Quantitative Relationships Between Perceived and Objective Need for Health Care —Dentistry as a Model—

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ALTHOUGH MANY PSYCHOSOCIAL and economic factors that influence health behavior and use of health care resources have been identified, little success has been achieved in quantifying their contribution to patients' behavior. Part of the difficulty has been the lack of a directly quantifiable continuum from health to disease that can be related to social factors, patients' perceptions, and, ultimately, patterns of use.

Even when objective measures of need for treatment have been obtained, another problem in predicting use of resources arises: clinically judged need for treatment is not necessarily translated into demand for care. The inability to identify and measure the important intervening variable of perceived need for preventive or therapeutic care compounds this problem. The perception of need may differ considerably among groups with essentially the same objective clinical findings, depending on various psychosocial and economic factors.

By virtue of well-established, reliable and valid methods for measuring oral disease, dentistry provides a model for the study of the relationships between objective (clinically determined) and subjective (perceived) need for health care. Although methods exist for determining the magnitude of gingival and periodontal disease, as well as dental caries, the simplest measure with which to explore the possibility of quantifying these relationships is the number of decayed (D), missing (M), and filled (F) teeth. The sum of D + M + F teeth is a measure of susceptibility to oral disease, and the magnitude of each component reflects one aspect of the disease or therapeutic process. For example, D is a measure of actual need, and F is a measure of care received. By using dental health status as a quantifiable continuum with definitive end points, therefore, we can relate these dental indices to other dependent indicators of health and to intervening variables such as perceived need and differing delivery systems.

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Although some efforts have been made to relate objective clinical findings to subjective assessment of general health (*1,2*) and of dental health (*3–6*), most of the studies have provided only a categorical or simple correlational analysis. They have offered little opportunity for quantitative assessment of the contribution of intervening perceptual variables. Some of the issues in quantifying such relationships were addressed in a recent conference on health status indices (*7*).

As one approach to the quantification of the intervening perceptual variables, Giddon and Nornoo (*8*) developed a procedure that combined the statistical analysis of bioassay (*9*) with the psychophysical method for determination of absolute thresholds (*10*). This procedure required the calculation of the proportion of persons with an unfavorable self-assessment of their teeth for each increment in the DMF and component scores. Application of this procedure to a large sample of the populations of two towns in England (*5*) yielded quantitative differences in self-assessment of the teeth in relation to objective need (DMF) among age and sex categories. In this preliminary study, women appear to be less perceptive of the state of their teeth than men, but there were no differences among the age groups.

The present study was undertaken to:

1. Elaborate and refine this method of analysis.
2. Determine the relation of DMF scores to self-assessments of "need for treatment."
3. Determine the contribution of the D, M, and F components to self-assessments of "state of teeth" and "need for treatment."

Methods

The data for both clinical determinations and self-assessments of oral health were obtained from the study by Bulman and colleagues (*5*). A random sample of 588 persons (2 percent sample), ranging in age from 17 to over 70 years, was taken from the populations of Salisbury and Darlington, England. The following information was obtained for each person: age, sex, and socioeconomic status; number of decayed, missing, and filled teeth and a composite DMF score; and responses to the questions: What state do you think your own teeth are in now? If you went to the dentist today, how much treatment do you think you would need?

The two dimensions of the patients' perception of need—the state of their teeth and the need for treatment—were related separately to the objective measures of oral disease. Responses of "very good," "good," "fair," and "poor" to the question about state of teeth were dichotomized to yield the proportion of unfavorable to total responses among persons for each increment of objective disease classification. Specifically, the responses were reduced to the proportion of "fair" and "poor" among all replies for graded intervals of the scores for DMF and the components D, M, and F. Similarly, the proportion of persons who perceived a need for treatment—that is, those answering that they would need "some" or "a lot" of treatment or that they were "now under treatment"—was calculated for the same graded increments of DMF and component scores. An example of the calculation of the weighted least squares estimate of the DMF_{50} (x_i is midpoint of DMF interval) for reported need for treatment in relation to DMF teeth (x) follows (these data were used for determination of the line of best fit for females in figure 1):

x_i	n_i	p_i	$y_i=\log_e[p_i/(1-p_i)]$	$w_i=n_ip_i(1-p_i)$
2.5 ...	15	0.53	0.122	3.737
7.5 ...	68	0.34	−0.654	15.259
12.5 ...	97	0.44	−0.236	23.901
17.5 ...	68	0.51	0.039	16.993
22.5 ...	39	0.46	−0.163	9.688
27.5 ...	5	0.60	0.405	1.200

$\Sigma w_i = 70.777$

$\Sigma w_i x_i = 907.90$

$\Sigma w_i y_i = -15.60$

$\Sigma w_i x_i^2 = 15{,}632.36$

$\Sigma w_i x_i y_i = -154.78$

$\bar{x} = \Sigma w_i x_i / \Sigma w_i = 13.718$

$\bar{y} = \Sigma w_i y_i / \Sigma w_i = -0.220$

$$b \text{ (slope)} = [(\Sigma w_i)(\Sigma w_i x_i y_i) - (\Sigma w_i x_i)(\Sigma w_i y_i)] / [(\Sigma w_i)(\Sigma w_i x_i^2) - (\Sigma w_i x_i)^2]$$

$$= 4{,}186.258/163{,}755.166 = 0.026$$

$$a = \bar{y} - b\bar{x} = -0.220 - (.0256)(13.718) = -0.57118$$

$$DMF_{50} = -a/b = 22.3118$$

$$\text{Standard error } (DMF_{50}) = (1/b)\sqrt{(1/\Sigma w_i) + (\bar{y}^2/b^2)[1/\Sigma w_i (x_i - \bar{x})^2]} = 4.712$$

Just as the proportion of animals responding to drugs increases with increased drug dose, the proportion of unfavorable self-assessments increased with increments of objective oral disease. Empirical investigation of various transformations of the data yielded a reasonable linear dose-response curve when the logits of the proportion of unfavorable self-assessments were plotted against DMF scores.

Because of heteroscedasticity due to binomial variation and the unequal number of persons within each DMF interval, it was appropriate to determine the equation for the line of best fit by using the following method of weighted least squares (*9*):

Logit transformation of proportion of subjects giving specified response:
$y_i = \log_e[p_i/(1-p_i)]$, where p_i is proportion specified response at i^{th} DMF interval

Weights:
$w_i = n_i p_i (1 - p_i)$

Estimates of intercept a and slope b of fitted straight line $y = a + bx$:

$b = \Sigma w_i (x_i - \bar{x})(y_i - \bar{y}) / \Sigma w_i (x_i - \bar{x})^2$

$a = \bar{y} - b\bar{x}$, where x_i = midpoint of the i^{th} interval of DMF or D, M, or F teeth.

With the exception of the females' judgments of the state of their teeth relative to M, there were no significant deviations from linearity by the chi-square test for fitted relationships (*11*).

As noted in the previous study (*8*), the DMF_{50} can be obtained graphically from the weighted line of best fit by dropping a perpendicular to the abscissa from the intercept of the 50 percent point (logit = 0). The best estimate of the DMF_{50} values or component scores and standard errors may be obtained by dividing the intercept $(-a)$ by the slope (b) from the equation for the line of best fit.

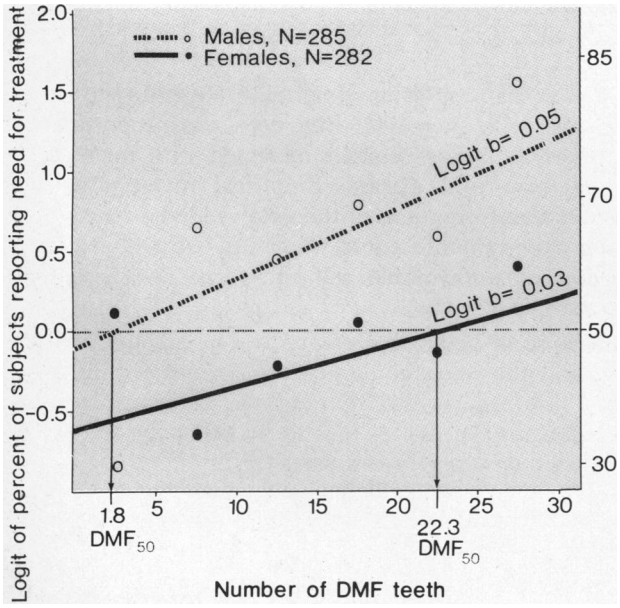
$DMF_{50} = -a/b$

Standard error $(-a/b)$

$$= (1/b)\sqrt{(1/\Sigma w_i) + (\bar{y}^2/b^2)[1/\Sigma w_i (x_i - \bar{x})^2]}$$

Analogous to the ED_{50} in bioassay (*9*), the DMF_{50} is the DMF value at which 50 percent of the persons in the sample perceived the state of their teeth to be unfavorable. In psychophysical terms this number is comparable to the threshold of awareness determined by the method of constant stimuli.

Figure 1. Weighted least squares determination of relation of DMF teeth to reported need for treatment

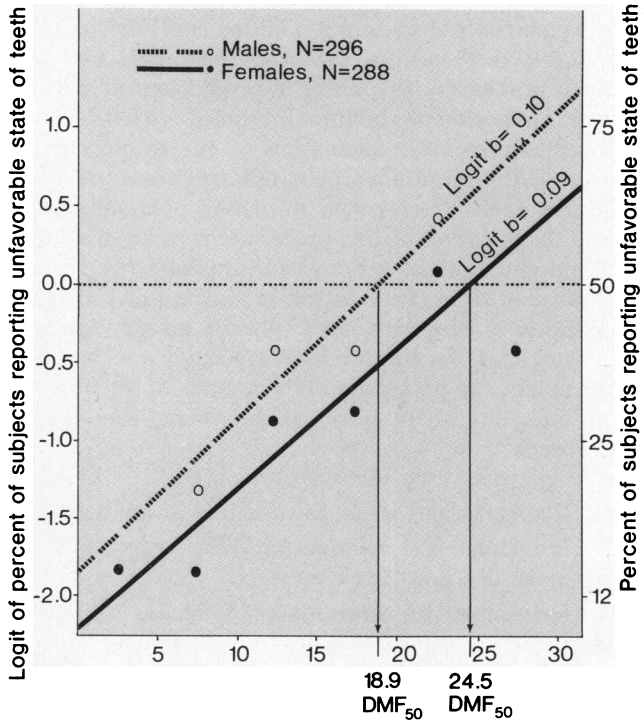


NOTE: DMF = decayed, missing, and filled.

Results

The relationships between the objectively determined DMF scores and the patients' self-assessments are shown in figure 1 for the need for treatment and in figure 2 for the state of teeth. The comparison of males and females is summarized in table 1.

Figure 2. Weighted least squares determination of relation of DMF teeth to reported state of teeth



NOTE: DMF = decayed, missing, and filled.

Table 1. Self-assessments of the state of teeth and the need for treatment in relation to DMF scores (±standard error), for males and females.

Measure	*Males*	*Females*	*Difference (males — females)*
	State of teeth		
Number in sample	296	288	
DMF_x	13.4 ±0.3	13.8 ±0.3	−0.4 ±0.4
DMF_{50}	18.9 ±1.4	24.5 ±1.5	[1] −5.6 ±2.0
Slope	0.096±0.003	0.090±0.003	0.006±0.004
	Need for treatment		
Number in sample	285	282	
DMF_x	13.4 ±0.3	13.8 ±0.3	−0.4 ±0.4
DMF_{50}	1.8 ±2.8	22.3 ±4.7	[2] −20.5 ±5.5
Slope	0.047±0.002	0.026±0.002	[2] 0.021±0.003

[1] $P < 0.01$. [2] $P < 0.001$.
NOTE: DMF = decayed, missing, and filled.

Although the means of the DMF scores for males and females were not significantly different, the males had a statistically significantly lower DMF_{50} threshold than the females ($P<0.01$) relative to the state of their teeth. The DMF score required for 50 percent of the males to give an unfavorable response about their teeth was 18.9, whereas the comparable DMF score for females was 24.5. As may be noted in tables 1–3, the standard errors of the scores are inversely related to the slopes. Thus, the slope provides an indication of the relative precision of the 50 percent threshold. The similarity of the slopes of the fitted lines for males and females, therefore, indicates that the males and females were similarly acute in their preceptions of the state of their teeth. In other words, the percentage increase in unfavorable perception of state of teeth per unit DMF was the same for males and females.

The difference between males and females in their perception of the need for treatment in relation to DMF scores was highly significant statistically ($P<0.001$) and was more pronounced than the difference in perception of the state of their teeth. It was possible to estimate from the weighted line of best fit that a DMF score of 2 was sufficient for 50 percent of the males to respond that they needed dental treatment, whereas an estimated score of 22 was required before 50 percent of the females in a DMF interval sample so responded. Note that the slope of the fitted regression line for males was significantly steeper than the line for females ($P<$ 0.001), a finding which indicates a greater sensitivity of the self-assessment of need for treatment to DMF teeth among males. Thus, for each unit increase in DMF teeth, the estimated increase in the logit of the proportion of males who responded that they needed treatment was almost twice that of the females.

Table 2. Self-assessments of the state of teeth in relation to D, M, and RI scores (± standard error), for males and females

Measure	Males (N = 296)	Females (N = 288)	Difference (males — females)
$D_{\bar{x}}$	3.0 ± 0.2	2.4 ± 0.2	[1]0.6 ± 0.3
D_{50}	7.9 ± 1.1	7.7 ± 0.7	0.2 ± 1.3
Slope	0.12± 0.01	0.20± 0.01	[2]−0.08± 0.01
$M_{\bar{x}}$	5.9 ± 0.3	5.8 ± 0.3	0.1 ± 0.4
M_{50}	23.1 ± 3.0	20.7 ± 2.4	2.4 ± 3.8
Slope	0.05± 0.01	0.06± 0.01	−0.01± 0.01
$RI_{\bar{x}}$	55.7 ± 2.1	62.1 ± 2.0	6.4 ± 2.9
RI_{50}	−11.8 ±29.4	−88.0 ±85.5	76.2 ±90.4
Slope	0.87± 0.36	0.71± 0.46	0.16± 0.58

[1] $P<0.05$. [2] $P<0.001$.
NOTE: D = decayed; M = missing; F = filled; RI = restorative index: 100 F / F + D.

Table 3. Self-assessments of the need for treatment in relation to D, M, and RI scores (± standard error), for males and females

Measure	Males (N = 285)	Females (N = 282)	Difference (males — females)
$D_{\bar{x}}$	3.0 ± 0.2	2.4 ± 0.2	[1]0.6 ± 0.3
D_{50}	0.5 ± 0.4	2.1 ± 0.4	[2]−1.6 ± 0.6
Slope	0.23± 0.01	0.34± 0.01	[3]−0.11± 0.01
$M_{\bar{x}}$	5.9 ± 0.3	5.8 ± 0.3	0.1 ± 0.4
M_{50}	−8.5 ± 3.8	6.4 ± 3.4	[2]−14.9 ± 5.1
Slope	0.04± 0.01	0.04± 0.01	0.0 ± 0.01
$RI_{\bar{x}}$	55.7 ± 2.1	62.1 ± 2.0	[1]6.4 ± 2.9
RI_{50}	110.2 ±20.9	62.1 ± 4.5	[1]48.1 ±21.4
Slope	1.05± 0.16	2.19± 0.17	[1]−1.14± 0.23

[1] $P<0.05$. [2] $P<0.01$. [3] $P<0.001$.
NOTE: D = decayed; M = missing; F = filled; RI = restorative index: 100 F / F + D.

Males had a significantly lower threshold for perceiving the need for treatment ($DMF_{50} = 1.8$) than for perceiving an unfavorable state of their teeth ($DMF_{50} = 18.9$). In contrast, females had about the same threshold for perceiving the need for treatment ($DMF_{50} = 22.3$) as for judging the state of their teeth to be unfavorable ($DMF_{50} = 24.5$). (See tables 1 and 4 for calculation of differences.)

Thus, it seemed that even though the males perceived the state of their teeth as favorable, they continued to perceive the need for at least some dental treatment. Possibly, of course, other factors than those measured by the combined DMF scores influenced their perceptions. This possibility is supported by recent observations that some dental symptoms are more likely to prompt a visit to the dentist than others; for example, pain is more likely to result in a visit than the presence of calculus, or tartar, on the teeth (*12*).

To evaluate the possibility that the D, M, and F components of the DMF scores had differential weights in the process of self-assessment, each of the components was analyzed in a manner similar to that for the DMF values. The results for D and M teeth are shown in tables 2 and 3.

Of the three components, D had the lowest threshold and the smallest standard error for perceptions of the state of teeth and thus appeared to be the most important in making these judgments. Comparison between the sexes with regard to the D analysis revealed that the threshold for reporting a need for treatment was significantly lower for males ($D_{50} = 0.5$) than for females ($D_{50} = 2.1$). Females, however, were more acute in their perceptions of the need for treatment and of the state of their teeth than males, as indicated by the significantly greater slopes.

Initial analysis of the F data revealed that this component alone was not related to patients' perceptions.

This finding is understandable since persons may well differ in their opinion of whether filled teeth represent good or bad teeth. The restorative index (RI) of Jackson (*13*) was therefore used to indicate the percentage of diseased teeth (F + D) that have been treated (F) : RI = 100 F /F + D. To maintain a positive slope relating the proportions of responses concerning the state of teeth or the need for treatment to the restorative index scores, the complements were used: 100 — RI. RI_{50} is therefore the threshold for reporting that no treatment was needed. As can be seen in table 3, females had a significantly lower threshold than males for reporting that no treatment was needed. Both sexes were more acute (as indicated by larger slopes) in judging the need for treatment than in assessing the state of their teeth in relation to both D and the restorative index, and females were significantly more acute than males in their judgments of the need for treatment in relation to the restorative index. The restorative index, which is an indicator of the need for treatment, was not related to the state of teeth.

The data also indicated that M had no substantial influence on perceptions of either the state of teeth or the need for treatment.

Finally, as shown in table 4, the DMF and component thresholds of males for perceived need for treatment were significantly lower than their thresholds for perceived unfavorable state of teeth ($P<0.001$). Among females, the differences were in the same direction as for males, but only for D_{50} and M_{50} were the differences statistically significant. The magnitude of the differences between the state of teeth and the need for treatment was greater for the males, significantly so for DMF_{50} and M_{50} ($P<0.05$).

Discussion

In evaluating the usefulness of the procedures examined in this study, two factors should be considered. First, the apparent lack of a relationship between self-assessments and the M component may be due in part to the unavailability of data on the number of teeth that had been replaced. Missing teeth that had been replaced would certainly be perceived differently from those not replaced and would particularly influence the patients' judgments of the need for treatment. Second, with dentistry as a model the range of objective data is fixed by the number of teeth in the mouth, whereas in bioassay the range depends on a pharmacologically established dose. This limitation partly accounts for the need to extrapolate the subjective data beyond the range of objective observations. Similar limitations may be of concern in the extension of this approach to the comparison of perceived health with other objective measures of health status, such as hearing loss, refractive errors, skinfold thickness, or vital capacity.

Despite these limitations, there seems to be little doubt that D was the most important correlate of perceived state of teeth, or oral health, and that the restorative index was the most important correlate of perceived need for treatment, or need for care. Where significant differences between males and females were identified—that is, for DMF_{50} relative to the need for treatment and the state of teeth, D_{50} relative to the need for treatment, and RI_{50} relative to no treatment needed—males consistently appeared to have lower thresholds for perceiving the state of their teeth as unfavorable and for recognizing a need for treatment. (Since RI_{50} is an index of no treatment needed, the males' higher threshold here is indicative of a lower threshold for need for treatment.) Consideration of these findings alone might suggest that males would use more dental services than females. However, other studies have demonstrated that males actually use fewer dental services than females (*14*). Thus, clearly, the differing thresholds are not translated directly into use of services. In addition to the unexplained sources of variation in the self-assessments of the state of teeth and the need for treatment, therefore, there are still intervening variables to be evaluated in relation to actual use of services.

Behavior with respect to dental care is similar to behavior with respect to other types of health care. Psychosocial and economic factors influence the patient's perceptions of both the need for dental treatment and the resources that provide the treatment, and these perceptions in turn affect use of dental care resources (*15*). Specifically identified by Kegeles (*15*) in the translation of objective need into demand for dental care are the patient's perceptions of his own susceptibility, of the seriousness of dental disease, and of its preventability relative to the availability, acceptability, and accessibility of resources for providing dental care.

The availability of dental care under the British National Health Service for the persons in this study precludes further generalizations from the results about use behavior in the United States. Part of the discrepancy between the behavior predicted from this model and actual behavior of males and females may also be

Table 4. Difference (± standard error) between state of teeth and need for treatment for DMF_{50}, D_{50}, M_{50}, and RI_{50}

Measure	Males	Females	Difference (males — females)
DMF_{50} ...	[1]17.1± 5.5	2.2± 4.9	[2]14.9± 7.4
D_{50}	[1]7.4± 1.2	[1]5.6± 0.9	1.8± 1.5
M_{50}	[1]31.6± 6.5	[1]14.3± 4.2	[2]17.3± 7.7
RI_{50}	[1]—122.0±36.1	—150.1±85.6	8.1±92.9

[1] $P < 0.001$. [2] $P < 0.05$.
NOTE: DMF = decayed, missing, and filled; RI = restorative index: 100 F /F + D.

due to the differences in threshold variability or acuity as reflected in the slopes; that is, the greater slopes for the female sample suggest that the females' perceptions of both the state of their teeth and the need for treatment are more acute than the males' perceptions in this study.

Even though these factors cannot be overlooked, the results obtained thus far have prompted interest in further analyses of these and other data. It may be possible with more sophisticated psychophysical techniques, for example, to use more than dichotomous data to achieve greater precision in relating the subjective assessments of oral health, such as patients' estimates of the number of diseased teeth, to data obtained from dental examination. Multivariate techniques and other statistical approaches could also be used to provide a more accurate measure of the contribution of the objective measures to subjective perceptions of oral health and need for treatment.

References

1. Friedsam, H. J., and Martin, J. W.: A comparison of self and physicians' health ratings in an older population. J Health Human Behav 4: 179–183, fall 1963.
2. Streib, G. F., Suchman, E. A., and Phillips, B. S.: An analysis of the validity of health questionnaires. Soc Forces 36: 223–232, March 1958.
3. Heloe, L. A.: Comparison of dental health data obtained from questionnaires, interviews and clinical examination. Scand J Dent Res 80: 495–499, June 1972.
4. Richards, N. D., Willocks, A. J., Bulman, J. S., and Slack, G.: A survey of the dental health and attitudes towards dentistry in two communities. Br Dent J 118: 199–205, March 1965.
5. Bulman, J. S., Richards, N. D., Slack, G. L., and Willocks, A. J.: Demand and need for dental care. Oxford University Press, New York, 1968.
6. Brunswick, A. F., and Nikias, M. K.: Dentist's measurements and adolescents' perception of oral health [Abstract]. J Dent Res 53 (special issue): 209, February 1974.
7. Berg, R. L., editor: Health status indexes. Proceedings of a conference conducted by Health Services Research. Hospital Research and Educational Trust, Chicago, 1973.
8. Giddon, D. B., and Nornoo, D.: Development of quantitative index of perceived relative to objective need for dental treatment [Abstract]. J Dent Res 53 (special issue): 209, February 1974.
9. Brown, B. W., Jr.: Quantal-response assays. *In* Statistics in endocrinology, edited by J. W. McArthur and T. Colton. Massachusetts Institute of Technology Press, Cambridge, Mass., 1970, pp. 129–143.
10. Engen, T.: Psychophysics, discrimination and detection. *In* Woodworth and Schlosberg's experimental psychology, edited by J. W. Kling and L. A. Riggs. Ed. 3. Holt, Rinehart and Winston, New York, 1971, pp. 11–46.
11. Finney, D. J.: Statistical methods in biological assay. Ed. 2. Charles Griffin and Co., London, 1964, p. 471.
12. Newman, J. F., and Anderson, O. W.: Patterns of dental service utilization in the United States: a nationwide social survey. Research Series No. 30. Center for Health Administration Studies, University of Chicago, Chicago, 1972.
13. Jackson, D.: Measuring restorative dental care in communities. Br Dent J 134: 385–388, May 1973.
14. U.S. National Center for Health Statistics: Dental visits: volume and interval since last visit, United States, 1969. Vital and Health Statistics, Series 10, No. 76. DHEW Publication No. (HSM) 72-1066. U.S. Government Printing Office, Washington, D.C., July 1972, p. 5.
15. Giddon, D. B.: Conceptual basis of behavioral science in dentistry. J Am Coll Dent 37: 276–280, October 1970.
16. Kegeles, S. S.: Adequate oral health: blocks and means by which they may be overcome. *In* Oral health, dentistry, and the American public, edited by W. E. Brown, University Press, Norman, Okla., 1974, pp. 73–122.

SYNOPSIS

GIDDON, DONALD B. (New York University Dental Center), MOSIER, MARILYN, COLTON, THEODORE, and BULMAN, JOHN S.: *Quantitative relationships between perceived and objective need for health care—dentistry as a model. Public Health Reports, Vol. 91, November–December, pp. 508–513.*

To elaborate and refine a previously devised method for quantifying the relationship between perceived and objectively determined dental disease, data on a random sample of 588 patients in two towns in England were analyzed. The data included the number of decayed (D), missing (M), and filled (F) teeth, composite DMF scores, and patients' self-assessments of the state of their teeth and the need for treatment.

The study method was a combination of bioassay and psychophysical techniques. Categorical self-assessments of the state of teeth and the need for treatment were dichotomized to yield proportions, which, when transformed into logits, resulted in a linear relation to increments of dental disease. A 50 percent point for each of the component D, M, and F scores was derived from the intercept of the line of best fit.

The D_{50} for both the state of teeth and the need for treatment was found to be closest to the objective measure ($D_{\bar{x}}$), with the smallest standard error. Although males had a significantly lower D_{50} (0.5) than females ($D_{50} = 2.1$) for need for treatment, with no differences in D_{50} for state of teeth, the females actually had a significantly lower $D_{\bar{x}}$. These data indicate that males as a group had a lower threshold for perception of the need for treatment. This finding contrasts with the observation in other studies that males actually use dental services less than females.