WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTE

WHO/ORH/EPID.PD/84.1

ORIGINAL: ENGLISH

Periodontal index

COMMUNITY PERIODONTAL INDEX OF TREATMENT NEEDS
DEVELOPMENT, FIELD TESTING AND STATISTICAL EVALUATION

Oral Health unit
World Health Organization
Geneva
1984

METHODOLOGICAL APPROACH AND STATISTICAL EVALUATION OF PERIODONTAL STATUS INDICATORS; THE DEVELOPMENT AND DEFINITION OF THE COMMUNITY PERIODONTAL INDEX OF TREATMENT NEEDS

1. Field testing an epidemiological method for the assessment of periodontal status and treatment needs.

   M. HIMMICHE, P. PERRUTA, J. SARDO INFIRRI, L. BENAMGHAR, A. ANTCZAK, D.E. BARMES.

2. The distribution of various indicators of periodontal status in relation to tooth type and position.

   P. KAMINSKI, L. BENAMGHAR, N. CHAU; J. MARTIN, J. SARDO INFIRRI, M. HIMMICHE, D.E. BARMES.

3. The relationship between missing teeth and periodontal status.

   L. BENAMGHAR, N. CHAU, J. MARTIN, J. SARDO INFIRRI, F. ABT.

4. Methodological aspects and criteria for the choice of a partial recording system for the assessment of periodontal status

   J. MARTIN, L. BENAMGHAR, N. CHAU, P. KAMINSKI, J. SARDO INFIRRI, D.E. BARMES.

5. Statistical prediction of periodontal status score based on a limited number of indicators and teeth.

   N. CHAU, L. BENAMGHAR, J. MARTIN, P. PERRUTA, F. ABT.

6. Evaluation of different partial recording systems for the assessment of periodontal treatment needs.

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ACKNOWLEDGEMENTS

The assistance of the following members and associates of the Joint FDI/WHO Working Group 1 on Integrated Planning of Oral Health Services with Special Attention to Periodontal Diseases, in carrying out the data collection is gratefully acknowledged. Without their contribution and excellent co-operation this study would have been impossible.

(Statistical and technical material presented in August 1982 for inclusion in final document)

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FIELD TESTING AN EPIDEMIOLOGICAL METHOD FOR THE ASSESSMENT OF PERIODONTAL STATUS AND TREATMENT NEEDS

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INTRODUCTION

The two most prevalent oral diseases which consume most of the oral health services available to any population are dental caries and periodontal diseases. Methodology and criteria for the diagnosis of dental caries and definition of related treatment needs of individual teeth are well defined, with the exception of those for the "preclinical" stages of the disease. Thus it has been possible to build up a very clear picture of the status and trends of that disease in countries around the world. However, the picture for periodontal diseases is much less well defined. This has happened in part because controversies about the disease processes of the periodontium have only been resolved and documented relatively recently, but also because of the various manifestations of the disease, some of which are reversible and difficult to measure in a standard and reproducible way, particularly in the early stages.

During the past 20-30 years, many indices have been developed for recording the clinical signs associated with periodontal diseases. The majority were designed for specific research projects and were later adopted by other investigators for use in epidemiological studies. Criteria and methodology for these indices vary widely, and several rely on combinations or associations of different indicators or clinical symptoms, e.g. the Gingival Index(1) and the Sulcus Bleeding Index(2). As has been reported(3), combinations of clinical symptoms present in a subject do not always correspond exactly with an index score. A further problem with many indices is the lack of reliability which stems principally from the use of visual criteria - oedema and colour changes - instead of actual measurement to determine sulcal or pocket depth and subsequent scoring of gingival bleeding. This lack of reliability was clearly documented(4) in a study where the various investigators involved were calibrated and then separately examined a series of subjects from different populations. The results obtained by each examiner varied very widely.

Another specific problem associated with the use of previously defined indices for periodontal assessments has been the lack of precise criteria for treatment needs in order that appropriate programmes for control and prevention of periodontal diseases can be planned and implemented.

Since 1968 the World Health Organization has assisted with the planning, organization and data summarization of 160 surveys of oral health and has participated in the planning and sample design only of a great many more. The compelling reason for WHO to advocate the collection of data on oral disease status and treatment needs is so that the planning, implementation and evaluation of oral care services can be based on valid baseline data; it is essential that all administrators make regular epidemiological surveys to guide them in the monitoring and evaluation of their work and to identify trends in levels and patterns of diseases within their population. Thus, there is a need for well-defined survey methodologies that are reliable, simple and rapid. Surveys of large samples and long duration aimed at increasing precision and reliability often defeat their purpose because of the increased risk of examiner variability due to use of multiple examiners and shifts in the interpretation of criteria over time. Other disadvantages of very large surveys are the greater costs of data checking and punching, salary and per diem expenses of examiners and assistants, delays in data availability, and the fact that excess time spent on survey work is lost to other activities, including response to survey findings.

It is therefore essential that recommended survey methodology will enable administrators to undertake regular, rapid and economic surveys of oral health status and treatment needs in order to plan relevant services and to monitor and evaluate their implementation, as well as to identify trends in levels and patterns of diseases within their communities in time to react to them effectively.

Therefore, in an effort to improve data collection for the planning and evaluation of services and, at the same time, to try to resolve most or all of the problems associated with use of existing indices for epidemiological studies, the development of methodology and criteria for determination of periodontal status and treatment needs was undertaken by a Joint Working Group of the International Dental Federation and the World Health Organization. The development and field testing of the criteria and the methodology, and the general results of the survey are described.

In 1977, the members of the WHO Scientific Group on Epidemiology, Etiology and Prevention of Periodontal Diseases discussed current methods of assessing the prevalence and severity of periodontal disease. In particular, during the meeting a critical review of the criteria used in these methods was made. The members of the group concluded that the most valuable combination of criteria for assessing periodontal diseases was not being used. They then proposed a different approach to the assessment of disease and determination of treatment needs.

The criteria to be used in surveys of periodontal status should be clear-cut observations that can be described in concise and definite terms so that they can be easily understood by dentists and other oral health care workers. A simple present/absent classification for the indicators, gingival bleeding, supra- and subgingival calculus and periodontal pockets, was proposed(5). It was recommended, however, that the method should only be adopted as a standard method by WHO after extensive field testing had proved that the assessment provided valid indications of disease status and estimations of treatment requirements.

MATERIALS AND METHODS

Recommendations for field testing

Field testing was recommended by the members of the Scientific Group for validation of both the proposed clinical criteria and the partial recording method.

The members and associates of the Joint FDI/WHO Working Group I on Integrated Planning of Oral Health Services with Special Attention to Periodontal Diseases undertook the field testing of the proposed methodology.

Investigators were asked to examine at least 100 subjects, and preferably 200, equally divided between the sexes and the age groupings of 15-19 and 35-44 years. The instructions to investigators also stipulated that, if possible, the subjects included should be a representative cross-section of the population. This being rather difficult to achieve, examiners were asked to record the socio-professional category of subjects included in the sample so that a general assessment of the sample representativity could be made.

A precoded form was designed so that all examination results could be summarized according to a standard programme. The form consisted of four parts:

1. General and subject specific data including information on country, age, sex and socio-professional category.

2. A recording layout for the Periodontal Index(6).

3. A special recording layout for the five indicators included space for all teeth except third molars, and allowed for recordings to be made on both the vestibular and lingual aspects of each tooth. It should be noted that vestibular and lingual aspects were to be interpreted as each encompassing one half of the gingiva around the tooth.

The following codes were defined:

Supragingival Calculus:	0 = absence 1 = presence
Subgingival Calculus:	0 = absence 1 = presence
Periodontal Pocket Depth:	0 = absence of pocket 1 = 4 or 5 mm pockets (first degree pockets) 2 = pockets of 6 mm and greater (second degree pockets)
Gingival Bleeding:	After probing, teeth were examined for bleeding from the gingival sulcus or pocket. 0 = no evidence of bleeding 1 = bleeding detected.
Recession	0 = root exposure of 3 mm or less 1 = root exposure of 4 or 5 mm 2 = root exposure of 6 mm or more

The examinations were made with a special probe distributed to all investigators by WHO. The design of the probe and explanation of its use are shown in Fig. 1. The probe has a shaded area between 3.5 and 5.5 mm from the ball tip. When the probe is inserted between the tooth and the gingiva, and the free margin of the gingiva falls below the shaded area, no pocket is recorded: if the shaded area is partly visible, a first degree pocket, of 4 or 5 mm depth is recorded; when the margin lies above the shaded area, a second degree pocket, 6 mm or more is present. The probe is also used to detect subgingival calculus (Fig. 2).

As very little data on recession was collected during the survey, and as recession relates mainly to status, (sometimes as a result of treatment provided), this assessment was not included in the analyses.

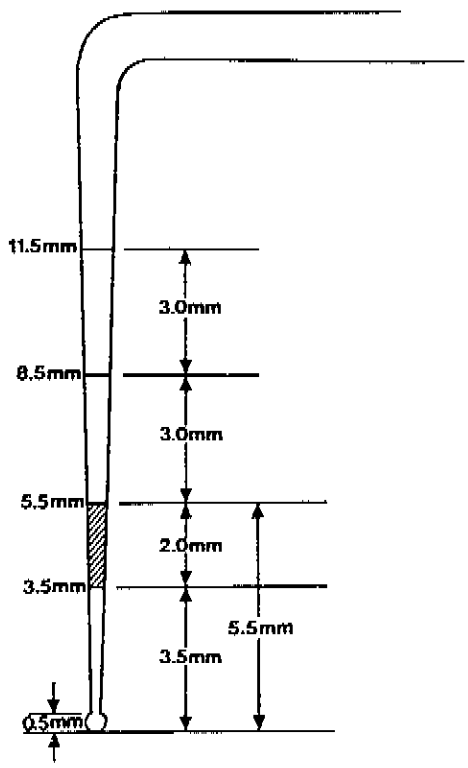
4. Two boxes for recording a periodontist's assessment of disease status and treatment needs, using the following codes were provided:

Disease Status:	0 = no disease 1 = gingivitis only 2 = advanced periodontal lesions only 3 = gingivitis with advanced periodontal lesions
Treatment Category:	0 = no treatment 1 = oral hygiene education only 2 = oral hygiene education and scaling 3 = deep scaling 4 = periodontal surgery

Space was also provided for comments to note difficulties experienced in placing subjects in the various treatment need categories.

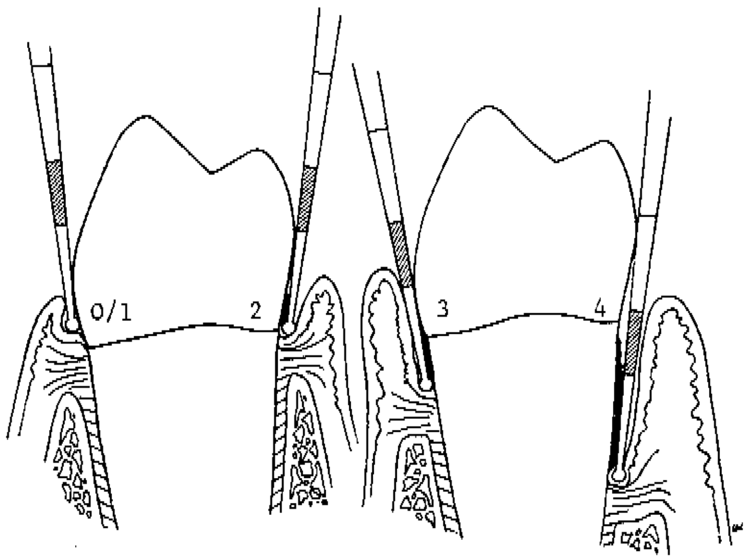
Using data collected in this manner, it was possible to assess the relevance of using various partial recording systems. It also was intended to compare the proposed methodology with the Periodontal Index and with the clinical assessment of the periodontist. However, as assessment of the Periodontal Index was not made by all examiners, no systematic evaluation of these results was undertaken.

Figure 1: The WHO periodontal probe used to detect subgingival calculus, evaluate pocket depth and bleeding



The probe is shaded between the 3.5 and 5.5 mm markings to allow for easy assessment of pocket depth. Sulci below the shaded area are scored 0 as normal gingival sulci, the shaded area includes 4 and 5 mm depth pockets scored 1, and the area above the shading indicates depths of 6 mm or more scored 2.

Figure 2: <u>Diagram showing recording of findings</u>



1. A normal gingival sulcus depth. The free margin of the gingiva falls below the shaded area.

2. A gingival sulcus of normal depth but with subgingival calculus.

3. A first degree periodontal pocket with subgingival calculus. The free margin of the gingiva falls within the shaded area.

4. A second degree periodontal pocket with subgingival calculus. The free margin of the gingiva falls above the shaded area.

It must be remembered that although the subjects examined do not constitute a random sample, the number of different countries represented, and the age and sex distributions, make data base an excellent tool for the investigation of associations between the various clinical symptoms or indicators of periodontal diseases and the assessment and evaluation of various partial recording systems.

Data collected

About 30 investigators in 12 countries participated in the field testing and examined 2,212 subjects ranging in age from 15-50 years. The countries were Argentina, Canada, England, Finland, France, German Democratic Republic, Italy, Norway, Portugal, Scotland, Syria, Uruguay and the United States of America. A full list of all those who participated in the field testing is given in the Acknowledgements.

Because of the large amount of data from each individual (4 indicators for 2 surfaces of 28 teeth), and the fact that data was collected by many investigators from 12 different countries, it was necessary to develop special techniques for organizing and validating the data. The statistical analyses of the data included multiple stepwise regressions, discriminant analysis and cluster analysis. The results of the analyses provide a great deal of information about conditions and associations between different periodontal indicators and their distribution by jaw, tooth type and tooth surface. The basic results for prevalence of bleeding, supragingival calculus, subgingival calculus and pockets are reported here. The statistical analyses and discussion of their significance are reported in the other papers in this document.

RESULTS

Distribution of subjects

Table I gives the distribution of subjects by age, sex and country. Totals in all categories are also included. Overall, subjects were fairly evenly distributed between the sexes; however, country and age group distribution was much less consistent. The high proportion of subjects in the age groups 15-19 years and 35-44 years stems from the request to survey these age groups especially. There are also very large differences in the number of subjects examined in each country.

Distribution of indicators

The term "indicator" has been used in this paper as a general term for a clinical symptom or lesion.

Table 2 presents the distribution of indicators by country. Indicators recorded were the presence of supragingival calculus, subgingival calculus, bleeding and periodontal pocketing. The percentage of all teeth with the indicator present is given by tooth surface, vestibular and lingual. For all indicators, lingual surfaces were generally affected more than vestibular.

Table 3 shows the distribution of indicators by age group. The percentage of teeth affected in each age group is given, for both vestibular and lingual surfaces. The percentage of teeth affected generally increased with age for all indicators. Comparison of the 15-19 and the 35-44 year age groups shows that for supragingival calculus the percentage affected doubles, for subgingival calculus it triples, for first degree pockets (4 or 5 mm) the percentage doubles and for second degree pockets (6 mm or more) it increases nearly ten-fold consistent with the commonly held belief that advanced periodontal lesions do not become evident until the third or fourth decade. Bleeding, however, was the most common indicator found, and it nearly doubled in frequency in this age range - see Table 3.

Table 4 organizes the data in another fashion. All the possible combinations of absence and presence of each indicator on at least one surface per subject are given, along with the

Table 1: Distribution of subjects by country, sex and age

Country	Number of subjects examined	Males	Females	Group						
				15-19	20-24	25-29	30-34	35-44	45-54	N.I.
Argentina	40	17	23	13	5	5	11	6	-	-
Canada	339	268	68	125	19	29	16	122	16	12
Finland	96	59	27	23	26	1	16	28	-	2
France	110	65	45	-	86	22	2	-	-	-
Italy	120	64	56	-	-	120	-	-	-	-
Norway	56	22	34	4	12	-	-	40	-	-
Portugal	27	21	6	-	9	10	2	4	1	1
England	187	120	67	94	53	20	10	9	1	-
Scotland	94	46	89	-	-	-	-	4	-	1
German Dem. Rep.	820	372	445	443	88	32	2	253	-	2
Syrian Arab Rep.	126	71	55	96	-	-	-	30	-	-
U.S.A. Non-Indian	99	52	46	-	-	4	42	42	10	1
U.S.A. Indian	78	37	40	63	-	-	7	5	-	3
Uruguay	20	10	10	1	-	3	2	4	5	5
TOTAL	2,212	1,224	1,021	862	298	246	110	547	33	27

Table 2: Distribution of Periodontal Disease Indicators by country (% of tooth surfaces affected)

Country	Supragingival calculus		Subgingival calculus		Pockets 1st degree P_1		Pockets 2nd degree P_2		Bleeding	
	V	L	V	L	V	L	V	L	V	L
Argentina	9.16	25.37	20.60	41.60	7.85	8.25	0.70	1.30	33.13	38.87
Canada	14.51	21.08	17.22	22.00	6.93	10.70	1.03	1.69	45.66	51.36
Finland	2.74	16.54	12.25	17.38	2.78	3.38	0.35	9.23	59.00	60.62
France	7.17	15.00	9.50	15.29	7.17	15.00	3.58	3.21	20.00	21.00
Italy	17.81	27.67	38.50	44.58	9.85	10.51	0.07	0.21	31.10	40.68
Norway	3.40	10.48	23.93	30.58	18.65	14.53	3.90	3.47	38.32	52.50
Portugal	10.24	32.56	31.34	55.65	6.57	14.22	0.15	0.30	28.74	59.10
England	2.97	6.60	1.43	5.17	2.11	2.55	0.06	0.06	36.90	19.76
Scotland	0.24	2.66	1.49	1.58	2.45	1.24	-	-	6.73	4.94
German Dem. Rep.	6.03	12.32	3.42	8.99	4.56	6.07	0.37	0.46	24.41	36.25
Syrian Arab Rep.	8.85	9.53	4.56	3.45	5.54	3.50	1.60	0.78	13.85	6.60
U.S.A. Non-Indian	31.73	47.20	5.00	7.96	1.22	1.87	0.65	0.80	63.14	77.13
U.S.A. Indian	3.14	8.05	52.18	54.78	36.11	33.68	2.38	2.47	28.48	33.53
Uruguay	23.38	34.32	55.22	70.14	25.12	25.12	3.73	2.23	61.44	67.16
TOTAL NUMBER EXAMINED = 2,212	8.63	14.71	11.76	16.21	6.50	7.30	0.70	0.80	71.21	37.15

Percentage calculated as: $\frac{\text{total number of tooth surfaces affected}}{\text{total number of tooth surfaces examined}} \times 100$

1st degree pockets = 4 or 5 mm
2nd degree pockets = 6 or more mm
surfaces: V - L = vestibular-lingual

Table 3: Distribution of indicators by age group

Age Group	Supragingival calculus		Subgingival calculus		Pockets 1st degree		Pockets 2nd degree		Bleeding	
	V	L	V	L	V	L	V	L	V	L
15 - 19	6.2	10.2	5.5	7.5	4.0	4.6	0.3	0.3	28.8	27.7
20 - 24	3.6	9.0	5.2	17.8	3.9	4.4	0.2	0.2	22.0	40.9
25 - 29	14.4	20.8	26.0	32.0	8.7	8.8	0.5	0.5	29.8	41.9
30 - 34	19.2	30.4	16.4	20.1	5.2	6.4	0.7	0.9	47.5	54.5
35 - 44	11.1	23.6	16.9	22.6	11.7	13.4	2.2	2.3	42.5	46.7
45 - 54	21.0	36.0	21.0	29.0	5.0	9.0	0.8	2.0	69.0	76.0
TOTAL	8.6	14.7	11.4	16.2	6.5	7.3	0.7	0.8	31.2	37.1

Percentage calculated as: $\frac{\text{total number of tooth surfaces affected}}{\text{total number of tooth surfaces examined}} \times 100$

1st degree pockets = 4 or 5 mm

2nd degree pockets = 6 or more mm

Surfaces: - V = vestibular

- L = lingual

Table 4: Distribution of subjects by number of indicators present

		Bleeding B	0			1		
Subgingival Calculus C_2	Supragingival Calculus C_1	Periodontal Pocket P	0	1	2	0	1	2
0	0		126	13	1	211	70	7
0	1		3	19	1	387	144	9
1	0		13	5	1	58	143	35
1	1		23	5	2	280	463	176

Codes: C_1, C_2, B – 0 = absent from all surfaces
1 = present on at least one surface
P – 0 = absent from all surfaces
1 = 4 or 5 mm pockets on at least one surface
2 = 6 or more mm pockets on at least one surface

The unshaded box contains subjects with no indicators

Subjects with only one indicator

Subjects with two indicators

Subjects with three indicators

Subjects with all four indicators

Thus the 463 subjects in the fifth box on the bottom line all had at least one surface with bleeding, one with supragingival calculus, one with subgingival calculus and one with a pocket of 4 – 5 mm

Table 5: Distribution of periodontal status as assessed by a periodontist by country

Country	No disease	Gingivitis only	Advanced periodontal lesions only	Gingivitis with advanced periodontal lesions
Argentina	5.00	72.50	0.00	20.00
Canada	12.68	59.88	10.32	13.86
Finland	23.96	69.79	1.04	5.31
France	55.46	38.18	0.91	5.45
Italy	NI	NI	NI	NI
Norway	10.79	50.00	5.36	33.93
Portugal	0.00	81.48	0.00	18.52
England	50.27	44.92	4.29	0.53
Scotland	38.30	58.51	0.00	2.13
German Dem. Rep.	10.85	66.71	1.10	21.22
Syrian Arab Rep.	57.14	34.92	2.38	4.76
U.S.A. Non-Indian	2.01	91.92	0.00	5.05
U.S.A. Indian	23.08	50.00	2.56	19.23
Uruguay	0.00	65.00	10.00	25.00
TOTAL = 2,212	20.16	57.14	2.89	13.47

The percentage of subjects in each periodontal status category is given by country.

NI = not indicated

Table 6: <u>Distribution of periodontal status as assessed by a periodontist</u>

Age Group	Periodontal Status			
	No disease	Gingivitis only	Advanced periodontal lesions only	Gingivitis with advanced periodontal lesions
15 - 19	27.87	66.88	0.53	4.10
20 - 24	29.53	57.38	2.01	10.74
25 - 29	18.03	63.11	3.28	15.57
30 - 34	13.64	68.18	3.64	12.73
35 - 44	9.14	50.46	6.95	32.72
45 - 54	12.12	51.52	12.12	21.21
TOTAL	20.16	57.14	2.89	13.97

The percentage of subjects in each periodontal status category is given by age group.

For a large number of subjects from Italy this was not recorded and those subjects were, therefore, excluded from the calculations.

number of subjects having that combination of indicators. The number of indicators present per subject increases from the upper left-hand corner, with no indicators, to the lower right, with all 4 indicators present. 126 subjects (5.7%) had no indicators present, 241 subjects (11.0%) had only one indicator present, 571 subjects (26.0%) had 2 indicators present, 618 subjects (28.2%) had three indicators present and 639 subjects (29.1%) had all 4 indicators present. Thus, 57.3% of subjects had three or more and 83.3% had 2 or more indicators of periodontal disease present.

Periodontal status as assessed by a periodontist

Periodontal status was assessed using the following categories: 'no disease', 'gingivitis only', 'advanced periodontal lesions only', and 'gingivitis with advanced periodontal lesions'. Table 5 shows the percentage of subjects in each category by country. Although the majority of subjects were in categories 'no disease' and 'gingivitis only', there was great variation between countries. Table 6 gives the distribution of periodontal status by age group. The 15-19 year age group had the least disease, and the 35-44 year age group the most. There was a relatively constant percentage of subject with 'gingivitis only' throughout all age groups: however, a marked increase in subjects with advanced periodontal lesions, with and without gingivitis, can be seen in subjects over 35 years of age. Overall, 'gingivitis with advanced periodontal lesions' and 'advanced periodontal lesions only' were least frequently recorded.

DISCUSSION

The data presented here includes the distribution of subjects, indicators of periodontal disease and periodontal status by sex, age and country. Although the number of subjects in each age group and from each country varies, overall trends can be seen. Both the number of teeth with indicators present and the number of subjects in disease categories increased with age. Differences between countries can usually be explained by differences in age groups examined in individual countries. The results also showed that most subjects (83.3%) had present at least two of the indicators recorded.

* * *

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* * *

THE DISTRIBUTION OF VARIOUS INDICATORS OF PERIODONTAL STATUS IN RELATION TO TOOTH TYPE AND POSITION

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INTRODUCTION

Numerous indicators have been used to assess periodontal status. However, the relationship of each indicator to progressions of the disease process, had not been clearly defined.(1, 2, 3, 4, 5) An attempt to address this issue was made by the analysis of data collected for field testing an index for assessing periodontal status and treatment needs. The statistical technique of multifactorial analysis was used to illustrate preferential localization of indicators, associations between indicators and the importance of position of teeth with respect to the presence of indicators.

MATERIAL AND METHODS

The data for this analysis comes from multinational field testing of the proposed survey methodology for periodontal status proposed by the WHO Scientific Group. Four indicators were measured on two surfaces of all teeth present in each of 2,212 subjects. The indicators were: bleeding, supra- and subgingival calculus and periodontal pockets.

Statistical analysis used the general programme LOGIST (6), developed especially to deal with the problems posed by the repetitive nature of the data. Multifactorial analysis (7, 8, 9, 10) allowed the formulation of hypotheses to which more classical statistical testing could then be applied.

Three methods of analysis were utilized: principal component analysis, analysis of correspondence, and ascending hierarchical classification.

The first method, principal component analysis (8, 9) can only be applied to quantitative data and, technically, is deduced from a linear Fisher correlation table. Subjects with incomplete data, i.e. those with missing teeth cannot be used in this analysis, so only data from subjects with complete dentitions were included. To transform presence/absence data into quantitiative data, it was necessary to construct scores by surface, by tooth or for the whole mouth. For each indicator, the arbitrary values attributed for absence or for presence, were added to obtain the scores. To explain the method, it is necessary to imagine that for each individual (or tooth, or indicator) there is a corresponding point in space in several dimensions. For example, if each dimension (or axis) corresponds to a tooth surface, there are 2 x 28 = 56 dimensions. On each axis, the coordinate of the individual is the score for the associated tooth surface.

The representative points of the group of individuals form a 'cloud' in the space. Since such a 'cloud' cannot be represented if the number of the dimensions is greater than 3, the technique consists of projecting the image of the cloud on a plane surface (i.e. in two dimensions) so that it resembles as much as possible the original cloud. The choice of the plane is determined so that the loss of information is minimized. Each diagram is defined by two perpendicular factorial axes. The first axis (F1) corresponds to the greatest elongation of the cloud and the second (F2), which is perpendicular to F1, represents the remaining maximum elongation. One can continue in this manner and calculate F3, F4.. and, for each axis, the percentage of variance (degree of dispersion) for the cloud. Usually the first two or three axes suffice to account for a very large part (70-80%) of the variance of the cloud, thus reducing the number of dimensions required. The interpretation of these axes is sometimes a difficult problem, but such analyses may provide a new approach to understanding biological processes.

The second method, analysis of correspondence, is directly adapted to qualitative data. In principle, it is similar to the preceding method, but technically it is deduced from contingency tables of the data by means of a 'distance' called "chi-square". Here, data from all subjects can be included in the analysis because the notion of missing teeth is itself qualitative.

Finally, the third method utilizes an ascending hierarchical classification technique. It regroups (stage by stage) the surfaces of the teeth as a function of their degree of similarity with respect to indicators.

Calculation of correlation coefficient between indicator scores

For each indicator and surface (lingual and vestibular), an 'indicator score' was calculated by adding the values assigned (absence : 0 and presence : 1 , for bleeding, sub and supragingival calculus, and 0,1 or 2 for pockets) of indicators on the surfaces of the teeth of an individual. The possible values for each tooth range from 0 to 10. The sum of the scores for the two surfaces gives the indicator score for the tooth. The sum of all the indicator scores gives the total score for the subject. Each score thus represents an 'index of pathology'. A correlation table of these scores for the groups of subjects with no missing teeth (1,037) can then be calculated. It should be noted that the values assigned to the indicators are arbitrary.

A review of the descriptive statistical results for indicators shows that bleeding was the indicator most frequently present, nearly 40% of subjects less than 20 years of age and more than 90% of subjects over 40 years of age having at least one surface that bled when probed. Supragingival calculus was the second most frequent, with more than 50% of all subjects having at least one surface affected, particularly the lingual surfaces of mandibular incisors. Subgingival calculus followed closely, but with a more homogeneous distribution on lingual surfaces. Pockets were the least frequently found indicators located preferentially on molars and premolars, with a slight predominance for the lingual surfaces.

The percentage of subjects affected and the mean number of surfaces affected per subject increased with age. Women were slightly less affected than men. Lingual surfaces were more frequently affected and had more severe lesions than vestibular surfaces.

The prevalence of bleeding sites was too great for this indicator to be of any use as a discriminating factor between groups of subjects.

Statistical analysis showed a strong relationship between subgingival calculus and pockets and between supragingival calculus and bleeding, but little connection between these two pairs of indicators.

The analysis describes relationships between indicators, between teeth and between indicators and teeth, using the three analytical techniques.

Correlations and principal component analysis between indicators and scores

Table I shows relationships between the indicator scores for lingual and vestibular surfaces of the teeth. The values of the correlation coefficients, marked *, were: $r = 0.84$ for subgingival calculus and pockets, $r = 0.71$ for bleeding and $r = 0.66$ for supragingival calculus.

Considering the relationships between indicators, those between pockets and subgingival calculus were greatest with the correlation coefficient r varying from 0.56 to 0.65, followed by bleeding and supragingival calculus (r between 0.38 to 0.49). The relationships between bleeding and pockets with r from 0.23 to 0.33 and between subgingival calculus and bleeding with r from 0.20 to 0.37 were moderate. Weak relationships existed between supragingival calculus and subgingival calculus with r from 0.17 to 0.29 and then supragingival calculus and pockets with r from 0.09 to 0.19.

Table 1: Correlation table of indicator scores by tooth surface (of 1,037 missing teeth)

Indicator		Total Oral Score	C_1		C_2		P		B
			L	V	L	V	L	V	L
C_1	L	0.63							
	V	0.52	0.66*						
C_2	L	0.73	0.29	0.17					
	V	0.72	0.27	0.24	0.84*				
P	L	0.68	0.19	0.10	0.63	0.63			
	V	0.64	0.14	0.09	0.56	0.65	0.84*		
B	L	0.77	0.49	0.38	0.37	0.25	0.33	0.25	
	V	0.71	0.47	0.39	0.20	0.25	0.24	0.23	0.71*

Code: C_1 = supragingival calculus P = periodontal pockets
C_2 = subgingival calculus B = bleeding

The linear correlation coefficient r, of 2 scores, lies at the intersection of the line and corresponding column. All correlations in this table were statistically significant ($p \leq 0.01$)

Table 2: Correlation coefficients for 'indicator scores' by tooth for the right and left sides of the mandible

Tooth No.	47	46	45	44	43	42	41
31	0.43	0.45	0.51	0.59	0.72	0.84	0.94*
32	0.53	0.48	0.56	0.61	0.75	0.85*	0.83
33	0.53	0.55	0.62	0.67	0.78*	0.78	0.72
34	0.59	0.63	0.70	0.73*	0.64	0.62	0.57
35	0.65	0.68	0.73*	0.70	0.58	0.56	0.50
36	0.73	0.76*	0.70	0.63	0.53	0.48	0.47
37	0.77*	0.71	0.67	0.62	0.55	0.50	0.48

The correlation of indicator scores by surface with the total indicator score for the mouth was generally high, with bleeding having the highest and supragingival calculus the lowest values.

The table of correlation coefficients for all 28 teeth is comprised of 378 values. All the correlation coefficients in this table were significant ($p \leq 0.01$). For teeth within a quadrant, the correlation coefficients were very high, ranging for adjacent teeth from $r = 0.85$ to $r = 0.40$ for more distant teeth.

To illustrate the other types of correlations, Table 2 contains coefficients for the left and right sides of the mandible. The highest correlations of 'indicator scores' corresponded to homologous teeth on opposite sides. These values are marked * on the diagonal of the table. The value for continguous incisors was greatest, $r = 0.94$, dropping off as a function of distance with the lowest value, $r = 0.43$.

Thus, using 'indicator scores' as a criteria, there exists a statistical relationship between teeth which is a function of both proximity and tooth type.

Fig. 1 shows the results of principal component analysis of the correlation table. The diagram, purely descriptive and simple, presents graphically the data of Table 1. The first two factorial axes account, respectively, for 47.0% and 23.6% of the total variance. Projected on the same diagram, but not included in the calculation of the principal axes, are the total scores by indicator (B, C_1, C_2, P), and the total scores by surface (L, V). This illustrates the grouping of bleeding and supragingival calculus on one hand and of pockets and subgingival calculus on the other. The relationship between surfaces is evident for each indicator and is reinforced by the close proximity of total lingual and vestibular scores (ML and MV) in relation to the total oral score (M).

Analysis of correspondence between indicators and teeth

Analysis of correspondence deals directly with qualitative aspects of the indicators. Here a table of correspondence between the 28 teeth, the two surfaces and the indicators (present or absent) was made to which was added the notion of 'tooth present' and 'tooth absent'. Each value in the table indicates how many times an indicator, or its absence, had been encountered with another for each surface of a tooth. For example, for a group of individuals, the number of times subgingival calculus was found on the lingual surface of tooth number 17 simultaneously with a first degree pocket on the vestibular surface of tooth number 36 in the same mouth is contained in the table. These values are available for all possible permutations of indicators and teeth.

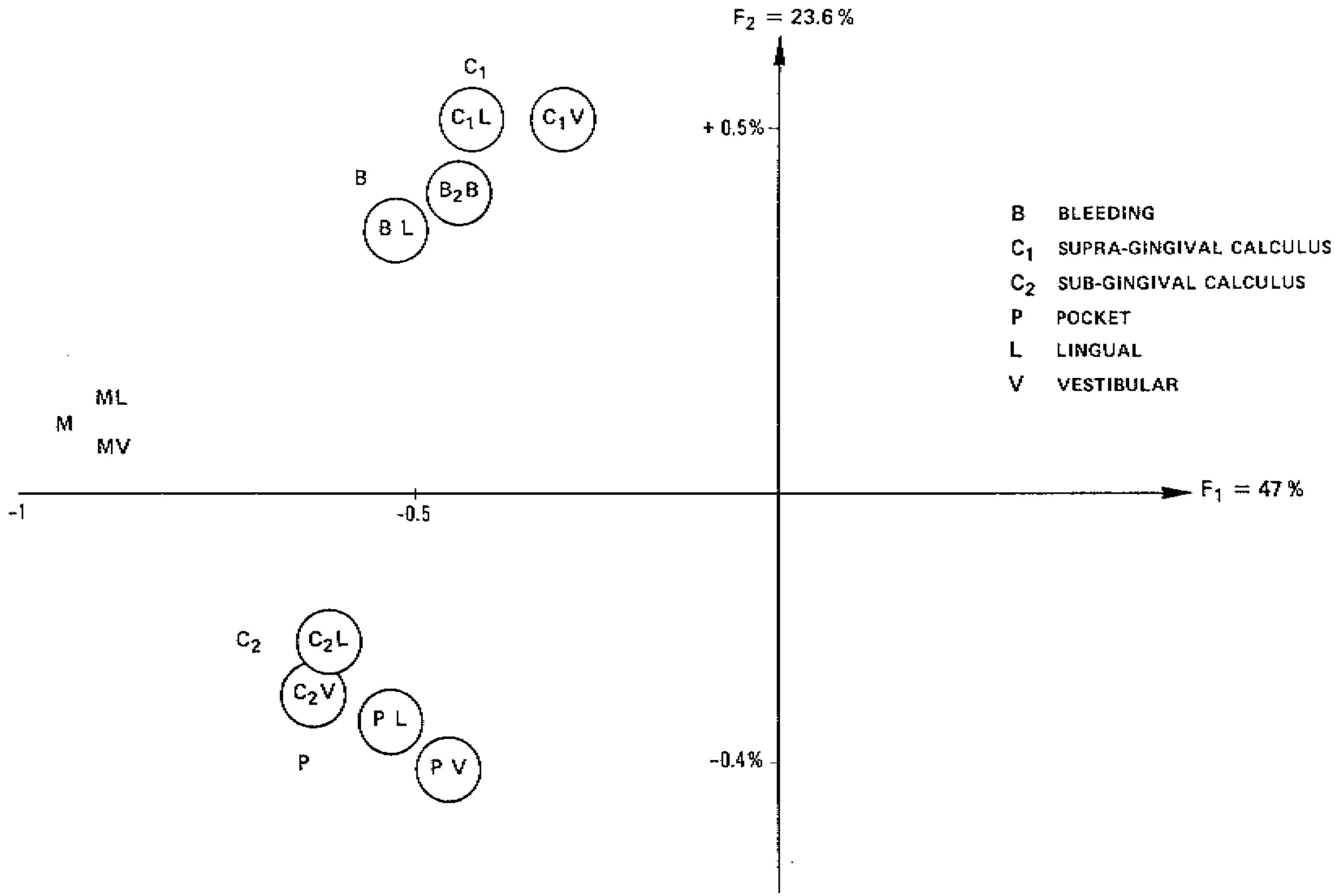
By mathematical techniques of analysis of the data, factorial axes were determined in a similar manner to those described for principal component analysis. A first series of analyses studied the relationships between teeth and between indicators, followed by an overall analysis of all the elements simultaneously.

When this technique was applied to all subjects, the first axis explained 65% of the total variance, and the second axis an additional 25%, making a total of 90% for F1 and F2.

Two separate analyses were done with and without the notion of missing teeth. Fig. 2 illustrates the results of the first analysis. Here the teeth are closely positioned in their anatomical order. This is uniquely contingent on indicator data, as no anatomical information was included in the calculations. The second axis separates the maxilla from the mandible fairly well. The left and right sides are intermixed. Note the strong separating effect the 'tooth absent' characteristic has on teeth 36 and 46, and the much weaker effect it has on teeth 16 and 26. Mandibular incisors and canines were positioned very close together and intermixed.

Fig. 3 illustrates the results of the same analysis without the inclusion of the notion of missing teeth. Here the first two axes give a much better separation of the two jaws, but maintain a zone of superimposition of mandibular incisors and canines.

Figure 1: Principal components analysis



The calculation has been made on the scores for each of the 4 indicators on each separate tooth surface, for each tooth, and for the whole mouth.

Figure 2: Analysis of correspondence (X^2 - distance)

Tooth position in connection with the first two axes of analysis including the notion of missing teeth

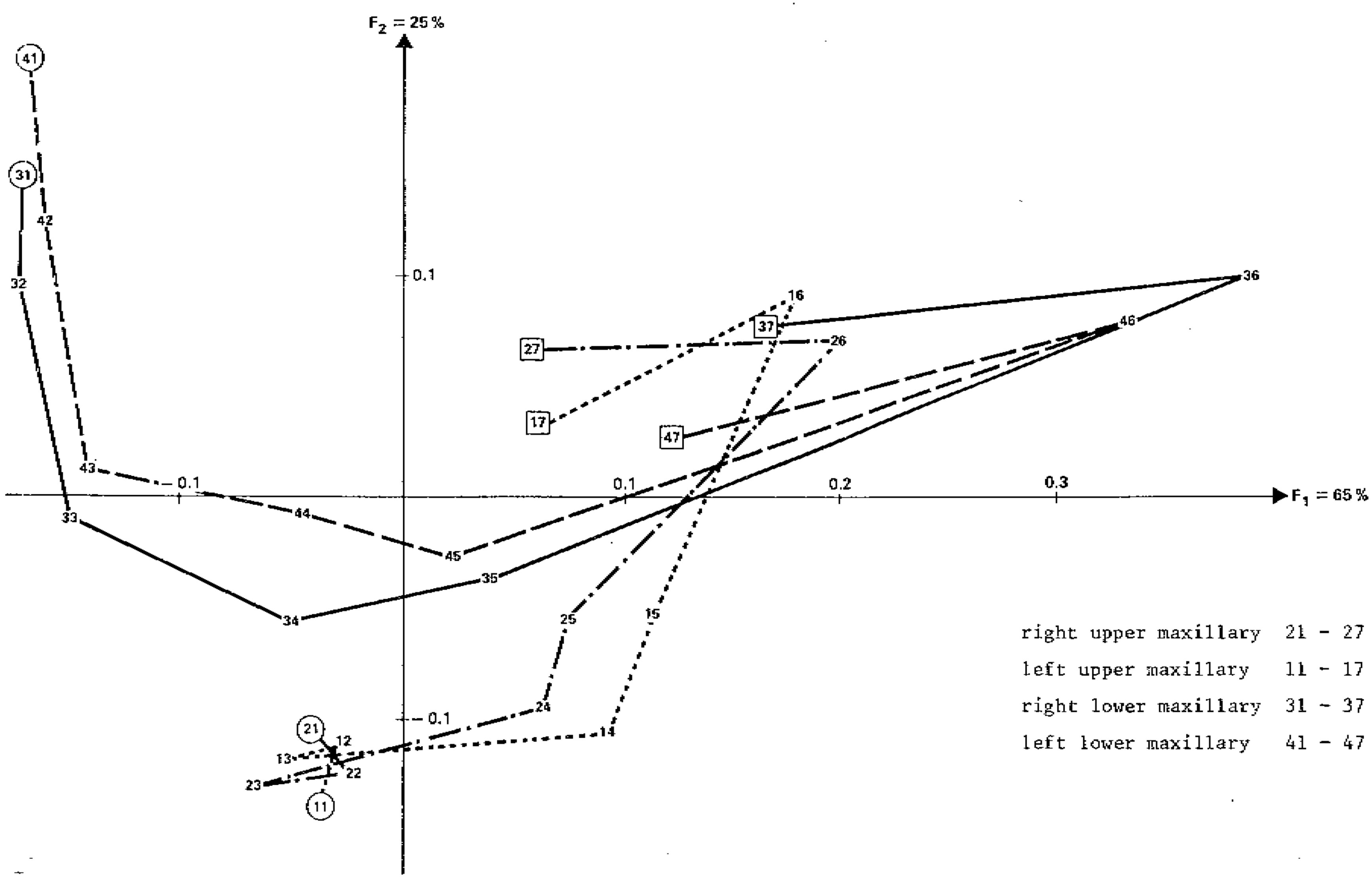
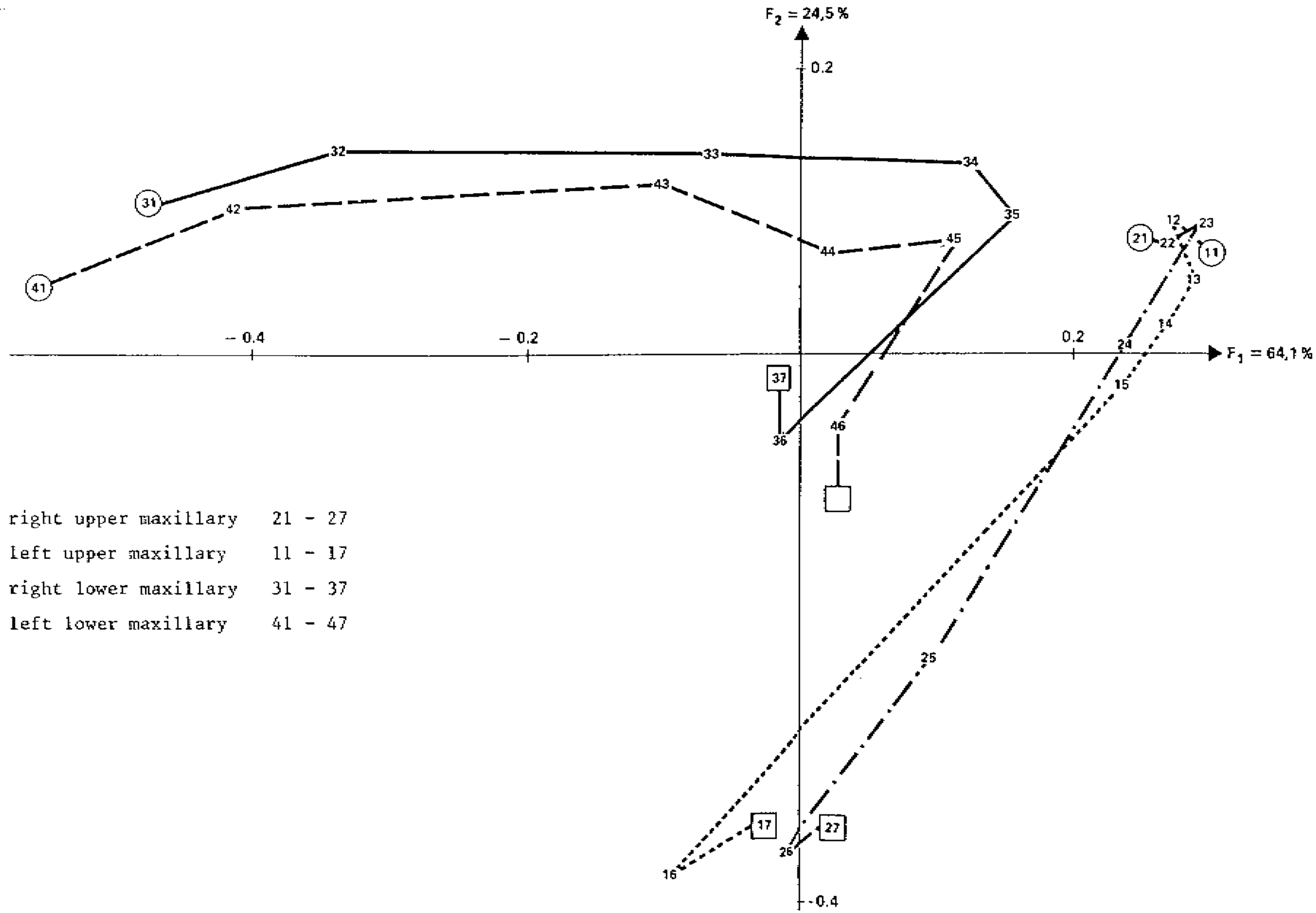


Figure 3: Analysis of correspondence (X^2 - distance)

Tooth position in connection with the first two axes of analysis not including the notion of missing teeth



Similar results were obtained when the analysis was performed on subgroups of subjects defined by sex, age group or country. There was close proximity, for each indicator, of the lingual and vestibular surfaces, with few exceptions. The structural representation of teeth maintained three fundamental configurations: separation of the maxilla from the mandible, proximity for each jaw of the right and left sides, and placement of teeth in their anatomical order except for a zone of superimposition for incisors and canines.

Fig. 4 presents the simultaneous projection of all indicators by surface for each tooth of the maxilla only. It is consistent with previous results: the factorial axes separate the four indicators remarkably well. In particular, F2 separates the pairs bleeding-supragingival calculus and pockets-subgingival calculus.

Ascending hierarchical classification

The third method of analysis utilizes an ascending hierarchical classification technique to present the contingency table of data 'indicators by surface of teeth'. Fig. 5 illustrates this for all indicators. The separation of the pairs bleeding-supragingival calculus and pockets-subgingival calculus can be seen clearly. Details of this classification are given for bleeding in Fig. 6. Teeth are organized as a function of their position, anterior or posterior, maxillary or mandibular and by surface, lingual or vestibular.

DISCUSSION

This study confirms a strong relationship between teeth and between the four indicators. Multifactorial analysis gives a particularly graphic representation of these interrelationships. This statistical technique aids in the study of rather complex data. In particular, in all the three analyses used, the relationships between lingual and vestibular surfaces of teeth and between indicators bleeding-supragingival calculus and pockets-subgingival calculus were demonstrated. For some indicators, the presence on the surface of a tooth carried with it a greater probability of being present on the other surface, and on adjacent teeth. Nearly all the analytical diagrams ordered teeth (with the exception of incisors and canines) in their anatomical positions, separating maxilla from mandible, and juxtaposing right and left sides. The consistency of these results warrants re-examination of periodontal disease indicators from a clinical and patho-physiological point of view.

Figure 4: Analysis of correspondence for all indicators for maxillary teeth

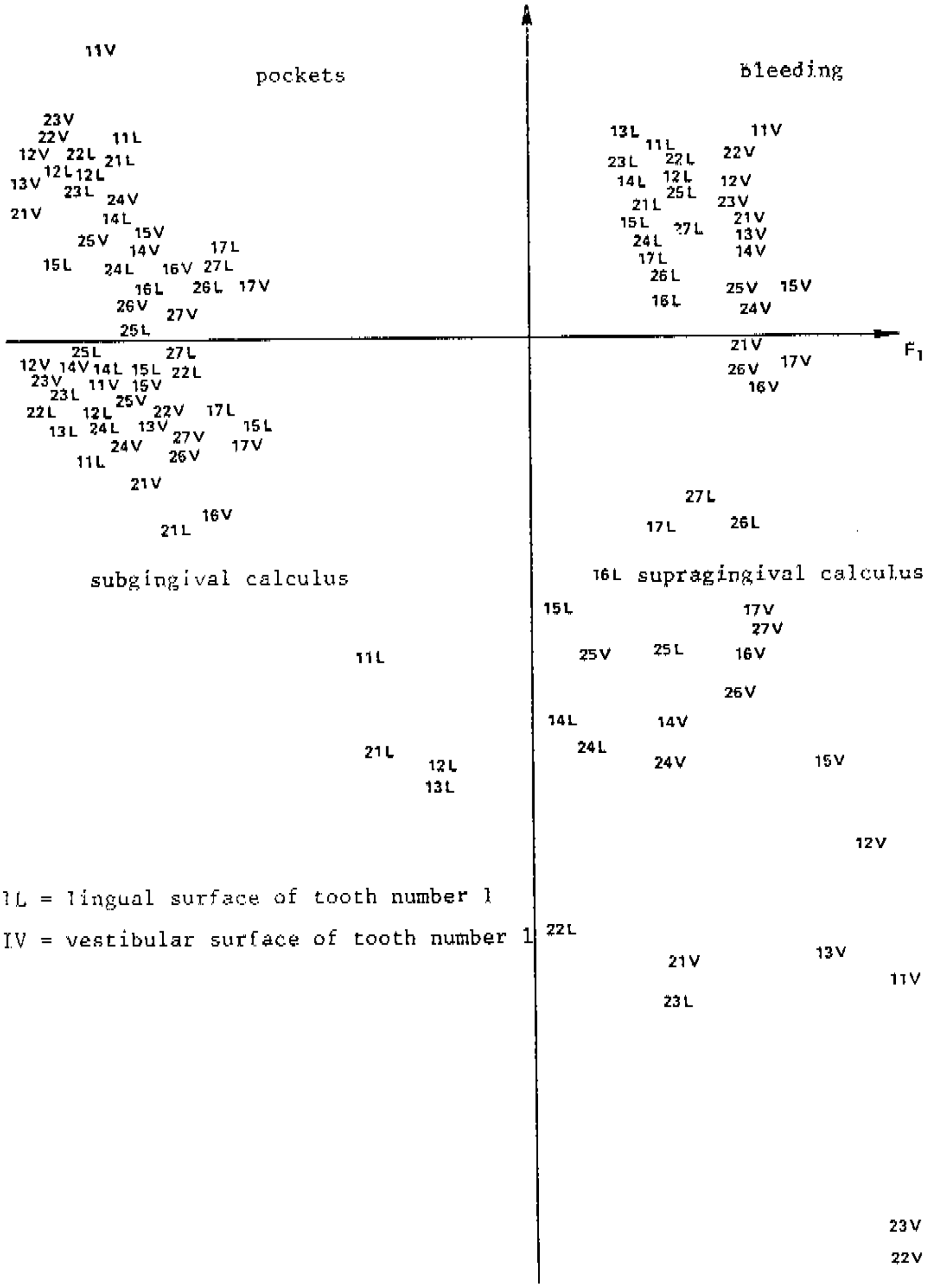
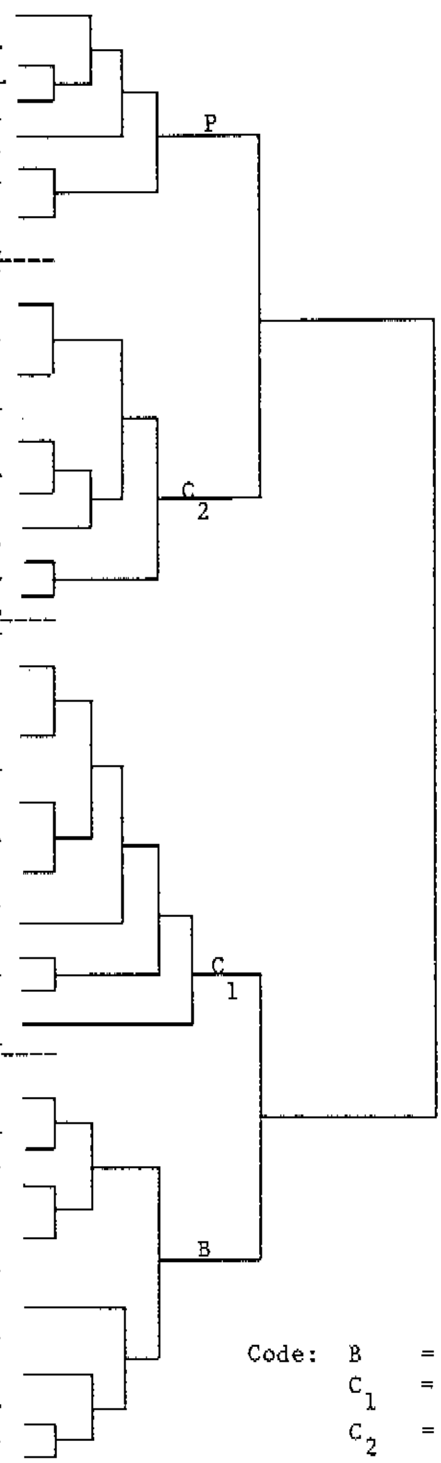


Figure 5: Ascending hierarchical classification for all indicators (X^2 - distance)

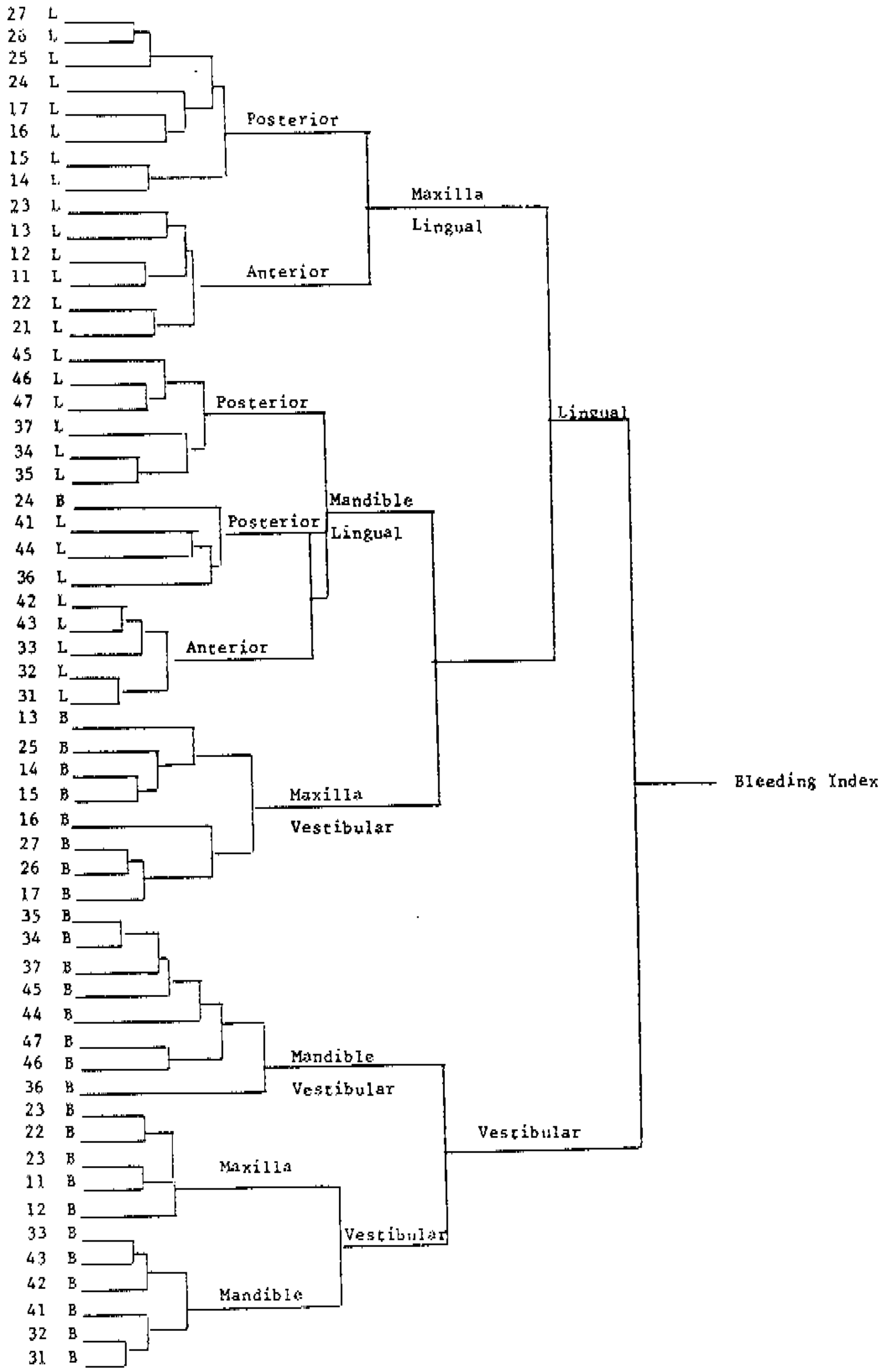
Tooth Surface

Lingual	Vestibular
13,14,15,16,17 23,24,25,26,27	15,16,17 23,24,25,26,27
36,37	36,37,46,47
34,35,44,45	
11,12,21,22	11,12,13,14,21,22
31,32,33,41,42,43	
	31,32,33,34,35 41,42,43,44,45
35,36,37 44,45,46,47	
15,16,17 24,25,26,27	
	14,15,16,17,25,26,27 34,35,36,37,44,45,46
	11,12,13,21,22,23,24
11,12,13,21,22,23	
	31,32,33,41,42,43
31,32,33,41,42,43	
34,35,36,37 44,45,46,47	
	14,15,16,17 24,25,26,27
	34,35,36,37 44,45,46,47
14,15,16,17 24,25,26,27	
	11,12,13,21,22,23
31,32,33,41,42,43	
	31,32,33,41,42,43
11,12,13,21,22,23	
34,35,36,37 44,45,46,47	
31,32,33,41,42,43	
11,12,13,21,22,23	
14,15,16,17 24,25,26,27	
	14,15,16,17 24,25,26,27
	34,35,36,37 44,45,46,47
	31,32,33,41,42,43
	11,12,13,21,22,23



Code: B = Bleeding
C_1 = Supragingival calculus
C_2 = Subgingival calculus
P = Periodontal pockets

Figure 6: Ascending hierarchical classification: detail for bleeding



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Acknowledgement - We wish to thank the Université de Nancy I for use of the computer La Délégation générale à la Recherche Scientifique et Technique pour la bourse d'étude de M. Kaminski.

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THE RELATIONSHIP BETWEEN MISSING TEETH AND PERIODONTAL STATUS

L. Benamghar, N. Chau, J. Martin, J. Sardo Infirri, F. Abt.

INTRODUCTION

Data from the multinational survey of periodontal status provides information on numbers of teeth present, as well as on periodontal indicators for several groups of adults. When assessing overall oral health status and treatment needs, it is important to take into consideration the number of standing teeth, particularly with regard to the need for replacement of missing teeth; likewise the types of restorative care that may be successfully provided depend on the interface conditions between remaining teeth and adjacent gingivae. Furthermore the fact that a tooth or a group of teeth is missing may be the result of the disease process being studied and therefore this information needs to be considered in the interpretation of survey results. Thus the standard comparisons of periodontal status between individuals, or groups of individuals, can only be made if information on the different complements of teeth at risk is included in the data. This paper presents information on the frequency of missing teeth, overall and by age, sex, socio-professional category and country, and on the relationship between missing teeth and the presence of periodontal disease indicators. As in a cross-sectional study it is impossible to collect reliable information on the causes of tooth loss, this was not attempted in this study and therefore no analysis of etiological factors causing loss has been possible. Multifactorial analysis of associations between missing teeth in subjects with multiple missing teeth has also been discussed.

MATERIALS AND METHODS

The data used in this analysis was provided by the WHO survey multinational field testing of periodontal status.

RESULTS

Frequency of missing teeth

Fig. 1 shows the distribution of missing teeth by the number missing and the frequency. Of the total possible number of teeth present in the subjects surveyed (28 teeth in 2,212 subjects), 7.5% were missing, giving an average of 2.06 missing teeth per subject. Just over one half of the individuals examined had at least one missing tooth. Considering only this subgroup, i.e. subjects having at least one tooth missing, the average number of missing teeth per subject increases to 3.88.

Differences in missing teeth by age, sex, socio-professional category and country

Both the percentage of subjects with missing teeth and the average number of missing teeth per subject increases with age. Table 1 presents data on missing teeth according to age group.

The distribution of missing teeth was very similar for both sexes, although women were somewhat less affected than men. Differences related to socio-professional category and country were not significant in this survey.

Location of missing teeth

Table 2 presents data on each tooth with respect to the percentage of subjects missing the tooth: it also indicates the relative proportion of the particular tooth to the total number of missing teeth. The predominant loss of molars and premolars, particularly in the mandible, can be seen. Although anterior teeth are infrequently missing, maxillary teeth dominate mandibular teeth in this respect. Fig 2 gives this data broken down by age group.

Multiple missing teeth

Only 1,037 subjects out of 2,212 surveys had all 28 teeth (Fig. 1). The distribution of missing teeth was very asymmetric with 26.4% of subjects having only one tooth missing - 13.7% having 8 or more missing teeth, and one subject having 24 teeth missing. The most frequently missing tooth overall

Analysis of associations between missing teeth showed, in order of decreasing frequency, combinations of teeth 36, 37, 47, 16, 26, 17 and 27 to be most common. Statistical testing revealed a relationship between missing teeth which was highly significant($p = \leq 0.001$).

To try and clarify this association, the theory of composite probabilities was used. According to this theory, if tooth loss is independent, the frequency of loss of any two teeth should be nearly equal to the product of the frequencies of loss of each tooth taken individually. Table 3 presents the results of this analysis for mandibular molars. In all the possible combinations for the 4 mandibular molars, the observed value of simultaneous absence of any 2 teeth was at least 2.5 and up to 5 times the value calculated by assuming independence.

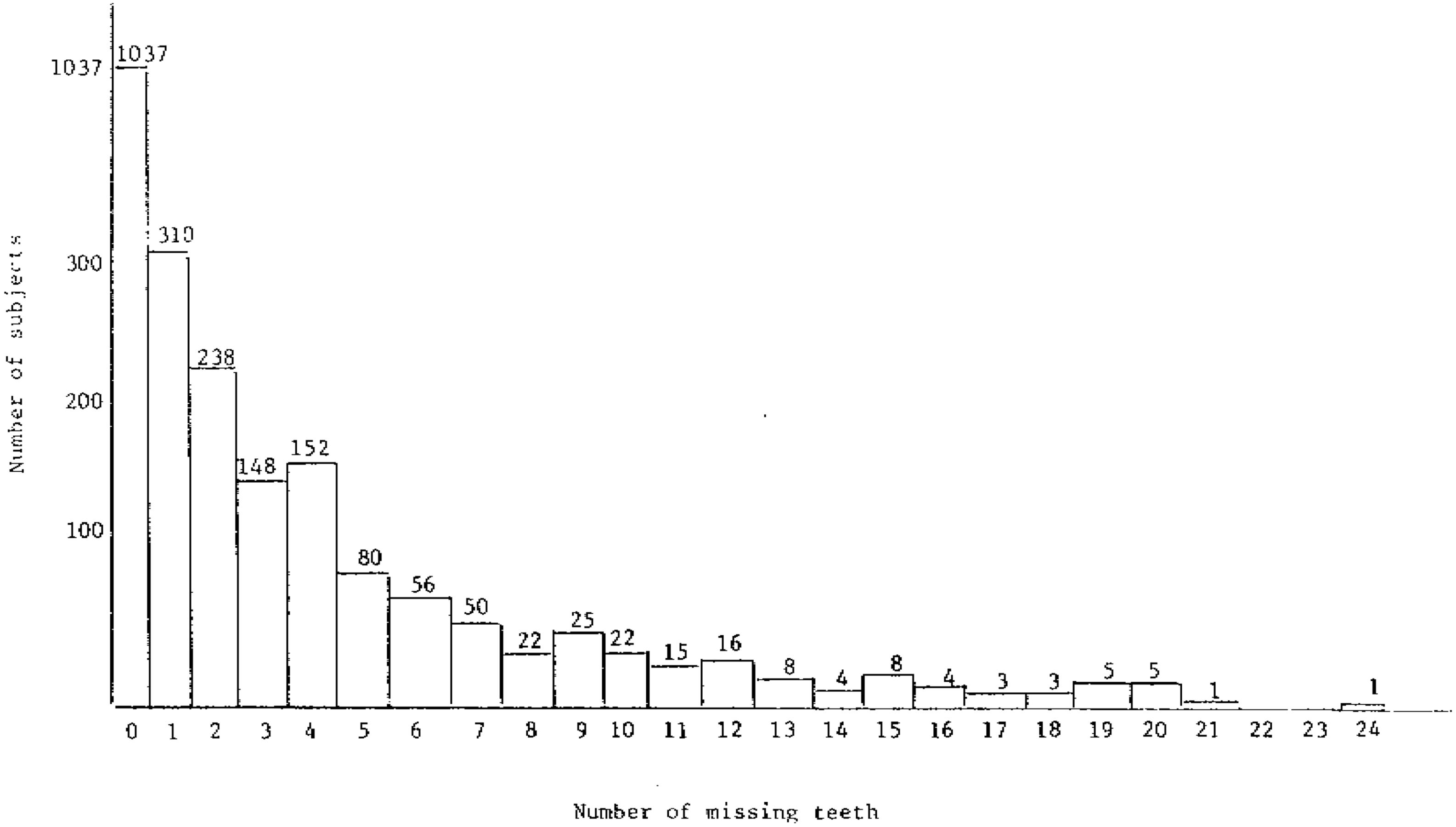
A similar, but less significant, dependence was found between maxillary posterior teeth and there was a slightly weaker relationship between maxillary and mandibular teeth on the same side. Maxillary incisors (12, 11 and 21, 22) demonstrated a lack of dependence in their simultaneous absence. However, absence of these teeth was statistically linked to the absence of teeth 36 and 46. In general, loss of canine teeth did not seem to be dependent on the loss of any other teeth except for a very weak connection with teeth 36 and 46.

Table 1: Missing teeth by age group

Age group	Average number of teeth missing for subjects in the age group	% of subjects with at least one tooth missing	Average number of missing teeth per subject of the group with at least one tooth missing
15 - 19	1.1	41.0	2.6
20 - 24	1.7	51.7	3.2
25 - 29	1.7	56.9	2.9
30 - 34	2.0	60.0	3.0
35 - 44	3.9	67.3	5.9

Data presented by age group on the average number of missing teeth for all subjects in the group, the percentage of subjects missing at least one tooth, and the average number of missing teeth per subject for the sub-group missing at least one tooth.

Figure 1: Frequency of missing teeth



Histogram of the distribution of subjects by number of teeth missing

Table 2: Topography of missing teeth

A.

Tooth Number	17	16	15	14	13	12	11	21	22	23	24	25	26	27
% of all subjects	8.3	13.9	10.2	10.3	3.4	5.3	3.8	3.3	4.4	3.0	10.8	9.3	14.7	8.8
	11.5	20.5	7.1	4.7	0.5	1.0	1.0	0.8	0.7	0.3	4.5	8.0	24.4	11.7
Tooth Number	47	46	45	44	43	42	41	31	32	33	34	35	36	37

Percentage of all subjects on which each tooth is missing. For example, 8.3% of all subjects were missing tooth number 17.

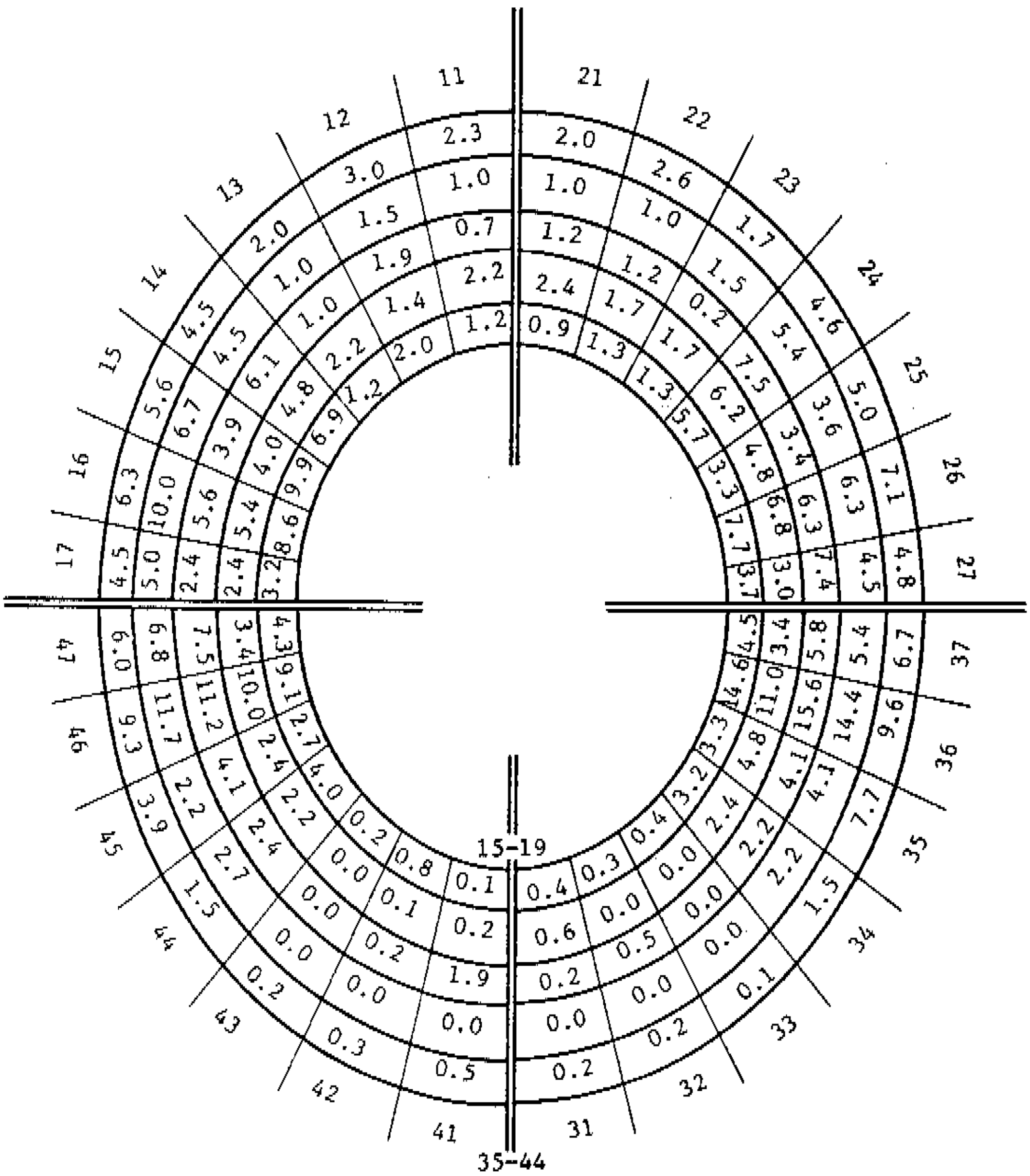
B.

Tooth Number	17	16	15	14	13	12	11	21	22	23	24	25	26	27
Relative proportion of all missing teeth	4.0	6.8	4.9	5.0	1.6	2.6	1.8	1.6	2.1	1.5	5.2	4.5	7.1	4.3
	5.6	10.0	3.4	2.3	0.2	0.5	0.5	0.4	0.3	0.1	2.2	3.9	11.8	5.7
Tooth Number	47	46	45	44	43	42	41	31	32	33	34	35	36	37

For each tooth, its relative proportion of all missing teeth. For example, tooth number 17 accounts for 40% of all missing teeth.

Figure 2: Percentage of subjects missing each tooth

% MISSING TEETH / AGE



This table gives, for each tooth, the percentage of subjects missing the specified tooth, in each age group: for example, tooth number 37 was missing in 6.7% of all subjects in the 35-44 year age group. From the centre to the circumference the following age groups are represented: 15-19, 20-24, 25-29, 30-34 and 35-44.

Table 3: Composite theory of probabilities applied to missing mandibular molars

Lines \ Columns	36	37	46	47
36	24.4	2.9	5.0	2.8
37	7.6*	11.7	2.4	1.3
46	14.1*	7.1*	20.5	2.4
47	7.2*	6.3*	6.8*	11.5

The influences of missing teeth in examinations using a limited number of representative teeth

The fact that teeth are missing and that no reliable information on reason for absence can be obtained can hamper epidemiological examinations carried out on a limited number of representative teeth. Ideally, teeth selected for partial recording methods would be missing as infrequently as possible. When a tooth is missing, it has been advocated that the distal tooth be used as a substitute since neighbouring teeth usually have similar lesions. There may, of course, be cases where both a tooth and its distal neighbour are missing. The extent of this problem can be seen by looking at two systems which examine a limited number of representative teeth: the system proposed by the WHO Scientific Group (WSG), teeth 16, 21, 24, 36, 41 and 44 and another set comprising teeth 17, 13, 25, 32, 37 and 45, computed by regression analysis. Table 4 contains this data. The regression calculated system (RCS) includes teeth which, as a rule, are less frequently missing than those of the WSG system. The WSG system, however, may be preferable with respect to replacement teeth, because the distal neighbouring teeth are of the same anatomical type.

The relationship between missing teeth and periodontal status

The periodontal disease indicators used in this survey include bleeding on probing, presence of supra- and subgingival calculus and first (4 or 5 mm) and second (6 mm or more) degree pockets measured on the lingual and vestibular gingivae of all 28 teeth. The relationship between missing teeth and periodontal status was analyzed from two perspectives:

(a) the number of missing teeth in relation to the severity of disease as determined by the presence of these indicators, and

(b) the frequency of disease indicators in subjects with varying numbers of missing teeth.

(a) Missing teeth in relation to presence of periodontal disease indicators

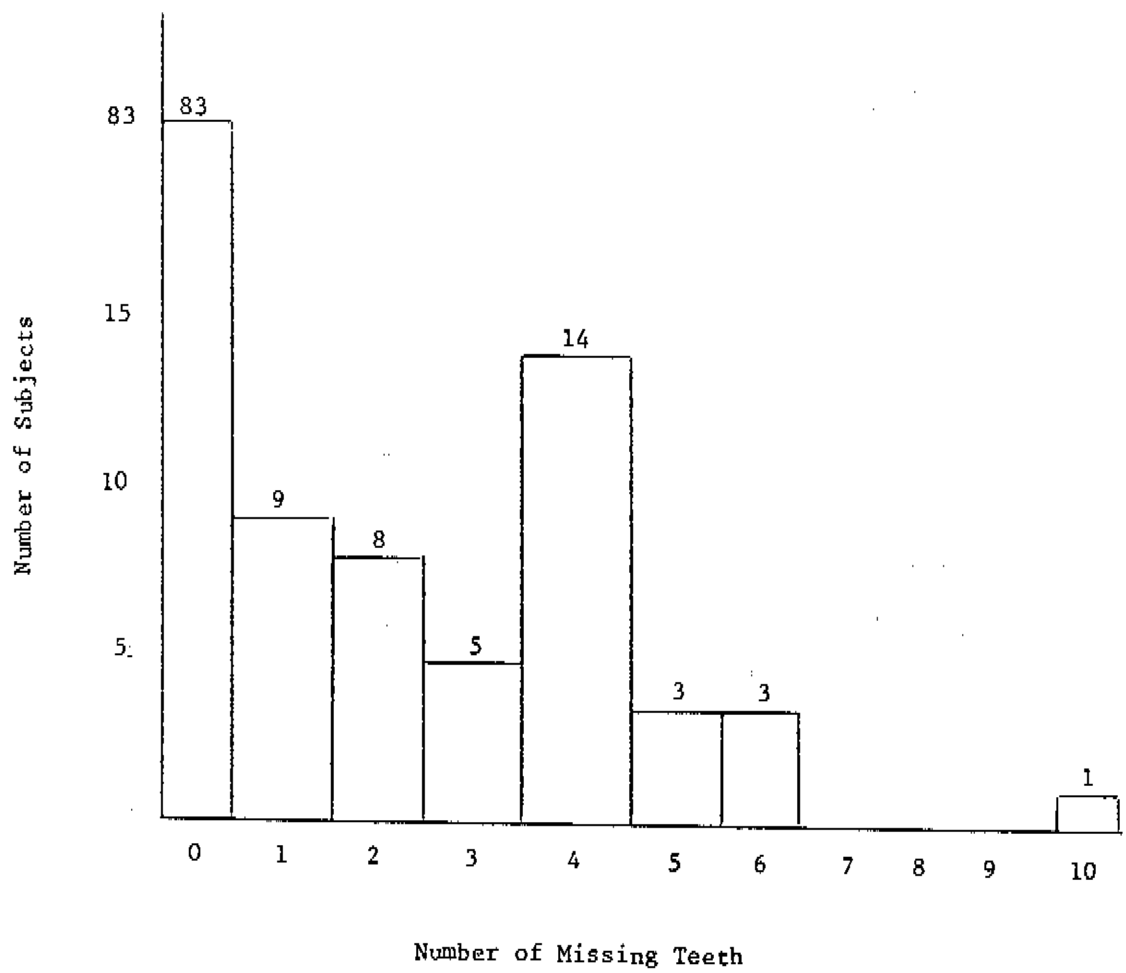
126 subjects out of 2,212 surveyed presented none of the periodontal disease indicators on any teeth, but 43 of these subjects had at least one tooth missing.

Table 4: Comparison of two limited systems of examination with respect to missing teeth

WHO System	% of subjects missing this tooth	% of subjects missing this and distal tooth	RCS System	% of subjects missing this tooth	% of subjects missing this and distal tooth
16	13.92	3.35	17	8.32	no distal replacement
21	3.30	2.31	13	3.39	1.45
24	10.80	3.21	25	9.31	4.39
36	24.37	7.55	37	11.71	no distal replacement
41	0.95	0.32	32	0.68	0.18
44	4.66	1.40	45	7.05	4.20

The average number of missing teeth for this subgroup was 3.23. The majority of these subjects (81%) were in the 15-19 year age group. Figure 3 gives the distribution of subjects in this subgroup by number of missing teeth. These subjects show a high frequency of missing molars and first premolars in all four quadrants. Of the total of 139 missing teeth, teeth 16, 26, 36 and 46 account for 48.9%, teeth 14, 24, 34 and 44 account for 20.8% and teeth 17, 27, 37 and 47 account for 16.5%.

Figure 3: Missing teeth in subjects having no periodontal disease indicators



The distribution of subjects (N = 126)with no periodontal disease indicators is given according to the number of missing teeth.

Table 5 gives the number of subjects in each subgroup as defined by all possible permutations of indicators: Table 5A for subjects with no missing teeth, and Table 5B for subjcts with at least one missing tooth. Overall, statistically, the two groups are significantly different ($p \leq 0.01$). A much higher percentage of subjects in the subgroup 'no missing teeth' is found in the upper left-hand area of the table with no, or very few, indicators present, as compared to the percentage of subjects in the subgroup 'at least one missing tooth' in the corresponding area. Conversely, the subgroup with 'at least one missing tooth' is found in a much higher frequency in the lower right-hand area with three or more indicators, as compared to the subgroup with 'no missing teeth'.

Table 5: Distribution of periodontal disease indicators in two groups: subjects with and without missing teeth

Supragingival Calculus C_1	Subgingival Calculus C_2	Bleeding 0, P 0	Bleeding 0, P 1	Bleeding 0, P 2	Bleeding 1, P 0	Bleeding 1, P 1	Bleeding 1, P 2
0	0	82 7.9%	10 1.0%	0 0.0%	134 12.9%	27 2.6%	1 0.1%
1	0	26 2.5%	5 0.5%	1 0.1%	214 20.6%	81 7.8%	4 0.4%
0	1	9 0.9%	3 0.3%	0 0.0%	22 2.1%	55 5.3%	13 1.3%
1	1	8 0.8%	1 0.1%	1 0.1%	109 10.5%	180 17.3%	52 5.0%

Periodontal Pockets P

Table A: 1,037 subjects with no missing teeth

The tables should be read as follows: top left-hand corner, no or very few indicators present; bottom right-hand corner, 3 or 4 indicators present.

Supragingival Calculus C_1	Subgingival Calculus C_2	Bleeding B 0, Periodontal Pockets P 0	Bleeding B 0, P 1	Bleeding B 0, P 2	Bleeding B 1, P 0	Bleeding B 1, P 1	Bleeding B 1, P 2
0	0	43 3.7%	3 0.3%	1 0.1%	77 6.6%	43 3.7%	6 0.5%
1	0	10 0.9%	4 0.3%	0 0.0%	167 1.4%	63 5.4%	5 0.4%
0	1	15 1.3%	2 0.2%	1 0.1%	36 3.1%	88 7.5%	22 1.9%
1	1	15 1.3%	4 0.3%	1 0.1%	171 14.6%	283 24.1%	124 10.5%

Table B. 1174 subjects with at least one missing tooth

Code: C_1, C_2, B - 0 = absent
1 = present

P - 1 = 4 or 5 mm pockets
2 = 6 or more mm pockets

Supragingival Calculus C_1	Subgingival Calculus C_2	Bleeding B 0, Periodontal Pockets P 0	Bleeding B 0, P 1	Bleeding B 0, P 2	Bleeding B 1, P 0	Bleeding B 1, P 1	Bleeding B 1, P 2
0	0	4.2	+ 0.7	- 0.1	+ 6.3	- 1.1	- 8.4
1	0	+ 1.7	+ 0.2	+ 0.1	+ 6.4*	2.4	0
0	1	- 0.4	+ 0.1	- 0.1	- 1.0	- 2.2	- 0.6
1	1	- 0.5	- 0.2	0	- 4.1	- 6.8*	- 5.5

* statistical significance P< 5%

Table C: gives the differences between Tables A and B. Only for two groups are the percentages significantly different between A and B: those with bleeding and supragingival calculus, but no subgingival calculus or pockets for which there are more subjects with no missing teeth, and those with bleeding and supra- and subgingival calculus, and first degree pockets, for which there are more subjects with at least one missing tooth.

Another approach to this analysis is to divide each indicator into three classes of severity. This classification is based on the number of surfaces, out of a possible 56 surfaces per subject, which have the indicator present: Class 1, the indicator is not present on any surface; Class 2, the indicator is present on 1 to 10 surfaces, and Class 3, the indicator is present on 11 to 56 surfaces. In the case of second degree pockets, the last two classes are collapsed into one, with the indicator present on 1 to 56 surfaces. Table 6 utilizes this classification scheme and considers, by age group, only the subgroup of subjects with at least one missing tooth. There is a general increase in the percentage of subjects with missing teeth and in the mean number of missing teeth per subject with increasing age. There is not, however, a consistent increase in either parameter with increasing severity class for any indicator for subjects over 40 years of age who have more than 10 first degree pockets. It would therefore seem that the extent to which periodontal disease indicators were present did not relate to the number of missing teeth.

(b) Distribution of periodontal disease indicators in subjects with missing teeth

An alternative way of analyzing the relationship between missing teeth and periodontal disease indicators examines the extent to which indicators are present in subjects with varying numbers of missing teeth. Table 7 divides subjects into three major categories based on the number of missing teeth: those with no missing teeth, those with 1-4 missing teeth, and those with 5 or more missing teeth. Within each category, subjects were subdivided by age: less than 20 years, 20-29 years and 30 or more years. For each indicator the percentage of subjects with at least one surface affected is given, followed by the mean number of affected surfaces per subject in that group. The percentage of subjects with indicators depends greatly on age, and only slightly on the number of missing teeth. With few exceptions, the percentage of subjects and the mean number of surfaces affected per subject increases with increasing age for each indicator and for each group defined by the number of missing teeth. In contrast, the change in the percentage of subjects and the mean number of surfaces affected is smaller and less consistent within an age group when one compares the groups with different numbers of missing teeth for each indicator. If one considers the subgroup of subjects with at least one surface affected by each indicator (i.e. at least one surface with B_1, C_1, C_2 and P_1 or P_2), it comprises 17.3% of subjects with no missing teeth and 24,19% of subjects with at least one missing tooth.

DISCUSSION

The data presented here confirms the results of previous studies on missing teeth. The percentage of subjects with missing teeth and the mean number of missing teeth per subject increases with age. The teeth most frequently missing are first molars. The relationship between missing teeth and periodontal status, as determined by this survey, was much less pronounced than is generally thought to be the case. The prevalence of periodontal disease indicators increased slightly as the number of missing teeth increased, but the number of missing teeth did not seem to depend on the severity of the periodontal disease indicators present. However this study population included only subjects aged less than 45 years and very few with deep pockets or more than a few missing teeth, thus no clearly definable progression in breakdown of the dentine in relation to severity of periodontal involvement could be documented here. Furthermore, except in a population where there is very low caries prevalence and eventually almost 100% loss of teeth from periodontal diseases, cross-sectional studies do not provide a useful or valid mechanism to document this process.

Table 6: Distribution of missing teeth by indicator and severity class

Indicator	Number of surfaces affected	Less than 20 years		20 - 29 years		30 - 39 years		40 - 49 years	
		% of subjects	mean no. missing	% of subjects	mean no. missing	% of subjects	mean no. missing	% of subjects	mean no. missing
Bleeding	0	27.8	2.8	50.2	2.4	72.2	5.1	92.8	8.8
	1-10	42.7	2.4	44.3	2.7	80.2	6.3	84.4	7.8
	11-56	44.1	2.6	54.8	3.0	58.0	4.7	70.2	5.8
Supragingival calculus	0	35.9	2.7	57.7	2.9	63.1	5.9	71.4	6.8
	1-10	41.6	2.4	53.5	2.8	61.2	5.5	76.3	7.2
	11-56	51.6	2.4	49.6	3.1	65.9	4.0	72.6	5.2
Subgingival calculus	0	38.7	2.6	55.1	2.8	41.7	4.7	51.9	6.1
	1-10	34.8	2.6	54.6	2.9	67.1	5.4	80.2	6.5
	11-56	34.0	2.1	52.9	3.0	77.9	4.9	85.3	6.7
Periodontal pockets 1st degree	0	40.0	2.7	55.6	3.0	50.5	4.5	64.3	6.5
	1-10	43.8	2.4	54.8	2.9	70.1	5.3	74.8	6.7
	11-56	26.7	1.6	41.8	2.6	74.3	5.4	87.2	9.3
2nd degree	1-56	32.3	1.6	60.5	3.3	70.0	5.5	81.7	6.6

The first figure in each column shows the percentage of subjects missing at least one tooth for each indicator class. The second figure shows the mean number of missing teeth in these subgroups. For example, the first box in the top left-hand corner shows that 27.8% of the subjects less than 20 years of age without any bleeding surfaces have at least one missing tooth. The number to the right shows that, for these subjects, the mean number of missing teeth is 2.8.

Table 7: Distribution of indicators by category of missing teeth

Number of missing teeth	Bleeding			Supragingival Calculus			Subgingival Calculus			Periodontal Pockets		
	20 years	20-29 years	30 + years	20 years	20-29 years	30 + years	20 years	20-29 years	30 + years	20 years	20-29 years	30 + years
0	77.9%	94.4%	97.4%	57.5%	68.0%	84.3%	25.1%	78.8%	50.4%	30.2%	61.2%	64.3%
	12.8	14.7	19.0	6.3	8.1	8.6	10.3	10.9	9.1	6.4	5.2	5.2
1-4	86.9%	94.8%	94.8%	63.6%	62.0%	84.8%	31.7%	77.4%	80.0%	38.3%	64.1%	84.8%
	12.6	13.9	16.7	6.3	7.2	10.2	6.9	9.1	10.5	3.7	4.0	6.3
5-28	92.3%	97.8%	94.3%	61.5%	67.4%	82.9%	48.7%	80.0%	80.5%	25.6%	50.0%	91.0%
	13.4	12.8	11.4	6.3	10.2	7.4	4.7	3.6	9.8	2.9	3.6	4.9

Subjects are divided into categories by the number of missing teeth: 0 missing teeth, 1-4 missing teeth and 5-28 missing teeth. Within these categories, they are subdivided by age group: less than 20 years, 20-29 years and 30 or more years. For each indicator, the percentage of subjects with at least one surface affected is given for each subgroup as well as the mean number of surfaces affected in these subjects. For example, in the category of subjects with 0 missing teeth, 77.9% of those less than 20 years of age had at least one surface bleeding, and the mean number of surfaces affected per subject was 12.8.

METHODOLOGICAL ASPECTS AND CRITERIA FOR THE CHOICE OF A PARTIAL RECORDING SYSTEM FOR THE ASSESSMENT OF PERIODONTAL STATUS

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INTRODUCTION

Epidemiological investigations of the periodontal disease status of populations can be very costly, both in time and money. In order to minimize these costs, examinations limited in both the disease indicators recorded and the number of teeth examined, need to be devised and evaluated. This concept has been used previously(1, 2), the limited systems having been based principally on clinical experience. A number of alternative systems and methods of evaluation of such systems are presented here. The objective is to determine a system which gives a good representation of the overall periodontal status by recording only a few disease indicators on a limited number of teeth. These representations of the total oral state of individuals can then be used to determine periodontal status and treatment needs for a population, and such data can then be used in the planning of oral health services. The aim is not to obtain an accurate assessment of a particular disease in an individual, but to get an overall estimation of the periodontal status of a population group.

Once a set of teeth has been defined, it is necessary to evaluate the sensitivity and specificity of recording of methods based on that set of teeth as a function of the stated objectives. The ability to detect lesions in a group of individuals can be statistically tested, and different sets of teeth can be compared in this manner.

The data available from this field study indicates that periodontal lesions or indicators are not randomly distributed in an individual. An understanding of the underlying relationships between indicators, between teeth and between indicators and teeth is thus very important in the determination of such examination systems. Data from field testing of the WHO proposed survey methodology for periodontal status provides some useful information on these relationships. The results, are summarized here.

Statistical analysis performed on the data showed strong and consistent relationships between indicators, between teeth and between indicators and teeth. Bleeding, the most frequently found indicator, was often associated with supragingival calculus, and had very little relationship to subgingival calculus and pockets. Supragingival calculus and subgingival calculus, also frequently found, had very little connection with each other. Pockets, the least frequently found indicator, had a very strong relationship to subgingival calculus. The prevalence of all indicators increased with age, both in the percentage of subjects affected and in the mean number of surfaces affected per subject. Although lingual surfaces were generally affected more than vestibular surfaces, the two surfaces showed a very strong relationship for any one tooth. Diagramatic projections of the results of multifactorial statistical analysis placed the teeth in their anatomical order and showed a consistent relationship between teeth of similar types on opposite sides of the jaw and within the quadrant. All these results were consistent when the analyses were repeated on subgroups of the file defined by age, sex or country.

MATERIALS AND METHODS

Data on four indicators for both lingual and vestibular surfaces of 28 teeth per subject, collected for the field testing of a proposed methodology for assessment of periodontal status and treatment needs, consistuted the data base for these analyses.

There are two types of methods for choosing a limited number of teeth to be examined: empirical, or à priori, and calculated, or à postériori. In the first method the teeth chosen for examination are based on clinical experience or prior statistical knowledge (3). The set of teeth proposed by the WHO Scientific Group (WSG System) was 16, 21, 24, 36, 41 and

44. A second set based on equal distribution between the jaws and types of teeth, and taking into account ease of examination, was also evaluated. This set consisted of teeth 11, 16, 26, 31, 36 and 46 (SYST 1 system)

In the second method (à postériori), the teeth chosen result from analyses and calculations performed on the data from the field survey to test the methodology. Several methods of analysis were employed, including discriminant function, regression and canonical analysis. A number of limited sets of teeth can be derived this way, depending on defined objectives and criteria used. For example, the objective may be to determine the teeth that are most representative of the mouth for all four indicators, or for one specific indicator only. If one were interested in a system which simply examined one tooth surface for one indicator only, the solution would be simple. The tooth surface most frequently affected should be the one chosen in order to maximize detection of subjects with disease. As soon as one considers a more elaborate system, i.e. more than one indicator and more than one surface, determination of the optimum teeth to be examined rapidly increases in complexity.

Two approaches to this determination were tried. The first involved principal component analysis (on quantitative data) and analysis of correspondence (on qualitative data) to determine the structure of the data and relationships between indicators, surfaces and teeth.

The second method, linear regression analysis, provided 'explanation' of a quantitative variable, the total buccal score for all surfaces of all teeth for the indicator(s) of interest by a linear combination equation of the explanatory variables (the scores of a limited number of teeth). This gave a statistical prediction, or estimation, of a total score from data from a limited number of teeth. A limitation of this technique is that it can only be used on subjects with no missing teeth; thus, the total file for this analysis was reduced to the 1,037 subjects with a complete dentition.

RESULTS

Of the various calculated systems, two will be detailed here. Both have been derived by the method of prediction of a total score by regression analysis. The first set of teeth, Regression Calculated System (RCS 1), is based on the additive score of all indicators for the two surfaces of the limited number of teeth. It attempts to predict the total score for all teeth for all the indicators. The 6 teeth derived in this manner were 13, 17, 25, 32, 37 and 45.

The second set of teeth, 12, 17, 26, 36, 42 and 47, (RCS 2) was used to predict the same score as the first system, but using only the indicator scores for subgingival calculus and pockets on both surfaces. Since most of the à priori systems were composed of 6 teeth, this number was also used in the à postériori systems.

The linear regression technique gives very highly multiplication coefficients indicating a strong relationship betwen indicators and teeth. The score of a single tooth, number 45, was sufficient to obtain a good representation of the total oral score, as its correlation coefficient r was greater than 0.80. When the analysis was extended to include 4 teeth, the ones selected were evenly distributed between types and location. They were 45, 17, 32 and 25, and had a multiple correlation coefficient r of 0.965. The addition of teeth 13 and 37 increased the multiple correlation coefficient to 0.983.

Several criteria can be used to evaluate the effectiveness of these systems. Three will be considered here: behaviour with respect to missing teeth, quality of the estimation of the total oral score, and ability of individual detection.

Behaviour with respect to missing teeth of the 2,212 subjects examined; 53.0% had at least one missing tooth, with a mean loss of 3.9 teeth per subject, or 7.2% of the dentition. If the WSG system of 6 teeth is used, 35.8% of subjects have at least 1 of the designated teeth missing, with a mean of 1.6 teeth per subject, or 26.7% of the teeth measured. For the SYST 1 system, 24.3% of subjects have at least 1 missing tooth, and a mean loss of 1.7 teeth per subject, or 28.3% of the dentition measured. The other RCS system Behaved similarly. Each of these systems detects about one half of the subjects with at least 1 missing tooth.

The second criteria, quality of the estimation of the total oral score, was evaluated using regression analysis to calculate a correlation coefficient between the total oral score for each subject and the score estimated by the limited examination. All four systems resulted in very high correlation coefficients. When 6 randomly chosen teeth were evaluated in this manner, the multiple correlation coefficient was greater than 0.65. This relatively high value is a consequence of the very strong statistical relationship between indicators, surfaces and teeth(5).

The third method of evaluation compares the number of subjects detected for a given indicator (or group of indicators) by the limited system of examination with the number determined by a complete oral examination. This method can be applied to a number of factors, but always uses, as reference, the results of complete examination of 28 teeth.

Table 1 gives data on the number of subjects with no indicators present detected by complete examination and by the four systems of limited examination. All the limited systems overestimated, to some degree, the number of healthy individuals.

Table 1: Subjects with no indicators present as detected by various subtems

Complete Examination	Examination by Limited Systems			
	WSG	SYST 1	RCS 1	RCS 2
126	226	202	262	213

Table 2 presents data on the presence of indicators taken individually for these systems. Only lingual surfaces were considered, but the results for vestibular surfaces were similar. The limited systems gave reasonable estimations for these indicators, with no single system being better, overall, than the others. In most cases, the frequency estimated was less than that obtained by complete examination. The least good estimation, that for pockets, may have resulted from the very variable distribution of this indicator in the populations being considered(3).

The 'index of detection' is defined as a comparison of the number of subjects detected by an examination made on a limited number of surfaces or teeth, with the number of subjects truly having the indicator as determined by a complete examination. The 'index of detection' is thus an evaluation of the quality of the system tested.

Table 3 shows the index of detection of each system for each indicator. Overall, bleeding has the best index and pockets the worst.

Table 2: Results from examination of lingual surfaces for each indicator: comparison of complete and partial examinations

System	Bleeding		Supragingival Calculus		Subgingival Calculus		1st Degree Pockets		2nd Degree Pockets	
	% Subjects	Mean No	% Subjects	Mean No	% Subjects	Mean No	% Subjects	Mean No	% Subjects	Mean No
Complete (28 teeth)	83.9%	11.6	62.6%	6.6	50.7%	8.3	41.9%	4.6	8.2%	2.4
WSG (6 teeth)	72.2%	13.4	56.1%	7.5	56.1%	10.5	22.7%	7.7	2.6%	6.2
SYST 1 (6 teeth)	74.4%	13.8	56.8%	7.8	50.0%	10.7	26.7%	8.2	4.5%	6.0
RCS 1 (6 teeth)	73.9%	13.9	50.2%	7.7	40.0%	10.8	29.2%	7.7	3.8%	5.7
RCS 2 (6 teeth)	75.0%	13.9	53.5%	7.9	41.7%	10.6	30.9%	8.0	5.3%	6.0

Table 3: Comparison of index of detection for all indicators for the limited system using lingual surfaces only

Index of Detection	Bleeding	Supragingival Calculus	Subgingival Calculus	1st Degree Pockets	2nd Degree Pockets
WSG	86.1%	89.6%	80.3%	54.2%	31.7%
SYST I	88.7%	90.7%	98.6%	63.7%	54.5%
RCS I	88.1%	80.2%	78.9%	69.7%	46.3%
RCS 2	89.4%	85.5%	82.2%	73.7%	64.6%

DISCUSSION

The structure and strength of the relationships between indicators, between teeth, and between indicators and teeth, shown in this analysis, justify the use of a limited examination in lieu of complete oral examinations. It is necessary, however, to define clearly the objectives of such a study at various stages. Indicators of disease should first be chosen and evaluated on a sample of the population to be studied. This allows determination of the most appropriate set of teeth to examine in epidemiological surveys of the population. It is also possible to weight the indicators differentially, as deemed necessary by the study objectives. Using an index of effectiveness of detection of a system, one can evaluate the quality of the system and make corrections for the estimates. There are a number of statistical methods available for such evaluations.

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STATISTICAL PREDICTION OF PERIODONTAL STATUS SCORE BASED ON A LIMITED NUMBER OF INDICATOR AND TEETH

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INTRODUCTION

Surveys of periodontal status of populations are costly in terms of personnel and time. The principal problem associated with large surveys is increased variability and results due to examiner fatigue and the consequent shifts in interpretation of criteria; however, the other disadvantages of very large surveys are mainly the greater costs of data checking and entry, and the salary and per diem expenses of the examining team. These constraints make desirable the evaluation of limited status examinations to be used in lieu of full mouth recordings. Such an examination should provide, by measurement of a group of disease indicators on a limited number of teeth per subject, a reliable overall assessment of a population's disease status and treatment needs.

While the indicators measured in this study are similar to, or identical with, those used in conventional examinations, the important concept under study here is the ability to examine only a small number of teeth per subject and obtain a reliable indication overall of the periodontal status of the mouth. A number of investigators have utilized this concept, basing the teeth to be examined on clinical experience. Previously used groups of teeth include: teeth 11, 14, 26, 31, 34 and 46 used by Ramfjord in India in 1957(1), and teeth 12, 16, 44, 32, 36 and 24 used by Löe et al(2).

The data used in this analysis pertain to the field testing study of a new epidemiological method proposed by a WHO Scientific Group in Epidemiology, Etiology and Prevention of Periodontal Diseases(3). In this field testing four indicators (bleeding, supragingival calculus, subgingival calculus and periodontal pockets) were measured on two surfaces (lingual and vestibular) each of all teeth present in each subject. This analysis evaluates several different groups of teeth with respect to their ability to provide reliable indications of overall disease status of a population.

MATERIALS AND METHODS

The objective in establishing a periodontal status score is to quantify, by means of a single number, the extent of a subject's periodontal lesions. A score can be obtained simply by summing the number of tooth surfaces affected by the indicator measures. For the indicators bleeding, supragingival calculus and subgingival calculus, the values 0 and 1 were attributed for absence and presence of the indicator respectively. For pockets the values used were 0 = absence, 1 = a pocket of 4 or 5 mm and 2 = a pocket of depth greater than 6 mm: Thus the total score for the two surfaces of each tooth can range between 0 and 10, and the overall score of a subject with 28 teeth can range from 0 to 280. Indicators could also be weighted differently so as to reflect the relative importance of each indicator in the overall score, but this possibility was not used.

The teeth to be used in a limited status examination should give a calculated score as close as possible to that obtained when all teeth are measured.

One method used to determine the most appropriate teeth was stepwise linear regression (4, 5). In this method an equation is derived which uses the score of representative teeth to estimate the actual score recorded for all the teeth. Each tooth contributes a determined proportion to the overall score. An example of such an equation is as follows:

$$M_{est} = a\,S_1 + b\,S_2 + \ldots\ldots + j\,S_i + E$$

where M_{est} is the estimate given by the equation for the subject's true overall score M, S_i is the score for tooth i and a, b, j and E are coefficients determined for the group of subjects examined. Teeth are added to the equation in a stepwise fashion, the first, S_1, being the most highly correlated with the overall score M, S_2, the second best complement of the preceding term S_1, and so on until all, or some predetermined number of teeth, have been added to the equation. For any given subject, M_{est}, calculated using the equation, is not as a rule exactly equal to the true M as determined by addition of the scores of all the teeth. The statistical dispersion of the values is characterized by the 'multiple correlation coefficient' between M_{est} and the real M. This method can be used for a variety of indicators and numbers of teeth. It can be specifically applied to subgroups of the population, or to the full complement of subjects.

A limitation of the linear regression method is that it does no accept any subject with missing teeth. However one could attribute arbitrary values for each indicator to a missing tooth, i.e. the values of the distal neighbouring tooth. But this approach was not used here because it would have biased the results. Therefore, these calculations were performed only on the subgroup of subjects examined who had all 28 teeth (1,037 of 2,212). The set of representative teeth so determined, however, can also be applied to subjects who have missing teeth when estimating the periodontal status of populations.

Estimates of a periodontal status score on the basis of a single indicator

In this, the simplest case, the score, M, is the total number of tooth surfaces with the chosen indicator present. M_{est} is determined by the equation developed with the regression method. As an example, consider the best representative teeth for the indicators first and second degree pockets on vestibular surfaces only. In order of importance were teeth 36, 42, 24, 27, 44 and 16. The multiple correlation coefficient with 4 teeth was 0.94; with 6 teeth it was 0.96.

In order of importance for second degree pockets only were teeth 36, 41, 24, 37, 32 and 17. The multiple correlation coefficient with 4 teeth was 0.89, with 6 teeth it was 0.94.

Table 1: Results of stepwise linear regeession using all indicators

Step No.	Explanatory Variable (tooth no.)	Regression Coefficient	Multiple Correlation Coefficient
1	45	4.83	0.823
2	17	3.57	0.903
3	32	5.63	0.947
4	25	4.29	0.965
5	13	4.81	0.974
6	37	2.94	0.979

In equation form:

$$M_{est} = 4.83 \text{ (score 45)} + 3.57 \text{ (score 17)} + 5.63 \text{ (score 32)} + 4.29 \text{ (score 25)} + 4.81 \text{ (score 13)} + 2.94 \text{ (score 37)} + 0.20$$

Estimation of a periodontal status score on the basis of all indicators

When all the indicators were used to estimate the periodontal status score, the correlation was very high. Here, a score for a tooth was the sum of all indicators present on the two surfaces (vestibular and lingual). Table 1 gives the results of the stepwise regression for a system limited to 6 teeth. The order in which the teeth were introduced into the equation indicates their relative importance. Also listed are the regression coefficients for each tooth and the multiple correlation coefficient of each step. The first explanatory variable (tooth 45) already had a high correlation coefficient, r = 0.823. The explanatory power of additional variables diminishes rapidly; for example, the second variable (tooth 17) added 0.08, but the sixth variable (tooth 37) contributed only 0.005. The 6 teeth chosen were: 13, 17, 25, 32, 37 and 45. This group of 6 teeth is called the Regression Computed System of Teeth (RCS).

The same calculations can be made for subgroups based on age, country, etc. These results are similar to those obtained using all subjects and can be seen in Tables 2 and 3.

Comparison of different systems

Fig. 1 displays different groups of teeth that have been used in various limited status examination methods. Included are the systems used by Ramfjord (R), Löe and Silness (LS), that advocated by the WHO Scientific Group (WSG)(5) and the system derived by regression analysis from indicator data on subjects having no missing teeth (RCS). A direct comparison was made of the results using the WSG and RCS systems for each age group. The mutiple correlation coefficient for each step in the regression analysis for both systems was very high for all age groups. It was generally greater than 0.95 as soon as four teeth were included. Although the coefficient was usually slightly higher for the RCS system of teeth, it never varied by more than 0.062, and the average difference was 0.016. Analysis using randomly chosen groups of teeth did not give the same high correlations.

The consistently high correlation coefficients can be fairly well explained by analysis of the interrelationships between indicators and the teeth themselves. Between indicators, the correlation was greatest between subgingival calculus and pockets, (r varied from 0.56 to 0.63). It was less between supragingival calculus and bleeding, (r varied from 0.38 to 0.49), and only moderate between supragingival and subgingival calulculus and between pockets and bleeding (r was less than 0.37).

Analysis of the correlations between indicators by tooth surface shows a high degree of association between the two surfaces of a given tooth (r is greater than 0.66). The correlations between teeth were also contributory. The scores for 2 adjacent teeth had high correlation values of between 0.75 to 0.90. The scores of 2 teeth of the same type in different quadrants had correlations bewtween 0.50 and 0.80. Any 2 teeth randomly chosen had correlations exceeding 0.40. The moderate to strong correlations between indicators, surfaces and teeth explain why it is possible to obtain several satisfactory models of linear regression with such a small number of teeth. In fact, even with only 1 tooth, it is possible to 'explain' (in a statistical sense) more than 0.823 of the variation of the overall score (see Table 1). These high correlations mean that the data are not independent and are relatively interchangeable. There is no single solution to the problem of defining a limited group of teeth that are 'representative' of the overall oral condition. Other criteria can be used, therefore, to decide which among these groups of teeth will be used in a particular survey.

The WSG and RSC systems, although they have no teeth in common, are very similar with respect to tooth types used (Fig. 1). The only major difference lies in their inclusion in the sets of teeth that are frequently missing. In the WSG system, 3 teeth were missing with an overall frequency of at least 5%: number 36, 13%, number 16, 7%, number 24, 5%. Only 1 tooth in the RCS system was missing at such a high frequency: number 37, 5%.

Table 2: Results of stepwise linear regression for all indicators for age groups. The regression was done for all indicators by age group. The total number of subjects in each subgroup is given in parenthesis. Tooth number and correlation coefficient are given for each step.

Step Number	15 - 19 years (551 subjects)	20 - 24 years (144 subjects)	25 - 99 years (104 subjects)	30 - 34 years (44 subjects)	35 - 44 years (174 subjects)
1					
Tooth Number	35	16	43	34	35
Correlation Coefficient	0.872	0.83L	0.781	0.867	0.758
2					
Tooth Number	42	34	37	16	31
Correlation Coefficient	0.931	0.911	0.899	0.939	0.855
3					
Tooth Number	13	42	16	47	36
Correlation Coefficient	0.962	0.937	0.926	0.959	0.916
4					
Tooth Number	27	25	22	22	24
Correlation Coefficient	0.974	0.962	0.956	0.976	0.947
5					
Tooth Number	15	12	45	27	11
Correlation Coefficient	0.980	0.972	0.967	0.984	0.960
6					
Tooth Number	46	47	31	42	17
Correlation Coefficient	0.984	0.980	0.975	0.989	0.970

Table 3: Results of stepwise linear regression for all indicators by country. The total number of subjects in each subgroup is given in parenthesis. Tooth number and correlation coefficient are given for each step

Step Number	Canada (81) subjects	Finland (58) subjects	France (56) subjects	G.D.R. (499) subjects	Italy (61) subjects	Scotland (32) subjects	England (57) subjects	U.S.A. 1 (43) subjects	U.S.A. 2 (52) subjects	Syria (102) subjects
1										
Tooth Number	16	42	45	42	14	16	16	15	17	33
Correlation Coefficient	0.819	0.882	0.887	0.786	0.727	0.814	0.791	0.828	0.851	0.875
2										
Tooth Number	11	23	14	24	35	41	42	34	33	37
Correlation Coefficient	0.915	0.946	0.947	0.871	0.853	0.917	0.894	0.913	0.954	0.955
3										
Tooth Number	32	44	31	36	42	21	13	36	35	21
Correlation Coefficient	0.955	0.971	0.974	0.911	0.908	0.953	0.937	0.950	0.970	0.978
4										
Tooth Number	37	24	47	12	45	42	34	22	22	16
Correlation Coefficient	0.973	0.982	0.985	0.934	0.935	0.980	0.953	0.968	0.981	0.986
5										
Tooth Number	24	26	11	15	16	25	11	12	45	42
Correlation Coefficient	0.982	0.937	0.991	0.950	0.950	0.991	0.964	0.970	0.980	0.990
6										
Tooth Number	27	41	27	33	37	37	14	16	37	34
Correlation Coefficient	0.986	0.991	0.993	0.963	0.960	0.996	0.972	0.982	0.989	0.993

Figure 1: Representative tooth groupings for periodontal measurements

RCS				RCS							RCS		
	WSG						WSG			WSG			
	LS				LS					LS			
			R			R						R	
17	16	15	14	13	12	11	21	22	23	24	25	26	27
47	46	45	44	43	42	41	31	32	33	34	35	36	37
	R						R			R			
			LS					LS				LS	
			WSG			WSG						WSG	
		RCS						RCS					RCS

Several systems using six representative teeth have been proposed: Ramfjord (R), Loë and Silness (LS), WHO Scientific Group (WSG), and the one based on the regression study presented in this article (RCS).

DISCUSSION

There are a number of satisfactory solutions to the question of a limited group of 'representative' teeth when evaluation is based on the prediction of an overall oral score. This results from considerable interdependence of the data with respect to indicators, surfaces and teeth. Other constraints may therefore determine which system to use, such as objectives of the study, or particular characteristics of the population to be examined. The WSG and RCS systems give similar results when applied to the WHO data.

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EVALUATION OF DIFFERENT PARTIAL RECORDING SYSTEMS FOR THE ASSESSMENT OF PERIODONTAL TREATMENT NEEDS.

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INTRODUCTION

A recent study to field test a new methodology for the evaluation of periodontal status and treatment needs for the planning of personnel and facilities for community programmes of periodontal disease prevention and control, has provided a large amount of epidemiological data on periodontal indicators. Analysis of this data has enabled several partial recording systems for the assessment of periodontal status to be defined and evaluated with respect to their possible use in epidemiological surveys for the determination of periodontal status of population groups. It is important to distinguish between epidemiological studies and screening surveys. In the first, a representative sample of a population is examined and, on the basis of the results for this sample, the types and amounts of different types of care needed for prevention and control of the disease in the whole population can be calculated. In a screening examination, the objective is to actually identify those individuals that need different types of care. Although these two types of survey activity have different objectives, they are not incompatible and it is possible that similar or identical methodology could be used for both. The analysis of this data has indicated that there are several sets of representative teeth that can be used for the assessment of periodontal status.

The problem of classifying subjects into treatment groups is now addressed. The definition of different groups of treatment need may be made in two ways:

a) <u>Definition 'à priori'</u>

Each investigator classifies each individual he examines according to his own professional criteria. The disadvantages of this procedure relate to differences in treatment need classification which depends on the education and experience of the examiner. There may be wide variations between examiners.

b) <u>Definition 'à postériori'</u>

This method, while grouping subjects into treatment need categories, uses not a global appreciation of the state of the mouth, but observations recorded in a precise fashion on the presence, or absence, of certain indicators on specified surfaces of the teeth. In this way it is possible to classify individuals into treatment need groups on the basis of the recorded data using the computer, rather than the examiner.

Using this method it is also possible to modify the definitions and the parameters of treatments classification without having to perform additional examinations, or re-examinations of subjects, an additional advantage being that the presence or absence of each indicator may be judged separately, and the confusion relating to visual appreciations of clinical changes in the gingivae, or combinations of such changes, is thus avoided. This paper compares the results of different methods of determination of treatment needs 'à priori' and 'à postériori', using the results of the FDI/WHO multinational survey. It also evaluates the different partial recording systems in their efficiency to classify correctly subjects into the various treatment need categories.

MATERIAL AND METHODS

In this study, the state of the periodontium in each subject was assessed visually by the examiner and coded in the following categories: 0 = no pathology, 1 = gingivitis only, 2 = advanced periodontal lesions only, 3 = gingivitis, with advanced periodontal lesions. Subjects were then classified into four treatment categories (TC):

TC 1 no treatment necessary

TC 2 education and oral hygiene needed

TC 3 deep scaling

TC 4 surgery

In addition, each subject was also classified into a treatment need category (TN) on the basis of the associations of periodontal indicators that had been recorded during the full mouth examination, as follows:

TN 0 no treatment needed: no bleeding, calculus, nor pockets

TN 1 oral hygiene education only: bleeding and no calculus or pockets

TN 2 oral hygiene education and scaling: bleeding and calculus, and/or pockets of the first degree (4 and 5 mm): no deep pockets.

TN 3 complex treatment: presence of pockets of depth 6 mm and more.

Evaluation of the efficiency of partial examinations

The results obtained by the examination of the whole mouth (vestibular and lingual surfaces of all teeth in the mouth) and those obtained by using different partial recording methods can be compared to evaluate their efficiency in placing subjects in the various treatment need categories. This evaluation compared:

1. the set of teeth proposed by the WHO Scientific Group meeting (WSG)

2. the set of teeth computed by regression analysis (RCS)

3. other sets of teeth of similar distribution based on clinical experience.

Comparison of the two methods of evaluation of treatment needs

Table 1 give the results of subjects classified into treatment categories by clinical assessment of periodontists (TC), and Table 2 the same subjects classified into treatment need categories on the basis of results of the full mouth examination (TN).

Table 3 gives the comparison between the numbers in the different treatment need groups according to the two methods. The categories corresponding to the first method are indicated on the top of the table, and those using the results of the full mouth recordings of indicators on the left-hand side of the table. Because of the difference in classification and criteria used for the two methods, a strict comparison is difficult. However, certain discordances are quite clear. For example, the first row of the table corresponds to subjects where no periodontal indicator was found on a full mouth examination. However, 40 subjects were classified in TC I and 11 in TC 2 by the clinical assessment. The first column of the table corresponds to subjects for which no treatment was indicated by the periodontal examiner, and there are 233 subjects in this group. According to the full mouth examination, 59 of these subjects needed oral health education and a further 101 had need of oral health education and scaling. Other, quite wide, discrepancies are evident.

Comparison between the complete examination and partial examination using different sets of teeth

Full mouth examination is considered the reference examination classifying all subjects into one of the treatment categories, as already defined. The imperfect efficiency of any

Table 1: Subjects classified into treatment categories (TC) by clinical assessment for all subjects and by age groupings

	All Subjects	TC0	TC1	TC2	TC3	TC4	Others
	n	233	371	1065	320	202	21
	%	10.53	16.77	48.15	14.47	9.13	0.95
Age 15 - 19	n	130	220	517	71	6	7
	%	13.69	23.13	54.36	7.47	0.63	0.73
20 - 24	n	51	57	149	40	0	1
	%	17.11	19.13	50.00	13.42	0	0.33
25 - 29	n	13	24	68	40	97	4
	%	5.28	9.76	27.64	16.26	39.43	0.16
30 - 34	n	9	11	67	16	4	3
	%	8.18	10.00	60.91	14.55	3.64	0.27
35 - 44	n	25	55	242	137	85	3
	%	4.57	10.05	44.24	25.05	15.54	0.91

Table 2: Subjects classified into treatment need categories (TN) on the basis of results of the full mouth examination for all subjects and age groupings

	All Subjects	TNCO	TNC1	TNC2	TNC3	Total
	n	126	211	1643	232	2122
	%	5.69	9.53	74.27	10.48	100
Age 15 - 19	n	108	142	671	30	951
	%	11.35	14.93	70.55	3.15	100
20 - 24	n	6	31	244	17	298
	%	2.01	10.40	81.87	5.70	100
25 - 29	n	5	8	212	21	246
	%	2.03	3.25	86.17	8.53	100
30 - 34	n	1	1	96	12	110
	%	0.90	0.90	87.27	10.90	100
35 - 44	n	4	25	3.87	131	547
	%	0.73	4.57	70.74	23.93	100

Table 3: Comparison of Table 1 and Table 2 treatment need assessments

TABLE 2 ASSESSMENT	TABLE 1 ASSESSMENT						
	TC0	TC1	TC2	TC3	TC4	Errors Blanks	Total
TN0	72	40	11	0	0	3 blanks	126
TN1	59	137	12	2	1	0	211
TN2	101	190	996	231	111	5 errors 9 blanks	1643
TN3	1	4	46	87	90	2 errors 2 blanks	232
TOTAL	233	371	1065	320	202	7 errors 14 blanks	

partial examination will result in a certain number of subjects being misclassified. A misclassification in one subgrouping will result automatically in errors within the other treatment need classifications. The index of detection of a partial recording system, will therefore be determined for any one category of treatment need by comparison of the number of subjects classified into this category on the basis of the partial recording system, compared to the number of subjects classified according to the whole mouth, or reference examination. The closer this ratio is to one, the more efficient is the partial recording system. If it is greater than one, it means that more subjects are being classified in the category than should be and the method is not sufficiently specific. If it is less than one, then this indicates too few subjects are being placed in the correct category and the examination is not sufficiently sensitive. The efficiency of the following partial recording systems was considered.

The first type was proposed on an empirical base (clinical experience, notion of symmetry and use of the different tooth types). These systems generally include between four and eight teeth. One such system was proposed by the WHO Scientific Group (WSG) meeting and includes teeth 16, 21, 24, 36, 41 and 44. Another, rather similar, set of teeth proposed for testing was teeth 11, 16, 26, 36, 31 and 46, being a system more simple to remember and thus easier to learn. The following sets, calculated by discriminant analysis and stepwise multiple regression(2), were included: regression calculated system (RCS), including teeth 13, 17, 25, 32, 37 and 45, calculated using all indicators: RCS2 calculated to predict full mouth scores using only scores for subgingival calculus and pockets, including teeth 17, 24, 26, 36, 37 and 41. Finally, two systems containing teeth 11, 16, 26, 31, 36 and 46, plus teeth 17, 27, 37 and 47(1), and another system containing the same basic six teeth, with the addition of the four second molars and the four second premolars.

Table 4: Subjects classified into treatment need categories by various partial examination systems compared with full examination

TN Category	Full Mouth Exam.	Various Partial Examination Systems and Detection Values											
		36-41-24 16-44-21	Index of Detection	45-17-32 25-13-37	Index of Detection	17-12-26 36-37-42	Index of Detection	16-11-26 46-31-36	Index of Detection	16-17-11-26 27-37-36-31 46-47	Index of Detection	17-16-15-11-25-26-27 37-36-35-31-46-45-47	Index of Detection
0	126	226	1.8	262	2.18	213	1.7	202	1.60	158	1.25	144	1.14
1	211	299	1.40	327	1.54	300	1.40	273	1.29	235	1.11	236	1.11
2	1643	1602	0.97	1602	0.91	1548	0.94	1607	0.98	1625	0.99	1624	0.99
3	232	85	0.36	121	0.52	151	0.65	130	0.56	194	0.84	208	0.89

N.B. no substitution for missing teeth mas been made

Table 4 indicates, for each partial examination system, and for the reference system, the number of subjects classified in each treatment need category overall and by age group and the detection index. As is to be expected in any partial recording system, the overall oral pathology is underestimated. All the systems overestimate category TN0, absence of oral indicators, and TN1, bleeding only, and tend to underestimate categories TN2 and TN3. The detection indices are improved on increasing the number of teeth examined, as is demonstrated by adding the second molars to the system 16, 11, 26, 36, 31 and 46, the improvement is considerable for TN1, marginal for TN2 and of great importance in TN3. Adding the second premolars to the same group of teeth only improves group TN3 index of detection from 0.84 to 0.89. However, it is necessary to define very precisely the objectives of a calculation in order to define the best set of teeth.

Analysis of TN 2

The group TN2 (presence of at least one tooth with calculus and/or a pocket of first degree, but no pockets of second degree) is the largest subgroup in this survey. Table 5 indicates the subjects detected by the complete examination of 28 teeth, by examination of the WSG set of six teeth and by examination of the RCS, and gives a breakdown of this subgroup into the different contributing indicators for two of the systems used. Thus it can be seen that if the most important objective is the identification of calculus, the group of teeth proposed by the Scientific Group (WSG) is better than the RCS set: on the other hand, RCS is superior for the detection of first degree pockets.

Table 5: Subjects classified according to identification of disease categories by various partial examination systems compared with full mouth examinations

	Full Examination of 28 Teeth	Examination Using Teeth 36-41-24-16 -44&21		Examination Using Teeth 45-17-32 25 13&37	
	number examined	number of subjects detected	index of detection	number of subjects detected	index of detection
Bleeding	1345	1291	96.0%	1270	94.4%
Supragingival Calculus	1203	1173	97.5%	1025	85.2%
Subgingival Calculus	917	827	90.0%	790	86.2%
Pockets 1	717	443	61.8%	562	78.8%

DISCUSSION

In the past investigators have chosen, à priori, groups of representative teeth in order to formulate partial recording systems. In general, they have included teeth from the four quadrants of the mouth, based on a clinical experience. It is evident from the results of these statistical analyses that six teeth, more or less symmetrically distributed in the four quadrants of the mouth, can proviude a satisfactory partial recording system. The method of evaluation of these systems can be generalized to all definitions of groups of treatment need. The determination of the detection index for a partial examination made on a group of subjects that are representative of the population under study would permit the calculation of a proportional factor of correction that would substantially improve the estimations of treatment needs for subsequent surveys.

CONCLUSION

The definition of treatment need groups on the basis of observations of indicators in order to decide which treatment needs or preventive actions to apply is an objective and satisfactory method. From the epidemiological point of view, if one wishes to extrapolate results of a large population, it is necessary to test the use of partial recording methods chosen on a more representative sample. In these conditions one could, using the detection index, from a limited system of teeth carefully chosen in accordance with the precise objectives of a study, calculate a coefficient of correction.

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