

*The prevention of periodontal disease requires improved oral hygiene. This conclusion is drawn on the basis of data presented in the following paper. The data were obtained by studying 4,000 people of Ecuador in 1959, and some 1,500 American Indians in Montana in 1961. These findings in the author's opinion provide a basis for further research on periodontal disease and lack of oral cleanliness.*

## **ORAL HYGIENE AND PERIODONTAL DISEASE**

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FOR MANY years people in public health have attempted to develop educational programs which stress the importance of adequate professional and personal health care services. The public has been told repeatedly through public health programs and commercial advertising media that toothbrushing to achieve a clean oral environment is a particularly important aspect of personal health care. The reasons most often given for maintaining clean mouths are that it helps to prevent tooth decay and makes a person more acceptable socially.

While I do not intend to discount either of these ideas, it seems very strange to me that there has been so little recognition of the importance of oral hygiene in preventing periodontal disease. I can only assume that the relationship between oral hygiene and periodontal disease has not been demonstrated pointedly enough to bring about enthusiastic action in the form of organized public health programs to improve oral hygiene practices. Therefore, I will review briefly the work of some other investigators who have contributed to our understanding of the oral hygiene-periodontal disease relationship. Then I will describe and discuss some data we recently analyzed at the Dental Health

Center which, in my opinion, leave little room for further doubt about the importance of oral hygiene in the development of periodontal disease.

In the late 1950's, research workers in Oslo, Norway, reported in a series of articles<sup>1-3</sup> on a study of factory workers that the people with poor oral hygiene had more gingivitis, more alveolar bone loss, and greater tooth mobility than the people with good oral hygiene. Russell and Ayers, in their study in Birmingham, Ala.,<sup>4</sup> found that there was a higher prevalence of periodontal disease in Negroes than in whites—a difference which they attributed largely to poorer oral hygiene among the Negroes. Studies in Bombay, India, and Atlanta, Ga.,<sup>5,6</sup> demonstrated a positive relationship between gingivitis and oral debris and calculus in young males. An even more striking demonstration of the oral hygiene-periodontal disease relationship was shown by Lovdal and his co-workers<sup>7</sup> who were able to reduce the incidence of gingivitis by subgingival scaling and controlled oral hygiene.

All these studies—and there are others—represent significant contributions to our understanding of periodontal disease and oral hygiene, but because they either employed gross methods for assessing

**Table 1—Number of Persons Examined by Age Group, Civilian-Military Status, and Sex: Ecuador and Montana**

Age Group	Ecuador						Montana (Civilians)			
	Total Persons Examined	Mean Age	Military (Male)	Civilians			Total Persons Examined	Mean Age	Male	Female
				Total	Male	Female				
All ages	4,205	21.8	1,834	2,371	1,002	1,369	1,480	17.1	710	770
5-9	621	7.7	—	621	242	379	451	7.5	209	242
10-14	704	11.7	—	704	299	405	543	11.7	300	243
15-19	545	17.7	251	294	110	184	128	16.6	73	55
20-29	1,422	23.0	1,135	287	141	146	137	24.5	27	110
30-39	554	34.1	332	222	91	131	94	34.0	36	58
40-49	201	43.2	87	114	52	62	50	43.7	21	29
50 and over	158	57.1	29	129	67	62	77	60.9	44	33

oral hygiene, included only small numbers of persons, or were restricted to certain age groups, their real significance may have been overlooked.

### Methods

The data used in this report were derived from two studies, both of which were integral parts of investigations conducted by the Interdepartmental Committee on Nutrition for National Defense. The first study took place in Ecuador, South America, during the summer of 1959. The second was a study of American Indians on the Blackfeet and Fort Belknap Reservations in Montana during September, 1961. In Ecuador, over 4,000 persons were examined. In Montana, nearly 1,500 were examined. Persons as young as five years and as old as 90 were represented in these groups (Table 1).\*

The same two dentists† conducted all of the dental examinations in both the

\* In both studies, additional persons were examined, but this report is based only on persons having sufficient natural teeth to be scored for oral hygiene and periodontal disease.

† The two examiners were the author and Dr. Ernest Leatherwood, formerly of the Epidemiology and Biometry Branch, National Institute of Dental Research.

Ecuador and the Montana studies. Each examiner contributed approximately equal numbers of examinations in each age group in the two studies. Thus, if there were any interexaminer variation, its significance should have been minimized.

The examinations were conducted with the aid of mouth mirrors and explorers while the patients were seated in portable dental chairs. In Ecuador, electricity seldom was available, so chairs were positioned to afford maximum use of natural light. Natural light also was used in Montana except on the few occasions when examinations were made during the evening hours. On those occasions, portable dental lights were used.

The condition of the periodontium was estimated by using the Periodontal Index developed by Russell.<sup>8</sup> The Periodontal Index (PI) has a possible range of scores from zero to eight—the poorer the condition of the periodontal tissues, the larger the assigned score.

The Simplified Oral Hygiene Index (OHI-S), described by Greene and Vermillion,<sup>9</sup> was used for estimating individual and group oral hygiene. The OHI-S has two component parts—debris and calculus—each with a possible range of scores from zero to three. As with

**Table 2—Mean Periodontal, Debris, Calculus, and Oral Hygiene Index Scores by Age Group for All Persons Examined in Ecuador and Montana**

Age Group	Number of Persons Examined	Mean Index Scores			
		Periodontal Index (PI)	Debris Index (DI-S)	Calculus Index (CI-S)	Oral Hygiene Index (OHI-S)
All ages	5,685				
5-9	1,072	0.21	1.64	0.12	1.76
10-14	1,247	0.33	1.68	0.42	2.10
15-19	673	0.40	1.44	0.86	2.30
20-29	1,559	0.45	1.35	1.08	2.42
30-39	648	0.99	1.61	1.53	3.14
40-49	251	1.68	1.80	1.90	3.70
50 and over	235	2.52	2.07	2.22	4.29

the Periodontal Index, the highest score is a reflection of the poorest condition.

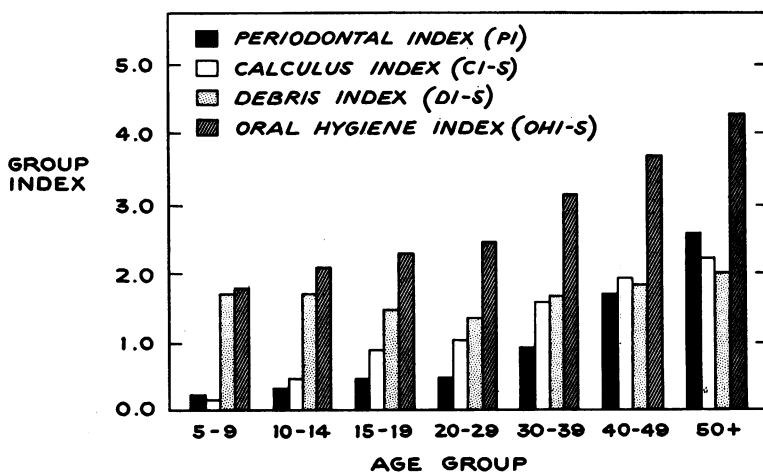
Though the population groups studied in Ecuador and Montana differed with respect to their cultural backgrounds, a preliminary analysis made of the data on the two groups separately showed that there was a very strong relationship between oral hygiene and periodontal disease in both groups. Also, the characteristics of this relationship were very

similar in the two groups. Therefore, to obtain sufficiently large numbers of people in each age group to permit making a fairly detailed analysis, the data for Montana and Ecuador were combined and will be presented as a whole.

**Findings**

For the 5,685 persons studied, group periodontal disease scores consistently increase with age (Table 2, Figure 1)

**Figure 1—Mean Periodontal, Debris, Calculus, and Oral Hygiene Index Scores by Age Group for All Persons Examined in Ecuador and Montana**



Source—Table 2.

**Table 3—Mean Periodontal, Debris, Calculus, and Oral Hygiene Index Scores by Selected Age Groups for Civilians 15 Years of Age and Older and for All Military Personnel Examined in Ecuador and Montana**

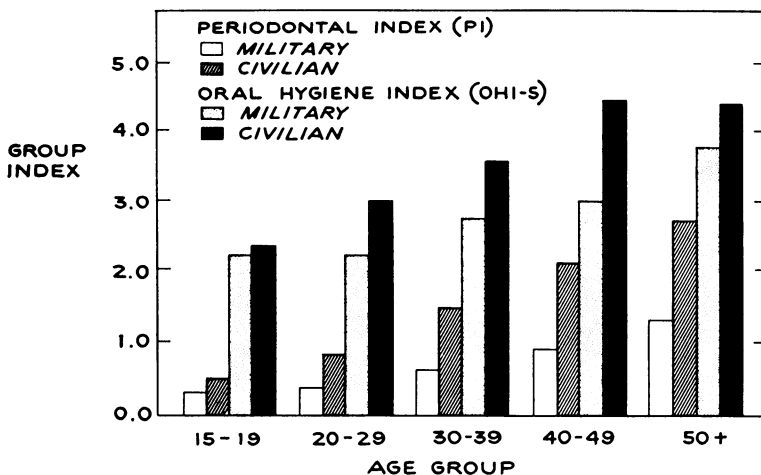
Age Group	Number of Persons Examined		Mean Index Scores								
			Periodontal Index (PI)		Debris Index (DI-S)		Calculus Index (CI-S)		Oral Hygiene Index (OHI-S)		
	Civilian	Military	Civilian	Military	Civilian	Military	Civilian	Military	Civilian	Military	
All ages 15 and over	1,532	1,834									
15-19	422	251	0.46	0.29	1.54	1.27	0.81	0.95	2.35	2.21	
20-29	424	1,135	0.80	0.32	1.74	1.20	1.28	1.00	3.02	2.20	
30-39	316	332	1.40	0.59	1.85	1.37	1.69	1.38	3.54	2.75	
40-49	164	87	2.12	0.86	1.97	1.47	2.07	1.59	4.04	3.06	
50 and over	206	29	2.70	1.29	2.13	1.69	2.24	2.07	4.37	3.76	

from 0.21 for age group 5-9 to 2.52 for people 50 years and over—more than a tenfold increase.

In the same table and figure, the Simplified Oral Hygiene Index (OHI-S) scores and its calculus component also are shown to increase with age. But the Debris Index (DI-S) scores behave very differently. The two youngest age groups have very high debris scores. On the

other hand, the young adult group, ages 15-19 years, has a lower debris score than the two preceding age groups. This same type of dip in debris scores was seen previously among young adults 15 and 17 years of age in India and Atlanta.<sup>6</sup> Cleaner mouths at this age may be a reflection of beginning maturity and an increasing interest in personal well-being. Perhaps young adults become

**Figure 2—Mean Periodontal, Debris, Calculus, and Oral Hygiene Index Scores by Selected Age Groups for Civilians 15 Years of Age and Older and for All Military Personnel Examined in Ecuador and Montana**



Source—Table 3.

more concerned about their appearance and health because of their desire for social acceptance, or perhaps at this stage in life young people make a real effort to behave in the manner they were told at some earlier time in their lives was appropriate and beneficial for them; or it may be that youngsters in the middle and late teens are more readily motivated by dental and other health education teachings than are children of younger ages. Whatever the reasons, the improvement in oral cleanliness—as far as debris is concerned—is marked and is statistically significant.

For the 20-29-year-age group, the debris scores again drop slightly. This drop, however, can be explained on the basis of the large number of military personnel in this age group whose oral hygiene status was generally superior to that of civilians. Out of 1,559 persons in age group 20-29, only slightly more than one-third of them were civilian.

Turning now from this general portrayal of the relationship among age, periodontal disease, and oral hygiene to the data in Table 3 (Figure 2) we see the rather striking difference in the oral hygiene status and condition of the periodontal tissues between the combined civilians from Ecuador and Montana and the Ecuadorian military. These data

lend further support to the oral hygiene-periodontal disease relationship. The PI scores for the military personnel are lower than those of civilians in each age group. These differences are significant at the 0.01 level. Corresponding to the healthier gingiva in the military personnel are lower Debris, Calculus and Simplified Oral Hygiene Indexes for each age group, with one exception. The exception is in the 15-19 age group where the Calculus Index is lower for the civilians than for the military personnel.

Studies in other developing countries<sup>10,11</sup> also have demonstrated the military-civilian difference in the severity of periodontal disease. Moreover, in these studies, too, the level of oral hygiene was found to be better among the military personnel than among the civilians. Though the military-civilian differences which we have seen here do lend support to the proposition with which we are concerned, for the remainder of the analysis the military have been excluded. This is done in recognition of the fact that the Ecuadorian military are very different from the others in the study.

An interesting aspect of periodontal disease is the possible difference in the severity of its occurrence in men and women. Russell reported in one study that there was less severe periodontal

**Table 4—Mean Periodontal, Debris, Calculus, and Oral Hygiene Index Scores by Age Group and Sex for All Civilians Examined in Ecuador and Montana**

Age Group	Number of Civilians Examined		Mean Index Scores								
			Periodontal Index (PI)		Debris Index (DI-S)		Calculus Index (CI-S)		Oral Hygiene Index (OHI-S)		
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
All ages	1,712	2,139									
5- 9	451	621	0.21	0.20	1.75	1.57	0.10	0.13	1.85	1.70	
10-14	599	648	0.36	0.31	1.82	1.55	0.37	0.47	2.19	2.02	
15-19	183	239	0.48	0.44	1.65	1.47	0.81	0.80	2.46	2.27	
20-29	168	256	0.85	0.77	1.74	1.74	1.46	1.16	3.21	2.90	
30-39	127	189	1.59	1.28	1.95	1.79	1.91	1.55	3.85	3.34	
40-49	73	91	2.31	1.97	2.13	1.84	2.24	1.93	4.38	3.77	
50 and over	111	95	2.73	2.67	2.15	2.11	2.40	2.05	4.55	4.16	

**Table 5—Mean Periodontal Index Scores by Age Group, Oral Hygiene Index Score Group, and Sex, for All Civilians Examined in Ecuador and Montana**

Age Group	Oral Hygiene Index (OHI-S) Score Group											
	Total		0.0-1.0		1.1-2.0		2.1-3.0		3.1-4.0		4.1 and over	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Mean Periodontal Index (PI) Scores												
5- 9	0.21	0.20	0.05	0.05	0.21	0.20	0.28	0.30	0.39	0.52	*	—
10-14	0.36	0.31	0.07	0.06	0.24	0.22	0.43	0.37	0.63	0.66	0.85	0.95
15-19	0.48	0.44	0.03	0.12	0.23	0.23	0.50	0.44	0.77	0.81	1.21	1.19
20-29	0.85	0.77	0.02	0.16	0.36	0.31	0.60	0.67	0.79	0.96	1.55	1.41
30-39	1.59	1.28	*	0.17	0.30	0.35	0.71	0.73	1.01	1.28	2.46	2.30
40-49	2.31	1.97	—	*	*	0.55	*	0.98	1.30	1.77	3.04	3.04
50 and over	2.73	2.67	*	*	*	*	1.25	0.94	2.31	2.43	3.09	3.49
Number of Persons Examined												
All ages	1,712	2,139	178	380	549	675	478	537	213	289	294	258
5- 9	451	621	75	150	209	272	151	177	14	22	2	—
10-14	599	648	58	127	238	236	210	180	66	83	27	22
15-19	183	239	23	43	60	72	48	67	30	36	22	21
20-29	168	256	16	36	22	51	37	50	43	59	50	60
30-39	127	189	5	16	14	26	15	37	29	49	64	61
40-49	73	91	—	5	4	11	7	15	14	21	48	39
50 and over	111	95	1	3	2	7	10	11	17	19	81	55

\* Mean Periodontal Index score not calculated for fewer than ten cases.

disease in females than in males over 25 years of age.<sup>12</sup> However, he found that during the teen years, when periodontal disease is present, it tends to be more severe in girls than in boys. Referring to Table 4, the PI scores for Montana and Ecuador are found to be slightly, but consistently, higher for the males than for the females of all ages. The difference between the age-adjusted PI scores\* for all males (0.71) and all females (0.64) is significant at the 0.05 level. In the same table, the OHI-S also is shown to be higher for the males in each age group than for the females. In order to examine this apparent difference between sexes in the severity of periodontal disease more carefully, PI scores were calculated for males and for females of the same age and oral hygiene group

\* Female rates were standardized against the age distribution of the males.

(Table 5). When the data are treated in this manner, the pattern of consistently higher PI scores for the males disappears. In fact, the PI scores are higher for the females in a number of the cells. Therefore, at least among this study group, higher PI scores in men do not persist when males and females of similar age and oral hygiene status are compared. Thus, oral hygiene status rather than the individual's sex appears to be the more important variable with respect to the development of periodontal disease.

Some of the statistical correlations between the components of the OHI-S and the PI scores are presented in Table 6. The correlation coefficients among individual Debris, Calculus, and the Simplified Oral Hygiene Index scores with the PI scores are of statistically significant magnitudes. But some explanation of the

statistical methodology employed is required to provide a better understanding of the correlation values obtained. When choosing the computer program\* to calculate the correlation coefficients, linear relationships were assumed. However, scatter diagrams suggest that in the three upper age groups the relationship between the PI scores and OHI-S scores may be curvilinear rather than linear. Thus, these coefficients of correlation represent minimum values and may underestimate the true correlations. Even if the correlation values were increased by using another method to calculate them, they still would not be increased sufficiently to approach a perfect correlation between OHI-S and PI. Thus, for these data, there is some unexplained residual variation in the PI score which is not accounted for by the OHI-S scores. Some of this residual variation in the PI scores may be explained by individual variation in response to local irritating agents.

Though not presented in tabular form, correlation coefficients also showed that in the younger age groups the debris scores were more closely associated with variations in the PI scores than were calculus scores, and, at older ages, the calculus scores had the higher correlation

with the PI scores. A multiple correlation analysis using the PI scores as the dependent variable, and age, DI-S scores, and CI-S scores as independent variables yields a multiple correlation coefficient of 0.76. This correlation value is of sufficient magnitude to indicate positive association between periodontal disease scores and age, debris, and calculus scores. It also indicates that not all the variation in the PI scores is explained by these three independent variables.

To analyze the data still further, regression lines for OHI-S on PI were calculated for each age group.\* These lines are shown in Figure 3. Again, the computer program used to obtain these lines was based on an assumption of a linear relationship between the dependent and independent variables. Probably the point of departure from the horizontal axis for the upper three age groups is shifted to the right of each true locus because of this assumption of linearity. Nevertheless, the slope of the regression line is steeper for each succeeding age group. A possible explanation for this change in slope is the influence of the length of exposure to the irritants and

\* Multiple regression statistics were calculated on an IBM 7090 computer at CEIR in Oakland, Calif., using the CQMR program.

\* Regression equations are: age 5-9,  $Y = -0.02 + 0.13X$ ; 10-14,  $Y = -0.10 + 0.21X$ ; 15-19,  $Y = -0.18 + 0.27X$ ; 20-29,  $Y = -0.21 + 0.33X$ ; 30-39,  $Y = -0.76 + 0.61X$ ; 40-49,  $Y = -1.17 + 0.82X$ ; 50+,  $Y = -1.19 + 0.89X$ .

**Table 6—Simple Linear Correlation Matrix for Four Selected Independent Variables (Age, Debris Index, Calculus Index, and Oral Hygiene Index), with Periodontal Index as the Dependent Variable, for All Civilians Examined in Ecuador and Montana**

Variable	Variable				
	Age	Debris Index (DI-S)	Calculus Index (CI-S)	Oral Hygiene Index (OHI-S)	Periodontal Index (PI)
Age	1.00	0.22	0.68	0.56	0.66
Debris Index (DI-S)		1.00	0.43	0.80	0.41
Calculus Index (CI-S)			1.00	0.89	0.71
Oral Hygiene Index (OHI-S)				1.00	0.69

**Table 7—Mean Periodontal Index Scores by Age Group and Oral Hygiene Index Score Group for All Civilians Examined in Ecuador and Montana**

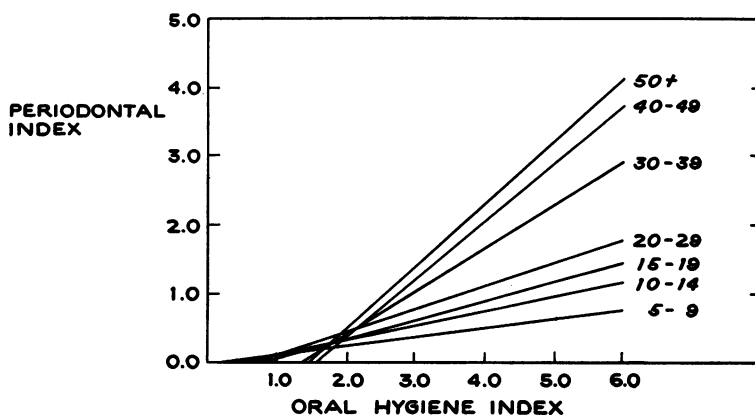
Age Group	Mean Periodontal Index Scores (PI)						Number of Persons Examined					
	Oral Hygiene Index (OHI-S) Group						Oral Hygiene Index (OHI-S) Group					
	Total	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1 and over	Total	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1 and over
All ages							3,851	558	1,224	1,015	502	552
5- 9	0.21	0.05	0.21	0.29	0.47	*	1,072	225	481	328	36	2
10-14	0.33	0.06	0.23	0.40	0.65	0.90	1,247	185	474	390	149	49
15-19	0.46	0.09	0.23	0.46	0.79	1.20	422	66	132	115	66	43
20-29	0.80	0.12	0.32	0.64	0.89	1.48	424	52	73	87	102	110
30-39	1.40	0.14	0.33	0.73	1.18	2.38	316	21	40	52	78	125
40-49	2.12	*	0.45	0.87	1.58	3.04	164	5	15	22	35	87
50 and over	2.70	*	*	1.09	2.38	3.25	206	4	9	21	36	136

\* Mean Periodontal Index score not calculated for fewer than ten cases.

the additional possibility that with aging there is a real increase in inflammatory response to local irritants. Also, with increasing age the reparative and destructive mechanisms of the body may be thrown further out of balance than at younger ages and thus permit more bone loss in response to a given amount of stimulus.

In Table 7 (Figure 4), mean PI scores for each age group and each group of

oral hygiene scores are shown for all civilians examined in the two countries. Within each age group, the mean PI scores increase with each advance to a group having poorer oral hygiene status. Even in the older age groups, persons with low OHI-S scores have relatively low PI scores. At the other end of the scale, for example, in the oral hygiene group with OHI-S scores of 4.1 and over, the PI scores are high even in the early



**Figure 3—Calculated Regression Lines: Oral Hygiene Index (OHI-S) on Periodontal Index (PI) for All Civilians Examined in Ecuador and Montana**



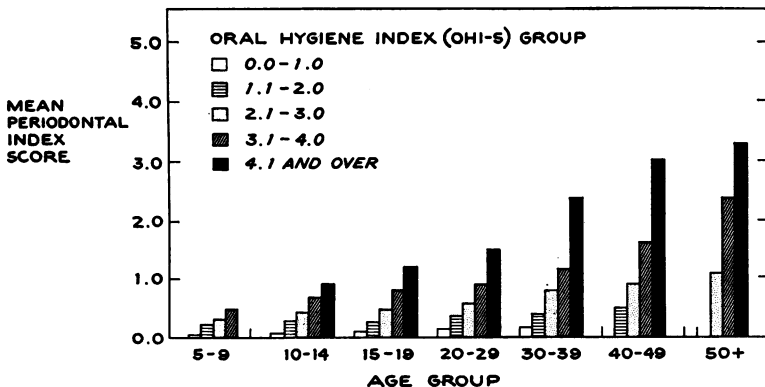
teens, and they rapidly soar even to higher scores which can result only from advanced destructive periodontal disease.

It appears that even if a person maintains only a moderately good oral hygiene status, such as an OHI-S of 2.1-3.0, over a long enough period, the person will develop serious periodontal disease. It is almost as if there were two necessary ingredients—a local irritant and time—required to trigger the development and progression of periodontal disease to a given severity. This idea might be expressed in the equation: healthy tissue + debris/calculus  $\xrightarrow{\text{time}}$  periodontal disease. The age at which one might attain a given severity of periodontal disease would be determined by the amounts of debris or calculus present and the length of time the tissue is exposed to these local irritants. Obviously this formulation is an oversimplification of a very complex disease process, but such a simple approach to understanding this disease phenomenon might be helpful in developing hypotheses for further study.

The implications of these data are of considerable moment. If a person were to maintain a good level of oral cleanliness, for example, an OHI-S below 2.0

from age 5 to age 50, he very likely would avoid the ravages of destructive periodontal disease during this major period of his life. Also, if we make some assumptions, we can conclude from these data that if a person maintains poor oral hygiene for even a very few years, he is apt to experience rapidly advancing destructive periodontal disease. But to accept these conclusions, we must be willing to assume that the majority of the people who have unclean mouths and advanced bone loss today have always had poor oral hygiene and that the people whose mouths were clean on the day of examination always kept their mouths clean. Though these are reasonable assumptions, they are not fact. Nevertheless, the data are consistent enough and the implications are sufficiently significant to warrant the institution of detailed prospective investigations to test the oral hygiene-periodontal disease relationship directly. To go even further, I believe the data now at hand are sufficiently convincing to propose that much more emphasis should be given in dental public health programs to the improvement of oral hygiene as a major step in the prevention of periodontal disease.

Figure 4—Mean Periodontal Index Scores by Age Group and Oral Hygiene Index Score Group for All Civilians Examined in Ecuador and Montana



Source—Table 7.

## Summary

Several authors have shown a relationship between oral cleanliness and periodontal disease. Data from examinations of 5,685 persons in Ecuador and Montana lend support to their findings and have provided the basis for exploring in greater detail some of the characteristics of this relationship. The data presented in this report indicate that:

1. Periodontal Index scores increase with increasing age. Paralleling this increase in Periodontal Index scores are ascending Simplified Oral Hygiene Index scores.
2. Sex differences in the severity of periodontal disease disappear when persons of similar oral hygiene status are compared.
3. Correlation coefficients show significant correlations of individual debris, calculus, and OHI-S scores with PI scores.
4. Generally, persons with good oral hygiene status—regardless of age—have low PI scores. Persons with very poor oral hygiene status—regardless of age—have high PI scores.
5. Greater emphasis should be given in dental public health programs to the improvement of oral hygiene as an important periodontal disease preventive measure.

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