counties of Clatsop and Klamath, the former having an average number of 111 clear and 145 cloudy days per year and the latter an average number of 164 clear and 107 cloudy days.

Similarly, wide variations are also noted in the range of altitude between the two geographic regions. While the communities of the Coast counties lie within elevations not exceeding 300 feet, those of the Central Oregon counties are located at altitudes ranging from 2,870 to almost 5,000 feet above sea level.

Discussion

The evidence presented by Dean and his associates[24] from their investigation in twenty-one cities of four states has firmly established the existence of an inverse relationship between minute amounts of fluorides occurring naturally in public water supplies and the incidence of caries in children. On this basis, chemical analyses of communal waters for the determination of the fluorine content, as well as for other constituents, are a necessary part for the interpretation of the findings of an epidemiological study on dental caries among population groups. Prior to the present study, data on the fluoride concentrations in the public water supplies of Oregon were not available. In 1941 two areas of endemic dental fluorosis were reported but not verified.[25] In a recent investigation to determine the distribution of fluorine in the water supplies of the United States, an unidentified source of water in Jackson County of Oregon was mentioned as containing 1.5 ppm or more of fluorine.[26] Information obtained from another source* indicated that the fluorine content of the waters of a few localities situated in different parts of Oregon was negligible, except in three cases where a range of 0.6 to 0.8 ppm was reported.

The present results of the fluorine determinations supported by the retroactive investigation of the public water supplies do not point to this factor as being responsible for the observed differences in

* Oregon State Board of Health, personal communications.

caries experience among the subject population of the two geographic regions. Conclusions based on a single water sample are arguable since it is known that the mineral content of public water supplies varies, but in view of the fact that in Klamath County most of the communal waters are derived from ground waters which generally in analyses of repeated samples do not show marked changes in fluorine content,[20 21] the possibility of erroneous reasonings is not very likely. In the case of Clatsop, Coos, and Deschutes counties where surface waters are used, it seems reasonable, because of the high rates of caries experience noted among the subjects examined there, to state that even monthly analyses carried over a period of one year could not have shown any material differences in fluorine concentrations.

Reports in the literature of the past decade or so have suggested that hardness of public water supplies and the dental caries experience of population groups are inversely related.[27 28] As a result of recent studies on the fluorine-dental caries relationship, however, it was indicated that the caries-inhibitory factor was not the hardness but the presence of minute amounts of fluorine in the domestic waters.[24] The data on total hardness of the communal water supplies in the two geographic regions which were presented in Table 15 showed that in general the waters are classified as "soft." Previous analyses of public water supplies in a number of cities and towns located in different parts of the state also revealed that the waters of Oregon are generally classified as soft.* From the evidence at hand, it is obvious that the differences in caries experience among the subjects examined in the four counties cannot be explained on the basis of water hardness.

Since of the total number of public water supplies in the four counties two-thirds have been investigated, it is believed that omission in analyzing domestic water supplies of a few small communities as well as individual sources of water does not constitute a major shortcoming regarding the interpretation of the findings and the conclusions drawn.

The second factor considered for investigation dealt with the dentist-population ratios in the four counties. This was done with the thought of inquiring whether or not the differences in caries experience could possibly be interpreted on the basis of accessibility to dental care. From the data presented in Table 16 and Figure 2 it can be concluded that in the present study the caries attack rates in the two geographic regions have not been influenced by the availability of dental services. In a recent study of child health services in Oregon[29], it was also reported that in Clatsop County with the

* Oregon State Board of Health, personal communications.

highest DMF rates per person the number of dentists per 1,000 children was almost twice that of Klamath County where the subjects examined were found to be less vulnerable to caries. Although the amount of time devoted to the care of children by the dentists in each one of the four counties is not available, this lack of information does not seem to alter the conclusion drawn since it is known that in general services for children occupy only a small part of the time of practicing dentists.

In addition, per capita buying income has been comparatively high in recent years in Oregon.[29] Hence marked variations in the economic status of the communities affecting the ability of the average family to pay for dental services do not seem to have been responsible for the differences in caries experience observed among the subjects of the four counties.

In a number of studies which appeared in the literature of recent years, it was indicated that an inverse relationship exists between the amount of sunshine and the susceptibility to dental caries.[30 31 32 33] This is brought about by the formation of Vitamin D, which is necessary for proper calcification of bones and teeth, through the action of the ultraviolet rays of sunlight upon the provitamin present just beneath the surface of the skin.

Basically, this observation is in agreement with the accepted opinion that teeth formed at a period of Vitamin D deficiency are more prone to caries.[34] However, the evidence contained in the above-mentioned studies cannot be considered conclusive for two reasons: (1) the different factors which cause variations in the biological action of the ultraviolet rays of sunlight were not studied in detail and (2) the influence of other factors having a bearing on caries resistance was not taken into consideration.

It has been demonstrated that mere consideration of the hours or days of sunshine from observation made by the Weather Bureau cannot be taken as an indication of the value of the ultraviolet component of the sunlight.

Frawley[35] measured the ultraviolet content of the sunlight at three points in California, Sierra Nevada mountains (elevation 8,000 feet), Santa Barbara, and Fresno, which are located in about the same latitude but are widely different in altitude. The findings showed that because of local climatic conditions great variations in the amount of ultraviolet radiation existed. In Fresno, which is characterized by a high degree of solar energy, the sunlight was found to be deficient in the amount of ultraviolet rays because the haze which hangs over the valley where the city is located prevents their transmission.

Frawley and Brown[36] compared the readings of the ultraviolet radiation in the sunlight of two localities in central California, Auberry and Fresno, situated in the same latitude and only 40 miles apart. The main difference between the two was the altitude; Auberry lies 2,000 feet above sea level while the elevation of Fresno is only 300 feet. The observations disclosed that Auberry, being located at a higher altitude, above the hazy atmosphere of the San Joaquin Valley, showed higher readings than those noted in Fresno. The authors believed this to be an adequate explanation for the presence in Fresno of a large proportion of children with mild rickets who were examined there over a period of three years.

Earp[37] observed that the ultraviolet radiation of the sun in Baltimore, Maryland, and in Boulder, Colorado, is very similar during the summer months. However, because of higher humidity, clouds of smoke, and lower altitude, the winter radiation in Baltimore is only one-third that in Boulder.

Manville[38] in a study of the ultraviolet component of the sunlight in Portland, Oregon, noted that during the summer months the ultraviolet light of sunshine is considerably reduced although at this time of the year the amount of sunshine is greater. He attributed this to the excessive pollution of the air by smoke from forest fires which absorbed the ultraviolet rays.

Moore and his associates[39] examined approximately 1,000 children entering school for the first time in the cities of Portland, Oregon, and San Diego, California. Both cities are located at sea level, but they show considerable variation in the quantity of sunshine. San Diego registers 3,000 hours of sunshine per year, whereas Portland has only 2,000 hours. Despite this difference in the amount of sunshine, the authors reported that the percentage of rickets among the San Diego children was nearly as great as among those of Portland. On the other hand, they found that 54.5 per cent of the children of San Diego had teeth with no cavities or fillings as compared with 22.4 per cent of those in Portland. East[30] attributed this disparity in the incidence of dental caries to differences in the hours of sunshine between the two cities, although the same variations in the amount of sunshine failed to influence the percentage of rickets among the subjects of both places. In this connection, it seems of interest to note that mineral analyses of the water from the four terminal reservoirs serving the city of San Diego showed a range of fluoride concentration from 0 to 0.45 ppm,* while the fluoride level in the public water supply of Portland is reported to be zero.†

* Water Department, City of San Diego, personal communications.
† Oregon State Board of Health, personal communications.

Dean and his associates[24] noted that when both the fluorine content of the public water supply of a community and the amount of sunshine were taken into consideration, the factor responsible in reducing the caries attack rates of the population was the fluoride level of the water.

From the foregoing discussion it is evident that since even places comparatively close together show wide variations in the ultraviolet component of sunlight depending on different local conditions, observations based on quantity rather than on quality and made over large sections of the country cannot be relied on for an evaluation of the role played by sunshine in reducing the incidence of dental caries. Furthermore, no results can be considered conclusive without a simultaneous inquiry into other factors which may have influenced the caries attack rates.

The data on the condition of the sky presented in Table 17 disclosed that the amount of sunshine and the caries experience of the subjects examined in four counties of Oregon (Figure 2) were inversely related. Although this observation is based on the quantity and not on the quality of the available sunshine, the fact that the counties of the Central Oregon region where the subjects experienced lower caries attack rates than those living in the Coast region are located at high elevations suggests that the biological action of the ultraviolet rays of the sunlight may have been more effective. At the same time the evidence here presented indicates that some other factors which do or may have a bearing on the incidence of caries cannot be held responsible in the present study for the differences in caries attack rates observed among the subject population of the four counties. Despite the foregoing factors, however, we do not consider the evidence presented here regarding the relationship of sunshine to dental caries entirely conclusive, because no readings of the ultraviolet radiation of the sun in the two regions under consideration are available.

Parenthentically, if the present food intake can be taken as indicating the trend of food habits in the past, it seems of interest to mention that an investigation of the diet of the subjects carried on at the time of the dental examination did not reveal appreciable variations in the amount of candy bars and carbonated beverages consumed.*

* A discussion of the relationship between the food habits of the children and the condition of their teeth will appear in the over-all publication on the Oregon phase of the regional study.

Conclusions

The results of an inquiry into a number of environmental factors did not produce evidence indicative of an explanation for the differences in caries experience observed among the subjects examined in four counties of Oregon. The only factor of relative significance seemed to be the variation in the amount of sunshine between the two regions. It is believed that because the present investigation was confined to children native born and reared, and also the influence of some factors which do or may have an inhibitory effect on caries attack rates has been excluded, a study of the ultraviolet component of sunlight in the two regions will be of great value in clarifying the sunshine-dental caries relationship. Moreover, since our knowledge of the factors associated with caries resistance is far from complete, the possibility that some constituent of the drinking water may render the teeth more susceptible to caries, as has been suggested[40], must not be overlooked.

3. DENTAL CARIES AMONG INSTITUTIONALIZED CHILDREN

The third phase of the studies on the caries experience of selected population groups in the State of Oregon dealt with the children living in an institution known as the Children's Farm Home of Oregon.

The subjects of this study were all the children between the ages 6 to 16 years residing at the Children's Farm Home. The dental examination was conducted in a trailer by means of mouth mirror and explorers. The procedure employed for the examination as well as the criteria of what were considered carious lesions have been described in the preceding investigation among the school children of the two geographic regions of the state.

All examinations were done by one examiner (D.M.H.); therefore, variation in caries diagnosis was minimized.

Observations were made only for permanent teeth exclusive of third molars. The dental caries experience was measured by counting the number of filled teeth, missing teeth because of caries, teeth indicated for extraction, and carious teeth indicated for filling. A tooth both carious and filled was counted only once in the total. The symbol "DMF" was used to express the past and present dental caries experience in terms of teeth.

For a better understanding of the pattern of living of the subjects, it seems pertinent to give some information about the institu-

Table 18. Number of Subjects at the Children's Farm Home Given Dental Examination, by Specified Age and Sex Groups

Subject	Age last birthday											
	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	15 years	16 years	All ages
Boys	2	3	4	10	7	12	14	14	12	10	4	92
Girls	2	7	6	2	5	9	7	10	13	4	6	71
Both sexes	4	10	10	12	12	21	21	24	25	14	10	163

tion. The Children's Farm Home of Oregon, which is located three miles north of the city of Corvallis, was established in 1923 and is sponsored by the Women's Christian Temperance Union. The Home cares for dependent children from the State of Oregon only, and is supported by state and county funds, contributions, and the Oregon W.C.T.U. The ages of the children residing there are between 5 and 18 years, but preference for admittance is given to the younger age groups. The length of time each child spends in residence varies considerably depending on the reestablishment of normal living conditions in his family. The capacity of the Home is approximately 160 children who live in eight cottages. Education is provided for all children either at the institution or in Corvallis. A farm of approximately 200 acres adjacent to the Home supplies a great amount of all the foods consumed there. The same amount and kind of foodstuffs are provided for all the children, but the preparation of the food varies depending on the cook and the housemother in each cottage. Every week the older children receive some pocket money provided by the Home which is spent either for small personal items needed or for delicacies when visiting neighboring towns. During the summer months the children stay at the Home except on rare occasions when some of them visit with relatives and friends for a few days. Medical and dental services are provided regularly, and a registered nurse is in residence. The Home also provides toothbrushes and toothpaste to all the children at regular intervals.

Findings

The total number of children examined and their distribution by age and sex are given in Table 18. Altogether 163 children, between the ages 6 to 16 years inclusive, were included in the examination. The number of boys was slightly higher than that of girls.

Table 19 gives a picture of the period the subjects had spent in residence at the institution up to the time of the examination. This is expressed in terms of median and range by age groups, because of

Table 19. LENGTH OF RESIDENCE TIME OF THE SUBJECTS AT THE INSTITUTION IN TERMS OF MEDIAN AND RANGE BY AGE GROUPS

Age groups	Subjects	Median	Range
6-7	14	1 year 3 months	1 month to 2 years 8 months
8-10	34	1 year 7 months	3 months to 4 years 8 months
11-13	66	2 years 5 months	2 months to 9 years 1 month
14-16	49	4 years 6 months	6 months to 11 years 6 months

Table 20. • Summary of Dental Caries Experience of 163 Subjects Residing at the Children's Farm Home. Rates Are Expressed per Child by Specified Age Groups

Permanent teeth	Age last birthday											
	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	15 years	16 years	All ages
	Average	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*	*Average*
Filled	0.0	0.0	0.1	0.7	0.8	1.3	1.4	2.6	3.5	2.6	4.8	1.9
Missing	0.0	0.0	0.1	0.0	0.4	0.1	0.0	0.2	0.4	0.4	1.0	0.2
Extraction indicated	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.8	0.2	0.1
Filling indicated	0.0	0.2	1.2	1.4	2.3	2.7	2.1	3.0	4.5	5.4	3.7	2.8
DMF teeth	0.0	0.2	1.3	2.0	3.3	3.7	3.4	5.0	7.2	8.4	8.5	4.5

the wide variability in length of residence observed among the children. On this basis, the age group 6-7 years old had a median of 1 year and 3 months' time of residence at the institution. As could be expected, the length of residence increased as the children advanced in chronological age and reached a median of 4 years 6 months at the age group 14-16 years old.

The data presented in Table 20 provide information per child by specified age groups on the rates for each one of the four items comprising the dental caries experience, as well as on the rates for the DMF teeth. As can be seen, the caries experience of the subjects increases simultaneously with their chronological age. While the 6-year-old child was free of dental caries, at the age of 16 years his dental caries experience had increased to an average of 8.5 DMF teeth. In general, the average number of missing teeth and teeth requiring extraction because of extensive caries was found to be negligible. On the other hand, the average number of filled teeth per child was 1.9, while the average number of carious teeth requiring filling was 2.8, a difference of almost one tooth. This disparity between the number of filled teeth and teeth requiring filling reflects the amount of dental care received by the children at the institution. Of all the children examined, 30 were found to be caries-free, the majority of whom were observed among the younger age groups.

From the previous two investigations on the incidence of dental caries among selected groups of people in the State of Oregon reported here, it had been pointed out that the incidence of the disease among them was high as compared with the same age groups examined in other parts of the country. In order to be able to compare the findings of the present study with the previous one conducted in four counties of the state, Table 21 was prepared. It is evident from this table that the DMF teeth rates of the children residing at the Children's Farm Home were considerably lower than the rates of school children examined in four counties of the state. The greatest difference was observed between the children examined in Clatsop

Table 21. COMPARISON OF AVERAGE NUMBER OF DMF TEETH PER PERSON BY SPECIFIED AGE GROUPS OF SUBJECTS RESIDING AT THE CHILDREN'S FARM HOME AND IN FOUR COUNTIES OF THE STATE OF OREGON

Age last birthday	Locality				
	Children's Farm Home	Clatsop County	Coos County	Deschutes County	Klamath County
	Average	*Average*	*Average*	*Average*	*Average*
14	7.2	13.3	11.1	9.6	7.5
15	8.4	15.1	13.6	12.0	9.6
16	8.5	15.3	13.9	12.3	10.0
All ages	7.8	14.4	12.7	11.3	9.0

County, and the least in those of Klamath County. Comparison of the DMF teeth rate of all ages between the Children's Farm Home and each one of the four counties showed that the differences are statistically significant with the exception of those for Klamath County. However, it should be remembered that the dental examination in the four counties of the state was conducted only among those children who were born and reared in their respective counties.

Discussion

In an effort to explain the wide differences in the dental caries attack rates noted between the school children residing at the Farm Home and those examined in four counties of the state, a two-fold approach was undertaken: first, the fluorine content of the water supply used at the institution was determined; second, the over-all diet pattern of the subjects while in residence there was investigated.

The source of the water supply at the institution is a well approximately 65 feet deep. It has been in continuous use since some years previous to the admittance of the subject with the longest period of residence included in the present study. The fluorine content of the water was determined (C.A.S.) and was found to be 0.3 ppm. This small amount of fluorine in the water is certainly not the factor which can be held responsible for the low incidence of dental caries observed among the children of the institution.

The diet pattern of the subject population is in the main demonstrated in the following list which represents the typical weekly allotments of basic foods for each one of the eight cottages serving as living quarters of the children. The complement of each cottage averages 20 children and 3 adult personnel.

Weekly Allotments of Basic Foods per Cottage

Eggs	10 dozen
Butter	7 pounds
Butter substitute	10 pounds
Cheese (American)	5 pounds
Meat	30-45 pounds, according to kind
Fish	15 pounds (twice a month, served in place of meat)
Bacon	5 pounds
Milk	56 gallons (whole milk for drinking, top milk for cereals, etc.)
Cream	As required for ice creams, etc.
Oranges	4-5 dozen, or the equivalent in citrus juices

Tomatoes	3 gallons canned, all they wish in season
Assorted vegetables	7 gallons canned, all they wish in season
Assorted fruits	9 gallons canned, all they wish in season
Leafy and raw vegetables	All they wish
Potatoes	100 pounds
Cereals	Ready prepared once a week, cooked cereals other days
Bread	All they wish

A variety of different other foods is also included in the weekly allotments. In addition, every child receives 2 vitamin pills daily, each one containing 800 International Units of vitamin D and 3,000 International Units of vitamin A. The use of sugar as such is unrestricted. Desserts, such as pie, cake, and pudding, are served once or twice daily. Candy bars, carbonated beverages, and sweets, in general, are not used often, as the sale of these items is not allowed on the grounds of the institution.

The same diet pattern always had been followed by the authorities of the institution, as great amounts of the foods consumed there are produced at the farm owned by it. The consumption of sugar, butter, and butter substitutes had been curtailed to a certain degree during the war years.

The topic regarding the influence the type of diet exerts on the incidence of dental decay has been debated for a number of years. The two main schools of thought on this subject are represented by the Iowa and Michigan groups. The former maintains that an arrest of caries is observed in persons of normal physiological state who consume a well balanced diet, while the latter asserts that caries activity is related to excessive consumption of carbohydrates in general and refined sugars in particular, and not to the nutritional adequacy of the diet. However, while studies by a number of investigators have indicated that the restriction of sugar, either natural or refined, can effectively control dental caries, there is no conclusive evidence as yet that an optimal diet alone will influence its occurrence.[34]

From the point of view of our present knowledge on nutrition, it is generally agreed that the inclusion in our daily diet, and in specified amounts, of foods which have been classified as basic in addition to other foodstuffs of choice, is a guarantee for optimum diet. From the description of the over-all diet pattern presented above, it can be stated reasonably that the daily food intake of the subjects while in residence at the institution meets the Recommended Dietary Allowances proposed for a normal diet[41], with the exception of citrus fruits

and juices. However, in a recent survey of the ascorbic acid in plasma of a number of children residing at the institution, it was reported[42] that the mean plasma value of the entire group tested was found to be near the level which is considered to be adequate. Apparently this came about by the inclusion of foods, other than citrus fruits, which are good sources of vitamin C in the daily diet of the children.

Although there was no deliberate restriction in the consumption of refined sugars and concentrated sweets among the subjects, it seems logical to assume that there was no excessive use of them, as the case may well be in a typical American community, because the sale of candy bars, carbonated beverages, and sweets generally is not allowed on the grounds of the institution.

Moreover, the sheltered life of the subjects as well as the adequacy of their diets automatically may have served to decrease further the consumption of refined sugars and sweets in general. A similar observation was made in another study.[43]

From the foregoing prolegomena, we are inclined to conclude that the low incidence of caries observed among the institutionalized children as compared with those of the same age groups examined in four counties of the state, all other factors influencing the caries attack rates being equal, was brought about by a combination of both factors: the adequacy of the diet and the restriction of the intake of refined sugars and sweets, in general.

The data obtained from this study seem to be in agreement with the work of other investigators[44 45 46 47] who observed a decrease in caries activity when an optimum diet was provided in combination with a reduction of the excessive intake of refined sugars and concentrated sweets.

SUMMARY

Three studies undertaken for the purpose of finding the dental caries experience among selected groups of people in Oregon and also some of the possible etiological factors which influence it produced the following results:

First Study: THE INCIDENCE OF DENTAL CARIES AMONG FRESHMAN STUDENTS AT OREGON STATE COLLEGE.

The dental caries experience of 582 college freshman students, as compared with subjects of the same age groups examined at various geographic areas of the country, was found to be considerably higher among the freshmen. Female students showed a higher rate of DMF teeth and tooth surfaces than male students. The teeth of female students had received greater dental care.

In general, the students at Oregon State College, although they had a high caries experience, showed fewer teeth missing and fewer teeth requiring extraction when compared with subjects from other studies in which lower rates of caries experience were reported. The better financial status of the families from which the students come, as well as other factors, is considered as an explanation. The value of bite-wing radiographs as a diagnostic tool for the detection of carious lesions was demonstrated. Geographic division of the State of Oregon into six areas revealed that the students from the Coast region showed a high and that those from the Central Oregon region a low dental caries experience.

Second Study: GEOGRAPHIC VARIATIONS OF DENTAL CARIES IN OREGON.

Data from dental records of 741 native born and reared white school children of 14, 15, and 16 years of age in two geographic regions of Oregon revealed that there exists a difference of varying degree in the incidence of dental caries among school children living in two areas of the state and that the more pronounced one was observed between Clatsop County of the Coast region, where the caries attack rates were the highest, and Klamath County of the Central Oregon region, where the caries attack rates were the lowest. The dental caries experience of school children in both regions was found to be higher in comparison with that of subjects of the same age groups examined in other parts of the country.

In general, boys experienced a lower rate of caries attack than girls of the same chronological age. The teeth of girls have received greater dental care although their dental caries attack rate was higher than that of boys. Posterior bite-wing radiographs taken of 505 children revealed 25.3 per cent of all the carious surfaces requiring filling. No cases of enamel hypoplasia were discovered among the school children examined in both areas.

An investigation into some environmental factors for an explanation of the differences in caries experience noted among the native born and reared school children examined in the four counties of Oregon gave the following results:

1. The fluoride concentrations in the communal waters analyzed in each county were found to be negligible.

2. Calculations of total hardness showed that, in general, the drinking waters of the four counties are classified as "soft."

3. A retroactive investigation of the public water supplies under consideration revealed that, with the exception of a few small com-

munities, no changes which may have altered significantly the present composition of the waters were made during the lifetime of the subjects examined.

4. Availability of dental services in the two geographic regions does not seem to have influenced the caries experience of the subjects.

5. The amount of sunshine in the two regions of the state and the dental caries experience of the subject population examined there were found to be inversely related. Since this observation is based on the quantity and not on the quality of the sunlight, the evidence presented is not considered entirely conclusive. A study of the ultraviolet component of sunlight in the two regions is recommended. The counties of the Coast region, where the caries attack rates were highest, were characterized by fewer hours of sunlight and by lower altitudes than those of the Central Oregon region. Although no study was made of the ultraviolet component of the sunlight in the two regions, it is probable that the populations of the Central Oregon region were subjected to more of the biologically active shorter wave lengths.

6. An investigation of the current food intake of the subjects at the time of the dental examination did not show appreciable differences in the amount of candy bars and carbonated beverages consumed.

Third Study: DENTAL CARIES AMONG INSTITUTIONALIZED CHILDREN.

A dental examination by means of mouth mirror and explorers was given to 163 children between the ages 6 to 16 years, inclusive, residing in an institution known as the Children's Farm Home of Oregon. Their dental caries attack rates were found to be considerably lower in comparison with those of school children of the same age groups examined in four counties of the State of Oregon. The fluorine content of the water supply used at the institution was determined and found to be 0.3 ppm.

An investigation of the over-all food intake of the children while in residence at the institution revealed that their diets were nutritionally adequate. Moreover, certain reasons seem to indicate that the use of refined sugars and concentrated sweets was not "excessive." A comparatively low incidence of dental caries was observed among the subjects studied and since these individuals had an optimum diet and restricted intake of refined sugars and sweets, generally, it may have been due to either or both of the factors in combination. The authors believe, however, it was brought about by a combination of both factors.

BIBLIOGRAPHY

1. Special Report of the Department of Public Health. The Decay of Teeth Resulting from a Lack of Fluorine. Boston, Mass., Dec. 1945.
2. Klein, H., and Palmer, C. E.: On the Epidemiology of Dental Caries, University of Pennsylvania Bicentennial Conference, Dental Caries, Philadelphia, 1941, University of Pennsylvania Press.
3. Stoughton, A. L., and Meaker, V. T.: Sex Differences in the Prevalence of Dental Caries; Based on 12,435 Oral Examinations by Dental Personnel in Georgia, Illinois, Missouri, and Hagerstown, Maryland, Pub. Health Rep. 47: 26, 1932.
4. Klein, H., Palmer, C. E., and Knutson, J. W.: Studies on Dental Caries: I. Dental Status and Dental Needs of Elementary School Children, Pub. Health Rep. 53: 751, 1938.
5. Klein, H., and Palmer, C. E.: Studies on Dental Caries: VII. Sex Differences in Dental Caries Experience of Elementary School Children, Pub. Health Rep. 53: 1685, 1938.
6. Klein, H., and Palmer, C. E.: Community Economic Status and the Dental Problems of School Children, Pub. Health Rep. 55: 187, 1940.
7. Klein, H., and Palmer, C. E.: Studies on Dental Caries: IX. The Prevalence and Incidence of Dental Caries Experience, Dental Care, and Carious Defects Requiring Treatment in High School Children, Pub. Health Rep. 55: 1258, 1940.
8. White, D. P.: Preliminary Bite-Wing Roentgenographic Examination of Naval Aviation Cadets, U. S. Nav. M. Bull. 43: 901, 1944.
9. Grey, W. A.: The Dental Section of the Carleton College Health Service, J. A. D. A. 20: 541, 1933.
10. Chilton, N. W., and Greenwald, L. E.: Studies in Dental Public Health Administration: II. The Role of Roentgenograms in Public Health Surveys, J. D. Res. 26: 129, 1947.
11. Hanke, M. T.: Diet and Dental Health, The University of Chicago Press, Chicago, Illinois, 1933.
12. Noyes, H. J.: Dental Caries and the Orthodontic Patient, J.A.D.A. 24: 1243, 1937.
13. Massler, M.: Teen-Age Caries, J. Dent. Child. XII: 57, 1945.
14. Hadjimarkos, D. M., and Storvick, C. A.: The Incidence of Dental Caries Among Freshman Students at Oregon State College, J. D. Res. 27: 299, 1948.
15. Sarnat, B. G., and Schour, I.: Enamel Hypoplasia (Chronologic Enamel Aplasia) in Relation to Systemic Disease: A Chronologic, Morphologic, and Etiologic Classification, J.A.D.A. 28: 1989, 1941; 29: 67, 1942.
16. Sterling, E. B.: Health Studies of Negro Children, Pub. Health Rep. 43: 2713, 1928.
17. Mellanby, H.: Hypoplasia and Caries Among Children of Finnish Lapps, Brit. M. J. 1: 682, 1940.
18. Brucker, M.: Studies on the Incidence and Cause of Dental Defects in Children. II. Hypoplasia, J. D. Res. 22: 115, 1943.

19. Dean, H. T., Jay, P., Arnold, F. A., Jr., McClure, F. J., and Elvove, E.: Domestic Waters and Dental Caries, Including Certain Epidemiological Aspects of Oral Lactobacillus Acidophilus, Pub. Health Rep. 54: 862, 1939.

20. Dean, H. T., Jay, P., Arnold, F. A., Jr., and Elvove, E.: Domestic Water and Dental Caries. II. 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. 56: 761, 1941.

21. Dean, H. T., Arnold, F. A., Jr., and Elvove, E.: Domestic Waters and Dental Caries. V. Additional Studies of the Relation of Fluoride Domestic Waters to Dental Caries Experience in 4,425 White Children, Age 12-14 Years, of Thirteen Cities in Four States, Pub. Health Rep. 57: 1155, 1942.

22. O'Rourke, C. E.: General Engineering Handbook, New York and London, 1940, McGraw-Hill, 2nd Ed., p. 703.

23. Boire, L.: The Dental Manpower of the State of Oregon, J. Ore. St. Dent. Assn. XVI: 21, 1947.

24. Dean, H. T.: Epidemiological Studies in the United States, in Dental Caries and Fluorine, Amer. Assn. Adv. Sc., Washington, D. C., 1946, p. 5.

25. Dean, H. T.: Geographical Distribution of Endemic Dental Fluorosis (Mottled Enamel), in Fluorine and Dental Health, Amer. Assn. Adv. Sc., Washington, D. C., 1942, p. 6.

26. Van Burkalow, A.: Fluorine in United States Water Supplies, Geograph. Rev. 36: 177, 1946.

27. Mills, C. A.: Factors Affecting the Incidence of Dental Caries in Population Groups, J. D. Res. 16: 417, 1937.

28. East, B. R.: Association of Dental Caries in School Children with Hardness of Common Water Supplies, J. D. Res. 20: 323, 1941.

29. Report of the American Academy of Pediatrics, Study of Child Health Services in Oregon, Oregon State Board of Health, Portland, 1948.

30. East, B. R.: Mean Annual Hours of Sunshine and the Incidence of Dental Caries, Am. J. Pub. Health 29: 777, 1939.

31. East, B. R., and Kaiser, H.: Relation of Dental Caries in Rural Children to Sex, Age, and Environment, Am. J. Dis. Child. 60: 1289, 1940.

32. East, B. R.: Relation of Dental Caries in City Children to Sex, Age, and Environment, Am. J. Dis. Child. 61: 494, 1941.

33. Blackerby, P. E.: Intrastate Geographic Variations in Dental Caries Rates, J. A. D. A. 30: 1241, 1943.

34. The Michigan Workshop on the Evaluation of Dental Caries Control Technics, J. A. D. A. 36: 3, 1948.

35. Frawley, J. M.: Ultraviolet Light in California Summer Sunshine, Am. J. Dis. Child. 41: 751, 1931.

36. Frawley, J. M., and Brown, F. A.: Ultraviolet Component of Central California Sunlight, Calif. and West. Med. 40: 358, 1934.

37. Earp, J. R.: Note of Observation of Ultraviolet Radiation of Sun and Sky Measured by the Zinc Sulphide Method in Boulder, Colorado, Am. J. Hyg. 9: 663, 1929.

38. Manville, I. A.: The Ultraviolet Component of the Sunlight of Portland, Ore., Am. J. Dis. Child. 37: 972, 1929.

39. Moore, C. U., Broodie, J. L., Thornton, A. J., Lesem, A. M., and Cordua, O. B.: Failure of Abundant Sunshine to Protect Against Rickets, Am. J. Dis. Child. 54: 1227, 1937.

40. Klein, H.: Do Certain Drinking Waters Favor Dental Caries? Science 105: 4, 1947.

41. Food and Nutrition Board: Recommended Dietary Allowances, Revised. National Research Council Reprint and Circ. Series, No. 129, 1948.

42. Storvick, C. A., Fincke, M. L., Quinn, J. P., and Davey, B. L.: A Study of Ascorbic Acid Metabolism of Adolescent Children, Oregon State College Tech. Bul. 12, Dec. 1947.

43. Macy, I. G.: Nutrition and Chemical Growth in Childhood, Springfield, Illinois, 1942, Charles C. Thomas, Vol. I., p. 84.

44. Collins, R. O., Jensen, A. L., and Becks, H.: Study of Caries-Free Individuals: II. Is an Optimum Diet or Reduced Carbohydrate Intake Required to Arrest Dental Caries? J. A. D. A. 29: 1169, 1942.

45. Becks, H., Jensen, A. L., and Millarr, C.: Rampant Dental Caries: Prevention and Prognosis, A Five-Year Clinical Survey, J. A. D. A. 31: 1189, 1944.

46. Howe, P. R., White, R. L., and Rabine, M.: Retardation of Dental Caries in Outpatients of a Dental Infirmary, Am. J. Dis. Child. 46: 1045, 1933.

47. Howe, P. R., White, R. L., and Elliott, M. D.: The Influence of Nutritional Supervision on Dental Caries, J. A. D. A. 29: 38, 1942.