AN ABSTRACT OF THE THESIS OF

MICHAEL J. LANGAN for the MASTER OF SCIENCE
(Name of student) (Degree)

in FOODS AND NUTRITION presented on June 14, 1974
(Major department) (Date)

Title: THE EFFECTS OF IMPROVED ORAL HYGIENE ON THE NUTRITION OF THE ELDERLY

Abstract approved: _____
Dr. Elisabeth Yearick

The effects of improved oral hygiene on the nutrition of 23 elderly institutionalized men and women were investigated. An experimental group of 12 received professional oral hygiene treatments three times weekly for a period of five weeks, while a control group of 11 received only placebo work. Changes in taste perception, nutrient intake, and selected blood parameters were measured.

Improved oral hygiene appeared to be responsible for increases in taste acuity. There were significantly more experimental than control subjects who showed improved ability to detect sweet, sour, and salty tastes, and improved identification thresholds for sweet and salty tastes.

The nutrient intake of many of the subjects fell below the recommended dietary allowances for this age group, especially for folate. No significant dietary improvement was directly attributable

to improved oral hygiene. However, at the end of the five-week period, both groups showed significant increases in their mean dietary calories, protein, calcium, vitamin A, and riboflavin. In addition, the diet of the experimental group increased significantly in iron and thiamin. The dietary improvement appeared to be associated with the psychological effect of frequent professional attention.

No significant improvements in blood parameters were shown by either group as a result of the treatment. However, significantly more experimental than control subjects showed an increase in hemoglobin concentration, plasma protein, and plasma ascorbic acid. Low plasma folate concentrations were found in all subjects and there was no folate response to either treatment.

The Effects of Improved Oral Hygiene on the Nutrition of the Elderly

by

Michael Joseph Langan

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

June 1975

APPROVED:

Professor of Foods and Nutrition
in charge of major

Head of Department of Foods and Nutrition

Dean of Graduate School

Date thesis is presented June 14, 1974

Typed by Velda D. Mullins for Michael Joseph Langan

ACKNOWLEDGMENT

I wish to extend my appreciation to Dr. Elisabeth Yearick for her untiring guidance throughout my study and in preparation of this manuscript.

My appreciation also goes out to Dr. James Bennett, from whom the idea for this study was derived. Appreciation also goes to the staff members of Mt. St. Joseph and Parkview retirement homes, who allowed me to use their facilities for the study. I am also appreciative of the work done by Shan Aromalo and Mel Ott, for their aid in analyzing my data.

Last but far from least, I would like to extend my appreciation to the 23 elderly men and women who participated in this study, without whom this study would not have been possible.

TABLE OF CONTENTS

LIST OF TABLES

THE EFFECTS OF IMPROVED ORAL HYGIENE ON THE NUTRITION OF THE ELDERLY

INTRODUCTION

Gross malnutrition is not an apparent problem with the elderly but there is growing concern about subclinical malnutrition which may lead to poor health, apathy and disinterest, thus initiating a self-perpetuating cycle in elderly people (Anderson, 1968). Many reasons have been cited for the reduction in nutrient intake by the elderly, such as environmental surroundings (Weinberg, 1972), economics (Anonymous, J. Am. Diet. Assoc., 1971) and psychological factors (Grant, 1968; Pelcovits, 1972; Weinberg, 1972). One reason that has not been sufficiently considered is impaired taste perception. If the pleasure of taste received by eating is not present, an elderly person in an apathetic state of mind could lose interest in eating.

One factor that could play a major role in taste perception is oral hygiene. Poor oral hygiene, with ensuing periodontal disease, could cause impaired taste perception. The impairment could be either (1) physical, due to debris covering the taste buds; or (2) chemical, due to taste fatigue resulting from constant stimulation caused by the decaying material within the mouth.

In order to evaluate this hypothesis, the present study was

initiated to examine the effects of an oral hygiene program on the taste perception, nutrient intake and certain biochemical parameters of nutrition in elderly subjects.

REVIEW OF LITERATURE

Oral Hygiene

Oral hygiene is defined as the science of maintaining the oral cavity in a healthy state. Suomi (1971) and others have stated that a strong association exists between improper oral hygiene and periodontal disease. This disease is the major cause of tooth loss after the age of 35. In the United States, approximately 67 million adults have periodontal disease and more than 20 million have lost all of their natural dentition because of it (Nizel, 1972). In a study by Day et al. (1955), the prevalence of periodontal disease among persons over the age of 60 was 95%.

Periodontal disease is an inflammatory condition caused by local irritating factors such as dental plaque, calculus, materia alba, food impaction, and mechanical trauma (Nizel, 1972). Dental plaque, probably the most important, consists mainly of bacteria with their toxins, enzymes, and antigens.

There is sufficient evidence from controlled clinical studies to suggest that proper oral hygiene is an effective means of controlling periodontal disease (Nizel, 1972; Ash et al., 1964; Ainamo, 1971). To implement a program of proper oral hygiene, several techniques must be utilized. Toothbrushing is the basic technique employed in

maintaining the health of the oral cavity. Various toothbrushing methods may be utilized, but according to the Committee on Oral Health Care in 1966 (Suomi, 1971), "The conscientious and correct application of a brushing method is more important than the method itself".

Ideally, the teeth should be brushed twice a day. However, effective oral hygiene procedures at intervals of 48 hours are compatible with periodontal health. According to Lang et al. (1973), gingivitis (a specific form of periodontal disease) will develop if the interval between complete removal of bacterial plaque exeeds 48 hours. Other investigators suggest that the maximum interval could be 72 hours (Reitz, 1971; Falaschitti et al., 1970).

Dental floss (Suomi, 1971), oral physiotherapy of the tongue and palate (Jacobson et al., 1973; Gillmore and Bhaskar, 1971), and rinsing of the mouth with water (Suomi, 1971) are also essential in the prevention and control of periodontal disease. If the proper techniques for maintaining the oral cavity are not known, formal training by dental technologists is necessary (Brandtzaeg et al., 1964).

Taste Perception Tests

There are four basic taste sensations that are used for classification. These are sweet, sour, salty, and bitter. In

assessing taste perception, investigators commonly use solutions of sucrose, organic acids, sodium chloride, and caffeine or quinine.

Taste acuity is measured by means of threshold determinations. There are two types of thresholds: detectability threshold and identification threshold. According to Williams (1970), the detectability threshold for each chemical is defined as the concentration that is reported as "different" from water 50% of the time. The identification threshold is defined as that concentration at which the identify of the chemical can first be determined. Threshold values, gathered from various authors are presented in Table 1. The ranges reported by Mackey and Jones (1954) are representative of most data published. The range of the thresholds for sucrose was 0.003 to 0.05 M; sodium chloride 0.001 to 0.08 M; tartaric acid 0.00012 to 0.003 M; and caffeine 0.0002 to 0.005 M.

A number of factors influence the outcome of taste perception tests. One of the most crucial factors is the testing medium. The ideal medium is a neutral liquid, such as distilled water. According to Mackey and Valassi (1956), taste substances were easiest to detect in the liquid state. They determined that threshold values were lower for test substances in water solution than for the same substance added to food. Closely related to this is the effect of taste interaction. Fabian and Blum (1943) found that sodium chloride in subthreshold concentrations consistently reduced the sourness of all

Table 1. Taste Thresholds (concentrations in moles/liter).

Reference	Sucrose	Sodium chloride	Tartaric acid	Caffeine
Richter and Campbell (1940)	.0356 [a, b]	-	-	-
Knowles and Johnson (1941)	.0222 [c]	.0250 [c]	.0005 [c]	.0015 [c]
Fabian and Blum (1943)	.016 [d] .037 [e]	.011 [d] .039 [e]	.0004 [d] .0007 [e]	- -
Hopkins (1946)	.0195	.0192	.0002	.0018
Janowitz and Grossman (1949)	-	-	-	low .002 high .0032
Mackey and Jones (1954)	low .003 med .0224 high .05	low .0011 med .0217 high .08	low .00012 med .00045 high .003	low .002 med .0015 high .005
Mackey and Valassi (1956)	.0063	.0012	.00019	.00049 [d]
Cooper et al. (1959)	.013 [a, d] .029 [a, e] .012 [b, d] .027 [b, e]	.021 [a, d] .046 [a, e] .017 [b, d] .053 [b, e]	-	-
Pangborn (1959)	.005-.016 [d] .012-.037 [e]	.003 [d]	- -	.0003 [d] .0004 [e]
Tilgner and Bruylko-Pikielna (1959)	.0029-.0116	.017-.031	.005-.0011	.00019 [c]
McBurney and Pfaffmann (1963)	-	.00014 [f] .0043 [g]	-	-

[a] for age group 60-74

[b] for age group 75-89

[c] average

[d] detectable threshold

[e] identification threshold

[f] rinsed between samples with distilled water.

[g] adaptation by saliva

acids tested. Sodium chloride increased the sweetness of all sugars tested, with sucrose being affected least. Subthreshold concentrations of hydrochloric acid had no effect on the taste of sodium chloride, while tartaric and the other acids tested increased the saltiness of sodium chloride. The sweetness of sucrose was increased by malic, citric and tartaric acids and was unchanged by hydrochloric or acetic acid. Sucrose in subthreshold concentration reduced the sourness of tartaric acid and the saltiness or sodium chloride. Taste interaction may occur when subjects sample several solutions in quick succession. To prevent an additive effect from previously sampled solutions, Crocker (1945) suggested that the subjects rinse between samples with distilled water. This method was also used by Kaplan and Glanville (1964) and McCutcheon and Saunders (1972). It was also pointed out by McBurney and Pfaffman (1963) that subjects using water rinses between samples gave different threshold values than did saliva-adapted subjects. They showed the threshold for sodium chloride depends upon the concentration of sodium chloride already in the saliva (Table 1).

The temperature of the medium is another important factor. Howell (1922) stated a temperature between 10°C and 30°C gives the optimum reaction for taste. In partial agreement, Komuro (1921) reported a doubling of sensitivity to acid, salt, sugar, and quinine when the temperature was raised from 10°C to 20°C. The

sensitivity remained on a plateau from 20°C to 30°C, but fell off from 30°C to 40°C. Therefore, it appears that a temperature in the range of 20°C to 30°C would be desirable. Powers et al. (1971) stated that unless the judgment about taste is made very quickly, the temperature of the solution within the mouth will become body temperature. They suggested that some of the determinations reported at 20° to 30°C may truly be values at 37°C, body temperature, simply because the taster took too long in making a decision.

When using an organoleptic test, fatigue is a major concern. Laue et al. (1954) defined taste fatigue as the diminishing ability of a taster to recognize small differences in flavor as tasting is prolonged. They suggested limiting the number of samples to be tested in order to minimize this effect. Janowitz and Grossman (1949), however, found little or no effect of fatigue on taste acuity where tests were conducted with sugar and salt solutions. Variation in the time interval between samples is a good way to minimize fatigue. Crocker (1945) suggested that the tester should use a slow tempo with not more than one or two samples per minute being tested. McCutcheon and Saunder (1972) used a resting period of one minute between samples.

Hunger can be another factor that might influence taste acuity. Janowitz and Grossman (1949) failed to demonstrate a consistent change in the acuity of taste due to hunger. Pangborn (1959)

concluded that fasting versus non-fasting conditions had no pronounced effects on difference thresholds, nor upon identification thresholds for sucrose, citric acid, sodium chloride or caffeine. Moore et al. (1965) stated there was no difference in the taste sensitivity when a lunch and no lunch condition was compared. This evidence would appear to suggest that hunger and eating will have no effect upon taste thresholds.

Dawson et al. (1963) gave some important suggestions for administering taste tests. Samples should be prepared and served as uniformly as possible in all aspects not related to taste. Size of sample, temperature, texture, appearance and color must be uniformly controlled. The true identity of each sample must be concealed by coding. Instructions to the subjects must be clear, concise, and appropriate for the experiment.

Taste Perception in the Elderly

Taste is a complex physiological action that is influenced by many factors. Taste is sensed by the taste buds located not only on the tongue, but on the hard and soft palate, mucosal surfaces of the oral cavity, and in the pharynx (Henkin, 1967).

Taste buds change in number and distribution with change in age, more buds being found on the dorsal surface of the tongue in children. Arey et al. (1935) reported a decrease in the number of

taste buds per papilla from an average of 206 in young and middle aged, to 88 in a group whose ages ranged from 74 to 85. Moore (1962) found similar results when he compared young adults with subjects 70 to 85 in age. Byrd and Gertman (1959) state that taste buds respond in an "all or none" manner. Therefore, even with a decrease in taste bud numbers, the remaining functional buds provide stimulation to the central nervous system enabling accurate perception.

Studies of the effects of age on taste acuity have provided conflicting reports. Campbell and Richter (1940) found a much higher sweet threshold in a 52 to 85 year old group than in a 15 to 19 year old group. Cooper et al. (1959), using subjects 15 to 87 years old, found a decline in sensitivity for the four basic tastes starting in the late 50's, with the sour threshold being affected the least (Table 1). Hermal et al. (1970), comparing subjects from 4 to 60 years in age, suggested that the salt threshold remains unchanged up to the age of 60. For sweet, sour, or bitter taste sensation, a decreased sensitivity was observed in the group aged 48 to 60 years. Cohen and Gitman (1959) reported more complaints among the aged (65-96 years) regarding the ability to recognize basic tastes, but did not find any impairment in their taste perception. Similarly, Knowles and Johnson (1941) found that neither age nor experience in judging could be correlated with the ability to identify tastes.

Taste acuity in the aged may be affected by other factors. For example, the loss of teeth, that usually accompanies increasing age, causes a reduction in salivary flow (Klaptocz, 1964; Cohen and Gitman, 1959; Suomi, 1971). Saliva is necessary for dissolving chemical stimuli for taste. Furthermore, many elderly persons have had to resort to dentures. According to Herkin (1967), the detection and recognition thresholds for the taste of sodium chloride and sucrose were within normal limits, with or without a maxillary denture in place. For the detection of hydrochloric acid and urea, a decrease of 50% and 25%, respectively, were found with the upper denture in place. The decrease was 10% for hydrochloric acid recognition and 33.3% for urea recognition. Detection and recognition thresholds for hydrochloric acid and urea were within the normal range after the upper denture had been removed.

Smoking also appears to have some effect on taste perception. Kaplan et al. (1965), working with smokers and non-smokers, concluded there was no significant difference between non-smoking males and females, either in mean threshold or in the apparent effect of age upon taste. Taste thresholds for sucrose, citric acid, and sodium chloride were similar for smokers and non-smokers. Smokers, however, were significantly less sensitive to quinine. The threshold for quinine also deterioriated with increasing age in the smoking group, unlike the thresholds for the other tastes.

According to Jackson (1967), heavy smokers appear to need 12 to 14 times more salt before identification is possible. Kaplan and Glanville (1964) state that bitter thresholds for smokers are higher than those for non-smokers. They used quinine and 6-N-propyl thiouracil for the bitter stimuli.

Nutrient Intake of Elderly Persons

A number of investigators have surveyed the nutrient intake of elderly people. However, no single report provides complete information on all nutrients, and not many surveys seem to have been made on institutionalized individuals. Data from some of these surveys, with emphasis on hospitalized and institutionalized subjects, appear in Table 2. Also presented in Table 2 are the recommended dietary allowances (RDA) for men and women over 50 years of age, recently revised by the National Research Council (Harper, 1973).

The various studies cited in Table 2 suggest that the mean nutrient intakes of older persons were generally close to the recommended allowances, with the exception of folate. Furthermore, the mean intakes of both folate and ascorbate were somewhat lower for the institutionalized subjects than for those who lived at home. Also noteworthy in the data on institutionalized persons is the wide range of intakes observed for protein, ascorbic acid (Evans and Stock, 1971), and folic acid (Hurdle and Path, 1968a). It is apparent that

Table 2. Dietary Intake of Elderly Persons.

Reference	Age	Sex	Residence	Energy	Protein[a]	Vitamin A	Calcium	Thiamin	Riboflavin	Niacin	Iron	Ascorbic acid[a]	Folic acid[a]
				Kcal	gm	I.U.	mg	mg	mg	mg	mg	mg	µg
Morgan et al.	50+	M	Home	-	-	-	-	-	-	-	-	99	-
(1955)	64-75+	M	Institution									(36-44)	
Lyons and Trulson	65+	M	Home	2458	88	10873	1060	1.29	2.00	15.7	13.5	105	-
(1956)	65+	F	Home	1831	66	8570	870	0.94	1.58	11.6	10.0	95	
Steinkamp et al.	50-75+	M	Home	2075	76	7961	800	1.1	1.7	14	12	82	-
(1965)	50-75+	F	Home	1605	62	8065	600	0.9	1.4	12	10	90	
Chanarin et al.		M/F	Home	-	-	-	-	-	-	-	-	-	145
(1968)		M/F	Institution										101
Hurdle and Path	70+		Home	2300	82	-	-	-	-	-	-	-	146
(1968a)													(94-250)
	70+		Institution	1431	60								101
													(40-190)
Hurdle and Path	72-91		Institution	-	-	-	-	-	-	-	-	-	85
(1968b)													(61-128)
FAO-WHO	60+	M/F	Institution	-	-	-	-	-	-	-	-	-	157
(1970)													(37-297)
Wirths	72/73	M/F	Institution	-	-	-	-	-	-	-	-	43[b]	-
(1970)												(21-63)	
	72/73	M/F	Institution	-	-	-	-	-	-	-	-	22[c]	-
												(10-31)	
Evans and Stocks	61/94	M/F	Institution	1560	61	-	-	-	-	-	-	40	-
(1971)					(36-79)							(9-66)	
U.S. Dept. HEW V	60+	M	Home	1950	80	4980	736	1.14	1.76	19.1	13.1	59	-
(1972)	60+	F	Home	1412	60	5172	568	0.86	1.40	14.7	9.6	67	
U.S. Dept. HEW	60	M/F	Institution and Home	1640	68	6500	650	-	-	-	11.2	96	-
(1974)													
Recommended Dietary Allowances- Harper (1973)	50+	M		2400	56	5000	800	1.2	1.5	16	10	45	400
	50+	F		1800	46	4000	800	1.0	1.1	12	10	45	400

[a] mean and range ( ) [b] values calculated from food tables [c] values calculated by chemical analysis

some of these subjects were consuming very inadequate diets.

The nutrient intake data presented in Table 2 were obtained by dietary interview, diet records and diet recall. There is general consensus that the diet record is the most accurate of the three methods.

For an individual, according to Chappel (1955), a long term diet record is necessary for an accurate estimate of the normal dietary intake. However, Huenemann and Turner (1942) stated that dietary habits may change from time to time as a result of emotional or health changes and thus a typical diet probably does not exist. Because of the money and time required to conduct long term studies, short cross-sectional studies are more commonly used.

Young et al. (1953) found that 28-day diet records and 7-day records gave comparable estimates of an individual's intake of calories, protein, iron, vitamin A, thiamine, riboflavin, and niacin, but not of calcium or ascorbic acid. Chalmers et al. (1952) stated that, while the day by day dietary intake of calories and protein is fairly constant, dietary ascorbic acid shows a marked daily variation. Thus, a longer testing period is needed to achieve some degree of accuracy in estimating ascorbic acid intake. Cellier and Hankin (1963) proposed that even shorter recording intervals may give satisfactory results. They found that the 4-day records

retained 90% of the data of the 7-day records. It would appear that the shorter dietary intake record would lend itself ideally to a study of elderly institutionalized people because of their sedentary habits and their repetitive day to day existence.

For estimating the diet pattern of a group, only a 1-day record is necessary (Eads and Meredith, 1948; Chalmers et al., 1952). To increase the accuracy of a group mean, larger numbers of subjects are needed instead of additional days of analysis.

Along with the diet record, a diet history may be taken. According to Burke (1947) the diet history is helpful in finding inadequacies in the diet. It also helps to identify subjects with between meal feeding patterns. Most important, the diet history serves as a cross check on the dietary record, to see if the record is representative of the person's food consumption.

A major source of error in the diet record is the inaccurate estimation of portion size. Eagles et al. (1966) showed that even when trained nutritionists calculated the nutrient value of the same diet, using the same food table, there were differences as great as 573 calories, 33 gm. protein, and 85 gm. fat. These differences were attributed to divergent interpretation of descriptive terms and portion sizes. Greater accuracy might be obtained by weighing the food, especially in dealing with institutionalized subjects.

When either weighed or estimated dietary records are used,

food tables are generally consulted to determine the nutritive content of the meals. The food table used also introduced a variable. Eagles et al. (1966), in a study comparing food tables found that when the same diet was calculated by different food tables, the nutrient content varied by as much as 460 calories, 28 gm. protein and 56 gm. fat. Obviously, the weighed chemical analysis is the most desirable means of determining dietary nutrients. By chemically analyzing samples of food offered the subjects, the investigator gets the most precise measure of the nutritive content of the diet. Some nutrients are sensitive to improper cooking practices and thus may be destroyed. A food table would be insensitive to these extraordinary losses.

Nutrients which are most affected by improper cooking are the heat labile, water soluble, or easily oxidized vitamins, such as thiamin, folic acid and ascorbic acid. According to Herbert (1968), from 50 to 95% of the folate in food can be lost as a result of improper cooking or canning. Herbert also suggests that this is the major reason for folate deficiency in man.

According to Morgan et al. (1955), low ascorbic acid values obtained in their study resulted, at least in part, from institutional use of long cooking processes and steam tables. Buzina et al. (1971) found the analyzed content of ascorbic acid in prepared meals to be 55% lower than that calculated from the food tables. Evans

and Stock (1971) also compared values obtained by calculations from food composition tables with those obtained by analysis of food samples. They stated that the mean analyzed vitamin C intake of each subject was only a quarter of the estimated intake. They attributed the discrepancy to large losses occurring during food preparation and service, but added that it is almost impossible to avoid such losses in large scale catering. Brin et al. (1964) gave a logical explanation for some of the improper handling of institutional food. They state that food served in institutions for the aged may require cooking and steaming for periods beyond normal, in order to provide meals which are suitably tender and easily digested by geriatric patients.

Even though weighed chemical analysis is the most accurate method for determining nutrient intake, it is also very time-consuming and costly. Time and expense could be two of the most important factors to consider when choosing the method for a dietary study.

The dietary analysis can be used to gain a fuller insight into the subject's nutritional status, when it is correlated with hematological data.

Selected Blood Values of Elderly Persons

Numerous investigations have been undertaken to provide typical blood measurements for healthy elderly persons. These investigations have been conducted upon institutionalized and hospitalized subjects as well as persons who reside at home. Because of the large intersubject variation, blood values are frequently reported in terms of a range with a calculated mean. Table 3 shows data from some of the reported studies, with emphasis on blood values of institutionalized or hospitalized subject. Included in Table 3 are data from studies like the Ten-State Nutrition Survey of 1968-1970 (U.S. Dept. of Health, Education and Welfare IV, 1972) which is one of the recent and significant investigations in terms of the numbers of persons involved. The blood values of the elderly persons participating in the Ten-State Survey were generally higher than those reported for residents of hospitals or geriatric institutions.

As an index for reference, a composite of means for the investigations listed in Table 3 is assembled in Table 4. Also included in Table 4 are the values which were considered acceptable by those who evaluated the National Nutrition Survey (U.S. Dept. of Health, Education and Welfare I, 1972). With these values, a guideline is set by which to evaluate the nutritional status of the elderly.

Table 3. Selected Blood Values of Elderly Persons.

Reference	Age	Sex	Residence	Hematocrit[a]	Hemoglobin[a]	Serum protein[a]	Serum or plasma ascorbic acid[a]	Serum folic acid[a]
				Percent	gm/100 ml	gm/100 ml	mg/100 ml	ng/~~100~~ ml
Gillum and Morgan (1955)	50/80	M	Home	47.1 (33-63)	14.5 (9.0-18.3)	-	-	-
	50/80	F	Home	44.6 (32-56)	13.5 (8.4-20)	-	-	-
	60/75+	M	Institution	43.3 (34.5-51)	14.3 (11.7-16.8)	-	-	-
Morgan et al. (1955)	50/75+	M	Home	-	-	-	0.83[d] (0.11-2.28)	-
	64/75+	M	Institution	-	-	-	0.26 d/ (0.05-1.16)	-
Brin et al. (1964)	62-96	M	Institution	-	-	-	1.56 e/ (0.80-3.45)	-
Brin et al. (1965)	65+	M	Home and	43.9±4.4	-	-	0.55±0.35 e/	-
	65+	F	Institution	40.5±3.9	-	-	0.84±0.43 e/	-
Dibble et al. (1967)		M	Institution	44.0	-	-	0.67±0.42 e/	-
		F	Institution	41.0	-	-	0.91±0.53 e/	-
Girdwood et al. (1967)	75/77	M/F	Home	-	14.1 (8.8-17.6)	-	-	6.4±3.5 d/
	79	M/F	Institution	-	14.3 (11 -17.4)	-	-	4.8±2 d/ (1.6-9.1)
Hurdle and Path (1968a)	70	M/F	Institution	-	-	-	-	(1.8-5.0) d/
Hurdle and Path (1968b)	72/91	M/F	Institution	-	(9.7-16.2)	-	-	5.4 d/ (2.2-10.6)
Wirths (1970)	72	M	Institution	-	-	-	0.33[e]	-
	73	F	Institution				0.62[e]	
U.S.Dept. HEW IV (1972)	60+	M	Home	45.1[b]	14.5[b]	7.2[b]	0.57[b, d]	(5.9-7.2)[d]
	60+	F	Home	45.1[c]	14.7[c]	7.3[c]	0.84[c]	
	60+	F	Home	42.2[b]	13.4[b]	7.1[b]	0.72[b, d]	(6.9-7.8)[d]
	60+	F	Home	42.4[c]	13.7[c]	7.2[c]	1.08[c]	
U.S.Dept. HEW	60+	M/F	Home	43.5	14.7	7.1	-	-

a/ mean and range ( ) b/ low income c/ high income d/ serum levels e/ plasma levels

Table 4. Selected Blood Values of Elderly Subjects. Ranges and Means from Table 3 and Acceptable Values.

Blood component	Sex	Range of means	Acceptable values[a/]
Hematocrit percent	Males	42 to 47	≥ 44
	Females	40 to 45	≥ 38
Hemoglobin gm/100 ml	Males	14.1 to 14.7	≥ 14.0
	Females	13.4 to 13.7	≥ 12.0
Total serum protein mg/100 ml	Males	7.2 to 7.4	≥ 6.5
	Females	7.1 to 7.2	≥ 6.5
Serum ascorbic acid mg/100 ml	Males	0.33 to 1.56	≥ 0.2
	Females	0.62 to 1.07	≥ 0.2
Serum folic acid ng/ml	Males and females	4.8 to 6.4	≥ 6.0

[a/] U.S. Dept. H.E.W. I, 1970.

The hematocrit, hemoglobin concentration, and serum protein concentration serve as gross indicators of nutritional status. The hematocrit measures the volume of red cells as percentage of whole blood. Low hematocrit values may be observed in anemia or in hydremia. The hemoglobin concentration usually reflects iron nutriture, but low hemoglobin levels may also be seen when other nutrients essential to hemoglobin synthesis are lacking, e.g., pyridoxine and protein. However, although anemia usually accompanies severe protein malnutrition, moderate protein deficiency does not seem to seriously affect hemoglobin production. The body seems to protect the amount of circulating hemoglobin so well that hemoglobin may be regenerated even during the development of

hypoproteinemia (Davies, 1945). It is interesting to note that some of the elderly subjects, whose data appear in Table 3, had less than acceptable hematocrits and hemoglobin concentrations. Unless there was frank blood loss in these subjects, the possibility of long term dietary deficiency of iron is suggested.

The serum protein concentration in healthy individuals does not correlate with age, sex, or dietary protein (Morgan et al., 1955). However, the total serum protein is usually depressed in severe malnutrition. Thus, it has been used in nutrition surveys as a means of identifying protein-malnourished individuals (Interdepartmental Committee on Nutrition for National Defense, 1963, U.S. Dept. of Health, Education and Welfare, 1972, 1974). The mean serum protein concentrations of elderly individuals (Table 4) did not indicate gross malnutrition. However, the distribution of protein between the albumin and globulin fractions may have been abnormal. According to Rafsky et al. (1952) the serum albumin decreases significantly with age, and the beta-globulin fraction increases.

Low hematocrits, hemoglobins, and serum protein concentrations indicate long term malnutrition and these measurements respond slowly to repletion. In contrast, plasma concentrations of ascorbic and folic acid reflect recent dietary intake. According to Lowry et al. (1946) the serum ascorbic acid will respond within

four days to a supplement of 500 mg. per day. Potgieter et al. (1955) showed that, even on a modest supplement of 25 mg. per day, increases in serum ascorbic acid could be demonstrated. However, Loh (1972) found no relationship between dietary intake and plasma ascorbic acid of geriatric subjects, although there was a significant correlation in the case of young adults. The mean serum ascorbic acid levels recorded in Table 3 are satisfactory but some of these elderly individuals had low concentrations (Morgan et al., 1955).

The serum folic acid concentrations in the elderly appear to be generally low or borderline (Table 3). According to Hurdle and Path (1968b) folic acid status correlates with dietary intake. They showed that patients with low serum folate levels consumed less folate daily than those whose serum folate was normal. An intake of 80-100 μg. of pure folate per day was considered necessary to maintain normal serum folate levels. Herbert (1963) found satisfactory clinical and hematological response within ten days where patients with uncomplicated folate deficiency were given 100 μg. of pure folate per day.

PROCEDURE

Experimental Plan

Two groups of elderly institutionalized persons were selected as subjects for this study. One group, designated as the experimental group, consisted of 12 persons, while the other group, the controls, consisted of only 11 persons. Each subject had some degree of periodontal disease. The control group received a dental examination, followed only by placebo dental treatment. The experimental group received proper oral hygiene treatment three times a week by a dental hygienist, in addition to an initial oral examination, prophylaxis, and education in the maintenance of proper oral hygiene. The nutritional status and taste perception of all subjects were evaluated before initiating the dental care, and again five weeks following the start of the oral hygiene program.

Subjects

Twenty-three elderly men and women who resided in two geriatric homes in Portland, Oregon, were selected as subjects. The selection criteria were kept liberal, owing to the scarcity of individuals with natural dentition. Subject selection began with the criterion that individuals had to have approximately half of their

own teeth. Individuals with maxillary dentures were initially discouraged but, because of the lack of participants, several individuals with upper dentures were accepted. Also, to qualify for participation, it was stipulated that the subjects' oral hygiene had to be in poor condition, with some degree of periodontal disease. However, owing to the lack of participants, several subjects with stable oral hygiene were accepted. No person whose physical state would prevent the attainment of a normal nutritional status was accepted. In addition, individuals who smoked were not permitted to participate.

Prior to final acceptance, written permission to work with the individual was received either from the subject himself, if he was legally responsible, or from his legal guardian. The individual's personal physician was also contacted for medical clearance.

Of the subjects who participated, five were male and eighteen were female. Most of the individuals ate in a dining hall but eight received meals in their rooms. Only one of the subjects required assistance while feeding. The age range was 52 to 86 years.

Oral Hygiene Program

The subjects were divided at random into an experimental and a control group, composed of 12 and 11 members, respectively. The only restriction on the group dispersion was a balanced distribution of the sexes and the denture wearers. The experimental

group's oral hygiene treatment began with a mild prophylaxis, performed by a qualified hygienist. The prophylaxis consisted of removal of any gross calculus and debris from the subject's mouth. This was followed by regular visits three times a week by the same hygienist. During these weekly visits, the hygienist properly flossed and brushed the subject's teeth, gums and tongue. She also provided instructions so that the subject could perform the oral hygiene procedures properly on the days when the hygienist was not present. These weekly visits lasted for five weeks. During the same period of time, the control group also received weekly visits from the hygienist. However, for the control group, no prophylaxis was administered, and the three weekly visits consisted of placebo work only. The placebo work consisted of oral examinations, removal of debris from the mouth with swabs and minimal advice about the subject's oral hygiene status. The controls were allowed to continue with whatever oral hygiene procedure they were using.

Taste Perception Test

The taste perception test was applied before initiation of the oral hygiene program and again at the end of the experimental period.

Solutions of sucrose, tartaric acid, solium chloride, and caffeine were used to assess taste thresholds for the four primary

tastes: sweet, sour, salty and bitter. In order to cover the wide span of possible threshold values, the following ranges of molar concentrations were prepared in redistilled water:

1. Sucrose - 10 concentrations ranging from 0.005 M to 0.075 M,
2. Tartaric acid - 8 concentrations ranging from 0.00002 M to 0.005 M,
3. Sodium chloride - 11 concentrations ranging from 0.001 M to 0.075 M,
4. Caffeine - 12 concentrations ranging from 0.005 M to 0.02 M.

These solutions were stored in tightly sealed glass bottles and were kept refrigerated when not in use.

Before the testing began, each subject was informed as to the materials to be bested but not the order of testing. Thresholds for the four tastes were determined separately but all within the same session. The order selected for sampling was: sweet, bitter, salty, and sour, as suggested by Charley (1970) and Fabian and Blum (1945). The temperature of the solutions varied from 21° to 26°C.

Taste thresholds were tested by the dilution method described by Dawson et al. (1963), in which the subjects compare solutions of increasing concentration against redistilled water. Approximately 5 ml. of the test solution and of redistilled water were used for testing. A time span of 30 to 60 seconds was maintained between

tests, as recommended by Crocker (1945). The solutions were swallowed, except by patients having urinary or bladder problems, or patients who were on sodium restricted diets.

Two thresholds were determined for each taste. The first was the detection threshold which was reached when the subject was able to detect a difference between distilled water and the test solution. The second, or identification threshold, was reached when the subject was able to identify the taste as sweet, sour, salty, or bitter.

Dietary Analysis

An estimated three day diet analysis was obtained before and after the experimental phase. To insure accuracy, this investigator personally inspected the subjects' trays before and after each meal. With the aid of prior knowledge of the serving portions used at each geriatric home, it was possible to estimate the quantity of food consumed. In addition to the meal-time observations, a dietary history was used to further evaluate the subjects' intake. The diet history was used to determine if the food consumed during the recording periods was representative of that normally consumed. The history was also valuable in detecting between-meal snacking. Subjects who consumed food between meals were asked to keep a record of the kinds and amounts of snacks eaten. In cases where

subjects received bed-time feedings, the nursing staff recorded the items received and the quantity consumed. All food was included in the diet analysis.

Each subject's average daily intake of calories, protein, calcium, iron, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid was determined from data in Home and Garden Bulletin No. 72 (U.S. Dept. of Agriculture, 1971). These determinations were done by the OSU Computer Center, after the raw data had been coded for computer use. The data were divided according to experimental and control groups, and handled by the computer as both individual and group data. The results were reported as average daily intakes for the individuals within each group, before and after the experimental phase, and as the group mean daily intake, before and after the experimental phase.

Folic acid values were derived from data given by Hurdle et al. (1968), Streiff (1971), and Herbert (1963).

Blood Samples

Ten milliliters of venous blood were drawn from each subject, under fasting conditions, before and after the experimental phase of the study. The blood was collected in 10-ml. Vacutainers that had been treated with 12 mg. EDTA (ethylenediamine tetraacetic acid), and the samples were then packed in ice. The hematocrit and

hemoglobin analyses were completed within four hours of drawing. Plasma was separated by centrifugation at 3000 rpm for 20 minutes at 5°C. For each subject, two separate 200 μl. portions of plasma. were transferred into 7 x 70 mm tubes which contained 800 ml of 10% TCA (trichloroacetic acid). The remaining plasma was stored in two sealed glass containers at -10°C. The plasma which was placed in the 10% TCA was sealed, mixed thoroughly, and centrifuged at 3000 rpm for 10 minutes. Two 300μl. portions of supernatant were drawn off, placed in 7 x 70 mm tubes, capped tightly, and stored at -10°C. The acidified aliquots were used for ascorbic acid analyses.

Methods of Blood Analysis

Hematocrit

Hematocrit was determined by the micro-method (Richterich, 1968), and results are expressed as volume of packed red cells per 100 ml. whole blood.

Hemoglobin

The cyanomethemoglobin method was used to determine hemoglobin (Oser, 1965). Hemoglobin was oxidized by ferricyanide to Methemoglobin, which reacts with cyanide ions to form

cyanomethemoglobin. The color intensity of cyanomethemoglobin was measured with a Bausch and Lomb Spectronic 20 colorimeter at 540 nm, using Hycel cyanomethemoglobin as the standard. Results are reported as grams hemoglobin per 100 ml. blood.

Total Plasma Protein

Total plasma protein was determined by the micro-biuret technique (ICNND, 1963). Polypeptides react with copper salts in an alkaline solution to produce a violet color. The colored solution was allowed to stand for 30 minutes before measuring with a Bausch and Lomb Spectronic 20 colorimeter at 540 nm. Full strength Versatol from Ortho Diagnostics (Raritan, New Jersey) was used as a standard. The only modification of the original procedure was the use of 2.5 ml. of Biuret Reagent with 25 ul. of plasma. The results are reported as grams of protein per 100 ml. plasma.

Plasma Ascorbic Acid

Plasma ascorbic acid was measured by a modification of the dinitrophenylhydrazine method described by Roe (Gyorgy and Pearson, 1967). The ascorbic acid was oxidized to dehydro-ascorbic acid by copper ions. The dehydroascorbic acid formed a bis-2, 4-dinitrophenylhydrazine derivative which was dissolved by concentrated sulfuric acid to produce a red-orange product which

was measured with a Beckman Model DU Spectrophotometer. Results are reported as milligrams ascorbic acid per 100 ml. of plasma.

Roe's procedure was modified in this experiment with the following changes: 10% trichloroacetic acid, instead of 5%, was used to precipitate plasma proteins; all measurements of the micropro-cedure were increased by a factor of 10; and the incubation period was changed to 2 hours at 60°C in place of 4 hours at 37°C. The ascorbic acid concentrations of plasma were determined on the basis of a regression equation computed from a series of standards analyzed with each run.

Acidified deproteinized plasma samples were stored at -10°C for four months prior to analysis. Although Bradley et al. (1973) indicated that ascorbic acid which has been stabilized with TCA is sound for at least 21 days, preliminary studies in this laboratory indicated that samples could be held for several months.

Plasma Folic Acid

Plasma folic acid was measured by Brineman's (1974) modification of the aseptic addition method of Herbert (1966). This microbiological method uses the growth of Lactobacillus casei as a direct measure of plasma folic acid. Unknown plasma folic acid values were derived from a graph constructed by plotting folic acid standards against optical density. The results are reported as

nanograms of folic acid per milliliter of blood plasma.

Statistical Treatment

To evaluate the data from this experiment, three individual tests were used, namely, the student's t test, the chi square test and the paired t test.

The first procedure was to determine the difference between the before and after results for each individual within a group, for each parameter tested. From this information, the mean difference in response for both the experimental and control groups were determined for each parameter tested. With this information, the student's t test was used to determine if there was a significant difference in response between the experimental and control group, for each parameter tested (except for the taste perception). The critical value for t was taken at $\alpha_{.05}$ and 21 degrees of freedom.

To further evaluate the data, the chi square test was used. In this case, the number of positive and negative responses for the experimental group was compared with the positive and negative responses of the control group for each of the parameters tested, in order to determine if one group had a more positive response to the experiment than did the other group. The critical values of chi square were taken at $\alpha_{.05}$, $\alpha_{.025}$ and $\alpha_{.01}$, with one degree of freedom.

Finally, the paired t test was used to compare the before and after results of the total population. The critical value of the paired t test was taken at the 0.01 level with 22 degrees of freedom.

RESULTS AND DISCUSSION

Taste Perception

The results of the taste perception tests are presented in Tables 5 and 6. Both the detection and identification thresholds are within the limits reported by other investigators (Table 1).

One of the primary concerns of this study was to determine whether or not improved oral hygiene would improve the taste perception of the aged. If the taste test was to be of importance, the experimental group that received the improved oral hygiene would have improved taste acuity while the control group, receiving only placebo care, would have virtually unchanged acuity.

In order to evaluate the results of the changes in taste perception, the chi square test was used to determine if the number of experimental subjects whose taste perception had improved was significantly greater than the number of controls whose taste perception improved. It was found that significantly more of the experimental than the control subjects had improved ability to detect sweet ($\alpha_{.01}$), salty ($\alpha_{.05}$), and sour ($\alpha_{.05}$) tastes but were unable to detect the bitter taste more frequently than the controls. For the identification thresholds, the experimental group again had a significantly larger number of improvements for sweet ($\alpha_{.025}$) and

Table 5. Taste Detection Threshold of Experimental and Control Subjects, Before and After Treatment (concentrations in moles per liter).

Identification	Sucrose		Sodium chloride		Tartaric acid		Caffeine	
Experimental	Before	After	Before	After	Before	After	Before	After
132	0.01	0.005	0.02	0.005	0.0005	0.0002	0.005	0.002
205	0.015	(a)	0.01	0.005	0.0005	0.0001	0.001	0.001
221-P	0.02	(a)	0.02	0.01	0.001	0.005	0.002	0.005
224	0.02	0.01	0.01	0.01	0.0001	0.00002	0.004	0.003
308	0.02	0.015	0.025	(a)	0.0002	(a)	0.001	0.001
323	(a)	0.015	0.01	(a)	0.0002	0.0002	0.002	0.001
402	(a)	0.02	(a)	0.02	(a)	0.0002	0.002	0.002
408	0.025	0.0005	0.025	(a)	0.0007	0.0001	0.004	0.002
414	0.025	(a)	0.025	0.025	0.0007	(a)	0.02	0.01
425-1-P	0.02	0.01	0.02	0.02	0.001	0.0005	0.009	0.006
425-2-P	0.002	0.001	0.025	0.02	0.0002	0.0002	0.002	0.001
463	0.01	0.005	(a)	0.01	0.0005	0.0001	0.005	0.002
Control								
201	0.015	0.02	0.01	0.025	0.0005	0.0007	0.003	0.002
225-P	0.02	0.02	0.01	0.01	0.0002	0.0002	0.003	0.002
273-1	0.01	0.01	0.025	0.02	0.0001	0.0001	0.005	(a)
273-2	0.01	(a)	0.01	0.01	0.001	0.001	0.004	0.004
300	(a)	0.015	0.025	0.03	0.0001	0.0001	0.003	0.002
306	0.01	0.01	0.02	0.02	0.0001	0.0001	0.001	0.001
310	0.02	0.02	0.01	(a)	0.0002	(a)	(a)	0.007
377	0.015	0.015	0.005	0.01	0.0002	0.0002	0.003	0.002
414-P	0.005	0.005	0.001	0.001	0.0001	0.0002	0.002	(a)
424-P	0.025	0.015	(a)	0.001	0.0001	0.0002	0.001	0.0005
467	0.01	0.0005	0.001	0.005	0.0001	0.00002	0.001	0.0005

(a) could not detect

Table 6. Taste Identification Thresholds of Experimental and Control Subjects, Before and After Treatment (concentrations in moles per liter).

Identification	Sucrose		Sodium Chloride		Tartaric acid		Caffeine	
Experimental	Before	After	Before	After	Before	After	Before	After
132	0.015	0.01	0.06	0.05	0.002	0.001	>0.02	>0.02
205	0.02	0.01	0.03	0.015	0.001	0.002	0.004	0.003
221-P	0.025	0.01	0.03	0.04	0.005	0.005	0.004	0.006
224	0.075	0.03	0.025	0.02	0.0007	0.0005	>0.02	>0.02
308	0.035	0.025	0.04	(a)	0.0007	(a)	0.010	0.010
323	0.03	0.02	0.02	0.005	0.001	0.0005	0.005	0.003
402	0.025	0.025	0.01	0.03	0.0007	0.0005	0.006	0.004
408	0.03	0.01	0.07	0.02	0.005	0.002	>0.02	>0.02
414	0.03	0.03	0.05	0.03	0.001	0.0005	>0.03	0.02
425-1-P	0.025	0.035	0.075	0.05	0.005	0.002	>0.03	0.009
425-2-P	0.01	0.005	>0.075	>0.075	0.002	0.005	0.005	0.005
463	0.035	0.01	0.03	0.025	0.002	0.005	>0.03	0.02
Control								
201	0.025	0.025	0.03	0.03	>0.005	>0.005	0.025	0.025
225-P	0.025	0.025	0.02	0.02	0.0005	0.0007	0.005	0.003
273-1	0.04	0.03	0.06	0.06	0.0007	0.0005	0.04	0.03
272-2	0.02	0.02	0.025	0.03	0.005	0.002	0.02	0.02
300	0.02	0.02	>0.075	>0.075	>0.005	>0.005	>0.02	0.010
306	0.015	0.025	0.025	0.03	0.0002	0.0002	0.010	0.008
310	0.025	0.04	0.04	0.01	0.0005	0.0007	0.008	0.008
377	0.02	0.025	0.075	0.075	>0.005	>0.005	0.005	0.003
414-P	0.01	0.005	0.04	0.005	0.0007	0.0005	0.002	0.001
424-P	>0.075	0.035	0.01	0.025	0.0002	0.0002	0.006	0.002
467	0.02	0.025	0.02	0.01	0.0005	0.0002	0.002	0.002

(a) could not identify

salty ($\alpha_{.05}$) tastes but were unable to correctly identify sour or bitter tastes more often than the controls.

Faced with such an impressive showing for improved oral hygiene, one might surmise that the reduced taste acuities seen in the aged, as reported by Richter and Campbell (1940), Cooper et al. (1959), and Hermal et al. (1970), may have been due, in part, to poor oral hygiene status in their test subjects.

Nutrient Intake

The calculated nutrient intakes of the experimental and control subjects, before and after treatment, are recorded in Tables 7 and 8. Although the dietary nutrients are similar to those reported for other aged individuals, they fall short of the recommended dietary allowances (Table 2). Calorie intakes were generally low, as might be expected of institutionalized patients. At the beginning of the study, mean dietary values for folic acid, thiamin, niacin and calcium were low. The dietary folate was exceedingly low when compared to the recommended daily allowance of 400 ug. food folate. It should be noted that, although 100 ug. of pure folic acid are sufficient to maintain folate status, the conjugated folate which is found in food is considerably less well absorbed. For this reason, the recommended dietary allowance has been set at 400 ug. per day. The low folate values calculated for the diets in this study are

Table 7. Average Daily Nutrient Intake of Experimental Subjects, Before and After Oral Hygiene Treatment.

Identification[a/]	Food energy	Protein	Calcium	Iron	Vitamin A	Thiamin	Riboflavin	Niacin	Ascorbic acid	Folic acid
	Kcal	gm	mg	mg	I.U.	mg	mg	mg	mg	ug
132 Before	1192	60	346	10.6	6702	0.79	1.00	12.6	23	70
After	1148	55	403	10.2	10115	0.66	1.00	9.7	56	68
205 Before	963	41	298	10.3	5128	0.55	0.70	6.9	28	68
After	1094	58	588	7.6	6158	0.45	0.96	7.7	18	76
221-P Before	1484	58	584	9.5	4889	0.75	1.21	11.9	84	134
After	1728	70	650	11.3	8954	0.70	1.50	15.3	101	121
224 Before	1324	64	767	10.2	5390	0.98	1.49	9.2	85	181
After	1610	62	748	11.0	8984	1.05	1.53	8.2	69	148
308 Before	1730	74	433	13.6	7729	1.38	1.31	14.3	77	149
(M) After	2100	80	915	13.7	13180	1.26	1.98	10.4	73	124
323 Before	1460	94	572	15.2	17600	0.95	1.56	23.8	94	72
After	1665	112	628	19.0	20732	1.01	1.48	29.7	51	81
402 Before	966	31	452	8.6	1686	0.41	0.83	4.8	23	186
After	1416	56	984	9.5	7100	0.89	1.74	6.7	36	154
408 Before	1776	72	431	14.9	9775	1.51	1.41	13.6	74	107
(M) After	2162	89	972	15.6	14000	1.65	2.13	13.4	73	112
414 Before	1080	38	218	7.2	7336	0.54	0.68	7.0	64	127
After	1320	63	609	9.9	5024	0.97	1.32	9.0	66	123
425-1-P Before	1698	64	664	10.9	4998	0.76	1.38	11.8	140	148
After	1444	62	819	9.6	9504	0.87	1.67	11.0	112	110
425-2-P Before	1560	47	469	10.1	6760	0.69	1.06	8.8	146	120
After	1442	54	658	13.0	6126	0.82	1.28	11.9	160	90
463 Before	1318	46	234	7.8	7924	0.89	0.70	9.5	94	127
After	1732	68	508	13.7	12957	1.45	1.38	13.1	67	123
Mean Before	1378	57	456	10.4	7410	0.85	1.11	11.2	78	121
	±287	±18	±169	±2.9	±3932	±0.33	±0.33	±4.9	±40	±41
After	1582**	69***	707***	12.0**	10236***	0.98*	1.50***	12.2	74	107
	±333	±17	±183	±3.2	±4418	±0.34	±0.35	±6.1	±37	±29

a/ All subjects were female except those identified as (M)

* significant increase at 95% level with 11 d.f.

** significant increase at 99% level with 11 d.f.

*** significant increase at 99.5% level with 11 d.f.

Table 8. Average Daily Nutrient Intake of Control Subjects, Before and After Oral Placebo Treatment.

Identification[a]		Food energy	Protein	Calcium	Iron	Vitamin A	Thiamin	Riboflavin	Niacin	Ascorbic acid	Folic acid
		Kcal	gm	mg	mg	I.U.	mg	mg	mg	mg	ug
201	Before	786	32	289	5.4	2780	0.56	0.70	5.2	120	131
	After	1323	66	910	7.8	8947	0.81	1.66	8.3	80	124
225-P	Before	1272	53	460	13.2	1722	0.57	0.91	12.1	38	78
	After	1040	46	364	8.6	5203	0.55	0.90	9.2	82	40
273-1	Before	1229	44	278	13.6	6794	0.82	0.65	10.6	49	159
	After	1772	71	1075	15.5	9000	1.04	1.89	11.2	78	226
273-2	Before	1794	63	384	12.5	8210	1.25	1.09	12.1	34	87
	After	1639	68	524	12.2	20578	1.13	1.39	10.3	73	129
300	Before	1720	74	480	13.5	6516	1.08	1.30	12.1	90	152
(M)	After	1738	59	422	11.6	12116	0.99	1.11	10.3	55	80
306	Before	1652	67	672	12.3	8018	1.05	1.44	10.3	40	127
(M)	After	1706	70	764	13.4	11260	1.39	1.73	11.0	92	168
310	Before	884	38	231	7.7	5382	0.44	0.64	9.2	18	76
(M)	After	1220	58	883	8.1	9730	0.66	1.59	6.6	26	108
377	Before	1502	61	470	12.2	9034	1.33	1.21	11.6	134	176
	After	1492	72	555	14.0	10971	1.30	1.45	13.6	138	163
414-P	Before	1342	58	371	12.6	4308	0.63	0.88	10.9	79	120
	After	1236	57	567	12.8	11542	0.66	1.29	8.9	100	114
424-P	Before	1254	40	278	11.9	6434	0.46	0.83	7.1	110	138
	After	1695	70	940	13.9	7223	0.64	1.91	9.7	119	82
467	Before	966	46	246	8.2	5206	0.79	0.83	8.2	79	73
	After	1345	76	884	7.1	9272	0.67	1.76	7.2	74	94
Mean	Before	1312	52	378	11.2	5855	0.82	0.95	9.9	72	120
		±338	±13	±134	±2.8	±2271	±0.32	±0.27	±2.3	±39	±36
	After	1473*	65**	717***	11.4	10531**	0.89	1.52***	9.7	84	121
		± 273	±9	±239	±3.0	±3894	±0.29	±0.33	±2.0	±30	±51

[a] All subjects were female except those identified as (M)

* significant increase at the 95% level with 10 d.f.

** significant increase at the 97.5% level with 10 d.f.

*** significant increase at the 99.5% level with 10 d.f.

comparable to those reported by Hurdle and Path (1968a).

It was expected that improved oral hygiene and improved taste perception would be accompanied by an improvement in dietary intake of nutrients and that the control group, who received only placebo treatment, would show no dietary improvement. However, both groups showed significant increases in mean dietary calories, protein, calcium, vitamin A, and riboflavin (Tables 7 and 8). In addition, the experimental group improved their mean iron and thiamin intakes significantly (Table 7). During the five-week experimental phase, the mean caloric intake increased 12.4% for the controls and 14.1% for the experimental group. The total increase was significant at the 1% level, using the paired t test. It is interesting to note that there was no significant change by either group in the mean intake of ascorbic acid, which was adequate or of folic acid, which was inadequate. It is possible that the general improvement in dietary intake of both control and experimental subjects was a psychological response to the frequent visits by the dental hygienist.

Blood Values

The results of the blood analyses are presented in Table 9. Although a number of individuals had blood values which were less than acceptable, the mean values for the two groups compared

Table 9. Average Blood Values of Experimental and Control Subjects, Before and After Treatment.

Identification	Hematocrit		Hemoglobin		Plasma protein		Plasma ascorbic acid		Plasma folic acid	
Subjects a/	Percent		gm/100 ml		gm/100 ml		mg/100 ml		ng/ml	
Experimental	Before	After	Before	After	Before	After	Before	After	Before	After
132	42	43	14.5	14.1	6.9	7.0	1.11	1.58	3.4	3.7
205	33	35	11.0	11.2	4.6	4.9	0.13	0.31	0.5	0.7
221-P	40	38	12.4	12.4	6.3	6.4	0.33	0.40	1.5	1.9
224	38	37	13.4	12.0	7.5	6.6	1.08	0.97	2.2	1.5
308 (M)	44	46	14.2	14.8	7.0	6.8	0.58	0.89	2.3	3.5
324	44	47	15.3	16.0	7.4	7.2	0.98	1.33	4.2	3.7
402	36	38	11.2	12.4	6.1	6.5	0.32	0.35	1.6	1.9
408 (M)	46	47	15.8	16.3	6.3	7.1	1.36	1.36	2.7	4.7
414	42	36	13.6	12.5	6.6	6.2	0.79	0.93	3.7	2.7
425-1-P	35	35	12.1	12.0	5.8	5.7	1.07	1.39	2.1	2.3
425-2-P	38	39	13.0	14.1	6.7	6.4	0.89	1.35	1.5	1.5
463	35	36	11.9	12.9	5.8	6.4	1.45	1.62	4.7	4.3
Mean	39	40	13.2	13.4	6.4	6.4	0.84	1.04	2.5	2.7
±	±4	±4	±1.5	±1.6	±0.8	±0.6	±0.42	±0.48	±1.2	±1.3
Control										
201	37	38	13.0	12.8	8.2	7.8	1.32	1.15	2.4	2.5
225-P	43	41	14.3	14.0	6.3	6.0	0.86	1.21	2.1	2.1
273-1	43	44	15.2	14.9	7.6	7.4	0.29	0.32	1.4	1.6
273-2	40	41	13.2	13.3	7.4	6.4	1.03	1.02	3.4	3.4
300 (M)	47	46	16.3	15.6	6.4	6.1	1.11	0.94	2.2	1.5
306 (M)	41	41	14.7	13.9	5.8	5.6	0.44	0.53	1.7	1.7
310 (M)	39	39	13.9	13.2	6.0	6.0	0.62	1.07	1.7	2.2
377	39	38	13.4	12.6	6.7	6.7	1.43	1.29	2.9	3.2
414-P	38	41	12.1	13.9	5.7	6.1	1.04	0.93	2.5	3.4
424-P	38	36	12.2	12.0	5.8	5.5	1.72	2.21	1.2	1.1
467	43	43	14.6	14.4	6.9	6.6	1.19	1.49	2.2	1.6
Mean	41	41	14.2	13.7	6.6	6.4	1.00	1.11	2.1	2.2
±	±3	±3	±1.1	±1.1	±0.8	±0.7	±0.43	±0.49	±0.7	±0.8

a/ All subjects were female except those indicated as (M)

favorably with the guidelines used in the survey (Table 4), with the exception of folic acid. Folic acid was found to be consistently low in all subjects tested. In order to evaluate the results, the students' t test was used but no significant hematological improvement was noted for either the experimental or the control group.

The low levels of plasma folate and the lack of response to treatment were consistent with the low levels of dietary folate at each sampling period. The plasma folate concentrations were much lower than those reported by Hurdle and Path (1968a) despite the fact that the dietary folate in the two studies was comparable (Tables 2 and 3). Possibly the actual dietary folate in this study was lower than the amount calculated, due to losses through improper cooking procedures. Herbert (1968) stated that 50 to 95% of the folate in food can be destroyed by improper cooking.

Even though the improvements were not great, it appeared that more of the experimental subjects had improved blood values than did the controls. To test this, the chi square test was used. The results showed that significantly more of the experimental subjects had responded positively in their hemoglobin ($\alpha_{.025}$), total plasma protein ($\alpha_{.05}$) and plasma ascorbic acid ($\alpha_{.05}$), than had the controls. Even though the experimental subjects showed improvement in their hematocrit and plasma folic acid values the number who showed this improvement was not significantly greater

than the number of control subjects who responded.

SUMMARY

Twenty-three elderly institutionalized men and women, who had poor oral hygiene, served as subjects for this study. For five weeks, 12 of the subjects, identified as the experimental group, received oral hygiene treatments by a dental hygienist three times weekly. During this same period, the remaining 11 subjects, the controls, were also visited by the hygienist but received only placebo treatment.

At the beginning and again at the end of the five-week period, a 3-day diet record was taken for each subject from which the average daily nutrient intakes were computed. In addition, a taste perception test was administered and blood samples were drawn for analysis of hematocrit, hemoglobin concentration, plasma protein, ascorbic acid and folic acid.

When the subjects who received oral hygiene treatments were compared with those who received placebo treatment, significantly more of the experimental subjects showed improvement in their ability to detect sweet, sour, and salty tastes. There were also significantly more improvements in identification thresholds for sweet and salty tastes among the experimental subjects. However, the experimental subjects did not show significant improvements for bitter tastes or sour identification.

The mean intake of many nutrients, especially folate, fell short of the recommended dietary allowances for this age group. At the end of the experimental period, both groups showed significant improvement in mean dietary calories, protein, calcium, vitamin A and riboflavin. No improvement in folate intake occurred. It was concluded that both groups ate better as a result of the attention paid to them.

The mean blood values were quite adequate except for the plasma folate concentrations which were consistently low for all subjects. No significant improvement in the mean blood values was shown by either group as a result of the treatment. However, significantly more of the experimental than control subjects showed an increase in hemoglobin, plasma protein, and plasma ascorbic acid.

It would appear that proper oral hygiene exerted a positive effect on taste acuity of the elderly institutionalized subject. Furthermore the trends observed in this study suggest that improvement in nutritional status might result from improved oral hygiene carried out over a longer period of time.

BIBLIOGRAPHY

Ainamo, J. Effect of oral hygiene on caries and periodontal disease. Dent. Abs. 16(10):615-616,1971.

Anderson, W. Nutritional problems of the elderly. Proc. Nutr. Soc. 27:185-187, 1968.

Anonymous. Nutrition and eating problems of the elderly. Current Comment. J. Am. Diet. Assoc. 58:43-48, 1971.

Arey, L., Tremaine, M., and Monzingo, F. The numerical and topographical relations of taste buds to human circumvallate papillae throughout the life span. Anat. Rec. 64:9-25, 1935.

Ash, M., Gitlin, B., and Smith, W. Correlation between plaque and gingivitis. J. Periodontol. 35:424-429, 1964.

Bradley, D., Emery, G., and Maynard, J. Vitamin C in plasma: A comparative study of the vitamin stabilized with trichloracetic acid or metaphosphoric acid and the effects of storage at -70°, -20°, 4° and 25° on the stabilized vitamin. Clin. Chim Acta. 44:47-52, 1973.

Brandtzaeg, P., and Jamison, H. The effect of controlled cleaning of the teeth on peridontal health and oral hygiene in Norwegian army recruits. J. Periodontol 35:308-312, 1964.

Brineman, E. The effects of oral contraceptives on the serum folate levels in women. Master's thesis. Oregon State University. 1974.

Brin, M., Schwartzberg, S., and Davies, D. A vitamin evaluation program as applied to 10 elderly residents in a community home for the aged. J. Am. Geriatr. Soc. 12:493-499, 1964.

Brin, M., Dibble, M., Peel, A., McMullen, E., Bourquin, A., and Chen, N. Some preliminary findings on the nutritional status of the aged in Onondago County, New York. Am. J. Clin. Nutr. 17:240-258, 1965.

Burke, B. The dietary history as a tool in research. J. Am. Diet Assoc. 23:1041-1046, 1947.

Buzine, R., Brodarec, A., Jusic, M., Milanovic, N., Bernhard, K., Brubacher, G., Christeller, S., and Vuilleumier, J. The assessment of dietary vitamin intakes of 24 Istrian farmers: I. Laboratory analysis versus food tables. Int. J. Vitam. Nutr. Res. 41:129-140, 1971.

Byrd, E., and Gertman, S. Taste sensitivity in aging persons. Geriatrics. 14:381-384, 1959.

Cellier, K., and Hankin, M. Studies of nutrition in pregnancy. I. Some considerations in collecting dietary information. Am. J. Clin. Nutr. 13:55-62, 1963.

Chalmers, F., Clayton, M., Gate, L., Tucker, R., Wertz, A., Young, C., and Foster, W. The dietary record - How many and which days? J. Am. Diet. Assoc. 28:711-717, 1952.

Chanarin, I., Rothman, D., Perry, J., and Stratfull, D. Normal dietary folate, iron and protein intake, with particular reference to pregnancy. Br. Med. J. 2:394-397, 1968.

Chappell, G. Long-term individual dietary surveys. Br. J. Nutr. 9: 323-339, 1955.

Charley, H. "Food Science." The Ronald Press Company, New York, 1970, p. 17.

Cohen, T., and Gitman, L. Oral complaints and taste perception in the aged. J. Gerontol. 14:294-298, 1959.

Cooper, R., Bilash, I., and Zubek, J. The effect of age on taste sensitivity. J. Gerontol. 14:56-58, 1959.

Crocker, E. "Flavor." 1st Edition, McGraw-Hill Book Company. New York, London, 1945, p. 93-97.

Davies, T. Hypoproteinaemia during recovery from severe anemia. Br. Med. J. 1, 45-46, 1945.

Dawson, E., Brogdon, J., and McManus, S. Sensory testing of difference in taste. 1. Methods. Food Tech. 17:1125-1131, 1963.

Day, M., Stephens, R., and Quigley, L. Periodontal disease: Prevalence and incidence. J. Periodontol. 26:185-203, 1955.

Dibble, M., Brin, M., Thiele, V., Peel, A., Chen, N., and McMullen, E. Evaluation of the nutritional status of elderly subjects, with a comparison between fall and spring. J. Am., Geriatr. Soc. 15:1031-1061, 1967.

Eads, M., and Meredith, A. Nutrition studies. II. Methods of collecting dietary data. Pub. Health Rep. 63:777, 1948.

Eagles, J., Whiting, M., and Olson, R. Dietary appraisal - problems in processing dietary data. Am. J. Clin. Nutr. 19:1-9, 1966.

Evans, E., and Stock, A. Dietary intakes of geriatric patients in hospital. Nutr. Metab. 13:21035, 1971.

Fabian, F., and Blum, H. Relative taste potency of some basic food constituents and their competitive and compensatory action. Food Res. 8:179-193, 1943.

Falaschitti, L., Jennings, A., and Engle, K. Programming dental care for the nursing home patient. Unpublished Project, University of Oregon Dental School. March, 1970.

Gillum, H., and Morgan, A. Nutritional status of the aging. I. Hemoglobin levels, packed cell volumes and sedimentation rates of 577 normal men and women over 50 years of age. J. Nutr. 55:265-288, 1955.

Gillmore, E., and Bhaskar, S. Effect of tongue brushing on bacterial population. J. S. Calif. Dent. Assoc. 39: 893-895, 1971.

Girdwood, R., Thompson, A., and Willamson, J. Folate status in the elderly. Br. Med. J. 2:670-672, 1967.

Gyorgy, P. and Pearson, W. "The Vitamins." Second Edition, Academic Press, New York and London, Vol. VII, 1967. p. 44-46.

Harper, A. Recommended dietary allowances (revised - 1973). Nutr. Rev. 31:393-396, 1973.

Henkin, R., and Christiansen, R. Taste thresholds in patients with dentures. J. Am. Dent. Assoc. 75:118-120, 1967.

Henkin, R., and Christiansen, R. Taste localization on the tongue, palate and pharynx of normal man. J. Appl. Physiol. 22:316-320, 1967.

Herbert, V. A palatable diet for producing experimental folate deficiency in man. Am. J. Clin. Nutr. 12:17-20, 1963.

Herbert, V. Aseptic addition method for Lactobacillus casei assay of folate activity in human serum. J. Clin. Path. 19:12-16, 1966.

Herbert, V. Nutritional requirements for B_{12} and folic acid. Am. J. Clin. Nutr. 21(2):743-752, 1968.

Hermal, J., Schonwetter, S., and Samueloff, S. Taste sensation and age in man. J. Oral Med. 25:39-42, 1970.

Hopkins, J. Precision of assessment of palatability of food stuffs by laboratory panels. Can. J. Res. 24:203-214, 1946.

Howell, W. "Textbook of Physiology." 8th Edition. W. B. Saunders Company. Philadelphia and London, 1922, p. 295.

Huenemann, R., and Turner, D. Methods of dietary investigation. J. Am. Diet. Assoc. 18:562-568, 1942.

Hurdle, A., Barton, D., and Searles, I. A method for measuring folate in food and its application to a hospital diet. Am. J. Clin. Nutr. 21:1202-1207, 1968.

Hurdle, A., and Path, M. (1968a) An assessment of the folate intake of elderly patients in hospital. Med. J. Australia 2: 101-104, 1968.

Hurdle, A., and Path, M. (1968b) The influence of hospital food on the folic-acid status of long-stay elderly patients. Med. J. Australia 2:104-110, 1968.

Interdepartmental Committee on Nutrition for National Defense. Manual for Nutritional Surveys. 2nd Edition, 1963. p. 133-135.

Jackson, J. Heavy smoking and sodium chloride hypogeusia. J. Dent. Res. 46:742-744, 1967.

Jacobson, S., Crawford, J., and McFall, W. Oral physiotherapy of the tongue and palate: relationship to plaque control. J. Am. Dent. Assoc. 87:134-139, 1973.

Janowitz, H., and Grossman, M. Gusto-olfactory thresholds in relation to appetite and hunger sensations. J. Appl. Physiol. 2:217-222, 1949-1950.

Kaplan, A., and Glanville, E. Taste thresholds for bitterness and cigarette smoking. Nature 202:1366, 1964.

Kaplan, A., Glanville, E., and Fischer, R. Cumulative effect of age and smoking on taste sensitivity in males and females. J. Gerontol. 20:334-337, 1965.

Klaptocz, B. Loss of teeth and gland function. Dent. Abs. 9:557, 1964.

Knowles, D., and Johnson, P. A study of the sensitiveness of prospective food judges to the primary tastes. Food Res. 6:207-216, 1941.

Komuro, K. Is the sense of taste affected by temperature. Arch. Neural, Physiol. 5:572-579, 1971.

Lang, N., Cumming, B., and Loe, H. Toothbrushing frequency as it relates to plaque development and gingival health. J. Periodontol. 44:396-405, 1973.

Laue, E., Ishler, N., and Bullman, G. Reliability of taste testing and consumer testing methods. I. Fatigue in taste testing. Food Tech. 8:387-388, 1954.

Loh, H. The relationship between dietary ascorbic acid intake on buffy coat and plasma ascorbic acid concentrations at different ages. Int. J. Vitam. Nutr. Res. 42:80-85, 1972.

Lowry, O., Lopez, J., and Bessey, O. The determination of ascorbic acid in small amounts of blood serum. J. Biol. Chem. 160:609-615, 1945.

Lyons, J., and Trulson, M. Food practices of older people living at home. J. Gerontol. 11:66-72, 1956.

Mackey, A., and Jones, P. Selection of members of a food tasting panel: Discernment of primary tastes in water solution compares with judging ability for foods. Food Tech. 8: 527-530, 1954.

Mackey, A., and Valassi, K. The discernment of primary taste in the presence of different food textures. Food Tech. 10: 238-240, 1956.

McBurney, D., and Pfaffmann, C. Gustatory adaptation to saliva and sodium chloride. J. Exp. Psychol. 65:523-529, 1963.

McCutcheon, M., and Saunder, J. Human taste papilla stimulation: Stability of quality judgment over time. Science. 175: 214-216, 1972.

Moore, M., Linker, E., and Purcell, M. Taste sensitivity after eating: A signal-detection approach. Am. J. Psychol. 78: 107-111, 1965.

Morgan, A., Gillum, H. and Williams, R. Nutritional status of the aged (serum ascorbic acid and intake), J. Nutr. 55: 431-448, 1955.

Nizel, A. "Nutrition in Preventive Dentistry: Science and Practice." W. B. Saunders Company, Philadelphia, London, Toronto. 1972. p. 396-404.

Oser, B. "Hawk's Physiological Chemistry." 14th Edition, McGraw-Hill, New York. 1965. p. 1472.

Pangborn, R. Influence of hunger on sweetness preferences and taste thresholds. Am. J. Clin. Nutr. 7:280-287, 1959.

Potgieter, M., Morse, E., and Walker, G. Ascorbic acid utilization by women. J. Nutr. 55:217-224, 1955.

Pelcovits, J. Nutrition to meet the human needs of older Americans. J. Am. Diet. Assoc. 60:297-300, 1972.

Powers, J., Howell, A., Lillard, D., and Vacinek, S. Effect of temperature on threshold values for citric acid, malic acid, and quinine sulfate - energy of activation and extreme-value determination. J. Sci. Food Agric. 22:543-547, 1971.

Rafsky, H., Brill, K., Stern, K., and Corey, H. Electrophoretic studies on the serum of normal aged individuals. Am. J. Med. Sci. 224:522, 1952.

Reitz, M. A study of oral hygiene and health of gingiva in geriatric patients. Master's thesis. University of Oregon School of Nursing, 1971.

Report of a Joint FAO-WHO Expert Group. Requirements of ascorbic acid, vitamin D, vitamin B_{12}, folate, and iron. Tech. Report series 452:1-75, 1970.

Richter, C., and Campbell, K. Sucrose taste thresholds of rats and humans. Am. J. Physiol. 128:291-297, 1940.

Shock, N. The physiology of aging. Sci. Am. 206:100-110, 1962.

Streiff, R. Folate levels in citrus and other juices. Am. J. Clin. Nutr. 24(2):1390-1392, 1971.

Suomi, J. Prevention and control of periodontal disease. J. Am. Dent. Assoc. 83:1271-1287, 1971.

Tilgner, D. and Bruylko-Pikielna. Threshold and minimum sensitivity of the taste sense. Acta. Physiol. Pol. 10: 741-754, 1959.

U.S. Department of Agriculture. Consumer and Food Economics Research Division. Nutritive Value of Foods. Home and Garden Bulletin No. 72. 1971. 41 p.

U.S. Department of Health, Education and Welfare: Ten-State Nutrition Survey 1968-1970.
DHEW Publications (HSM) 72-8130 Series, 1972.
I - Historical Development. Pub. 72-8130.
IV - Biochemical. Pub. 72-8132.
V - Dietary. Pub. 72-8133.

U. S. Department of Health, Education and Welfare: Preliminary findings of the First Health and Nutrition Examination Survey, United States, 1971-1972. DHEW Publication No. (HRA) 74-1219-1, 1974.

Williams, R. Human detectability thresholds for saccharin, sodium saccharin and sodium chloride. J. Comp. Physiol. Psychol. 70:113-115, 1970.

Wirths, W. Supply of thiamine and ascorbic acid investigated in aged people and apprentices living in homes. Int. J. Vit. Nutr. Res. 40:556-557, 1970.

Weinberg, J. Psychologic implications of the nutritional needs of the elderly. J. Am. Diet. Assoc. 60:293-296, 1972.

Young, C., Franklin, R., Foster, W., and Steele, B. Weekly variation in nutrient intake of young adults. J. Am. Diet. Assoc. 29:459, 1953.