NATIONAL CENTER For HEALTH STATISTICS | Series 2 Number 25

VITAL and HEALTH STATISTICS
DATA EVALUATION AND METHODS RESEARCH

Orthodontic Treatment Priority Index

A description of the development of a system for studying malocclusion in population groups. Through the use of multiple regression equations the findings from the field examination procedure consisting of 10 objective components are weighted and summed to a single number on a 10-point scale of case severity. A computer program for data processing is included.

Washington, D.C. December 1967

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
John W. Gardner
Secretary

Public Health Service
William H. Stewart
Surgeon General

Public Health Service Publication No. 1000-Series 2-No. 25

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 40 cents

NATIONAL CENTER FOR HEALTH STATISTICS

THEODORE D. WOOLSEY, *DIRECTOR*

PHILIP S. LAWRENCE, Sc.D., *Associate Director*

OSWALD K. SAGEN, Ph.D., *Assistant Director for Health Statistics Development*

WALT R. SIMMONS, M.A., *Assistant Director for Research and Scientific Development*

ALICE M. WATERHOUSE, M.D., *Medical Consultant*

JAMES E. KELLY, D.D.S., *Dental Advisor*

LOUIS R. STOLCIS, M.A., *Executive Officer*

DONALD GREEN, *Information Officer*

DIVISION OF HEALTH EXAMINATION STATISTICS

ARTHUR J. McDOWELL, *Director*

JAMES T. BAIRD, JR., *Chief, Analysis and Reports Branch*

HENRY W. MILLER, *Chief, Operations and Quality Control Branch*

PETER V. HAMILL, M.D., *Medical Advisor*

LAWRENCE E. VAN KIRK, D.D.S., *Dental Advisor*

Public Health Service Publication No. 1000-Series 2-No. 25

Library of Congress Catalog Card Number 67-60072

FOREWORD

This study was begun as part of the Burlington Orthodontic Research Project of the University of Toronto and remains an essential part of the Canadian research. Interest in a treatment priority index—an index of the handicapping extent of malocclusion—began at Burlington when the need arose to decide objectively whether preventive treatment had reduced malocclusion below a level that might be considered of public health significance. A description of the proposed Treatment Priority Index (TPI) appeared in an annual report of the Burlington Orthodontic Research Centre.[1]

At about the same time, the Health Examination Survey, a major program of the National Center for Health Statistics, was making plans for its second cycle of examinations. In Cycle I, a national probability sample of adults aged 18 through 79 years was examined with primary emphasis on cardiovascular disease, arthritis and rheumatism, and other chronic diseases. Cycle II would survey a sample of children 6-11 years old and would focus on factors related to growth and development.

The dental examination would place special emphasis on the assessment of occlusion because of its importance in this age group. But unlike most other areas of the dental examination, no single survey assessment procedure had gained widespread acceptance or use. The items under consideration, when used together for the HES examination, would be a potpourri of time-tested clinical signs and symptoms, each in itself capable of producing interesting and useful data, but missing by a considerable distance the most important and most needed statistic of all—an estimate of the extent and severity of malocclusion in the population.

Now, the component parts of the TPI were quite similar to items already proposed for the Health Examination Survey and offered no new or untested measurement procedures. What was new was the potential ability of the index to summarize these heretofore disconnected clinical signs and symptoms into a single number on a 10-point scale of case severity and therefore make estimates of the severity of malocclusion in population groups. The value of such an index could not be overlooked and, to speed up the developmental work and the writing of a computer program for processing the results of Cycle II, financial assistance was provided by NCHS. Mr. Tavia Gordon, Assistant Chief, Division of Health Examination Statistics, participated by conveying the needs of the survey and, along with Dr. James E. Kelly, Dental Advisor to NCHS, and Dr. Lawrence Van Kirk, Jr., Dental Advisor, Division of Health Examination Statistics, assisted Dr. Grainger through discussion and consultation.

James E. Kelly, D.D.S.
Dental Advisor
National Center for Health Statistics

Lawrence E. Van Kirk, Jr., D.D.S.
Dental Advisor
Division of Health Examination Statistics

SYMBOLS	
Data not available------------------------	---
Category not applicable------------------	...
Quantity zero---------------------------	-
Quantity more than 0 but less than 0.05----	0.0
Figure does not meet standards of reliability or precision------------------	*

CONTENTS

This is a report on the research development of a means of objectively assessing the degree of handicap due to malocclusion in terms of a Treatment Priority Index. The work is based on the study of the interrelationships of 10 manifestations of malocclusion as they occurred in 375 12-year-old children with no history of orthodontic treatment. The group constitutes a representative sample of children, primarily of Anglo-Saxon origin, from three Ontario communities.

The method was to define the natural groupings of manifestations which tended to occur jointly and which might be referred to as syndromes. A judgment of the severity of the malocclusion for each child was obtained through direct examination by orthodontic specialists. The highest values in a 10-point scale indicated severe malocclusion. Using multiple regression methods, formulas were developed for estimating the judgment scores from the objective measurements. The correlation between the calculated score and the actual clinical judgment was comparable to that between two sets of clinical judgments. It is suggested that the index may be useful in epidemiological studies, as well as in initial screening of populations to determine the need for treatment while providing a rough description of the case type.

A fully computerized data-processing system and a manual form on which to record and calculate the Treatment Priority Index are provided.

ORTHODONTIC TREATMENT PRIORITY INDEX

R. M. Grainger, D.D.S., M.Sc.D., D.D.P.H., *Faculty of Dentistry, University of Toronto*

INTRODUCTION

The last decade has seen increasing interest in the development of indexes of occlusal status and many useful and interesting methods have been put forward.[2-7] No one method appears to be equally suitable for the use of epidemiologists, public health program planners, and clinicians.[8,9] Consequently it was felt that a renewed effort was needed to develop an assessment procedure that would objectively express the severity of malocclusion in clinically descriptive terms and, at the same time, would be simple enough to be used by individuals without specialty training.

The present interest in a treatment priority index, that is, an index of the degree of handicapping malocclusion, began in connection with the Burlington Interceptive Orthodontic Research Project,[10] where the need arose to decide objectively whether treatment had reduced the defect to below the level of public health significance. It was soon recognized thereafter that the same method would be useful for population surveys of the epidemiologic type and also as a screening device in public health programs.

This study describes the development and use of a simple method of assessing the severity of the most common types of malocclusion and hence provides a means for ranking individuals according to their severity of malocclusion, their degree of handicap, or their priority for treatment. Although each ranking implies a different purpose, each quite obviously assesses the same thing.

SOURCE OF DATA AND DEVELOPMENTAL METHOD

A storehouse of invaluable records, particularly for a developmental study, is available at the Burlington Orthodontic Research Centre. Sets of dental casts are on file from a cross-sectional sample of children of the town at ages 3, 6, 8, 10, and 12 years. In each age group, 85 to 90 percent of the children at that age are included. In addition, for two groups serial dental casts were made annually for a period of 10 years. The 3-year-olds in the cross-sectional sample became the serial experimental group on which preventive orthodontic procedures would be performed as needed. The 6-year-olds became the serial control group. These unique records are valuable for study because they are representative of all the types of occlusion in a typical community and also because, for these children, there had been very little treatment that might obscure the natural patterns of malocclusion.

Consideration of the Nature of Handicapping Malocclusion

Strictly speaking, malocclusion is any disharmonious variation from the accepted or theoretical normal arrangement of the teeth. But, in nature some degree of variation among individuals of a species is always present; hence the statement must be qualified as to the critical amount of variation which constitutes malocclusion. For the purpose of this study the ideal occlusion was taken to be the norm and the point from which variation is measured.

It is not so much the amount of variation of linear measurements from their respective norms that causes malocclusion, but more importantly the inconsistent variation of parts. Thus it does not matter if all measurements of a face are large compared with a set of skeletal norms; this merely means that the whole face is large. But when one measurement tends to be small while the rest are larger than average, there is disharmony, and if the disharmonious part is closely related to the masticatory structure, there is a great likelihood of malocclusion. Neither does lack of complete harmonious conformity to norms necessarily constitute a malocclusion, as is shown in making dentures, where the production of minor variations to give a lifelike appearance is a fine art. However, the degree of tolerated disharmony needs to be carefully determined for a specific population group if a realistic public health measure of handicapping defects is to be obtained.

After careful consideration of what constitutes a handicapping anomaly from both professional and lay standards, the Burlington project staff agreed upon the following as prerequisites for determining a handicap:

1. Unacceptable esthetics.
2. Significant reduction in the masticatory function.
3. A traumatic condition which predisposes to tissue destruction in the form of periodontal disease or caries.
4. Speech impairment.
5. Lack of stability so that the present occlusion will not be maintainable over a reasonable period of time.
6. In addition there exists a class of rare but gross, traumatic defects such as cleft palate, harelip, and pathological or surgical injuries which are unquestionably of very high treatment priority.

Malocclusion Severity Scale	*Interpretation*
0	Virtually classic normal occlusion
1, 2, 3	Minor manifestations and treatment need is slight
4, 5, 6	Definite malocclusion but treatment elective
7, 8, 9	Severe handicap, treatment highly desirable
10	Very severe handicap with treatment mandatory

Figure I. Arbitrary scale for expressing case severity by means of a simple integer value between zero and ten.

Table A. Number and percent distribution of 375 12-year-old children, by clinically judged case severity scores: Burlington, Brantford, and Orangeville, Ontario

Judgment score	Number	Percent distribution
Total	375	100.0
0	22	5.9
1	46	12.3
2	68	18.1
3	72	19.2
4	44	11.7
5	40	10.7
6	36	9.6
7	29	7.7
8	16	4.3
9	2	0.5
10	-	-

For practical purposes, it was agreed that six conditions should be detectable either through a measurement or because of the obvious severity of the condition. Neither the cost nor the difficulty of treatment would be considered in rating the handicap.

Establishment of a Scale for Expressing Case Severity

Figure 1 illustrates an arbitrary scale between zero and ten that was selected as a means of expressing the degree of handicap or the priority of treatment which should be given. It was assumed that case severity is a continuum and that no cutoff point existed below which treatment might be said with certainty to be unnecessary. The scale would express the degree and relative importance of the six conditions mentioned above as they occurred in a given individual.

Theoretically, if enough trained personnel were available, it would be possible to undertake surveys of populations by simply recording judgments of the individual person's position on the scale. The high cost of employing orthodontists, even if they were available, makes this approach impractical. The alternative of mathematically estimating the judgments from objective observations became the principal goal of the study.

In order to develop the estimating equations, a set of clinical judgments was needed. The dental casts of 203 12-year-old children in the Burlington collection and an additional 172 children in the nearby communities of Brantford and Orangeville were examined by members of the Burlington Project staff and the judgments recorded (table A).

The clinical judgments of case severity are in no sense absolute. Rather, they are subject to considerable inter- and intra-examiner error. Figure 2 shows the degree of agreement between two orthodontists on the Burlington staff for 95 cases. The product moment correlation r is +.84; the average difference is 1.35; and the standard deviation of the differences 1.40. Thus 19 out of 20 times, the examiners differed by as much as 2.8 points on a 10-point scale. However, a mathematically calculated estimate of case severity that differs no more from the judgment score of Orthodontist A than Orthodontist A differs from Orthodontist B has certain advantages: (1) the priority estimate mathematically computed

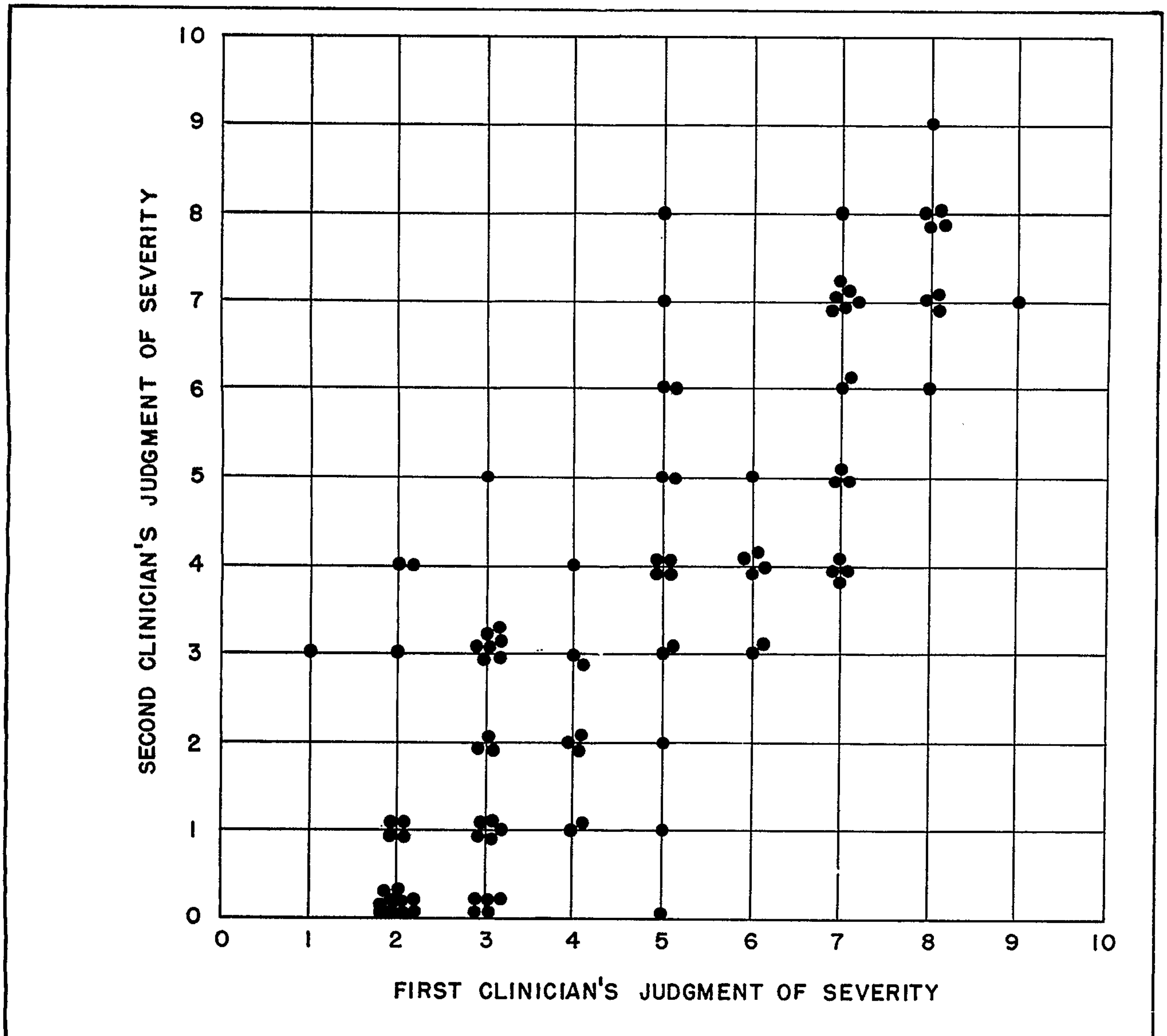

Figure 2. Relation between treatment priority judgments by two independent orthodontists for 95 cases from the Burlington cross-section control group of 12-year-old children.

Table B. Distribution of 10 manifestations of malocclusion and normalized scores for 375 12-year-old children: Burlington, Brantford, and Orangeville, Ontario

Measurement[1]	Upper anterior overjet		Lower anterior overjet		Cverbite		Openbite		Congen-ital missing incisor	
	f	*T*	*f*	*T*	*f*	*T*	*f*	*T*	*f*	*T*
0	1.9	27	98.9	50	1.1	24	98.9	50	97.9	50
1	6.7	34	0.5	74	3.5	31	1.0	76	0.8	71
2	26.4	42	0.5	78	46.9	44	-	...	1.3	75
3	24.3	49	-	...	20.5	60	-	...	-	...
4	16.3	55	-	...	2.4	69	-	...	-	...
5	0.8	57	-	...	1.6	74	-	...	-	...
6	7.5	62	-	...	-	...	-	...	-	...
7	4.5	66	-	...	-	...	-	...	-	...
8	1.6	70	-	...	-	...	-	...	-	...
9	2.4	72	-	...	-	...	-	...	-	...
10	0.5	76	-	...	-	...	-	...	-	...
Mean	3.54		0.02		2.01		0.01		0.04	
Variance	3.83		0.03		0.77		0.01		0.06	
Standard deviation	1.96		0.16		0.87		0.10		0.25	

Measurement[1]	Disto-clusion		Mesio-clusion		Posterior cross-bite, maxillary to buccal		Posterior cross-bite, maxillary to lingual		Tooth displace-ment	
	f	*T*	*f*	*T*	*f*	*T*	*f*	*T*	*f*	*T*
0	61.3	45	97.9	50	95.2	49	94.1	49	50.4	43
1	10.4	54	0.3	71	1.6	68	2.9	67	11.2	52
2	16.8	59	1.0	73	1.3	69	1.8	70	16.8	55
3	3.2	63	0.8	77	0.5	71	0.8	75	4.3	59
4	8.3	67	-	...	0.5	73	0.3	79	6.4	61
5	-	...	-	...	0.5	75	-	...	2.9	63
6	-	...	-	...	0.3	79	-	...	2.9	65
7	-	...	-	...	-	...	-	...	1.6	67
8	-	...	-	...	-	...	-	...	2.7	70
9	-	...	-	...	-	...	-	...	0.3	75
10	-	...	-	...	-	...	-	...	0.5	85
Mean	0.87		0.06		0.12		0.10		1.56	
Variance	1.64		0.17		0.42		0.21		4.81	
Standard deviation	1.28		0.41		0.65		0.46		2.19	

[1] See Appendix I for definitions.

f = frequency; *T* = normalized score calculated from areas in normal distribution $\bar{x} = 50$, $s = 10$.

from the basic recordings would be reproducible, hence more useful for epidemiologic work, (2) less trained personnel could be used for examining, (3) the bias of the calculated score would become defined after a period of use and hence could be offset by knowledgeable interpretation, but the bias in subjective clinical assessments is not constant, thus not correctable, and (4) a calculated severity score could be useful as basic data in estimating the need and costs of treatment by a panel of experts.

Selection and Interrelations of Recording Items

The items to be observed either from casts or direct clinical examination were selected because of their bearing on the six points used to determine the degree of handicapping. The items were rigidly restricted to those that describe an occlusion anomaly, excluding factors bearing on etiology such as habits, or underlying measurements which are related to malocclusion but are not malocclusion per se, such as arch width. Moreover, a few manifestations of malocclusion such as midline diastema and slight asymmetry were rejected as being of little public health significance. Ten manifestations were chosen to be of primary importance. An eleventh recording item was included for special cases in which measurements seem inappropriate. The rare but severe defects such as cleft palate and other gross dento-facial anomalies would be reported here and automatically assigned the highest case severity score. For definitions of these recording items, see Appendix I.

1. Upper anterior segment overjet.
2. Lower anterior segment overjet.
3. Overbite of upper anteriors over lower anteriors.
4. Anterior openbite.
5. Congenital absence of incisors.
6. Distoclusion as determined from buccal segments.
7. Mesioclusion as determined from buccal segments.
8. Posterior crossbite with maxillary segment to buccal of normal cusp relation.
9. Posterior crossbite with maxillary segment to lingual of normal cusp relation.
10. Displacement of individual teeth.
11. Cleft palate, traumatic conditions, and other gross facial anomalies.

The frequency distributions of the 10 recording items for the same 12-year-old children that were given judgment ratings for severity by the Burlington staff are shown in table B and in the detailed tables for other age groups with data from the dental examination of the National Center for Health Statistics' Health Examination Survey.[11] (It is important to notice that the distribution of measurements and scores was similar for the Burlington research data and the HES data.) The average changes in the observations with age are, no doubt, anatomically real and indicate the need for slightly different standards or interpretations for different ages.

Table C. Analysis of 105 pairs of replicated examinations (21 cases by 5 examiners)

Recording item	S.D. of distribution of differences between pairs $\sqrt{\Sigma d^2/2N}$	95 percent confidence range for recording reproducibility	Confidence range as a percent of possible range of scores		Order of recording reliability
			Range	Percent	
Anterior overjet	.969	±1.94	12 mm.	16.2	3
Anterior underjet	---	---	---	---	---
Anterior overbite	.412	± .82	5 points	16.4	4
Anterior openbite	.526	±1.06	5 mm.	21.2	6
Congenital missing incisor	---	---	---	---	---
Distoclusion	.572	±1.14	4 points	28.5	8
Mesioclusion	.265	± .54	4 points	13.5	1
Posterior crossbite, maxillary to buccal	1.28	±2.56	10 teeth	25.6	7
Posterior crossbite, maxillary to lingual	.701	±1.40	10 teeth	14.0	2
Tooth displacement	1.86	±2.72	15 points	18.1	5

S.D.—standard deviation.

Table D. Classification of 126 cases having manifestations of malocclusion of a clinically significant degree: Burlington, Brantford, and Orangeville, Ontario

Recording item and clinically significant degree	Disto-clusions with overjet				Disto-clusions with no overjet				Mesioclusions		
Maxillary overjet, 5 mm. and over----------	√	√	√	√							
Mandibular overjet, 1 mm. and over---------										√	
Overbite, score 3 or over------------------	√	√	√	√	√	√	√	√			
Openbite, 1 mm. and over-------------------									√		
Congenital incisor, score 1 or over--------								√			
Distoclusion, score 3 or over--------------	√	√	√	√	√	√	√	√			
Mesioclusion, score 3 or over--------------									√	√	√
Posterior crossbite, maxillary to buccal, score 1 or over---------------------------			√					√			√
Posterior crossbite, maxillary to lingual, score 1 or over---------------------------				√	√						√
Tooth displacement, score 4 or over--------	√						√				√
Observed frequency of combination----------	14	40	3	1	4	6	15	1	1	3	4
Totals---------------------------------	58				26				8		

Some idea of the reproducibility of the recording items was obtained by analysis of replicated examination of 21 cases by five different orthodontists. This gave 105 pairs of replications for each of the 10 recording items. The results given in table C are, of course, directly applicable to the particular cases and examiners involved, but they do indicate where the most difficulty is encountered and where the most concentrated calibration effort would be needed when instructing new examiners. The most difficulty seemed to arise in recording distoclusion, posterior crossbite, and anterior openbite.

As a first exploration of the interrelationship of the first 10 recording items, a classification of the various combinations of defects of severity sufficient to be of some significance was tabulated. The critical severity levels for the various defects were determined completely arbitrarily on an individual basis, and it is not suggested that these truly represent the levels of severity considered to be of public health signifi-

Table D. Classification of 126 cases having manifestations of malocclusion of a clinically significant degree: Burlington, Brantford, and Orangeville, Ontario—Con.

Neutroclusion displacements				Overbite, overjet cases			Cross-bites	Congen-ital incisor	Condensed table						
									D1	D2	M1	M2	Dis	0+0	C
				√		√			√					√	
											√				
	√				√	√			√	√				√	
											√				
								√							√
									√	√					
											√	√			
		√					√		√	√		√	√		
√							√		√	√		√	√		
√	√	√	√						√	√		√	√		
6	4	3	8	5	2	4	1	1	58	26	4	4	21	11	2
21				11			1	1							

cance. The levels used, as defined in table D, were:

1. Maxillary overjet-------5 mm. and over
2. Mandibular overjet -----1 mm. and over
3. Overbite---------------score of 3 or over
4. Openbite---------------1 mm. or over
5. Congenitally missing incisors--------------1 or more
6. Distoclusion -----------score of 3 or 4
7. Mesioclusion-----------score of 3 or 4

8,9. Posterior crossbite-----count of 1 or more

10. Tooth displacement-----score of 4 or over

At the extreme right of table D is a condensation of the main blocks which correspond well with earlier work.[12]

It is unlikely that the severity judgments set by the clinicians would be directly related to any specific single measurement change because the clinicians were told to judge the cases without, as it were, performing a formal diagnosis. Nor can it be assumed that the grossest defect was the cause of the high judgment score because more moderate variation of another factor could conceivably be more important clinically. The judgments then must in each case apply to a specific combination of observations.

In Appendix II, confirmation of the pattern of combinations (syndromes) originally proposed and presented in table D was undertaken by multiple group factor analysis. Table I of the appendix shows the results of analyzing a correlation matrix of phi coefficients. The general make up of the rotated factors was found similar to the syndromes in table D. The conclusion is that if the cases were separated into three sets—(1) the distoclusion group, (2) the mesioclusion group, and (3) the neutroclusion group—it would be reasonable to assume that the judgment expressed the severity of these syndromes and hence that multiple regression methods could be employed to estimate the score from the appropriate combinations of individual observations.

Table E. Results of multiple regression calculations for estimating the clinician's judgment using squares of predictors for distoclusion, neutroclusion, and mesioclusion cases

Buccal segment relation, recording item,[1] and judgment score	Mean	S.D.	Regression coefficient	*T* value for test of regression coefficient	Standard partial *r*	Multiple *R*	Vertical intercept constant
Distoclusion cases							
Upper overjet	21.12	22.30	.052	9.76	.588	.795	1.58
Upper overbite	5.37	4.72	.134	5.63	.386		
Distal molar score	4.69	5.55	.067	2.96	.215		
Posterior crossbite, maxillary to buccal	0.61	3.54	.115	3.88	.277		
Displacement	7.57	16.32	.023	3.40	.245		
Judgment score	3.96	2.31	...	...	...		
Neutroclusion cases							
Upper overjet	8.18	9.44	.088	13.71	.619	.855	0.33
Overbite	3.42	3.03	.066	3.25	.184		
Openbite	0.01	0.10	.222	0.34	.020		
Posterior crossbite, maxillary to buccal	0.15	1.70	.184	5.00	.276		
Posterior crossbite, maxillary to lingual	0.17	1.23	.251	4.79	.266		
Displacement	3.62	11.12	.112	19.06	.739		
Judgment score	1.76	1.99	...	...	...		
Mesioclusion cases							
Lower overjet	0.07	0.49	.475	2.14	.256	.835	1.33
Openbite	0.03	0.17	.100	0.14	.017		
Mesial molar score	1.41	3.38	.260	6.20	.610		
Posterior crossbite, maxillary to lingual	0.10	0.51	.403	1.63	.198		
Displacement	3.34	10.62	.059	5.75	.581		
Judgment score	1.97	1.56	...	...	...		

[1] All squared except judgment scores.
S.D.—standard deviation.

Development of Regression Equation for Estimating Treatment Priority Scores

In the work of developing a computing equation, squares of the individual recording items were used to provide better separation of the very severe cases and to decrease the treatment priority for cases with several minor defects that should not, even in combination, constitute a severe handicap.

It was recognized that the weights or importance of items differ according to the combination of other items present. To illustrate, 5 millimeters of anterior overjet is not an extreme handicap in a neutroclusion case but in combination with a slight distoclusion, it confirms the diagnosis of the syndrome and raises the importance of the findings. Alternately, a mild upper anterior overjet occurring in a case tending toward mesioclusion in the buccal segments may be an indication that the mesioclusion is of rather low severity and less likely to become worse.

The regression of the measurements is only crudely linear with respect to clinical handicap—in fact, obvious break points exist. As examples, horizontal overjet becomes more critical at the point where the lower lip can reside behind the upper anterior teeth. Vertical overbite becomes suddenly severely handicapping when the lower teeth begin to impinge on the upper soft tissues.

To compute the regression equations and determine the correlation of the judgment scores with the measurements, three subsets of records for the 12-year-old children were prepared according to the anteroposterior buccal segment relationship. In the distoclusion and mesioclusion sets, the groups used were all those individuals with some degree of distal or mesial molar defects, plus a few dozen very low priority scored cases in order to increase the effective range of variation. Under these circumstances the judgment score could be assumed to relate to the severity of the syndromes present. This would not have been so if the entire group of 375 had been used in each case. Calculations were made for the three molar relation groups using the BIMD # 6 program on the IBM 7094. Table E shows the resulting constants.

While the results were generally good in terms of the multiple correlation coefficients which compare favorably with between-examiner correlation (fig. 2), deficiencies were apparent upon examination. First, the regression lines did not pass through the origin because the positive vertical intercept constants combined with positive regression coefficients dictate that no estimate can fall below these values. Second, when the three equations were used in parallel on all cases, it was seen that the distoclusion equation gave estimates that were too low for the individuals with only one or two degrees of distoclusion. The neutroclusion formula provided a fairly suitable estimate of these low-degree distoclusion cases but was much too high if used for full distoclusion dentitions. Third, there were a fair number of very gross discrepancies. Upon examination it was evident these must be recording or judgment errors but they were included throughout the work because the source of the errors could not be verified. Fourth, the mesioclusion cases were rather poorly estimated as only a handful of serious cases were available.

The problem of the vertical axis intercept constant divergence from zero can be explained in terms of the fact that zero score had been taken as normal for the overjet and overbite. In the next round of calculations anterior overjet normal was to be taken as 2 millimeters and overbite as one-third so that all estimates might be reduced by this amount and some presumably to actual zeros.

The misfit of the distoclusion equation for cases with only slight buccal segment change and the value of the neutroclusion equation for these cases raised the problem of determining the buccal segment score cutoff point where one equation would be substituted by the other. What was needed was a single equation in which the weights for overjet, overbite, and displacement would gradually decrease as a function of the higher degrees of distoclusion. It was speculated also that the same need might exist while progressing from neutroclusion to mesioclusion. Consequently, another set of multiple regression computations was done using seven groups instead of three in which all cases included in a group had the same type of buccal segment relation and the same degree of variation.

For these calculations the data were rearranged so that anterior overjet-underjet and

Table F. Calculated regression coefficients and smooth values[1] for seven[2] buccal segment relations

Variable	Buccal segment relation						
	Distal 4	Distal 3	Distal 2	Distal 1	Neutral 0	Mesial 1	Mesial 2
Sample size	32	11	61	38	217	12	13
Y intercept	4.59	3.87	3.57	1.97	0.12	2.29	0.63
Multiple R	.64	.68	.58	.69	.86	.59	.87
Judgment average	5.78	5.09	4.98	3.68	1.99	2.33	3.69
	Regression coefficients						
Anterior horizontal	.03	.05	.08	.13	.24	-.22	.08
Anterior vertical	.09	.28	.16	.04	.26	.20	.35
Posterior crossbite, maxillary to buccal	.14	...	.11	.10	.16	-2.61	.14
Posterior crossbite, maxillary to lingual	.96	-.76	.09	...	.27	-.34	...
Displacement	.01	.01	.02	.03	.11	.03	.62
	Smoothed weights[1]						
Anterior horizontal[3]	.03	.05	.08	.14	.24	.14	.08
Anterior vertical[4]	.09	.11	.15	.19	.23	.19	.15
Posterior crossbite, maxillary to buccal[5]	.14	.14	.14	.14	.14	.14	.14
Posterior crossbite, maxillary to lingual[5]	.26	.26	.26	.26	.26	.26	.26
Displacement[6]	.01	.02	.03	.06	.10	.06	.03
Y intercept[7]	5.17	3.95	2.72	1.50	0.27	1.50	2.72

[1]Preliminary expressions from Appendix III used to construct smooth weights.

[2]No data were available for the obviously missing two higher degrees of mesioclusion groups.

[3]Horizontal $(Y_1 - Y_2 - 2.0)^2 e^{-(1.4 + 0.53(Y_6 + Y_7))}$

[4]Vertical $(Y_3 - Y_4 - 1.0)^2 e^{-(1.4 + 0.25(Y_6 + Y_7))}$

[5]Crossbites were weighted averages.

[6]Displacement $(Y_{10})^2 e^{-(2.28 + 0.61Y_6 + .23Y_7)}$

[7]Y intercept $= .27 + 1.2(Y_6 + Y_7)$

overbite-openbite would be continuous scales going from positive to negative. However posterior crossbite was not considered a continuum, because the two types can occur in the same individual. Both types were observed in the same neutroclusion individuals but there was a higher tendency for buccal crossbite in the distoclusions and lingual crossbite in the mesioclusions. Consequently, these were left as separate items along with the tooth displacement score. The buccal segment score was dropped from the calculations because all cases in the same group would have the same score and the contribution of this factor would be contained in the vertical intercept constant.

Table F gives the results of the calculations for the seven groups and preliminary smoothed out regression coefficients. The smoothing out was

Table G. Final smoothed weights according to buccal segment relations

Variable	Buccal segment relation								
	Distal				Neutral	Mesial			
	4	3	2	1	0	1	2	3	4
Horizontal component[1]	.07	.10	.14	.19	.26	.19	.14	.10	.07
Vertical component[2]	.24	.31	.39	.51	.65	.51	.39	.31	.24
Posterior crossbite, maxillary to buccal[3]	.14	.14	.14	.14	.14	.14	.14	.14	.14
Posterior crossbite, maxillary to lingual[3]	.26	.26	.26	.26	.26	.26	.26	.26	.26
Displacement[4]	.01	.02	.04	.07	.12	.08	.06	.05	.04
Constant[5]	5.07	3.95	2.72	1.50	0.27	1.50	2.72	3.95	5.07

[1]Horizontal $(Y_1 - Y_2 - 3.0)^2 e^{-(1.34 + .32(Y_6 + Y_7))}$

[2]Vertical $(Y_3 - Y_4 - 1.5)^2 e^{-(.43 + .26(Y_6 + Y_7))}$

[3]Crossbites were weighted averages.

[4]Displacement $(Y_{10})^2 e^{-(2.28 + .61Y_6 + .23Y_7)}$

[5]Vertical intercept constant $1.2(Y_6 + Y_7) + .27$

accomplished by expressing the regression coefficients as exponential functions of the anteroposterior buccal segment relation. After further adjustments (see Appendix III), the equation below was derived and it was thought that a reasonable estimate of the clinical judgment was provided.

$$J = 0.27 + 1.2(Y_6 + Y_7) + (Y_1 - Y_2 - 3.0)^2 e^{-(1.34 + .32(Y_6 + Y_7))} + (Y_3 - Y_4 - 1.5)^2 e^{-(.43 + .26(Y_6 + Y_7))} + .14 Y_8^2 + .26 Y_9^2 + Y_{10}^2 e^{-(2.28 + .61(Y_6 + .23 Y_7))}$$

Table G gives the resulting regression coefficients according to anteroposterior buccal segment relation.

When the formula was used on 386 cases (375 12-year-old controls plus 11 additional mesioclusion cases which became available clinically), the correlation with the clinical judgment was + .795. The scatter diagram is shown in figure 3. Very few cases judged 7 or higher are not calculated to be 6 or higher and variation in the lower end of the scale is judged to be of less consequence in that the important thing is for the calculated score to be reasonably linear and to be selective for the severe cases. There are a fair number of renegades. For most cases either a gross clerical error or an obviously gross clinical judgment error must be the primary explanation. A second source of discrepancy was that clinical judgments of deep overbite cases (scores 4 and 5) were generally lower than those calculated and lower than could be accepted. Discussion of specific cases with the clinicians led to their agreement that deep overbite cases were likely underestimated when being considered from the esthetic viewpoint and that higher scores were more compatible. A third reason for discrepancies is that the esthetic handicap, for example of a certain degree of crowding or of overjet, differs according to the facial type or lip fullness which may hide or emphasize the defect. It is not claimed at this stage that the weighting of the factors is

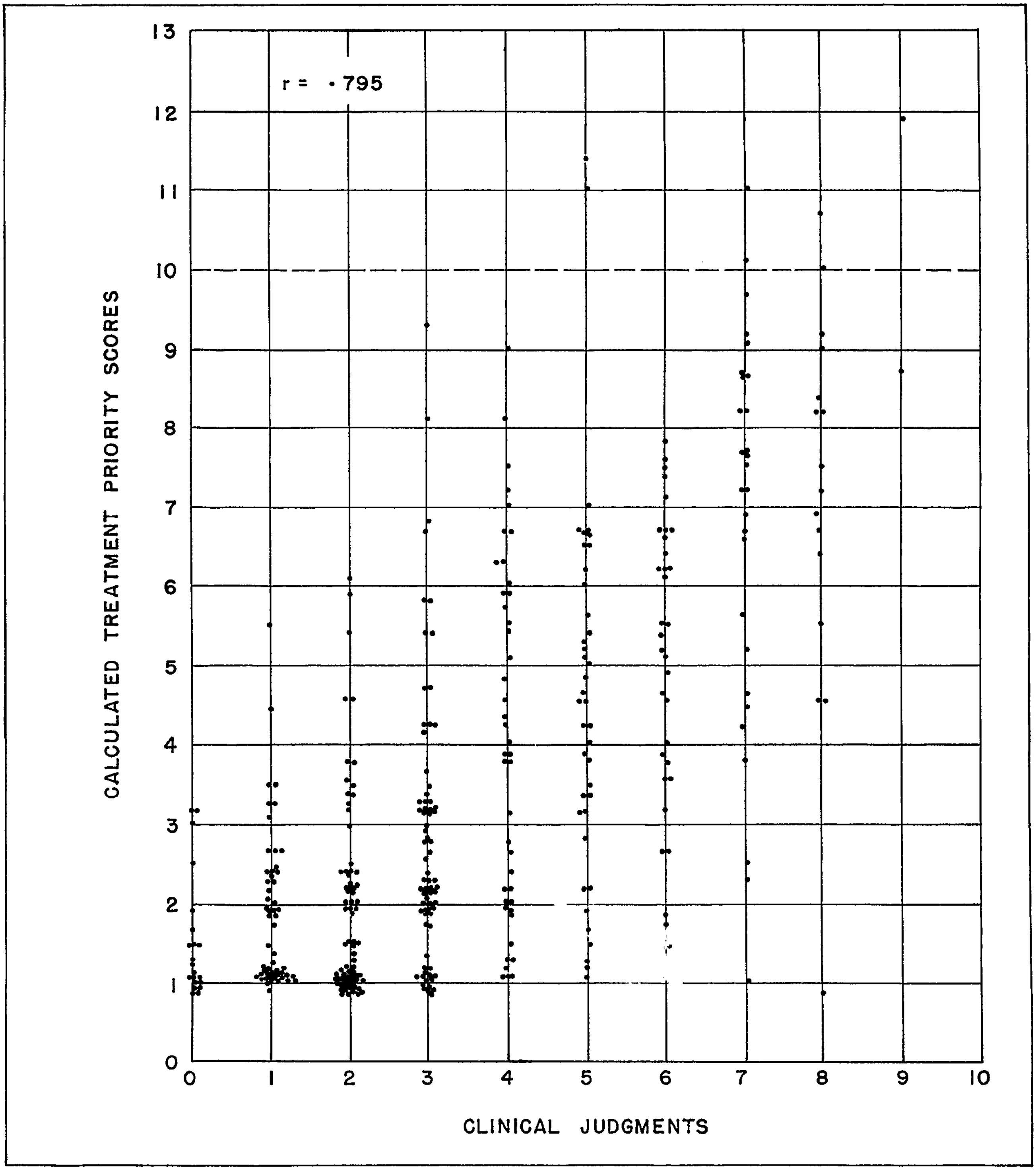

Figure 3. Relation between calculated scores and clinically judged scores for 386 12-year-old children. (375 controls + 11 extra mesioclusion cases which became available clinically)

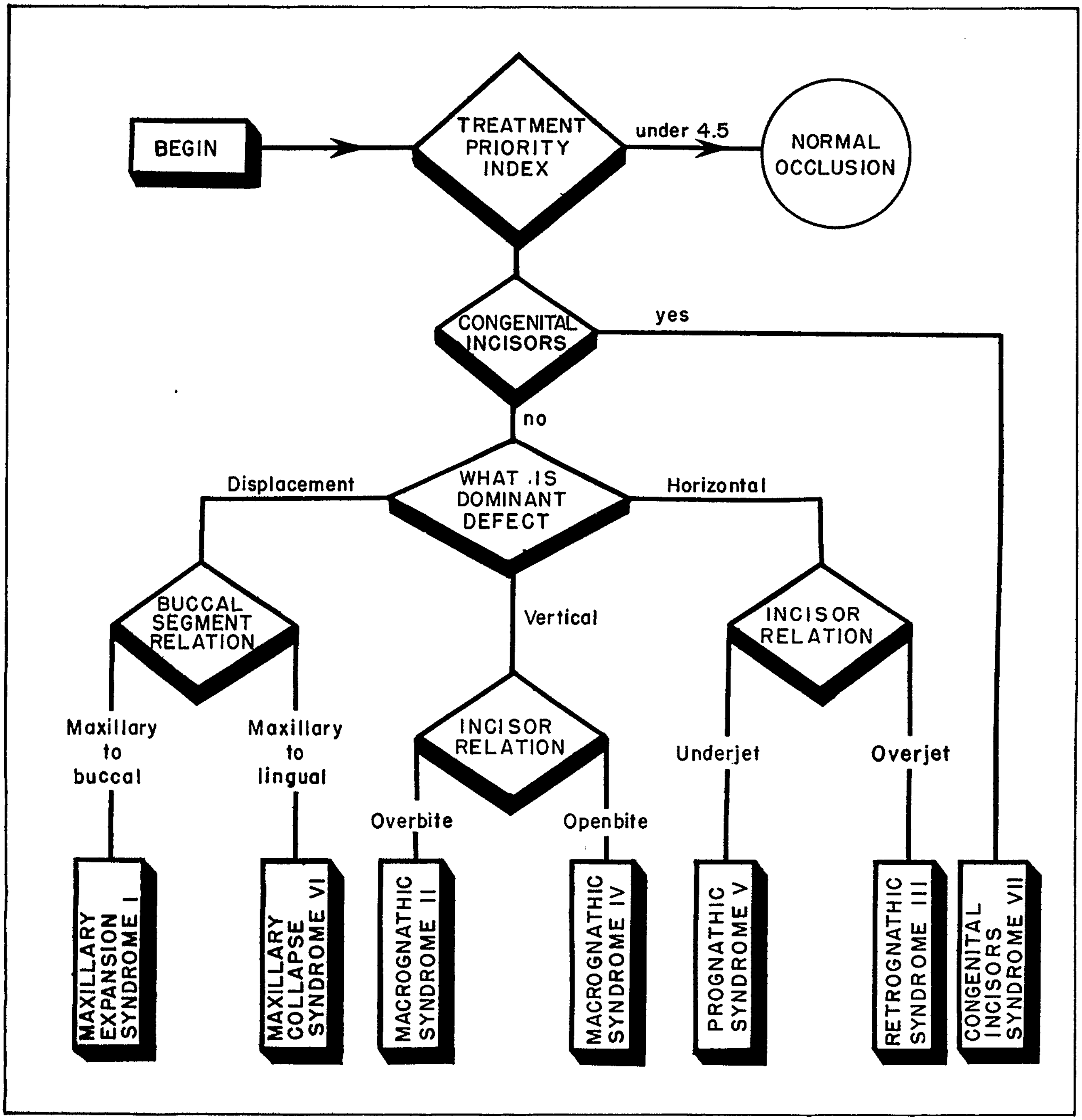

Figure 4. Method used to sort cases into syndromes corresponding to factor analysis in appendix table I.

perfect, but minor adjustments in the equation can be made in the light of experience.

The final equation produces an objective measure of the handicap in the public health sense but does not indicate the syndrome or main malocclusion characteristics which cause the high score. In terms of a flow diagram, figure 4 gives the method of sorting cases according to the dominant defect and in a way that is compatible with the syndromes defined in appendix table I.

Table H. Distribution of Treatment Priority Index for 375 12-year-old children, by syndrome: Burlington, Brantford, and Orangeville, Ontario

Treatment Priority Index	Total	Public health normal	Syndrome					
			Tooth displacement		Anterior			
			Buccal I	Lingual VI	Over-bite II	Open-bite IV	Under-jet V	Over-jet III
0	2.5	3.4	...	...	...	...	...	...
1	38.6	51.8	...	...	...	...	...	...
2	21.2	28.5	...	...	...	...	...	...
3	8.4	11.3	...	...	...	...	...	...
4	8.0	5.1	16.7	14.3	34.5	-	-	5.9
5	5.5	...	-	14.3	17.2	-	50.0	31.4
6	5.2	...	33.3	7.1	24.1	25.0	50.0	23.5
7	3.4	...	16.7	21.4	10.3	75.0	-	9.8
8	2.9	...	-	21.4	10.3	-	-	9.8
9	2.1	...	33.3	14.3	3.4	-	-	7.8
10	2.3	...	-	7.1	0.0	-	-	11.8
Number	375	269	6	14	29	4	2	51
Mean	2.87	1.60	6.87	7.00	5.63	6.51	5.94	6.71
Standard deviation	2.34	0.82	1.79	1.80	1.40	0.52	0.71	2.00
Standard error	0.12	0.05	0.73	0.48	0.26	0.26	0.49	0.28

Table H shows the syndrome breakdown and priority rating for the 375 12-year-olds in the basic tabulation for survey findings. Included are the average Treatment Priority Index, its standard error, and a percent distribution of children by index score for the group as a whole and for subgroups by syndrome.

RELATION OF TREATMENT PRIORITY INDEX TO AGE

The frequency distributions of the treatment priority scores and the scores sorted by syndromes are given in table J for the Burlington serial controls at ages 6, 9, 12, 14, and 16 years, and for some parents. The detailed tables give the individual syndrome summaries over the same ages, except syndrome V, prognathism, for which there were no cases. There is a general increasing average Treatment Priority Index of about one point from the youngest to the oldest age groups.

The trend shown is, of course, influenced by the fact that the norms for some of the recording items differ considerably with age from the values for the 12-year-olds used in constructing the index (table B). The age trends seem, by inspection, to be most associated with syndromes I and VI which involve tooth displacement. For older ages the only comment needed is that the syndrome picture becomes less clear due to increasing tooth loss.

For younger ages, three considerations are necessary: (1) until the permanent teeth are fully erupted, final tooth displacement syndromes are not observable, hence this syndrome picture must be incomplete; (2) there is a need to consider the severity of the malocclusion as it is currently present at the specific age; and (3) even more important is to attempt to project from the recordings how severe the anomalies will be at a later age if left untreated. This is the argument for expressing syndromes at early ages as estimates of the ultimate conditions at, say, age 12 years. It is better to use the same formula at all ages and to learn to interpret the results. It can be stated that because failure to detect syndromes at younger ages is due to failure of the syndromes to manifest themselves in terms of the 10 items

Table J. Distribution of Treatment Priority Index by specified ages: Burlington serial control group

Treatment Priority Index	6 years	9 years	12 years	14 years	16 years	Parents
0-------------------------	4.6	5.0	4.7	6.9	0.0	5.6
1-------------------------	32.0	21.5	23.2	28.1	25.6	25.0
2-------------------------	32.7	24.0	24.5	20.0	27.9	25.0
3-------------------------	13.4	20.7	18.0	17.5	14.0	22.2
4-------------------------	5.6	15.3	11.6	13.1	11.6	2.8
5-------------------------	5.6	7.4	8.2	6.3	11.6	8.3
6-------------------------	2.5	3.3	4.3	3.7	2.3	0.0
7-------------------------	1.1	0.8	1.7	3.7	2.3	0.0
8-------------------------	0.4	1.7	0.4	0.0	0.0	2.8
9-------------------------	0.4	0.0	2.1	0.6	2.3	0.0
10------------------------	1.8	0.4	1.3	0.0	2.3	8.3
Sample--------------------	284	242	238	160	43	36
Mean----------------------	2.30	2.69	2.85	2.56	3.07	3.54
Standard deviation--------	2.02	1.87	2.14	1.77	2.82	4.68
Standard error------------	0.12	0.12	0.14	0.14	0.43	0.78

recorded, the error is one of false negatives—i.e., the tendency will be to underrate malocclusion at early ages rather than to overrate it.

The final answer to the problem of accurately predicting the degree and type of malocclusion at later ages from early signs must come through detailed study of each syndrome and probably will necessitate inclusion of additional etiologic observations not included in this study of late clinical manifestations. As an example, a recent study by Scott[13] has indicated the importance of the discrepancy in incisor width and the space from cuspid to cuspid as an index of crowding.

COMPUTERIZED MARK SENSE EXAMINATION SYSTEM

A very convenient method of carrying out the Treatment Priority Index in field surveys has been developed, using an IBM mark sense card and a computer program. The card is shown in figure 5 and the computer program, written in IBM 7010 Fortran, given in Appendix IV, is used to compile the data. A summary of the computer output is given as table K. The IBM cards are marked with a special graphite pencil and the cards punched automatically on an IBM 514 punch in columns 1 to 20 after which the electronic computer completely finishes the survey report. Instructions for setting up the cards for insertion into the computer are also given in Appendix IV.

MANUAL FIELD EXAMINATION FORMS

Figure 6 gives a form on which the examinations may be entered and the Treatment Priority Index calculated. It is used as follows:

1. Observe the first molar relation and place a check mark in the column heading which applies.
2. On the left hand margin circle the appropriate measurement in millimeters for the horizontal incisor relation. Note that if this measurement is 2-4 millimeters it is considered normal with weight zero.
3. Also on the left hand margin circle the appropriate score for vertical incisor relation and for tooth displacement. An upper incisor overbite from zero to two-thirds is considered normal with weight zero. Also displacement scores zero and one are discarded with weight zero.
4. Find the appropriate weights for the first three items at the junction of the row and

Table K. Distribution of Treatment Priority Index for 375 12-year-old children, by occlusion group: Burlington, Brantford, and Orangeville, Ontario

Occlusion group	Sample	Average TPI	S.E.	Treatment Priority Index										
				0	1	2	3	4	5	6	7	8	9	10
Total---	375	2.87	0.12	2.5	38.6	21.2	8.4	8.0	5.5	5.2	3.4	2.9	2.1	2.3
<u>No malocclusion syndrome</u>														
Normal occlusion------	269	1.60	0.05	3.4	51.8	28.5	11.3	5.1	-	-	-	-	-	-
<u>Malocclusion syndrome</u>														
Buccal displacement----	6	6.87	0.73	-	-	-	-	16.7	-	33.3	16.7	-	33.3	-
Lingual displacement----	14	7.00	0.48	-	-	-	-	14.3	14.3	7.1	21.4	21.4	14.3	7.1
Overbite------	29	5.63	0.26	-	-	-	-	34.5	17.2	24.1	10.3	10.3	3.4	0.0
Openbite------	4	6.51	0.26	-	-	-	-	-	-	25.0	75.0	-	-	-
Prognathism---	2	5.94	0.49	-	-	-	-	-	50.0	50.0	-	-	-	-
Retrognathism-	51	6.71	0.28	-	-	-	-	5.9	31.4	23.5	9.8	9.8	7.8	11.8
Congenital----	-	...	...	-	-	-	-	-	-	-	-	-	-	-

S.E.—standard error.

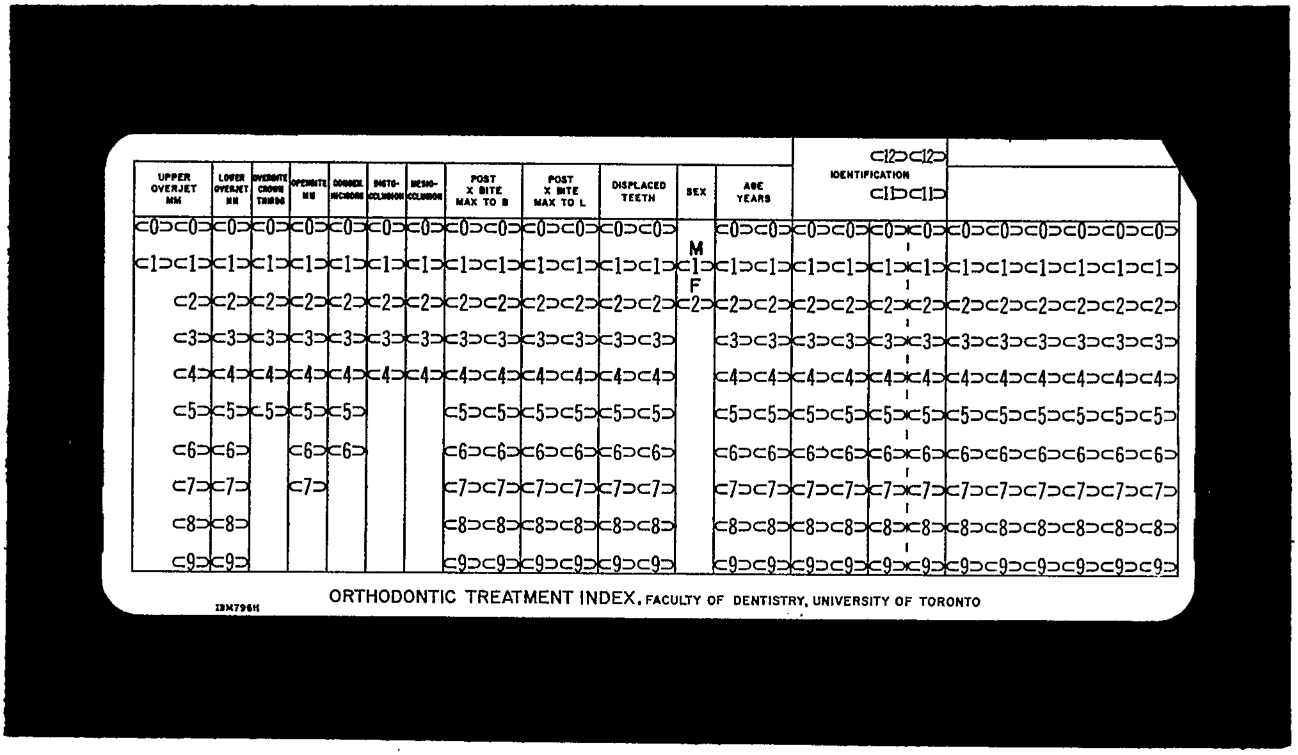

Figure 5. Mark sense card for field surveys of Treatment Priority Index.

NAME ....
....
DATE......................
EXAMINER...................

TREATMENT PRIORITY INDEX
National Center for Health Statistics
and
University of Toronto

AGE........................
SEX........................
CASE NO. ....
COMMUNITY......................

FIRST MOLAR RELATION Choose appropriate column		(6) Distoclusion 2 sides full c	1 side c to c and 1 side full	2 sides c to c or 1 side full	1 side c to c	Neutro	(7) Mesioclusion 1 side c to c	2 sides c to c or 1 side full	1 side c to c and 1 side full	2 sides c to c	Weights	CASE TYPE IS INDICATED BY THE DOMINANT DEFECT
HORIZONTAL INCISOR RELATION	mm											
(1) Upper Overjet	9+	2.0	3.4	5.4	9.3	10+	9.3	5.4	3.4	2.0		SYNDROME III RETROGNATHISM
	9	1.4	2.5	4.0	6.9	10+	6.9	4.0	2.5	1.4		
	8	1.0	1.8	2.8	4.8	8.0	4.8	2.8	1.8	1.0		
	7	.6	1.1	1.8	3.0	5.1	3.0	1.8	1.1	.6		
	6	.4	.6	1.0	1.7	2.9	1.7	1.0	.6	.4		
2-4mm NORMAL Score 0	5	.2	.3	.4	.8	1.3	.8	.4	.3	.2		
	1	.2	.3	.4	.8	1.3	.8	.4	.3	.2		SYNDROME V PROGNATHISM
	0	.4	.6	1.0	1.7	2.9	1.7	1.0	.6	.4		
	1	.6	1.1	1.8	3.0	5.1	3.0	1.8	1.1	.6		
(2) Lower Overjet	2	1.0	1.8	2.8	4.8	8.0	4.8	2.8	1.8	1.0		
	3	1.4	2.5	4.0	6.9	10+	6.9	4.0	2.5	1.4		
	3+	2.0	3.4	5.4	9.3	10+	9.3	5.4	3.4	2.0		
VERTICAL INCISOR RELATION (3) Overbite in crown thirds	Bite	2.9	3.8	4.8	6.2	8.0	6.2	4.8	3.8	4.9		SYNDROME II OVERBITE
	3/3+	1.5	2.0	2.4	3.2	4.1	3.2	2.4	2.0	1.5		
	2/3-3/3	.5	.7	.9	1.1	1.5	1.1	.9	.7	.5		
0-2/3 NORMAL Score 0	0	.5	.7	.9	1.1	1.5	1.1	.9	.7	.5		SYNDROME IV OPENBITE
	<2	1.5	2.0	2.4	3.2	4.1	3.2	2.4	2.0	1.5		
	2-4	2.9	3.8	4.8	6.2	8.0	6.2	4.8	3.8	2.9		
(4) Openbite in mm.	4+	4.9	6.3	7.9	10+	10+	10+	7.9	6.3	4.9		
(10) TOOTH DISPLACEMENT SCORE Count teeth rotated about 45° or displaced about 2mm. ☐	2	.1	.1	.2	.3	.4	.3	.2	.1	.1		IS DISTOCLUSION AND/OR POSTERIOR CROSSBITE MAX. TO BUCCAL PRESENT
	3	.2	.3	.4	.7	1.1	.7	.4	.3	.2		YES: Synd. I Max. Expansion Syndrome
	4	.3	.5	.9	1.2	1.9	1.2	.9	.5	.3		NO: Synd. VI Max. Collapse Syndrome
	5	.5	.8	1.2	1.9	3.0	1.9	1.2	.8	.5		
Count teeth rotated >45° or displaced more than 2mm) x 2 ☐	6	.7	1.1	1.8	2.8	4.3	2.8	1.8	1.1	.7		
	7	1.0	1.5	2.4	3.9	5.9	3.9	2.4	1.5	1.0		
	8	1.3	1.9	3.1	4.9	7.7	4.9	3.1	1.9	1.3		
Total (0, 1 no score) ☐	9	1.7	2.5	4.1	6.2	9.7	6.2	4.1	2.5	1.7		
	9+	2.0	3.0	4.9	7.7	10+	7.7	4.9	3.0	2.0		
CONSTANT		5.17	3.95	2.72	1.50	0.27	1.50	2.72	3.95	5.17		

(5) CONGENITALLY MISSING INCISORS						Weights	
	NO.	0	1	2	2+		SYNDROME VII
	WEIGHT	0	7	8	9		

(8) Posterior Crossbite Count No. of teeth											
MAX. TO BUCCAL	NO.	0	1	2	3	4	5	6	7	8	more
	WEIGHT	0	.1	.6	1.3	2.2	3.5	5.0	6.9	9.0	10
MAX. TO LINGUAL	NO.	0	1	2	3	4	5	6	more		
	WEIGHT	0	.3	1.0	2.3	4.2	6.5	9.4	10		

OTHER DEFECT --

Arbitrary Weight____________

SUM OF WEIGHTS IS TREATMENT PRIORITY INDEX

Figure 6. Manual examination and calculating form for deriving the Treatment Priority Index.

column and enter this in the column to the right.
5. Transpose the constant for the correct column to the right.
6. Circle the correct scores for congenitally missing incisors and posterior crossbite.
7. Transpose the appropriate weights to the right hand column.
8. Add information on any other rare defects, such as cleft palates, that are observed.
9. If a rare defect has been observed that seriously modifies the index, add an arbitrary weight to ensure that the index will indicate its severity.
10. Add the weighting column to derive the Treatment Priority Index.

The syndrome type is indicated by the dominant weight and the syndrome may be circled to be used as a crude description of the case. This does not constitute a diagnosis but does give an idea of the nature of the defect involved.

The Treatment Priority Index derived from the manual form will not be exactly the same as that derived by solution of the full equation by computer due to rounding-off errors but may be equated for all practical purposes.

The values in the manual form, figure 6, are the observed values multiplied by the appropriate regression coefficients. The constants are, of course, the vertical axis intercepts. Figure 6 suggests that a simplification might be possible. Many of the weights are negligible, hence, values corresponding are not worth recording. Also there is a level or point in the scale for most of the recording where clinical significance has been reached and recording much higher levels may be of only slight value. Thus future consideration may be given to recording the manifestations as dichotomies or at the most trichotomies, eliminating the labor of recording many relatively normal conditions.

SUMMARY

This is a report on the research development of a means of objectively assessing the degree of handicap due to malocclusion in terms of a Treatment Priority Index. The work is based on the study of the interrelationships of 10 manifestations of malocclusion as they occurred in 375 12-year-old children with no history of orthodontic treatment. The group constitutes a representative sample of children, principally of Anglo-Saxon origin, from three Ontario communities.

The method was to define the natural groupings of manifestations which tended to occur jointly and which might be referred to as syndromes and then, by regression methods, to determine weighting factors appropriate to each syndrome. A fully computerized data processing system and a manual form on which to record and calculate the Treatment Priority Index are provided.

The index may be useful in epidemiologic studies, as well as for initial screening of populations to determine need for treatment while providing a rough description of the case type.

REFERENCES

[1]Burlington Orthodontic Research Centre: Progress Report No. 5. Faculty of Dentistry, University of Toronto, 1960. (mimeographed)

[2]Bjork, A., Krebs, A., and Solow, B.: Method for epidemiological registration of malocclusion. *Acta Odont. Scand.* 22:27-41, Feb. 1964.

[3]Canadian Dental Association: Canadian Dental Survey Manual. A System for Recording and Statistical Analysis at the Community, Provincial and National Level. July 1959.

[4]Draker, H. L.: Handicapping labio-lingual deviations, a proposed index for public health purposes. *Am. J. Orthod.* 46:295-305, Apr. 1960.

[5]Elsasser, W. A.: Studies of dento-facial morphology. 1. A simple instrument for appraising variations. *Angle Orthod.* 21(3):163-171, July 1951.

[6]Poulton, D. R., and Aaronson, S. S.: Relationship between occlusion and periodontal status. *Am. J. Orthod.* 47: 690-699, Sept. 1961.

[7]Van Kirk, L. E., Jr., and Pennell, E. H.: Assessment of malocclusion in population groups. *Am. J. Pub. Health* 49(9):1157-1163, Sept. 1959.

[8]Grainger, R. M.: Indexing Handicapping Malocclusions. Working paper for meeting of Expert Committee on Dental Health, World Health Organization, Geneva, 1961.

[9]Grainger, R. M.: The Statistical Basis for International Dental Epidemiology. World Health Organization Document No. PA/98.65.

[10]Popovich, F., and Grainger, R. M.: One community's orthodontic problem, in R. E. Moyers and P. Jay, eds., *Orthodontics in Mid-Century*. St. Louis. C. V. Mosby Co., 1959.

[11]National Center for Health Statistics: preliminary unpublished data.

[12]Grainger, R. M.: Interrelations of malocclusion syndromes.in *Advances in Oral Biology* (in press).

[13]Scott, L.: Personal communication.

[14]Harman, H. H.: *Modern Factor Analysis*. Chicago. University of Chicago Press, 1960.

[15]Peters, C. C., and Van Voorhis, W. R.: *Statistical Procedures and Their Mathematical Bases*. New York. McGraw-Hill Book Co., 1940.

[16]Thurstone, L. L.: *Multiple Factor Analysis, A Development and Expansion of the Vectors of Mind*. Chicago. University of Chicago Press, 1947.

[17]BIMD: Computer programs. Division of Biostatistics, Department of Preventive Medicine & Public Health, School of Medicine, University of California, Los Angeles, Dec. 1961.

———o o o———

DETAILED TABLES

Table 1. Distributions of upper anterior overjet measurements, by specified ages: Burlington Project and Health Examination Survey trial data

Upper anterior overjet	6 years	7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
								Serial con-trol	Cross sec-tion			
	Burl.	HES[1]	HES[1]	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0 mm-----	5.2	-	-	2.1	10.9	1.0	2.5	1.7	2.8	7.5	4.8	3.0
1 mm-----	22.6	2.3	5.6	6.6	3.6	4.7	7.1	8.0	5.2	26.1	4.8	24.0
2 mm-----	34.8	12.9	13.5	24.4	14.9	16.4	14.0	23.1	23.5	32.9	28.6	28.0
3 mm-----	27.1	16.1	24.3	31.4	24.3	25.3	27.7	26.5	23.0	16.1	30.9	32.0
4 mm-----	10.1	2.7	19.1	17.3	20.2	22.8	23.8	21.0	19.7	11.2	23.8	5.0
5 mm-----	2.9	6.8	10.5	12.4	10.3	13.9	10.5	10.9	7.5	4.3	7.1	3.0
6 mm-----	1.4	3.5	8.2	3.3	6.1	7.9	5.6	5.5	8.0	1.2	4.8	4.0
7 mm-----	0.3	2.5	4.5	3.3	5.3	4.0	4.4	2.5	4.7	0.6	-	-
8 mm-----	0.3	1.3	2.2	0.4	2.0	2.5	1.0	0.4	1.4	-	-	1.0
9 mm-----	0.3	1.3	-	0.4	0.7	0.7	2.2	0.4	4.2	-	-	1.0
10 mm-----	-	1.3	0.7	-	0.3	0.2	0.7	-	-	-	-	1.0
11 mm-----	-	-	0.1	0.4	0.5	0.2	0.2	-	-	-	-	-
12 mm-----	-	-	-	-	0.2	-	-	-	-	-	-	-
13 mm-----	-	2.5	-	-	0.2	-	0.2	-	-	-	-	-
Sample----	302	394	267	247	603	402	408	238	213	160	43	36
Mean------	2.44	2.27	3.40	3.34	3.48	3.80	3.69	3.29	3.68	2.17	3.14	2.62
Variance--	1.54	8.94	4.33	2.46	4.71	3.10	3.84	2.46	4.08	1.93	1.44	2.82
Standard devia-tion-----	1.24	2.99	2.08	1.57	2.17	1.76	1.96	1.57	2.02	1.39	1.20	1.68

[1]Upper anterior overjet was not examined for primary dentitions in HES data.

Table 2. Distributions of lower anterior overjet measurements, by specified ages: Burlington Project and Health Examination Survey trial data

Lower anterior overjet	6 years	7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
								Serial con-trol	Cross sec-tion			
	Burl.	HES[1]	HES[1]	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0 mm.----	99.9	99.2	99.3	98.6	99.2	99.3	99.7	99.2	98.6	99.3	97.7	100.0
1 mm.----	0.3	0.8	0.7	0.8	0.7	0.2	0.2	0.8	0.9	0.6	2.3	-
2 mm.----	0.3	-	-	0.4	-	0.2	-	-	0.5	-	-	-
3 mm.----	-	-	-	-	-	0.2	-	-	-	-	-	-
Sample----	302	394	267	247	603	402	408	238	213	160	43	36
Mean------	0.01	0.0	0.01	0.02	0.01	0.01	0.0	0.01	0.02	0.01	0.02	-
Variance--	0.014	0.0	0.006	0.026	0.006	0.029	0.0	0.008	0.029	0.006	0.023	...
Standard devia-tion-----	0.120	0.0	0.083	0.155	0.083	0.167	0.0	0.089	0.170	0.077	0.151	...

[1]Lower anterior overjet was not examined for primary dentitions in HES data.

Table 3. Distributions of overbite measurements, by specified ages: Burlington Project and Health Examination Survey trial data

Overbite	6 years	7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
								Serial control	Cross section			
	Burl.	HES[1]	HES[1]	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0---------	10.0	-	-	2.0	14.4	4.7	6.4	2.5	-	0.8	2.0	6.1
1---------	62.4	25.3	29.5	10.1	24.4	24.3	24.0	36.5	23.9	49.7	52.4	70.7
2---------	17.6	23.5	42.6	42.4	46.7	55.3	52.9	47.5	50.2	39.2	38.1	22.2
3---------	9.3	5.8	12.3	14.5	13.4	14.9	14.7	13.0	24.4	9.2	7.1	-
4---------	0.3	0.5	0.4	-	0.7	0.5	1.7	0.4	-	1.8	2.4	1.0
5---------	0.3	0.5	-	-	-	-	0.2	-	1.4	-	-	-
Sample----	302	394	267	247	603	402	408	238	213	160	43	36
Mean------	1.28	0.94	1.53	1.38	1.61	1.82	1.82	1.72	2.05	1.63	1.60	1.19
Variance--	0.656	1.040	0.846	1.21	0.846	0.563	0.689	0.548	0.608	0.533	0.518	0.348
Standard deviation-----	0.810	1.02	0.915	1.10	0.920	0.754	0.834	0.739	0.780	0.727	0.718	0.585

[1]Overbite was not recorded for primary dentitions in HES data.

Table 4. Distributions of openbite measurements, by specified ages: Burlington Project and Health Examination Survey trial data

Openbite	6 years	7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
								Serial control	Cross section			
	Burl.	HES	HES	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0 mm------	92.3	96.0	95.0	98.2	95.7	95.2	96.0	98.3	100.0	99.3	97.7	95.0
1 mm------	5.6	3.3	3.0	1.6	3.0	3.2	3.4	1.7	-	-	2.3	2.0
2 mm------	2.0	0.8	1.1	-	0.2	1.2	0.2	-	-	-	-	2.0
3 mm------	-	-	0.7	-	0.5	-	0.2	-	-	0.6	-	-
Sample----	302	394	267	247	603	402	408	238	213	160	43	36
Mean------	0.10	0.05	0.07	0.02	0.05	0.06	0.04	0.02	-	0.01	0.02	0.06
Variance--	0.130	0.063	0.137	0.017	0.084	0.078	0.058	0.017	...	0.053	0.023	0.096
Standard deviation-----	0.356	0.251	0.365	0.125	0.285	0.277	0.243	0.129	...	0.233	0.151	0.312

Table 5. Distributions of number of congenitally missing incisors, by specified ages: Burlington Project and Health Examination Survey trial data

Number of congenitally missing incisors[1]	6 years		7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
									Serial control	Cross section			
	Burl.	HES	HES	HES	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0----------	99.6	---	---	---	99.4	---	---	---	99.6	97.7	99.3	100.0	97.9
1----------	0.3	---	---	---	0.4	---	---	---	0.4	0.9	0.6	-	2.3
2----------	-	---	---	---	-	---	---	---	-	1.4	-	-	-
3----------	-	---	---	---	-	---	---	---	-	-	-	-	-
Sample------	302	...	...	...	247	...	...	...	238	213	160	43	36
Mean--------	0.0	...	...	...	0.0	...	...	...	0.0	0.38	0.01	-	0.02
Variance----	0.0	...	...	...	0.0	...	...	...	0.0	0.063	0.006	...	0.023
Standard deviation--	0.0	...	...	...	0.0	...	...	...	0.0	0.250	0.077	...	0.151

[1]Burlington counts derived using radiographs.

Table 6. Distributions of distoclusion scores, by specified ages: Burlington Project and Health Examination Survey trial data

Distoclusion score	6 years		7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
									Serial control	Cross section			
	Burl.	HES	HES	HES	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0--------	71.6	77.2	64.5	61.7	50.1	64.5	62.2	60.0	61.3	56.8	68.2	65.1	78.4
1--------	13.8	6.2	12.1	10.8	20.8	11.4	11.4	15.2	14.7	10.8	11.6	18.6	13.5
2--------	10.1	12.6	17.5	20.9	22.2	16.0	20.1	14.7	17.2	21.1	13.4	11.6	8.1
3--------	3.0	1.3	2.5	3.7	5.3	3.6	3.5	3.7	2.9	2.8	4.3	2.3	-
4--------	1.3	2.7	3.0	2.6	1.6	4.0	-	6.4	3.8	8.4	2.4	2.3	-
Sample---	302	373	394	267	247	603	402	408	238	213	160	43	36
Mean-----	0.48	0.46	0.67	0.74	0.88	0.70	0.62	0.81	0.73	0.95	0.61	0.58	0.30
Variance-	0.792	0.922	1.082	1.166	1.061	1.232	0.865	1.464	1.704	1.664	1.188	0.903	0.372
Standard deviation----	0.893	0.955	1.04	1.08	1.03	1.11	0.926	1.21	1.31	1.29	1.09	0.947	0.610

Table 7. Distributions of mesioclusion scores, by specified ages: Burlington Project and Health Examination Survey trial data

Mesioclusion score	6 years		7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
									Serial control	Cross section			
	Burl.	HES	HES	HES	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0-------------	92.1	80.4	90.6	95.0	95.7	93.7	91.8	92.9	92.9	99.1	88.9	86.0	97.3
1-------------	5.4	4.0	3.8	1.5	3.6	2.8	4.2	3.4	4.6	-	4.9	9.3	2.7
2-------------	2.0	11.8	3.8	2.6	0.4	2.0	1.7	2.5	2.5	0.9	5.5	4.7	-
3-------------	0.3	1.6	1.0	0.4	-	0.8	1.0	0.5	-	-	0.6	-	-
4-------------	-	2.1	0.5	0.4	-	0.2	1.0	0.7	-	-	-	-	-
Sample--------	302	373	394	267	247	603	402	408	238	213	160	43	36
Mean----------	0.10	0.41	0.16	0.10	0.04	0.10	0.15	0.13	0.10	0.02	0.18	0.19	0.03
Variance------	0.152	0.828	0.548	0.212	0.053	0.203	0.336	0.281	0.137	0.036	0.292	0.250	0.026
Standard deviation---------	0.391	0.912	0.735	0.459	0.226	0.452	0.584	0.526	0.370	0.190	0.542	0.497	0.162

Table 8. Distributions of posterior crossbite, number of maxillary teeth to buccal, by specified ages: Burlington Project and Health Examination Survey trial data

Posterior crossbite, number of maxillary teeth to buccal	6 years		7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
									Serial control	Cross section			
	Burl.	HES	HES	HES	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0-------------	97.5	99.2	99.2	99.1	94.9	98.0	98.0	95.6	92.9	95.8	92.0	86.0	97.9
1-------------	0.7	0.5	0.3	0.4	3.6	0.7	1.0	1.7	3.8	0.9	4.3	9.3	1.0
2-------------	1.0	0.3	0.3	0.4	0.8	0.3	0.2	1.5	2.5	1.4	2.4	4.7	1.0
3-------------	0.7	-	-	-	0.4	0.2	0.2	0.7	0.8	0.9	0.6	-	-
4-------------	-	-	-	-	-	0.3	0.2	0.5	-	-	0.6	-	-
5-------------	-	-	-	-	-	-	-	-	-	0.5	-	-	-
6-------------	-	-	-	-	-	-	-	-	-	0.5	-	-	-
7-------------	-	-	-	-	-	-	-	-	-	-	-	-	-
8-------------	-	-	-	-	-	-	-	-	-	-	-	-	-
9-------------	-	-	-	-	-	-	-	-	-	-	-	-	-
10------------	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample--------	302	373	394	267	247	603	402	408	238	213	160	43	36
Mean----------	0.05	0.01	0.01	0.01	0.06	0.03	0.03	0.09	0.112	0.117	0.13	0.19	0.03
Variance------	0.109	0.017	0.014	0.020	0.102	0.084	0.068	0.212	0.203	0.423	0.270	0.250	0.04[illegible]
Standard deviation---------	0.330	0.130	0.122	0.141	0.318	0.291	0.260	0.463	0.447	0.650	0.524	0.497	0.222

Table 9. Distributions of posterior crossbite, number of maxillary teeth to lingual, by specified ages: Burlington Project and Health Examination Survey trial data

Posterior crossbite, number of maxillary teeth to lingual	6 years		7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
									Serial control	Cross section			
	Burl.	HES	HES	HES	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0	96.2	97.3	91.6	93.5	98.3	89.8	93.5	90.7	92.4	93.0	94.4	93.2	97.9
1	0.7	0.8	4.0	2.6	2.8	4.1	2.5	4.2	4.2	3.8	3.7	2.3	2.0
2	1.3	0.3	1.3	1.1	2.0	2.5	1.7	2.2	2.1	1.9	1.2	2.3	-
3	1.7	0.8	1.8	1.5	1.6	1.8	1.0	1.5	0.8	1.4	0.6	-	-
4	-	0.3	0.5	-	-	0.8	0.2	0.7	-	-	-	-	-
5	-	-	-	0.4	-	0.2	0.5	0.2	0.4	-	-	-	-
6	-	0.3	0.5	0.7	-	0.2	-	-	-	-	-	-	-
7	-	0.3	-	-	-	-	-	0.2	-	-	-	2.3	-
8	-	-	-	-	-	0.1	0.2	0.2	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample	302	373	394	267	247	603	402	408	238	213	160	43	36
Mean	0.08	0.09	0.17	0.16	0.12	0.21	0.14	0.20	0.13	0.12	0.08	0.23	0.02
Variance	0.212	0.397	0.490	0.533	0.240	0.578	0.449	0.624	0.281	0.230	0.137	1.188	0.020
Standard deviation	0.456	0.625	0.700	0.733	0.489	0.760	0.673	0.787	0.533	0.480	0.366	1.09	0.141

Table 10. Distributions of tooth displacement scores, by specified ages: Burlington Project and Health Examination Survey trial data

Tooth displacement score	6 years	7 years	8 years	9 years		10 years	11 years	12 years		14 years	16 years	Parents
								Serial control	Cross section			
	Burl.	HES	HES	Burl.	HES	HES	HES	Burl.	Burl.	Burl.	Burl.	Burl.
0	46.9	63.0	60.0	24.6	63.6	64.7	56.8	23.5	37.6	17.2	18.2	2.0
1	19.1	12.1	15.0	19.9	11.5	10.0	12.7	20.2	16.4	13.5	13.6	4.0
2	20.4	13.7	14.6	33.3	10.0	10.0	9.6	18.5	17.4	24.5	22.7	27.3
3	8.4	5.8	3.0	18.3	7.0	5.0	5.4	13.4	4.6	19.0	20.4	26.3
4	4.0	3.8	3.8	8.0	5.0	3.7	6.6	9.2	9.9	11.6	6.8	21.2
5	1.0	0.3	1.5	1.6	1.3	1.7	3.2	7.1	4.2	8.0	6.8	6.1
6	-	0.5	0.4	2.1	0.8	1.7	1.7	3.8	3.3	3.1	6.8	6.1
7	-	0.3	0.8	1.6	0.5	0.5	1.0	2.1	2.4	1.8	2.3	5.1
8	-	-	0.4	0.5	-	1.0	1.0	0.8	3.3	-	-	2.0
9	-	-	-	0.5	0.2	0.7	0.2	0.8	0.5	1.2	2.3	-
10	-	0.3	-	-	-	0.5	1.0	0.4	0.5	-	-	-
11	-	-	-	-	-	-	0.2	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	0.2	-	-	-	-	-	-
14	-	-	-	-	-	-	0.2	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	0.4	-	-	-	-	-	-	-	-	-
Sample	302	394	267	247	603	402	408	238	213	160	43	36
Mean	1.06	0.82	0.95	2.14	0.89	1.04	1.33	2.25	1.97	2.48	2.59	3.41
Variance	1.538	1.850	3.497	2.560	2.190	3.803	4.666	4.326	5.290	3.534	4.452	2.789
Standard deviation	1.24	1.36	1.87	1.60	1.48	1.95	2.16	2.08	2.30	1.88	2.11	1.67

Table 11. Distributions of Treatment Priority Index less than 4.5 (public health normal), by specified ages: Burlington untreated serial control group

Treatment Priority Index	Age nearest birthday					Parents
	6 years	9 years	12 years	14 years	16 years	
0 to 0.5	5.3	6.1	5.9	8.6	0.0	6.9
0.5 to 1.5	37.1	26.4	29.2	35.2	33.3	31.0
1.5 to 2.5	38.0	29.4	30.8	25.0	36.4	31.0
2.5 to 3.5	15.5	25.4	22.7	21.9	18.2	27.6
3.5 to 4.5	4.1	12.7	11.4	9.4	12.1	3.4
Number in sample	284	242	238	160	43	36
Number of cases	245	197	185	128	33	29
Percent of cases of sample	86.2	81.4	79.3	80.0	76.7	80.5
Average TPI	1.68	2.05	1.98	1.83	1.96	1.92
Standard error	0.06	0.08	0.08	0.09	0.18	0.19

Table 12. Distributions of Treatment Priority Index for syndrome I, buccal crossbite and displacement, by specified ages: Burlington untreated serial control group

Treatment Priority Index	Age nearest birthday					Parents
	6 years	9 years	12 years	14 years	16 years	
4.5 to 5.5	-	-	14.3	25.0	-	-
5.5 to 6.5	100.0	100.0	28.6	50.0	100.0	66.7
6.5 to 7.5	-	-	-	25.0	-	-
7.5 to 8.5	-	-	-	-	-	-
8.5 to 9.5	-	-	-	-	-	33.3
9.5 to 10.5	-	-	42.9	-	-	-
10.5+	-	-	14.3	-	-	-
Number in sample	284	242	238	160	43	36
Number of cases	1	2	7	4	1	3
Percent of cases of sample	0.4	0.8	3.0	2.5	2.3	8.3
Average TPI	...	5.09	7.76	5.00	...	5.62
Standard error	...	0.36	1.08	0.44	...	0.96

Table 13. Distributions of Treatment Priority Index for syndrome VI, lingual crossbite and displacement, by specified ages: Burlington untreated serial control group

Treatment Priority Index	Age nearest birthday					Parents
	6 years	9 years	12 years	14 years	16 years	
4.5 to 5.5	100.0	33.3	12.5	20.0	-	-
5.5 to 6.5	-	50.0	50.0	20.0	-	-
6.5 to 7.5	-	16.7	-	20.0	-	-
7.5 to 8.5	-	-	-	40.0	-	-
8.5 to 9.5	-	-	12.5	-	-	-
9.5 to 10.5	-	-	12.5	-	-	-
10.5+	-	-	12.5	-	100.0	-
Number in sample	284	242	238	160	43	36
Number of cases	1	6	8	5	1	-
Percent of cases of sample	0.4	2.5	3.4	3.1	2.3	-
Average TPI	...	4.77	6.52	5.93	...	...
Standard error	...	0.25	0.78	0.56	...	...

Table 14. Distributions of Treatment Priority Index for syndrome II, anterior overbite, by specified ages: Burlington untreated serial control group

Treatment Priority Index	Age nearest birthday					Parents
	6 years	9 years	12 years	14 years	16 years	
4.5 to 5.5	22.2	44.4	28.6	42.9	-	-
5.5 to 6.5	44.4	55.6	42.9	28.6	-	-
6.5 to 7.5	22.2	-	14.3	-	-	-
7.5 to 8.5	-	-	14.3	14.3	-	-
8.5 to 9.5	-	-	-	-	-	-
9.5 to 10.5	11.1	-	-	14.3	100.0	-
10.5+	-	-	-	-	-	-
Number in sample	284	242	238	160	43	36
Number of cases	9	9	7	7	1	-
Percent of cases of sample	3.2	3.7	3.0	4.4	2.3	-
Average TPI	5.37	4.63	5.30	5.49	...	...
Standard error	0.44	0.18	0.37	0.69	...	...

Table 15. Distributions of Treatment Priority Index for syndrome IV, anterior openbite, by specified ages: Burlington untreated serial control group

Treatment Priority Index	Age nearest birthday					Parents
	6 years	9 years	12 years	14 years	16 years	
5.5 to 6.5	35.7	-	33.3	-	-	-
6.5 to 7.5	28.5	-	-	-	-	-
7.5 to 8.5	7.1	-	66.7	-	-	-
8.5 to 9.5	-	-	-	-	-	-
9.5 to 10.5	-	-	-	-	-	-
10.5+	28.6	-	-	-	-	100.0
Number in sample	284	242	238	160	43	36
Number of cases	14	-	3	-	-	1
Percent of cases of sample	4.0	-	1.3	-	-	2.7
Average TPI	7.38	...	6.33	...	...	...
Standard error	0.87	...	0.46	...	...	...

Table 16. Distributions of Treatment Priority Index for syndrome III, retrognathism, by specified ages: Burlington untreated serial control group

Treatment Priority Index	Age nearest birthday					Parents
	6 years	9 years	12 years	14 years	16 years	
4.5 to 5.5	23.1	27.3	5.9	33.3	20.0	-
5.5 to 6.5	38.5	22.7	41.2	11.1	80.0	-
6.5 to 7.5	7.7	22.7	41.2	33.3	-	-
7.5 to 8.5	15.4	4.5	5.9	22.2	-	-
8.5 to 9.5	7.7	18.2	-	-	-	-
9.5 to 10.5	-	-	-	-	-	-
10.5+	7.7	4.5	5.9	-	-	100.0
Number in sample	284	242	238	160	43	36
Number of cases	13	22	17	9	5	2
Percent of cases of sample	4.6	9.1	7.3	5.6	11.6	5.6
Average TPI	5.84	6.00	5.74	5.46	4.78	12.07
Standard error	0.53	0.48	0.37	0.37	0.18	2.17

APPENDIX I. DEFINITIONS OF RECORDING ITEMS

For use in the Burlington Research Project, selected manifestations of malocclusion were used as recording items. For initial recording purposes, these items were defined as follows.

Horizontal incisor relationship.—The maxillary incisors may protrude beyond the lower incisors in the horizontal direction (Item 1. overjet) or vice versa (Item 2. underjet). Have the subject close together his posterior teeth; place a ruler horizontally at the midline against the labial central incisor surfaces of the less protrusive arch and measure to the outside of the incisor tip (fig. I). If the central incisors are not in similar anterior position, take an average judgment.

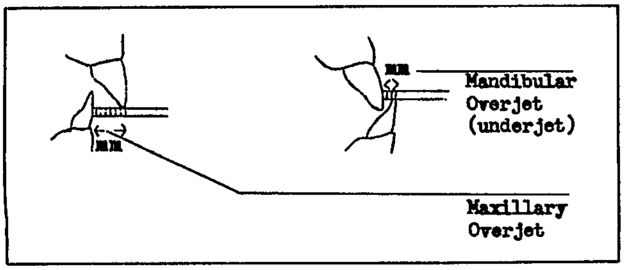

Figure I. Method of measuring horizontal incisor relationship.

Vertical incisor relationship.—Excluding cases where the incisors are not close to being completely erupted, have the subject close his posterior teeth and observe whether the central incisors overlap on the vertical direction (Item 3. overbite) or if they are still spaced (Item 4. openbite). Note the amount of overbite according to the horizontal position of the incisor tip of the most prominent arch. Judge the amount of openbite if present in millimeters (fig. II).

Congenitally missing permanent incisors (Item 5).—This could not be determined with certainty without radiographs but if at age 12 the teeth were obviously not in sight, the count was recorded.

Anteroposterior buccal segment relation (Item 6. distoclusion, neutroclusion, or Item 7. mesioclusion).—Describe the anteroposterior position of the lower teeth to the upper teeth, paying particular attention to the relation of the upper and lower first permanent molars and, if present, the deciduous second molars (fig. III).

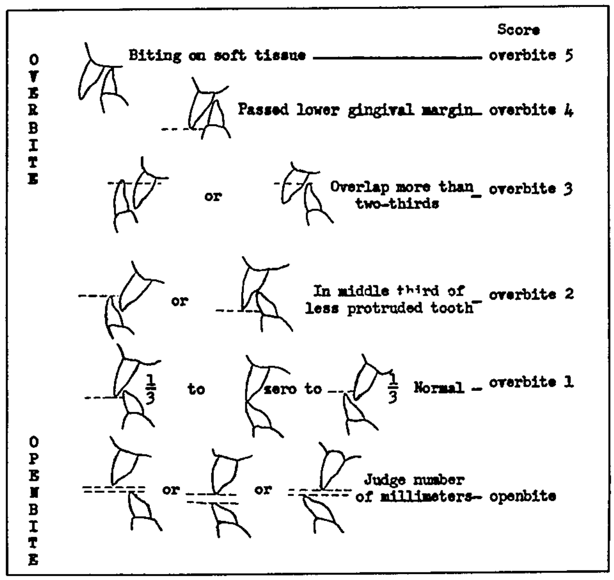

Figure II. Method of examining and recording vertical incisor relationship as overbite in thirds of tooth crown and openbite in millimeters.

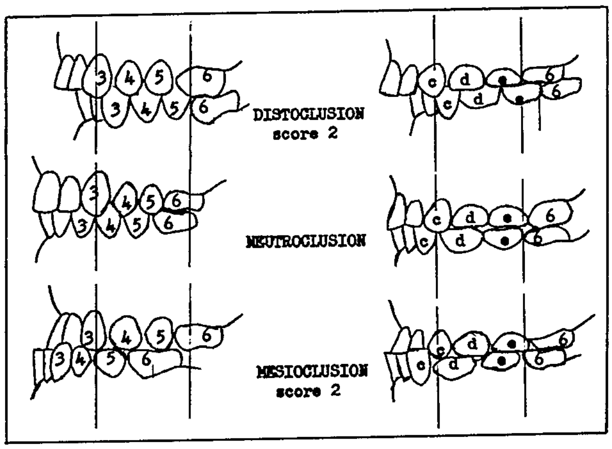

Figure III. Buccal segment relationships for permanent and mixed dentitions used in interpreting the anteroposterior molar relationship.

For each side of the mouth observe the degree of deviation from neutroclusion in terms of cusp units of the first molar. If the displacement on a side is such that the lower tooth cusp fits into the upper groove to the posterior of its normal position, the score is 2 for distoclusion on that side. If the lower tooth cusp fits into the groove to the anterior of the normal position, 2 is scored for mesioclusion. For partial displacement in either posterior or anterior direction such that the cusps do not fit into grooves but are roughly halfway or cusp to cusp, 1 is scored for distoclusion or 1 for mesioclusion. The scores for each side are added to give a single score unless one side was scored as mesioclusion and the other distoclusion, in which case the scores are separately recorded. In cases of doubt because of mutilation or extraction of molars, make the best judgment of the case status.

Posterior crossbite.—Disregarding single tooth malposition, record the number of teeth involved in a posterior arch crossbite. Figure IV illustrates how the crossbite is judged as buccal (Item 8) or lingual (Item 9) according to the position of the upper teeth to the lower teeth. The true underlying cause, i.e., which arch was really displaced, is ignored. Record the count of the number of teeth out of normal relation.

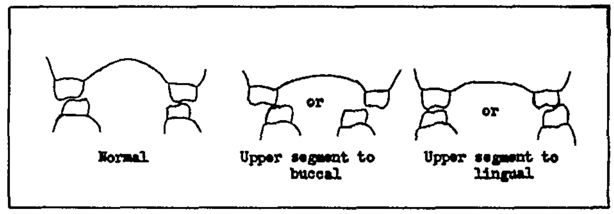

Figure IV. Method of judging posterior crossbite in terms of maxillary teeth to mandibular teeth.

Tooth displacement.—Measure the amount of tooth displacement (Item 10), using the method of Van Kirk and Pennell[7] (fig. V). A score of 1 is given for each tooth with a minor degree of malposition or rotation and a score of 2 for teeth in major malposition or rotation. Record the sum of the scores for the whole mouth.

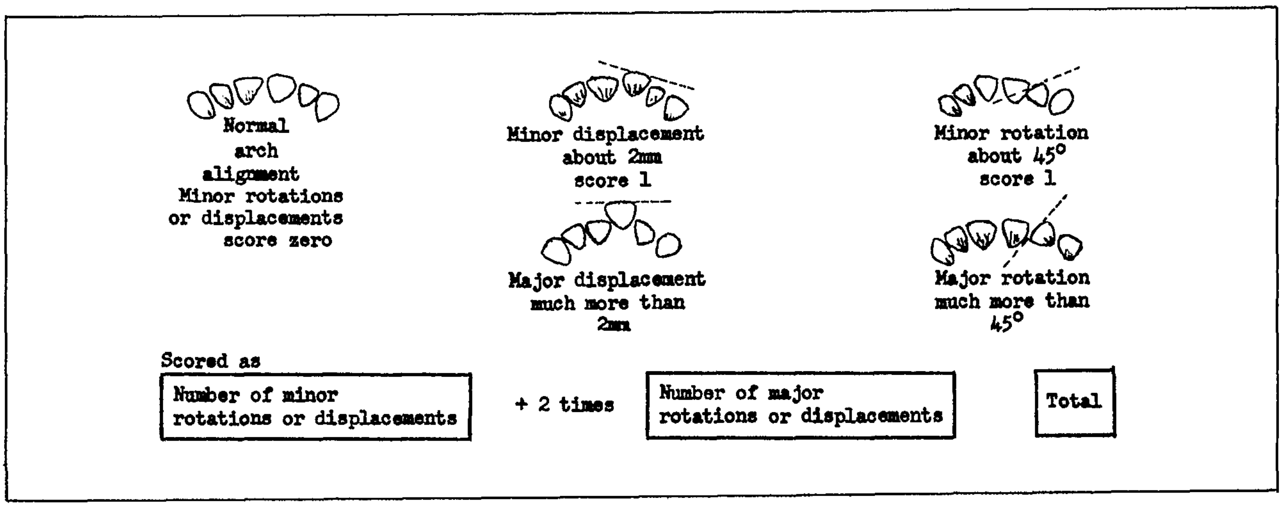

Figure V. Method of scoring the amount of tooth displacement according to the number of teeth in minor or major rotation or displacement.

———o o o———

APPENDIX II. DEFINITION OF MALOCCLUSION SYNDROMES BY FACTOR ANALYSIS

In an earlier work, using the Burlington orthodontic research data, some 21 syndromes were described. The direct method for the development of the Orthodontic Treatment Priority Index was to demonstrate the major syndromes by factor analysis and, if possible, to compute the amount of each present in an individual by regression methods following out of the factor analysis model.[14] This method proved impossible as no satis-

Table I. Multiple group factor analysis of crude and maximized phi coefficients for 375 12-year-old children and suggested names for syndromes: Burlington, Brantford, and Orangeville, Ontario

Recording item	Multiple group rotated factor [1,2]					
	I	II	III	IV	V	VI
	Maximized phi's					
Upper anterior overjet	.18		1.00			
Lower anterior overjet				.61		
Overbite	.20	.99				
Openbite				.34		
Congenital incisor	.61	.20	.27			.33
Distoclusion	.37	.27	.22			
Mesioclusion				.80		
Posterior crossbite, maxillary to buccal	.77					
Posterior crossbite, maxillary to lingual					.82	
Tooth displacement	.42				.75	
Suggested name of syndrome	Disto-clusion complete	Overbite	Overjet	Mesio-clusion	Displace-ment	Con-genital incisor
	I	II	III	IV	V	VI
	Crude phi's					
Upper anterior overjet	.20	.55				
Lower anterior overjet				.47		
Overbite	.36	.19				
Openbite			.47			
Congenital incisor						.41
Distoclusion	.55	.17				
Mesioclusion			.17	.15		
Posterior crossbite, maxillary to buccal	.20		.19			.34
Posterior crossbite, maxillary to lingual					.51	
Tooth displacement					.15	
Suggested name of syndrome	Disto-clusion	Overjet disto-clusion	Openbite mesio-clusion	Underjet mesio-clusion	Displace-ment	Con-genital incisor

[1]The order of factors generated from the crude and maximized phi matrices differed, and the columns were rearranged to make the similarity of the factors more apparent.

[2]Values under .15 were omitted.

Table II. Product moment correlation values for raw scores, normalized scores, and normalized score correlations corrected for coarse grouping error for 375 12-year-old children: Burlington, Brantford, and Orangeville, Ontario

Recording item	1	2	3	4	5	6	7	8	9	10
Upper anterior overjet	.313 .321 .513	-.178 -.244 -.289	.203 .230 .243	.011 .003 .005	-.083 -.098 -.115	.501 .476 .513	-.084 -.108 -.119	.026 .043 .045	-.004 .010 .011	.074 .069 .071
Lower anterior overjet		.108 .179 .400	-.019 -.032 -.039	-.010 -.010 -.015	-.014 -.015 -.021	.010 -.011 -.014	.226 .315 .400	-.019 -.023 -.028	-.022 -.025 -.031	.095 .077 .091
Overbite			.205 .202 .393	-.238 -.186 -.237	.086 .072 .087	.352 .355 .393	-.134 -.110 -.125	.060 .122 .131	-.115 -.110 -.121	.125 .144 .152
Openbite				.142 .098 .251	-.015 -.015 -.022	-.070 -.077 -.099	.238 .188 .251	.141 .111 .140	-.023 -.026 -.033	.033 .018 .022
Congenital incisor					.073 .053 .166	-.036 -.024 -.029	-.019 -.022 -.027	.041 .051 .062	.135 .135 .166	-.026 -.015 -.018
Distoclusion						.366 .352 .513	-.092 -.108 -.125	.130 .148 .161	-.073 -.071 -.080	.207 .186 .200
Mesioclusion							.136 .184 .400	.014 .052 .059	.111 .115 .134	.022 .018 .020
Posterior crossbite, maxillary to buccal								.054 .069 .161	-.042 -.055 -.060	.082 .082 .086
Posterior crossbite, maxillary to lingual									.111 .112 .176	.181 .164 .176
Tooth displacement										.180 .177 .200

NOTE: Values in diagonal cells are estimates of communality. The top two are multiple R's and the third is the highest row values.

factory or reproducible factor pattern could be produced, principally because a proper expression of the intercorrelations could not be obtained.

Table II shows three product moment matrices for raw data, normalized data, and data normalized and corrected for coarse grouping using the method of Peters and Van Voorhis.[15] A matrix of adjusted phi coefficients is given in table III. Clearly the latter cases provided the higher correlations generally and these two were used for the factor analysis where the essential purpose was to reflect the intrinsic relationships which would hold if the data were recorded perfectly on a continuous undistorted scale. The phi coefficient matrix is probably the most reliable because only it brings out fully the obviously expected complete negative correlations between factors I and II, III and IV, and VI and VII.

The factor analysis model chosen was the multiple group analysis, as discussed in Harmar.,[14] because sensitive examination of the interrelationships was desired rather than reduction of the dimension of the matrix. A very important point in the use of factor analysis is the decision regarding the value to be substituted for one in the diagonal of the symmetrical correlation matrix. These values represent the communality or the amount of the variance of each item which is related to the other items. A simple method used

Table III. Phi coefficients for 375 12-year-old children: Burlington, Brantford, and Orangeville, Ontario

Recording item	1	2	3	4	5	6	7	8	9	10
Upper anterior overjet										
Maximized phi coefficient-	1.000	-1.000	.246	.014	.522	.340	-.108	.121	.191	.066
Crude phi coefficient-----	.323	-.122	.221	.002	.052	.323	-.043	.038	.066	.060
Lower anterior overjet										
Maximized phi coefficient-		1.000	-.053	-.016	-.008	-.577	.640	-.051	-.063	-.087
Crude phi coefficient-----		.199	-.007	-.011	-.006	-.067	.199	-.020	-.022	-.010
Overbite										
Maximized phi coefficient-			1.000	-1.000	.421	.289	-.216	.122	-.135	.092
Crude phi coefficient-----			.247	-.193	.047	.247	-.095	.043	-.052	.075
Openbite										
Maximized phi coefficient-				1.000	-.016	-.577	.460	.124	.114	.185
Crude phi coefficient-----				.203	-.009	-.095	.203	.068	.057	.029
Congenital incisor										
Maximized phi coefficient-					.522	.211	-.081	.474	-.063	.185
Crude phi coefficient-----					.150	.020	-.020	.150	-.018	.017
Distoclusion										
Maximized phi coefficient-						.577	-.523	.419	-.238	.105
Crude phi coefficient----						.323	-.196	.125	-.077	.100
Mesioclusion										
Maximized phi coefficient-							.640	.033	.154	.101
Crude phi coefficient-----							.203	.026	.136	.036
Posterior crossbite, maxillary to buccal										
Maximized phi coefficient-								.485	-.063	.485
Crude phi coefficient----								.150	-.057	.139
Posterior crossbite, maxillary to lingual										
Maximized phi coefficient-									.646	.646
Crude phi coefficient-----									.204	.204
Tooth displacement										
Maximized phi coefficient-										.646
Crude phi coefficient-----										.204

successfully by Thurstone[16] is to use the largest correlation in the particular row and this value was used in the present work. If communalities are chosen to be too large, the matrix is not reduced enough; if too small, not enough factors are generated.

Results of the factor analysis using the BIMD#17 program[17] on the IBM 7094 at the Institute of Computer Science, University of Toronto, are given in table IV. These are based on the transformed and coarse grouping adjusted matrix in row three of table II.

It was highly interesting to see that the factor analysis defined two types of distoclusion and mesioclusion; a tooth-displacement syndrome and a congenitally-missing-incisor syndrome. No factor for overjet occurring in the neutroclusion cases could be defined. As stated above, it had been hoped to calculate the syndromes directly from these factor loadings but, because the correlation matrix was observed to be less than ideal, this was abandoned. Further exploration of the syndromes, in terms of phi coefficients, was carried

Table IV. Multiple group factor analysis of 10 malocclusion manifestations, using normalized scores and product moment correlation coefficients adjusted for coarse grouping, for 375 12-year-old children: Burlington, Brantford, and Orangeville, Ontario

Recording item	Rotated multiple group factor						
	I	II	III	IV	V	VI	VII
Upper anterior overjet----------	-.71	.22	-.03	.08	.01	.07	-.03
Lower anterior overjet----------	.16	-.64	.08	.08	.00	.09	.04
Overbite------------------------	-.33	.01	.47	-.05	.29	.08	-.04
Openbite------------------------	.02	-.08	-.51	.04	.19	-.01	-.02
Congenital incisor--------------	.08	.03	.08	-.42	.10	.00	.00
Distoclusion--------------------	-.63	.00	.25	.10	.24	.19	.05
Mesioclusion--------------------	.03	-.58	-.32	-.07	.02	.04	-.06
Posterior crossbite, maxillary to buccal--------------------	-.09	-.01	-.08	-.05	.42	.06	.00
Posterior crossbite, maxillary to lingual-------------------	-.00	-.03	-.13	-.35	-.21	.27	-.03
Tooth displacement--------------	-.11	-.08	.05	-.04	.09	.46	.00
Suggested name of syndrome	Distoclusion with overjet	Mesioclusion with lower overjet	Mesioclusion with openbite	Congenitally missing incisors	Distoclusion without overjet	Tooth displacement	Complex mesioclusion

Table V. Phi coefficients from appendix table II rearranged to make the clustering more apparent

	2	4	7	9	10	1	3	5	6	8
2	X	-.02	.64	-.06	-.09	-1.00	-.05	-.01	-.58	-.05
4	-.02	X	.46	.11	.19	.01	-1.00	-.02	-.58	.12
7	.64	.46	X	.15	.10	-.11	-.22	-.08	-.52	.03
9	-.06	.11	.15	X	.65	.19	-.14	-.06	-.23	-.06
10	-.09	.19	.10	.65	X	.07	.09	.19	.11	.49
1	-1.00	.01	-.11	.19	.07	X	.25	.52	.34	.12
3	-.05	-1.00	-.22	-.14	.09	.25	X	.42	.29	.12
5	-.01	-.02	-.08	-.06	.19	.52	.42	X	.21	.47
6	-.58	-.58	-.52	-.23	.11	.34	.29	.21	X	.42
8	-.05	.12	.03	-.06	.49	.12	.12	.47	.42	X

NOTE: These clusters are not completely unrelated or perfectly defined: e.g., the relation between factors 8 and 10 is large, +.49, but very low with 9, -.06. The relation of factor 8 to all others in the larger system is positive and hence it was so placed although it represents a correlative link between the two clusters.

Table VI. Rotated multiple group factor analysis of distoclusion system of phi's from table V

Recording item	Rotated multiple group factor[1]					
	I	II	III	IV	V	VI
Overjet	-.24				-.77	
Overbite	-.40		.27		-.29	
Congenital incisor	-.79				-.21	-.23
Distoclusion	-.18		.19			-.69
Posterior crossbite, maxillary to buccal	-.19	.23	.76			-.24
Posterior crossbite, maxillary to lingual		.15		-.82		
Displacement		.91	.17	-.20		
Suggested name of syndrome	Disto-clusion with overjet	Tooth dis-place-ment	Disto-clusion with crowding and no overjet	Tooth dis-place ment	Overjet, overbite inde-pendent of disto-clusion	Distoclusion without overjet, or overbite, probably from partial tooth drift

[1]Values under .15 were omitted.

NOTE: The fact that some columns are negative and some positive is of no interpretive significance.

out as below but because the phi matrix was obtained from a 2 x 2 dichotomy, factor loadings from phi's could not be used directly for regression calculations.

Perusal of the phi coefficient matrices in table III will reveal the complete inverse correlation between factors I and II, and III and IV. One might anticipate a complete negative correlation between distoclusion and mesioclusion, but it is clear that a low degree of each can occur in the same mouth unilaterally; hence, they are not completely mutually exclusive. Factor analysis of the crude and the maximized phi matrices is shown in table I. The maximized case is theoretically

Table VII. Rotated multiple group factor analysis of mesioclusion system of phi's from table V

Recording item	Rotated multiple group factor[1]					
	I	II	III	IV	V	VI
Overjet		.19		.75		
Openbite		.14			.68	.18
Congenital incisor	.19		.54			
Mesioclusion		.89		.23	.20	
Posterior crossbite, maxillary to buccal			.78			-.16
Posterior crossbite, maxillary to lingual	.21					-.75
Displacement	.84		.26			-.32
Suggested name of syndrome	Tooth displace-ment	Mesio-clusion with underjet and openbite	Tooth displace-ment	Mesio-clusion with underjet only	Mesio-clusion with openbite only	Openbite and displace-ment not related to mesio-clusion

[1]Values under .15 were omitted.

Table VIII. Adjusted phi coefficient matrix and multiple group factor analysis compiled for 217 cases with normal buccal segment relation

Recording item	Phi matrix 1	2	8	9	10
Horizontal	#.416	-.157	-.368	-.368	-.416
Vertical	-.157	#.327	.128	-.162	.327
Posterior crossbite, maxillary to buccal	-.368	.128	#.368	-.103	.194
Posterior crossbite, maxillary to lingual	-.368	-.162	-.103	#.368	-.204
Tooth displacement	-.416	.327	.194	-.204	#.416

	Rotated multiple group factor I	II	III	IV
Horizontal	-.329	-.518	-.419	-.107
Vertical	.520	-.082	.104	-.082
Posterior crossbite, maxillary to buccal	.164	-.079	.601	.010
Posterior crossbite, maxillary to lingual	-.149	.708	-.150	-.009
Tooth displacement	.610	.040	.213	.180
Suggested name of syndrome	Overjet-overbite-displacement	Lingual cross-bite	Buccal cross-bite	Displacement

#Diagonal items are substituted by highest in row.

preferred and it defines three distoclusion syndromes, a mesioclusion syndrome, and a tooth-displacement syndrome not related to buccal segment relation. The crude phi analysis separated the mesioclusion cases into two groups. In order to more clearly see the subdivisions of the distoclusion, mesioclusion, and neutroclusion systems, the complete matrix of phi's was rearranged in table V by observation of the clusters. The mesioclusion cluster is in the upper left, the distoclusion cluster in the lower right, and the remaining items apparently not correlated to either cluster are in the center. The mesial and distal systems are obviously mutually exclusive because they represent opposite extremes for several factors.

A further step was to carry out separate factor analysis of the two major clusters of coefficients from table V but including also the crossbite and displacement items. With the highest row values used as communalities, the factor analysis results for the two sets are shown in tables VI and VII. For clarity, all low factor loadings were omitted.

The distoclusion system (table VI) has factors I, III, and IV which are quite similar to those based on the product moment correlation matrix I, V, and VI (table IV). In addition, an overjet-overbite factor (column V, table VI) not related to buccal segment relation was detected. The mesioclusion system (table VII) had factors IV, V, and II similar to factors II, III, and VII in table IV, and, in addition, an openbite-crossbite-displacement factor not related to buccal segment position. Thus it was suspected that the overjet-overbite syndrome and the tooth-displacement-crossbite syndromes could be found in neutroclusion cases.

The neutroclusion cases were sorted out and processed accordingly. The phi matrix and the multiple group factor analysis for neutroclusion cases are shown in table VIII. The anterior vertical and horizontal relations were used in continuous scale form with underjet and openbite given negative signs. The overjet-overbite syndrome appears and also two syndromes representing the crossbites. They are not clearly identical with factors II, IV, and V of table VI or I, III, and VI of table VII. The difference is that in table VIII tooth displacement was more strongly related to the horizontal and vertical incisor defect than to crossbite. This is not illogical because, for example, anterior overjet occurs in distoclusion cases mainly because of the jaw displacement, but in neutroclusion cases it most likely involves changes in tooth position. These findings are compatible with more detailed study of the interrelationship of malocclusion syndromes by Grainger.[12]

Thus it was suspected that if sets of cases which were homogeneous regarding anteroposterior buccal segment relation were analyzed, using the horizontal

Table IX. Factor analysis of homogeneous buccal segment relationship groups

Buccal segment relation and recording item	Rotated multiple group factor[1]				
	I	II	III	IV	V
<u>Distal, 3 or 4</u>					
Horizontal $(x_1 - x_2 - 3)$---	-.33	+.42	+.52		
Vertical $(x_3 - x_4 - 1.5)$---	+.52				
Posterior crossbite, maxillary to buccal---	+.16	-.60			
Posterior crossbite, maxillary to lingual--	-.15	+.15	-.71		
Displacement-----------	+.61	-.21		+.18	
<u>Distal, 1 or 2</u>					
Horizontal $(x_1 - x_2 - 3)$---		+.79	+.23		
Vertical $(x_3 - x_4 - 1.5)$---	+.92	-.16	+.37		
Posterior crossbite, maxillary to buccal---	+.18		+.68		
Posterior crossbite, maxillary to lingual--	+.15	+.79	-.16		
Displacement-----------	+.97	+.17			
<u>Normal</u>					
Horizontal $(x_1 - x_2 - 3)$--		+.42			
Vertical $(x_3 - x_4 - 1.5)$--	+1.00				
Posterior crossbite, maxillary to buccal---		+.21		+.81	
Posterior crossbite, maxillary to lingual--		+.18			+.97
Displacement-----------	+.78	+.20		+.46	+.64
<u>Mesial, 1, 2, 3, or 4</u>					
Horizontal $(x_1 - x_2 - 3)$---		+.62			
Vertical $(x_3 - x_4 - 1.5)$---					
Posterior crossbite, maxillary to buccal---		-.26		+.68	
Posterior crossbite, maxillary to lingual--		+.64			
Displacement-----------		+.20		+.70	
Suggested name of syndrome	Anterior vertical, displacement and maxillary to buccal posterior crossbite	Anterior horizontal, displacement and maxillary to lingual posterior crossbite	Distoclusion horizontal with reverse crossbite All classes of displacement crossbite systems		

[1]Values under .15 were omitted.

and vertical incisor factors in continuous scale form and squaring all items, that a similar factor pattern might be present in all sets. Table IX gives the multiple group factors for four sets based on phi coefficient matrices and it will be observed that the situation was much simplified. Factor I represents a vertical defect accompanied by tooth displacement and in the distoclusion cases, posterior crossbite with the maxilla to the buccal. This factor was less clear in the neutroclusion cases and not defined in mesioclusion. Factor II was clearly a horizontal displacement defect accompanied by posterior crossbite with maxilla to the lingual and it was clearly defined in all four sets. Factor III was present only in distoclusion cases, and less clear but horizontal incisor relation and posterior crossbite with maxilla to the buccal dominated the picture and there was no tooth displacement. Factors IV and V were tooth displacement factors not involving either vertical or horizontal incisor position but again accompanied by posterior crossbites.

It is felt that the closest description of the clinical syndromes—the factor analysis of phi coefficients for the whole set of 375 cases—is given by table I, but that for the purpose of computing regression equations, separation into groups with homogeneous buccal segment relations presented an advantage because the similarity of the factor patterns would permit use of one equation in all cases. This lead was followed in Appendix III.

APPENDIX III. DEVELOPMENT OF REGRESSION EQUATION

A unique problem arose when the three equations (table E) expressing the regression of judgment scores on the recording items for three anteroposterior buccal segment relationships had to be combined. Following the lead from factor analysis of sets of data which were homogeneous in buccal segment relation, seven equations were derived (table F).

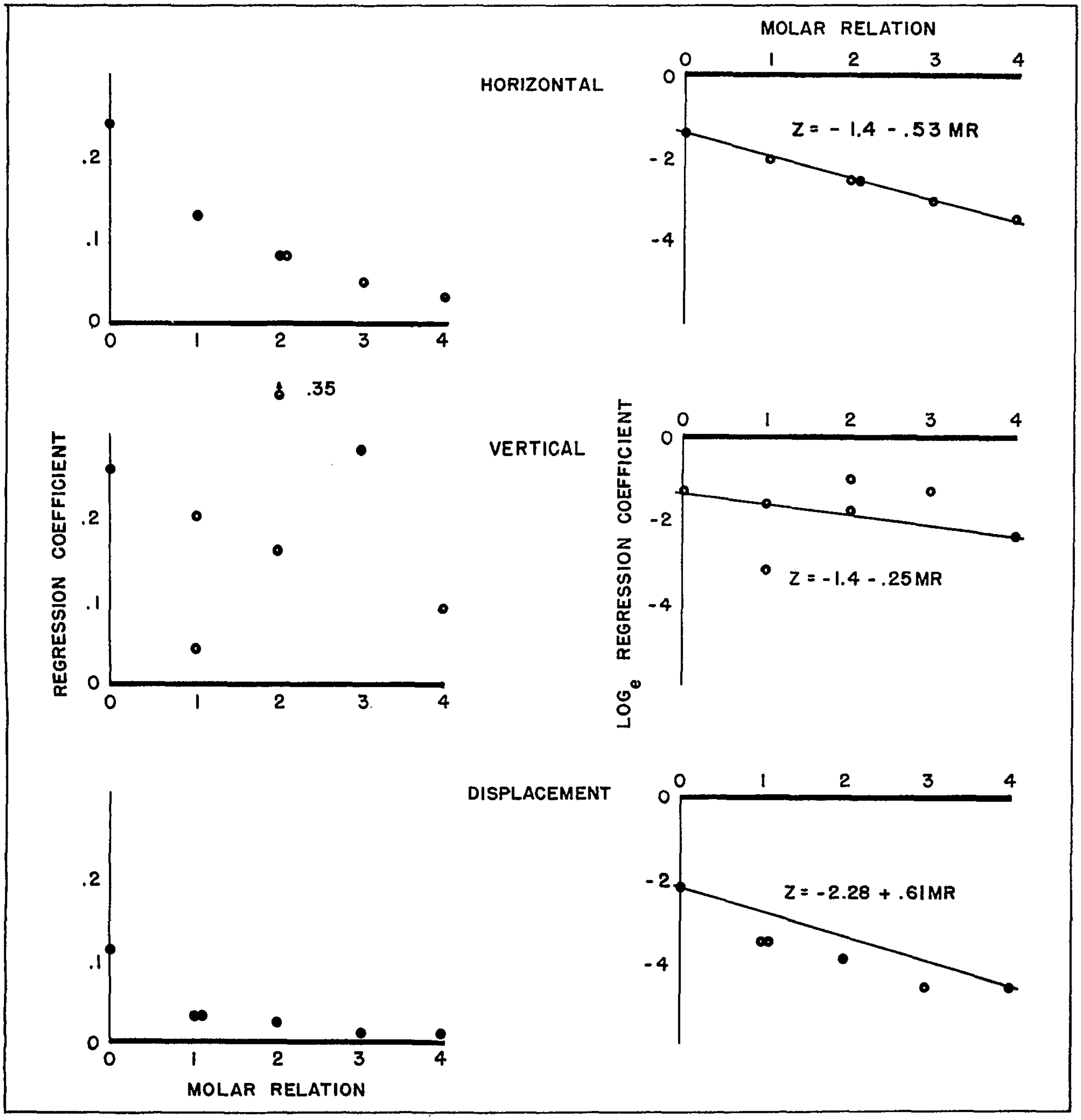

Figure VI. Regression coefficients of table F plotted according to molar relation and least squares fitted linear expressions of $log_e b$ according to molar relation from which smooth weights of table F were obtained.

There was a general pattern toward lower regression coefficients in the columns to the left or right of the normal buccal segment types expressing the higher intercorrelations of items in the distal and mesial molar relation cases. Some irregular cases are explainable on the basis of the small samples for distal 3, and mesial 1 and 2 groups (table F). The vertical intercept value for the neutroclusion column is nearly zero and rises as expected with the degree of malposition of the buccal segments. The pattern of change in the regression coefficients is shown graphically in the left half of figure VI. The task of smoothing out the regression coefficients and combining the seven equations into one was undertaken as follows.

From the general shape of the curves it was determined that an exponential expression

$$R = e^{-(a + bX)}$$

might be useful, where R represents a regression coefficient and $\bar{X}$ the buccal segment relation. Taking the natural logarithm of both sides of the equation, $Log_e\ R = -(a + bX)$ would produce a linear equation. The right half of figure VI shows diagrams plotting transformed regression coefficients on the buccal segment scores. The lines drawn in and the equations given were least squares fit, as shown in table X. In the lower part of the table the first iteration smoothed regression coefficients are arrayed and below, the exponential expressions which produce the smoothed coefficients according to the buccal segment score for a particular case.

The preliminary equation was tried on the 375 cases and the worst discrepancies studied. The regression coefficient for the horizontal incisal relation seemed to be too small in mesioclusion cases so a scale shift (subtracting 3 instead of 2 from the continuous variable, $Y_1 - Y_2$) was used, and the weights recalculated. The coefficient for the vertical component was obviously also too low in the mesioclusion cases and a similar small scale change was made by using the constant 1.5 instead of 1. In addition, it was clear that even in the neutroclusion cases the coefficient 0.26 was too small

Table X. Calculation of smoothed regression coefficients in figure VI
(example is for vertical component)

Molar relation *MR*	Sample *N*	Regression coefficient *W*	$Log_e\ W$ W'	*N.MR*	$N.MR^2$	$N.W'$	$N.MR.W'$
0	217	.26	-1.3	-	-	-282.1	-
1	38	.04	-3.2	38	38	-121.6	-121.6
1	12	.20	-1.6	12	12	-19.2	-19.2
2	61	.16	-1.8	122	244	-109.8	-219.6
2	13	.35	-1.0	26	52	-13.0	-26.0
3	11	.28	-1.3	33	99	-14.3	-42.9
4	32	.09	-2.4	128	512	-76.8	-307.2
Totals	384			359	957	-636.8	-736.5
Correction factors for arbitrary mean zero					336		595.3
Corrected sums of squares					621		-141.2

Slope $-141.2/621 = -0.23$

Weighted average molar relation $359/384 = 0.935$

Weighted average $Log_e\ W$ $-636.8/384 = 1.66$

Y intercept $1.66 - (.935 \times .23) = 1.44$

Equation $\hat{W}' = -1.44 + (-.23MR)$

Molar relation	Calculated average $Log_e\ W$	Calculated regression coefficient $e^{-(-1.44 + (-.23MR))}$
0	-1.44	.24
1	-1.67	.19
2	-1.90	.15
3	-2.13	.12
4	-2.36	.09

for an extreme overbite of 5 (actual impingement had to be rated as handicapping). By a simple calculation

$$8/(5-1.5)^2 = b$$

it was seen that the coefficient would need to be 0.64 for the neutroclusion cases and the smooth values for the other columns raised proportionately.

Finally the evidence was that tooth displacement should have more significance in the mesioclusion cases. This was also suggested in table IX where the tooth displacement syndromes had major importance in the mesioclusion set. Accordingly, the regression coefficient was doubled for these columns and separate weights used for Y_6 and Y_7 in the expression

$$e^{-(2.28 + .61Y_6 + .23Y_7)}.$$

The final weights and the exponential expressions for deriving them have been given in table G.

———o o o———

APPENDIX IV. IBM 7010 FORTRAN, MALOCCLUSION PROCESSOR TPS GRAINGER

Input:

Input may be from Mark Sense Cards, figure 5, punched as below or from National Health Survey Card 33 (HES II - 33 Dental).

A. Punching Format for Mark Sense Cards (Two-column integers)

Col. 1, 2 upper anterior overjet in mm
Col. 3, 4 lower anterior overjet in mm
Col. 5, 6 overbite in crown thirds
Col. 7, 8 openbite in mm
Col. 9,10 number of congenitally missing incisors
Col. 11,12 distoclusion score
Col. 13,14 mesioclusion score
Col. 15,16 number of teeth in posterior crossbite maxilla to buccal
Col. 17,18 number of teeth in posterior crossbite maxilla to lingual
Col. 19,20 tooth displacement score
Col. 66 sex, male 1, female 2
Col. 67, 68 age in years
Col. 69-72 identification number

B. Alternate Input Card 33 NHS II Dental

A subroutine called in converts data to input form A if a 1 is punched in column one of problem card. If in mark sense format, column one of problem card is left blank.

Order of Input:

System cards as required by the specific operating system*
Program deck
First problem card
Data deck
End of group card (-1 in col. 1, 2)
Second problem card
etc. etc.

Problem card:

Col. 1 Punch a 1 if input NHS card #33, if mark sense format, leave blank.
Col. 2 If data from NHS cards are to be punched in mark sense format, punch a 1, otherwise leave blank.
Col. 3 Punch 0, TPS and identification only.
Punch 1, TPS and syndromes and identification.
Punch 2, TPS, syndromes, raw data and identification will be printed or punched as called for by col. 4 and 5.
Col. 4 Punch 1, if output by individual cases is to be punched on cards.
Col. 5 Punch 1, if output by individual cases is to be printed, otherwise leave blank.
Col. 8,9 Leave blank.
Col. 10 to 72 Alphameric message identifying the pack.

*This program was first developed in IBM 7094 Fortran IV which is also available.

TPI Program Listing

```
      COMMON KW(7),Y(18),TITLE(11),SYND(9),SAM(9),T(9),TX(9),SE(9),AV(9)
     1,ID,FREQ(9,11)
    2 FORMAT(7I1,I2,10A6,A3)
    5 FORMAT(1X,41HOPERATOR  MESSAGE  WATCH FOR PUNCHED OUTPUT )
   22 FORMAT(1H1,43HANALYSIS OF ORTHODONTIC TREATMENT NEEDS FOR/1X,10A6,
     1A3)
    1 READ(1,2)(KW(I),I=1,7),K,(TITLE(L),L=1,11)
  100 DO 106 I = 1,9
      SYND(I) = 0.0
  101 SAM(I) = 0.0
  102 T(I) = 0.0
  103 TX(I) = 0.0
  104 SE(I) = 0.0
  105 DO 106 N = 1,11
      FREQ(I,N) = 0.0
  106 CONTINUE
    3 IF(KW(5)+KW(4)) 6,6,4
    4 WRITE(3,5)
    6 IF(KW(1)) 14,14,8
    8 CALL RESORT(SIG)
    9 IF(SIG+1.0) 25,21,10
   10 LW=KW(4)
   11 JW=KW(5)
   12 CALL COMP
   13 GO TO 8
   14 CALL BURL(SIG)
   15 IF(SIG+1.0) 25,21,16
   16 LW = KW(4)
   17 JW = KW(5)
   18 CALL COMP
   19 GO TO 14
   21 WRITE(3,22) (TITLE(L),L=1,11)
   23 CALL OUTPUT
   24 GO TO 1
   25 STOP
   26 END

      SUBROUTINE SUMRY(INK)
      COMMON KW(7),Y(18),TITLE(11),SYND(9),SAM(9),T(9),TX(9),SE(9),AV(9)
     1,ID,FREQ(9,11)
      SYND(INK) = SYND(1)
    1 SAM(INK) = SAM(INK) + 1.0
    2 T(INK) = T(INK) + SYND(INK)
    3 TX(INK) = TX(INK) + (SYND(INK)**2)
    4 IF(SYND(INK)-10.5)7,5,5
    5 N = 11
    6 GO TO 8
    7 N = IFIX(SYND(INK)+1.5)
    8 FREQ(INK,N) = FREQ(INK,N)+1.0
    9 RETURN
   10 END
```

```
      SUBROUTINE BURL(SIG)
      COMMON KW(7),Y(18),TITLE(11),SYND(9),SAM(9),T(9),TX(9),SE(9),AV(9)
     1,ID,FREQ(9,11)
    2 FORMAT(10F2.0,F3.0,2F2.0,3F3.0,28X,I8)
    1 READ(1,2)(Y(I),I=1,16),ID
    3 IF(Y(1))4,6,6
    4 SIG = -1.0
    5 GO TO 7
    6 SIG = 1.0
    7 RETURN
    8 END

      SUBROUTINE COMP
      DIMENSION B(20),S(16)
      COMMON KW(7),Y(18),TITLE(11),SYND(9),SAM(9),T(9),TX(9),SE(9),AV(9)
     1,ID,FREQ(9,11)
  117 FORMAT(F5.1,59X,I8)
  120 FORMAT(9F5.1,19X,I8)
  123 FORMAT(8F5.1,10I3,I8)
  127 FORMAT(1X,F5.1,67X,I8)
  130 FORMAT(1X,9F5.1,15X,I8)
  133 FORMAT(1X,9F5.1,10F4.0,1X,I8)
 1001 DO 1002 J = 1,9
 1002 SYND(J) = 0.0
    1 DO 3 I = 1,16
    2 S(I) = 0.0
    3 CONTINUE
    4 DO 12 I =1,16
    5 IF(Y(I))6,8,6
    6 S(I) = 1.0
    7 GO TO 12
    8 TEST = 1.0
    9 TEMP = SIGN(TEST,Y(I))
   10 IF(TEMP) 12,12,11
   11 S(I) = 1.0
   12 CONTINUE
      B(1) = (Y(1)-Y(2)-3.0)**2
      B(2) = (Y(3)-Y(4)-1.5)**2
      B(3) = Y(6) + Y(7)
      B(4) = Y(8)**2
      B(5) = Y(9)**2
      B(6) = Y(10)**2
   19 IF(S(1)+S(2)+S(3)+S(4)+S(6)+S(7)+S(8)+S(9)+S(10)-9.0)76,20,76
   20 SYND(1)=0.27+(1.2*(Y(6)+Y(7))+(B(1)/(2.7183*(1.34+(.32*B(3))))
     1+(B(2)/(2.7183*(.43+(.26*B(3))))+(.14*B(4))+(.26*B(5))+
     2(B(6)/(2.7183*(2.28+(.61*Y(6))+(.23*Y(7))))
   21 I = 1
   22 CALL SUMRY(I)
   23 IF(SYND(1)-4.0)58,24,24
   24 IF(Y(5)-1.0)31,25,27
   25 SYND(9) = 7.0
```

```
26 GO TO 31
27 IF(Y(5)-2.0)31,28,30
28 SYND(9) = 8.0
29 GO TO 31
30 SYND(9) = 9.0
31 A=((Y(1)-Y(2)-2.0)**2)*0.22
32 B=((Y(3)-Y(4)-1.0)**2)*0.50
33 C=(Y(10)**2)*0.12
34 IF(A-B) 50,35,35
35 IF (A-C) 43,36,36
36 IF(Y(1)-Y(2)) 40,37,37
37 I = 8
38 CALL SUMRY(I)
39 GO TO 114
40 I = 7
41 CALL SUMRY(I)
42 GO TO 114
43 IF(Y(6)+Y(9))47,44,47
44 I = 3
45 CALL SUMRY(I)
46 GO TO 114
47 I = 4
48 CALL SUMRY(I)
49 GO TO 114
50 IF(B-C)57,51,51
51 IF(Y(3)-Y(4))55,52,52
52 I = 5
53 CALL SUMRY(I)
54 GO TO 114
55 I = 6
56 CALL SUMRY(I)
57 GO TO 114
58 I = 2
59 CALL SUMRY(I)
114 IF(KW(4))124,124,115
115 IF(KW(3)-1)116,119,122
116 WRITE(2,117)SYND(1),ID
118 GO TO 124
119 WRITE(2,120)(SYND(I),I=1,9),ID
121 GO TO 124
122 DO 200 I = 1,10
200 M(Y) = I(Y)
201 WRITE(2,123)SYND(1),(SYND(I),I=2,9),(M(Y),Y=1,10),ID
124 IF(KW(5))76,76,125
125 IF(KW(3)-1)126,129,132
126 WRITE(3,127)SYND(1),ID
128 GO TO 76
129 WRITE(3,130)(SYND(I),I=1,9),ID
131 GO TO 76
132 WRITE(3,133)(SYND(I),I=1,9),(Y(I),I=1,10),ID
 76 RETURN
 77 END
```

```
      SUBROUTINE OUTPUT
      COMMON KW(7),Y(18),TITLE(11),SYND(9),SAM(9),T(9),TX(9),SE(9),AV(9)
     1,ID,FREQ(9,11)
   14 FORMAT(1HO,28HSYNDROME    AVER    SE    SAMPLE  ,10X,23HFREQUENCY DISTR
     1IBUTIONS )
   16 FORMAT(1X,31X,63HO         1         2         3         4         5         6         7         8
     1         9      10 )
   40 FORMAT(1HO,16HTREAT PRIORITY I/10X,2F6.2,1F6.0,11F6.3)
   42 FORMAT(1X,16HNORMAL OCCLUSION/10X,2F6.2,1F6.0,11F6.3)
   44 FORMAT(1X,16HBUCCAL DISPLACNT/10X,2F6.2,1F6.0,11F6.3)
   46 FORMAT(1X,16HLINGL DISPLACMNT/10X,2F6.2,1F6.0,11F6.3)
   48 FORMAT(1X,9HOVERBITE /10X,2F6.2,1F6.0,11F6.3)
   50 FORMAT(1X,9HOPENBITE /10X,2F6.2,1F6.0,11F6.3)
   52 FORMAT(1X,11HPROGNATHISM/10X,2F6.2,1F6.0,11F6.3)
   54 FORMAT(1X,13HRETROGNATHISM/10X,2F6.2,1F6.0,11F6.3)
 1206 DO 1210 I = 1,9
 1207 DO 1210 N =1,11
 1208 IF(SAM(I))1210,1210,1209
 1209 FREQ(I,N) = FREQ(I,N)/SAM(I)
 1210 CONTINUE
      DO 60 I = 1,9
      AV(I) = 0.0
      SE(I) = 0.0
   60 CONTINUE
 1200 DO 1205 I = 1,9
 1201 IF(SAM(I)-1.0) 1205,1205,1202
 1202 AV(I) = T(I)/SAM(I)
 1203 IF((TX(I)-(T(I)*T(I)/SAM(I))) /(SAM(I)*(SAM(I)-1.0)))1205,1205,1204
 1204 SE(I)=SQRT((TX(I)-(T(I)*T(I)/SAM(I)))/(SAM(I)*(SAM(I)-1.0)))
 1205 CONTINUE
   13 WRITE(3,14)
   15 WRITE(3,16)
   39 WRITE(3,40)AV(1),SE(1),SAM(1),(FREQ(1,N),N=1,11)
   41 WRITE(3,42)AV(2),SE(2),SAM(2),(FREQ(2,N),N=1,11)
   43 WRITE(3,44)AV(3),SE(3),SAM(3),(FREQ(3,N),N=1,11)
   45 WRITE(3,46)AV(4),SE(4),SAM(4),(FREQ(4,N),N=1,11)
   47 WRITE(3,48)AV(5),SE(5),SAM(5),(FREQ(5,N),N=1,11)
   49 WRITE(3,50)AV(6),SE(6),SAM(6),(FREQ(6,N),N=1,11)
   51 WRITE(3,52)AV(7),SE(7),SAM(7),(FREQ(7,N),N=1,11)
   53 WRITE(3,54)AV(8),SE(8),SAM(8),(FREQ(8,N),N=1,11)
   55 WRITE(3,56)AV(9),SE(9),SAM(9),(FREQ(9,N),N=1,11)
   29 RETURN
   30 END
```

```
      SUBROUTINE RESORT(SIG)
      DIMENSION X(47),J(27),
      COMMON KW(7),Y(18),TITLE(11),SYND(6),SAM(6),T(6),TX(6),SE(6),AV(6)
     1,ID,FREQ(6,11)
    2 FORMAT(I5,6F1.0,F2.0,2X,6F1.0,2F2.0,4X,2F2.0,F1.0,4F2.0,2F1.0,
     1F2.0,2F1.0,F2.0,2F1.0,F2.0,2F1.0,2F2.0,12F1.0)
   98 FORMAT(4I2,2X,5I2,I3,2I2,I3,3X,I3,28X,I8)
    1 READ(1,2)ID,(X(I),I=1,47)
  300 IF(ID)301,3,3
  301 SIG = -1.0
  302 GO TO 99
    3 SIG = 1.0
  603 Y(1) = ABS(X(14))
    4 Y(2) = ABS(X(15))
  105 IF(X(18))11,11,5
    5 IF(X(18)-3.0)6,6,9
    6 Y(4) = 4.0-X(18)
    7 Y(3) = 0.0
    8 GO TO 11
    9 Y(3) = X(18)-3.0
   10 Y(4) = 0.0
   11 MOL = X(8)
   12 IF(MOL)15,13,15
   13 Y(6) = 2.0
   14 GO TO 25
   15 GO TO(16,17,18,19,20,21,22,23,24),MOL
   16 Y(7) = 2.0
      GO TO 25
   17 Y(7) = 1.0
      GO TO 25
   18 GO TO 25
   19 Y(6) = 1.0
      GO TO 25
   20 Y(6) = 2.0
      GO TO 25
   21 Y(7) = 2.0
      GO TO 25
   22 Y(7) = 1.0
      GO TO 25
   23 GO TO 25
   24 Y(6) = 1.0
   25 MOL = X(9)
   26 IF(MOL)28,27,28
   27 Y(6) = Y(6)+2.0
      GO TO 38
   28 GO TO(29,30,31,32,33,34,35,36,37 ),MOL
   29 Y(7) = Y(7)+2.0
      GO TO 38
   30 Y(7) = Y(7)+1.0
      GO TO 38
   31 GO TO 38
   32 Y(6) = Y(6)+1.0
      GO TO 38
   33 Y(6) = Y(6)+2.0
      GO TO 38
   34 Y(7) = Y(7)+2.0
      GO TO 38
```

```
 35 Y(7) = Y(7)+1.0
    GO TO 38
 36 GO TO 38
 37 Y(6) = Y(6)+1.0
 38 NXB = X(10)
 39 IF(NXB)40,41,40
 40 Y(8) = X(10)
 41 NXB = X(11)
 42 IF(NXB)43,45,43
 43 Y(9) = X(11)
 45 NXB = X(12)
 46 IF(NXB)47,48,47
 47 Y(8) = Y(8)+X(12)
 48 NXB = X(13)
 49 IF(NXB)50,51,50
 50 Y(9) = Y(9)+X(13)
 51 Y(10)=X(36)+X(37)+X(38)+X(39)+2.0*(X(40)+X(41)+X(42)+X(43))
 52 IF(X(19))53,55,53
 53 IF(X(22))54,57,54
 54 Y(11) = ((X(19)+X(22))/2.0)
    GO TO 58
 55 IF(X(22))56,64,56
 56 Y(11) = X(22)
    GO TO 58
 57 Y(11) = X(19)
 58 IF(X(20))59,61,59
 59 IF(X(21))60,63,60
 60 Y(11) = Y(11)+((X(20)+X(21))/2.0)
    GO TO 64
 61 IF(X(21))62,64,62
 62 GO TO 64
 63 Y(11) = Y(11)+X(20)
 64 Y(13) = X(24)+X(27)+X(30)+X(33)
 65 Y(12) = X(23)+X(26)+X(29)+X(32)
 66 IF(Y(11))80,80,167
167 IF(X(25))168,168,67
 67 K1=((Y(11)/10.0)+X(23)-X(24)-X(25)+11.0)*10.0
168 IF(X(28))169,169,68
 68 K2=((Y(11)/10.0)+X(26)-X(27)-X(28)+11.0)*10.0
169 IF(X(31))170,170,69
 69 K3=((Y(11)/10.0)+X(29)-X(30)-X(31)+10.0)*10.0
170 IF(X(33)) 71,71,70
 70 K4=((Y(11)/10.0)+X(32)-X(33)-X(34)+10.0)*10.0
 71 IF(K1-K2)73,73,72
 72 Y(14) = K1
    GO TO 74
 73 Y(14) = K2
 74 F = K3
    IF(Y(14)-F)76,76,75
 75 GO TO 77
```

```
 76 Y(14) = K3
 77 F = K4
    IF(Y(14)-F)79,78,78
 78 GO TO 80
 79 Y(14) = K4
 80 Y(16) = X(35)*10.0
 90 Y(17) = X(6)
 91 Y(18) = X(7)
 92 DO 94 I =1,18
 93 J(I) = Y(I)
 94 CONTINUE
 95 ID=ID+(J(18)*100000)+(J(17)*1000000)
 96 IF(KW(2))99,99,97
 97 WRITE(2,98)(J(I),I=1,4),(J(I),I=6,14),J(16),ID
 99 RETURN
100 END
```

OUTLINE OF REPORT SERIES FOR VITAL AND HEALTH STATISTICS

Public Health Service Publication No. 1000

Series 1. Programs and collection procedures.—Reports which describe the general programs of the National Center for Health Statistics and its offices and divisions, data collection methods used, definitions, and other material necessary for understanding the data.

Series 2. Data evaluation and methods research.—Studies of new statistical methodology including: experimental tests of new survey methods, studies of vital statistics collection methods, new analytical techniques, objective evaluations of reliability of collected data, contributions to statistical theory.

Series 3. Analytical studies.—Reports presenting analytical or interpretive studies based on vital and health statistics, carrying the analysis further than the expository types of reports in the other series.

Series 4. Documents and committee reports.—Final reports of major committees concerned with vital and health statistics, and documents such as recommended model vital registration laws and revised birth and death certificates.

Series 10. Data from the Health Interview Survey.—Statistics on illness, accidental injuries, disability, use of hospital, medical, dental, and other services, and other health-related topics, based on data collected in a continuing national household interview survey.

Series 11. Data from the Health Examination Survey.—Data from direct examination, testing, and measurement of national samples of the population provide the basis for two types of reports: (1) estimates of the medically defined prevalence of specific diseases in the United States and the distributions of the population with respect to physical, physiological, and psychological characteristics; and (2) analysis of relationships among the various measurements without reference to an explicit finite universe of persons.

Series 12. Data from the Institutional Population Surveys.—Statistics relating to the health characteristics of persons in institutions, and on medical, nursing, and personal care received, based on national samples of establishments providing these services and samples of the residents or patients.

Series 13. Data from the Hospital Discharge Survey.—Statistics relating to discharged patients in short-stay hospitals, based on a sample of patient records in a national sample of hospitals.

Series 20. Data on mortality.—Various statistics on mortality other than as included in annual or monthly reports—special analyses by cause of death, age, and other demographic variables, also geographic and time series analyses.

Series 21. Data on natality, marriage, and divorce.—Various statistics on natality, marriage, and divorce other than as included in annual or monthly reports—special analyses by demographic variables, also geographic and time series analyses, studies of fertility.

Series 22. Data from the National Natality and Mortality Surveys.—Statistics on characteristics of births and deaths not available from the vital records, based on sample surveys stemming from these records, including such topics as mortality by socioeconomic class, medical experience in the last year of life, characteristics of pregnancy, etc.

For a list of titles of reports published in these series, write to:

Office of Information
National Center for Health Statistics
U.S. Public Health Service
Washington, D.C. 20201