

THE EFFECT OF MORALE ON THE QUALITY OF ANALYTICAL RESULTS*

Barry D. Stewart
Sr. Technical Specialist
Environmental Physics, Inc.
Charleston, SC

ABSTRACT

The quality of analytical laboratory results is determined by the accuracy and precision of the data. Although there are technical reasons why two laboratories may not obtain statistically equivalent results when analyzing the same sample or portions of the same sample, the objective of this research was to evaluate the effects on quality caused by morale.

Ten laboratories which perform radiochemical analyses and participate in the EPA Laboratory Intercomparison Program were selected for this study. A total of 185 participants completed survey questionnaires designed to provide information concerning the overall level of satisfaction among laboratory workers. A scale was devised to assign a numerical value to the level of satisfaction associated with each of the factors of the Maslow, Herzberg, and Alderfer content motivation theories. The resulting satisfaction index reflected the overall level of satisfaction, or morale, among the employees of each participating laboratory.

The quality of each laboratory's analytical results was evaluated using a scale based on the accuracy and precision of the results of the EPA Intercomparison Program. Least squares linear regression was used to determine the degree of association between quality and the level of employee satisfaction for each participating laboratory. No relationship was found between quality and morale.

The survey data indicated that the needs, desires, and morale issues of laboratory workers are not different from workers in other types of jobs. Satisfaction indices were higher for males than females. The number one issue about which laboratory workers in general indicated they were satisfied was relationships with co-workers and supervisors. The number one source of dissatisfaction was effectiveness of top management.

INTRODUCTION

The quality of analytical laboratory results affects every facet of technology. The impact of inaccurate data can be viewed as producing what is known in statistics as Type I or Type II errors, that is, either deciding a problem exists when it does not, or deciding that a problem does not exist when it does. These errors harbor serious health, safety, or financial consequences.

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Aside from nonhomogeneity issues, there are technical reasons why two laboratories might not provide similar results when analyzing the same sample or portions of the same sample. Even when laboratories are licensed and regulated, and equipment calibration and methodology are specified, there can still be serious discrepancies in analytical results.

The focus of this study¹ was to determine the extent to which human factors are associated with quality. The research was conducted from October 1993 through September 1994 during which time the author was employed at Los Alamos National Laboratory. The sample consisted of 10 laboratories located across the United States which currently participate in the Environmental Protection Agency (EPA) Laboratory Intercomparison Program. It was assumed that the results obtained for this sample will be applicable to other types of laboratories.

FACTORS WHICH AFFECT MORALE

Numerous attempts have been made to determine what it is that initiates motivated behavior. Three of the most publicized and researched content theories of motivation are Abraham Maslow's need hierarchy, Frederick Herzberg's hygiene - motivation theory, and Clayton Alderfer's ERG theory².

Maslow defined five groups of needs and arranged them in a hierarchy. According to Maslow, the lower level needs must be satisfied before an individual becomes concerned about higher level needs. For example, until basic safety and security needs are satisfied (such as pay, benefits, and working conditions), an individual's focus will be restricted to these issues.

In his classic research, Herzberg described two types of motivational factors. One set of *extrinsic* job conditions, when not present, results in dissatisfaction. The presence of these hygiene factors, which he called satisfiers, however, does not necessarily motivate employees.

The other set of *intrinsic* job conditions, known as motivators, inspires levels of motivation that result in good job performance. Herzberg theorized that it is not necessary to satisfy all needs in a hierarchical fashion. He believed that motivation could take place as long as the level of dissatisfaction among the hygiene factors was not excessive. In fact, some individuals might even tolerate high levels of dissatisfaction (such as low pay) if their strong need for intrinsic factors is being satisfied (such as recognition among peers).

Alderfer's ERG theory condenses the Maslow need hierarchy into three need categories, *existence*, *relatedness*, and *growth*. Alderfer's theory also differs from Maslow's in another, more important way. He theorized that a person will move upward through the need hierarchy until dissatisfaction occurs. Continued dissatisfaction will produce frustration and negative rewards. As a result, the individual focuses on a lower level need as a surrogate for the need where frustration occurred. Consistent frustration with higher level needs may, therefore, permanently prevent motivated performance.

The objective of this research was to determine if there are specific conditions present in laboratories which consistently produce high-quality results, and that these conditions are either absent or present to a lesser extent in laboratories that perform poorly or erratically. The survey of laboratory employees attempted to assess current morale. Laboratories with consistently good results should have motivated employees, effective leadership, and responsive management. Those laboratories with consistently poor results would therefore be expected to have little or no motivation among employees and/or ineffective leadership.

From the total number of very satisfied or satisfied responses to the survey questions in relation to the unsatisfied or very unsatisfied responses, a numerical rating could then be obtained from the percentage of respondents who are satisfied with that particular issue. An

index value could then be calculated which described overall morale of the organization. Similar indices were derived for the Maslow, Herzberg, and Alderfer theories.

METHODOLOGY

The participating laboratories were sent questionnaires to be completed by the organization's employees who were engaged in radiochemical analysis. The results of the survey were used to assess current morale. The level of morale at each laboratory was assigned a numerical value which was based on the number of "Satisfied" or "Very Satisfied" survey responses. This was accomplished by designing the survey questions to determine the importance of certain workplace issues to the respondent and the degree to which the respondent was satisfied with that issue. By evaluating each question for each respondent, a relative measure of his or her morale was obtained. The process was repeated for each respondent in the organization, and a mean value for the laboratory was then computed.

The next step was to devise a scale by which laboratory results could be compared. It was necessary to define "good analytical results" and "poor analytical results." The EPA Intercomparison Program was established to provide a means to evaluate the performance of laboratories engaged in the analysis of drinking water under the Safe Drinking Water Act (SDWA). In the EPA program, intercomparison samples submitted to the laboratory are analyzed in triplicate. This enables one to compute a mean value and standard deviation for the set of measurements. The EPA considers a mean value acceptable when it is within three standard deviations of the known value, where the standard deviation is defined as the "expected precision" (a somewhat arbitrary value) divided by 1.732.

Another way to compare results is to use a system that considers both accuracy and

precision. A method was devised which assigned a numerical score between 0 and 1 to each analysis mean. The score is the product of an accuracy rating and a precision rating, both of which could range from 0 to 1.

The instrument used to gather the data for this research was taken from the literature from V. Schletzer^{3*} and was abridged for this research. The questions were modified slightly so that the allowed responses (Very Satisfied, Satisfied, Neither, Unsatisfied, Very Unsatisfied) would be appropriate. Also, since morale is intangible and based on an individual's personal experiences, beliefs, and feelings, it was necessary to emphasize the importance to the participant of making his or her responses on the basis of how well he or she was satisfied with each of the survey items. A code known only to the author was included in the footer of each page to identify the organization from which the questionnaire was being returned.

The formulas used to calculate the accuracy, precision, and overall rating are given below.

$$Accuracy = 1 - \frac{|Known Value - Measured Value|}{Known Value} \quad (1)$$

$$Precision = 1 - \frac{\sigma}{Measured Value} \quad (2)$$

where σ = the standard deviation of the measured value. Since not all laboratories participated to the fullest extent in the EPA Intercomparison Program, a laboratory's overall quality rating

*"A Study of the Predictive Effectiveness of the Strong Vocational Interest Blank for Job Satisfaction," unpublished doctoral dissertation, University of Minnesota, 1965.

was weighted according to the number of Intercomparison samples analyzed. For example,

$$Score = \frac{\sum (Accuracy \times Precision)}{N} \quad (3)$$

where N is the number of EPA analyses performed. Most of the EPA samples contain multiple analytes, and therefore each analyte measured provides a basis for comparison. The highest value for the accuracy of a given analysis was 1.0 and would occur when the difference between the known value and measured value was zero. The maximum value for precision was also 1.0 and would be obtained when $\bar{I} = 0$. Such a situation sometimes occurs due to rounding of results to the EPA's required number of figures. The score for each analysis was the product of accuracy and precision. Dividing the sum of the individual scores by the number of analyses performed compared the rating to the maximum score possible.

By means of least squares regression techniques, the satisfaction index and analytical score from each laboratory were evaluated to determine what kind of, if any, correlation existed between morale and the quality rating. A coefficient of determination which is 0.8 or less indicates that there is very little predictive validity to the degree of association. In such cases, there are two possible explanations. The first is that there is simply no relationship between the two variables. The second is that while there may be a relationship, large uncertainties in the measurement of the variables prevent the accurate assessment of the strength of the relationship. The latter condition exists when the sample size is small. After calculation of the various indices used in the study, descriptive statistics were used to determine demographic information about the general attitude and morale of laboratory workers.

RESULTS

Figure 1 shows the least squares regression line for the satisfaction index vs. analytical score for the participating laboratories. The satisfaction indices for demographic categories age, gender, job classification, type of organization, and years of service with current employer are shown in Figures 2-6, respectively.

An issue unrelated to morale is the use of written procedures in the laboratory. There is widespread support among various regulatory agencies for verbatim compliance to written procedures. As shown in Figure 7, however, this research did not find clear evidence of a direct correlation between data quality and the use of written procedures.

The top five issues with which laboratory workers are most satisfied and dissatisfied are given in the table below.

<u>Most Satisfied</u>	<u>Most Dissatisfied</u>
Relationships with co-workers	Effectiveness of top management
Relationships with supervisors	Long-term stability of their jobs
Working hours	Opportunities for promotion
Quality of technical supervision	Opportunities for professional advancement
Chance to see results of their work	Freedom from stress

CONCLUSIONS

There was considerable variation in the quality of the analytical data among the participating laboratories. However, the variation was not as great as the satisfaction indices. All of the participating laboratories except one had positive Maslow social needs indices. This was demonstrated by the fact that relationships with co-workers and supervisors topped the list of the things about which laboratory workers are satisfied. The best explanation for the lack of correlation between quality and morale is found in the Alderfer ERG theory. Alderfer believed that when a person fails to obtain satisfaction for higher-level needs, he or she may revert to a

lower-level need where there has been consistent reward and fulfilment. In the case of laboratory workers studied in this research, social relationships in the work place seem to have served as the source of continued satisfaction.

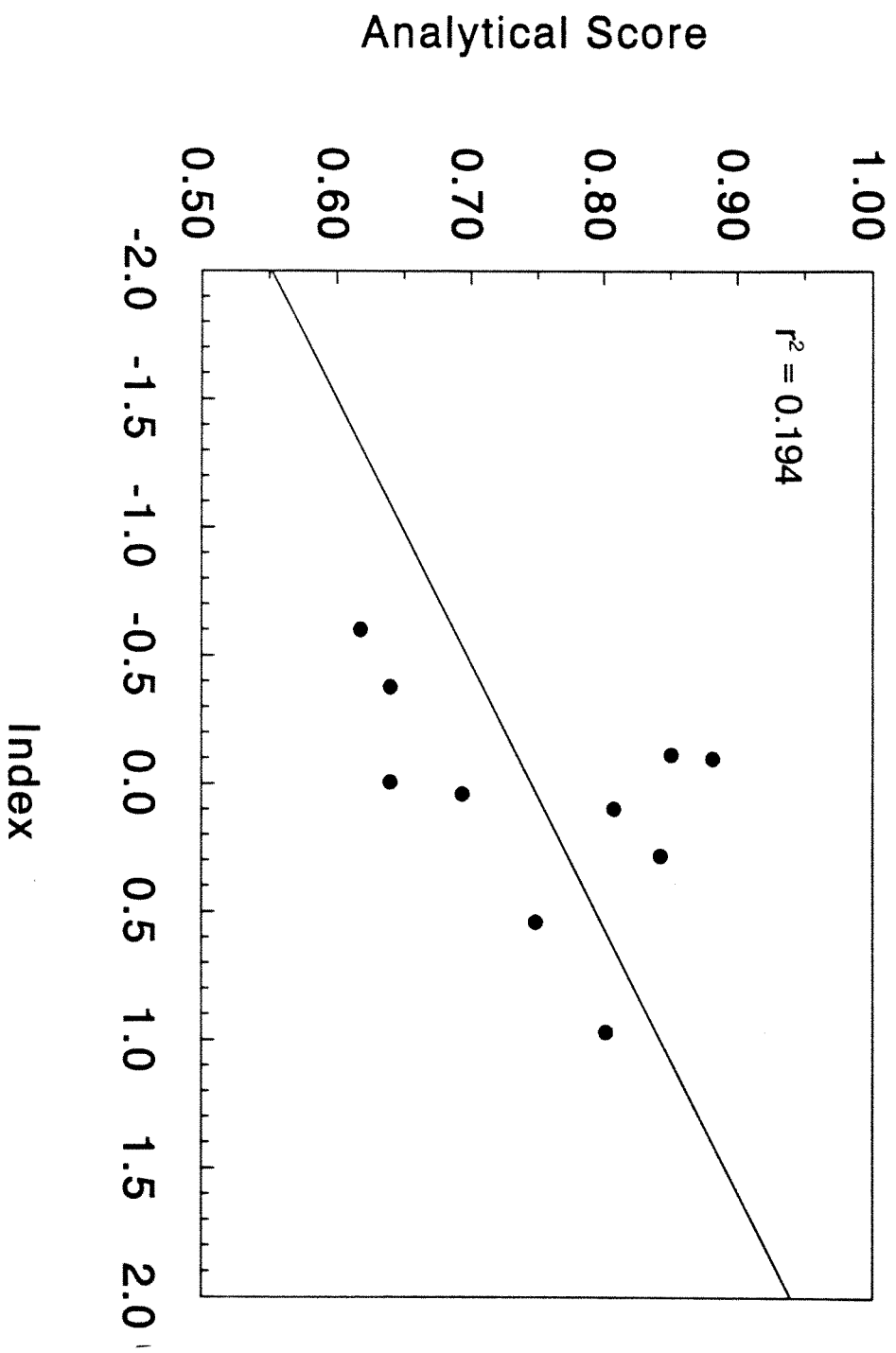
Although there is widespread use of written procedures among the laboratories studied, the results of this research suggest that written procedures by themselves do not necessarily guarantee quality data. This is an extremely important finding. It emphasizes the fact that with analytical laboratories, quality cannot be inspected into the final product. Analytical laboratories are not factories assembling high precision components to produce quality products. While procedures are necessary to control work and define acceptable levels of quality, perhaps it is more effective to rely on laboratory workers who are well-trained, educated, and experienced so that they may be afforded the flexibility to make necessary adjustments.

In today's world of rapid change, an organization must be flexible and innovative in order to survive. This requires the organization's employees to be able to deal with changes if management is to be effective in the implementation of tactical and strategic plans. Good morale is conducive to teamwork, and empowered teams will be effective in supporting the organization's leadership.

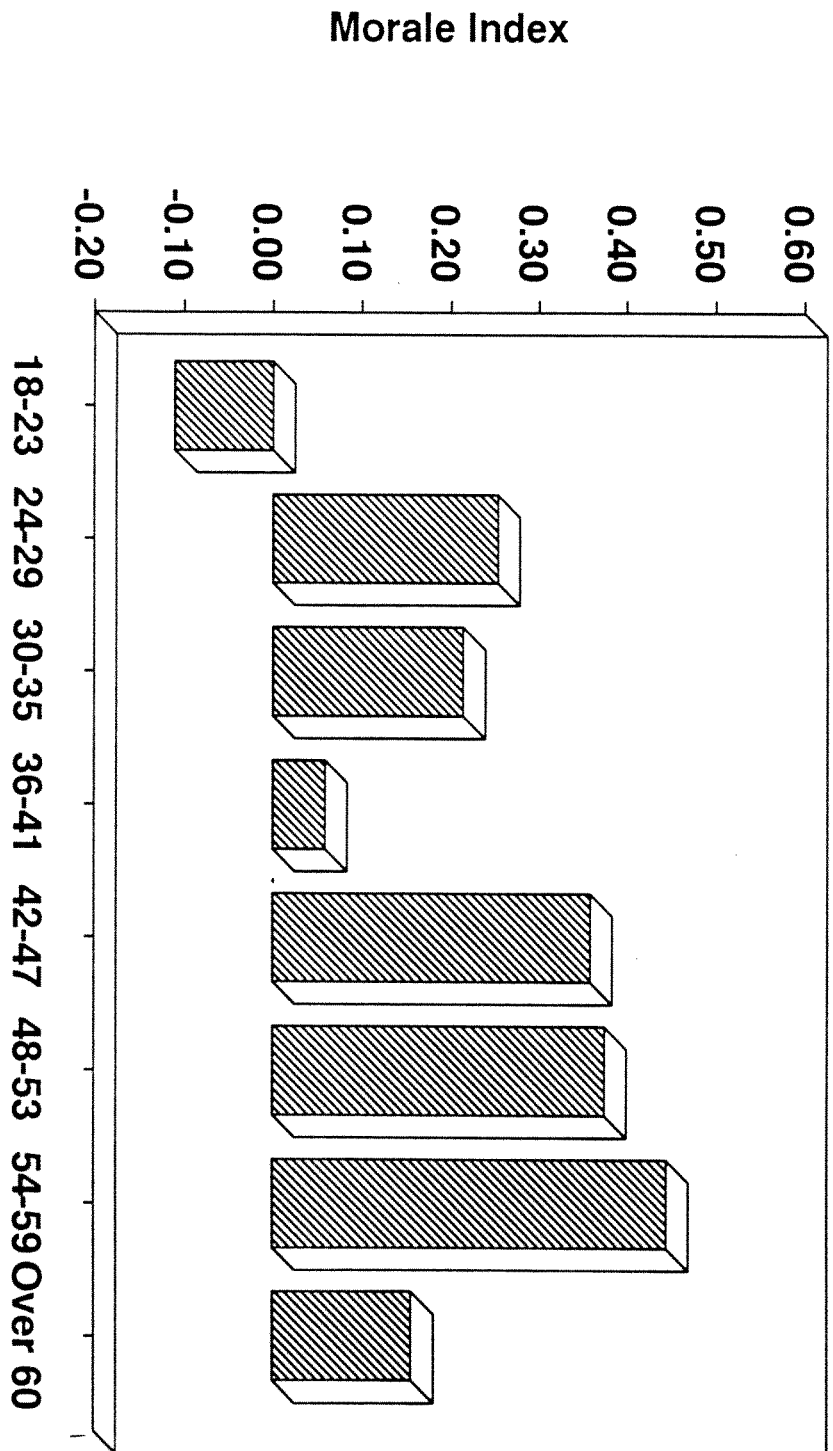
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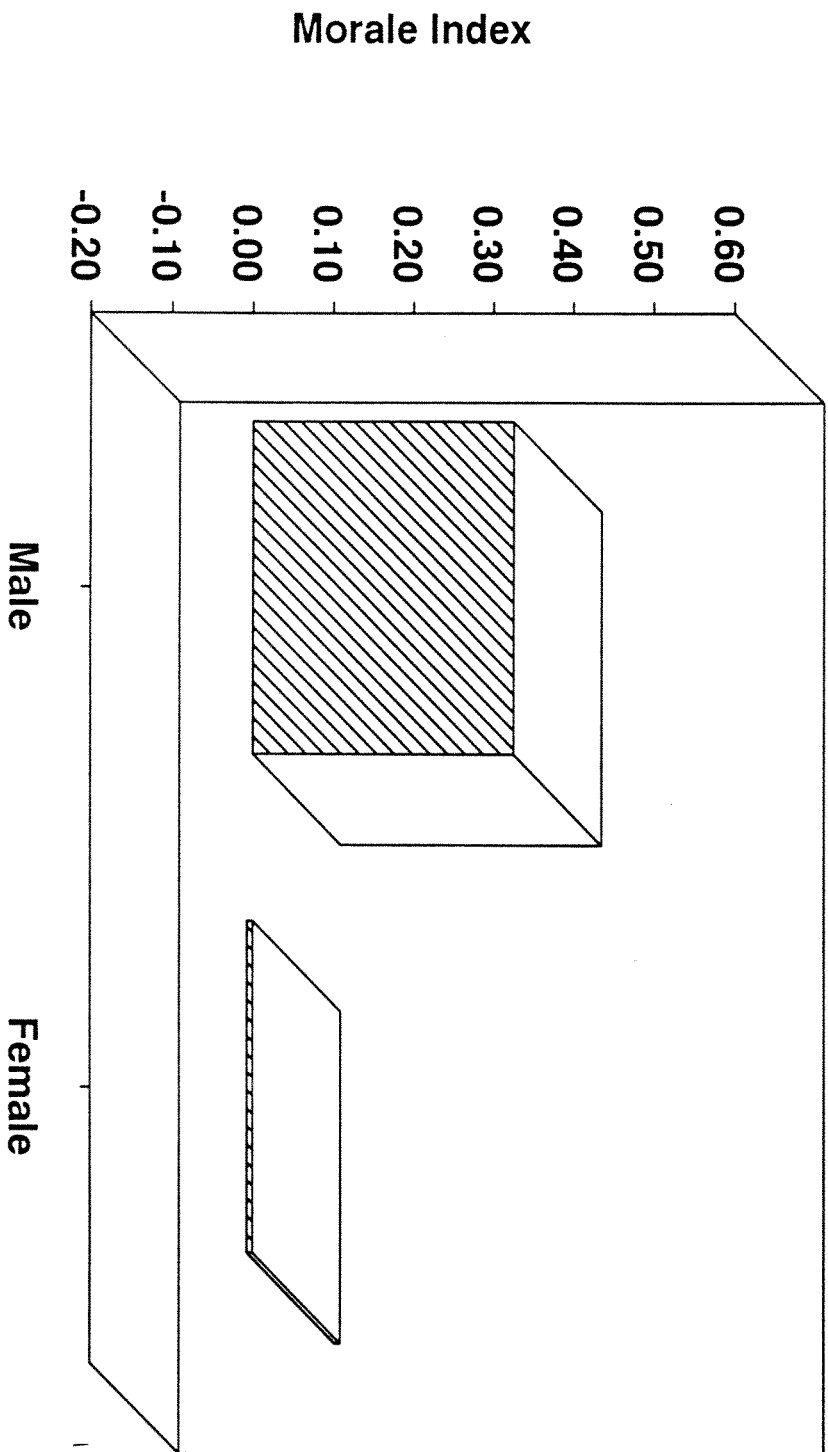
Satisfaction Index



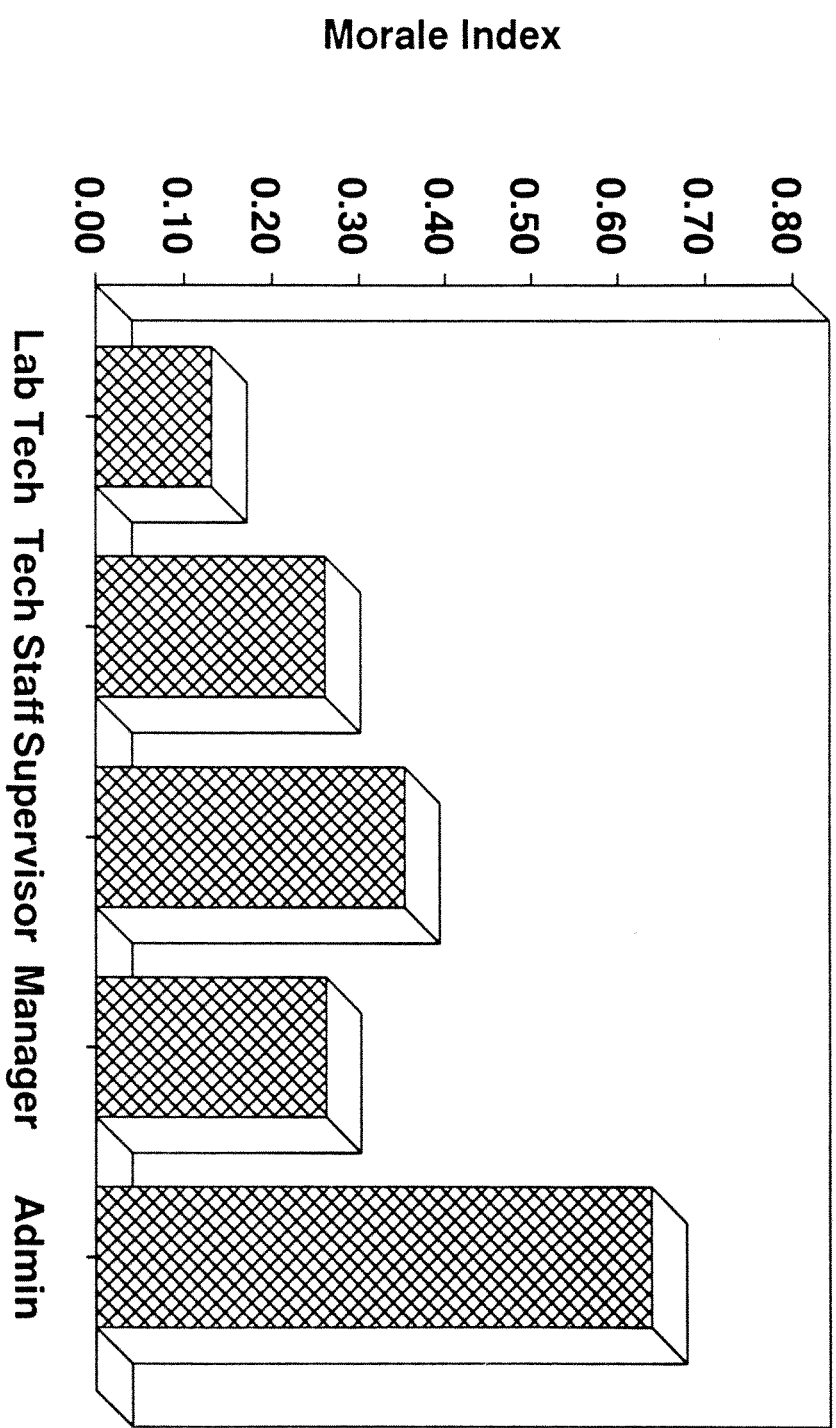
Morale Index and Age



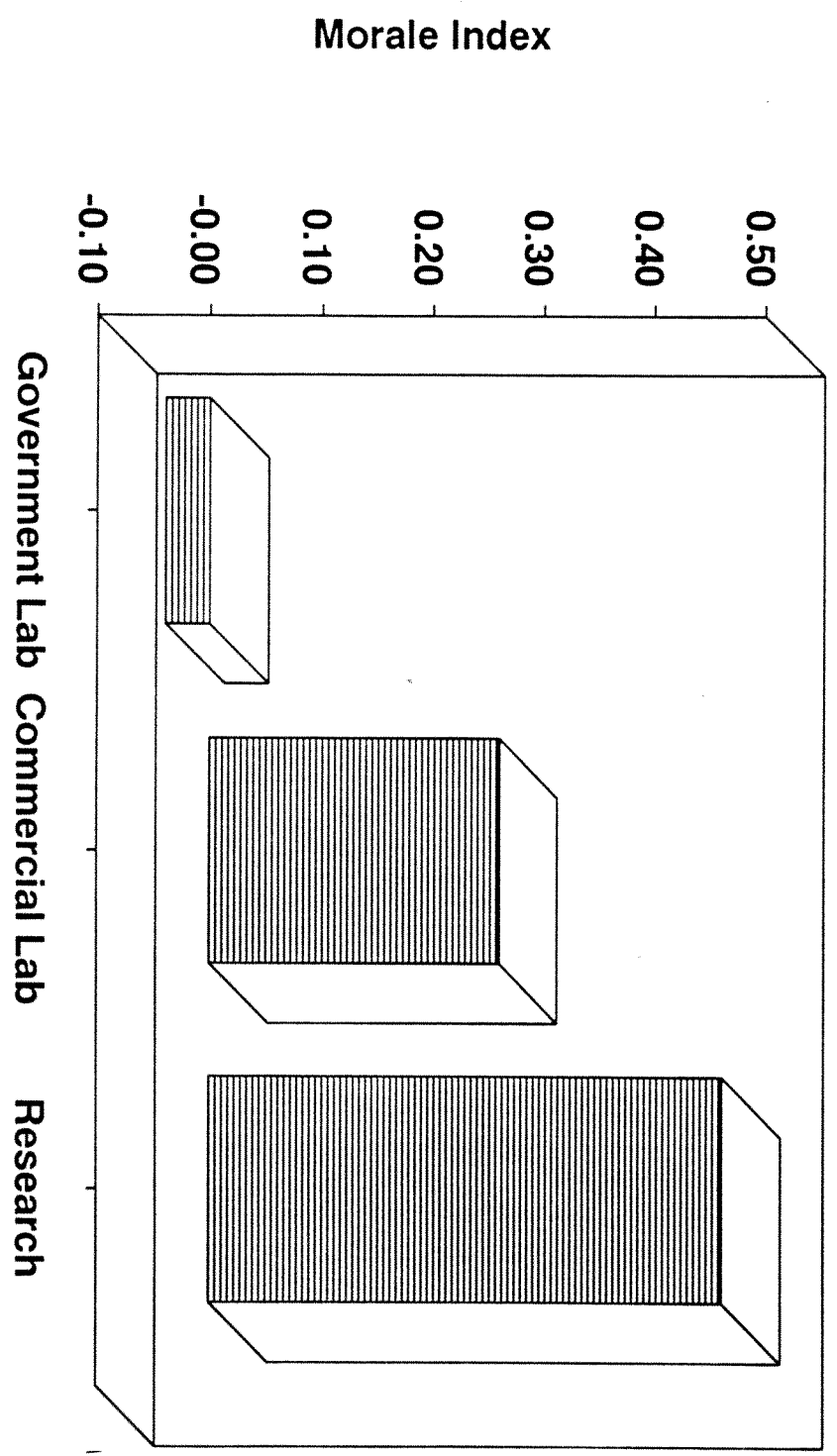
Morale Index and Gender



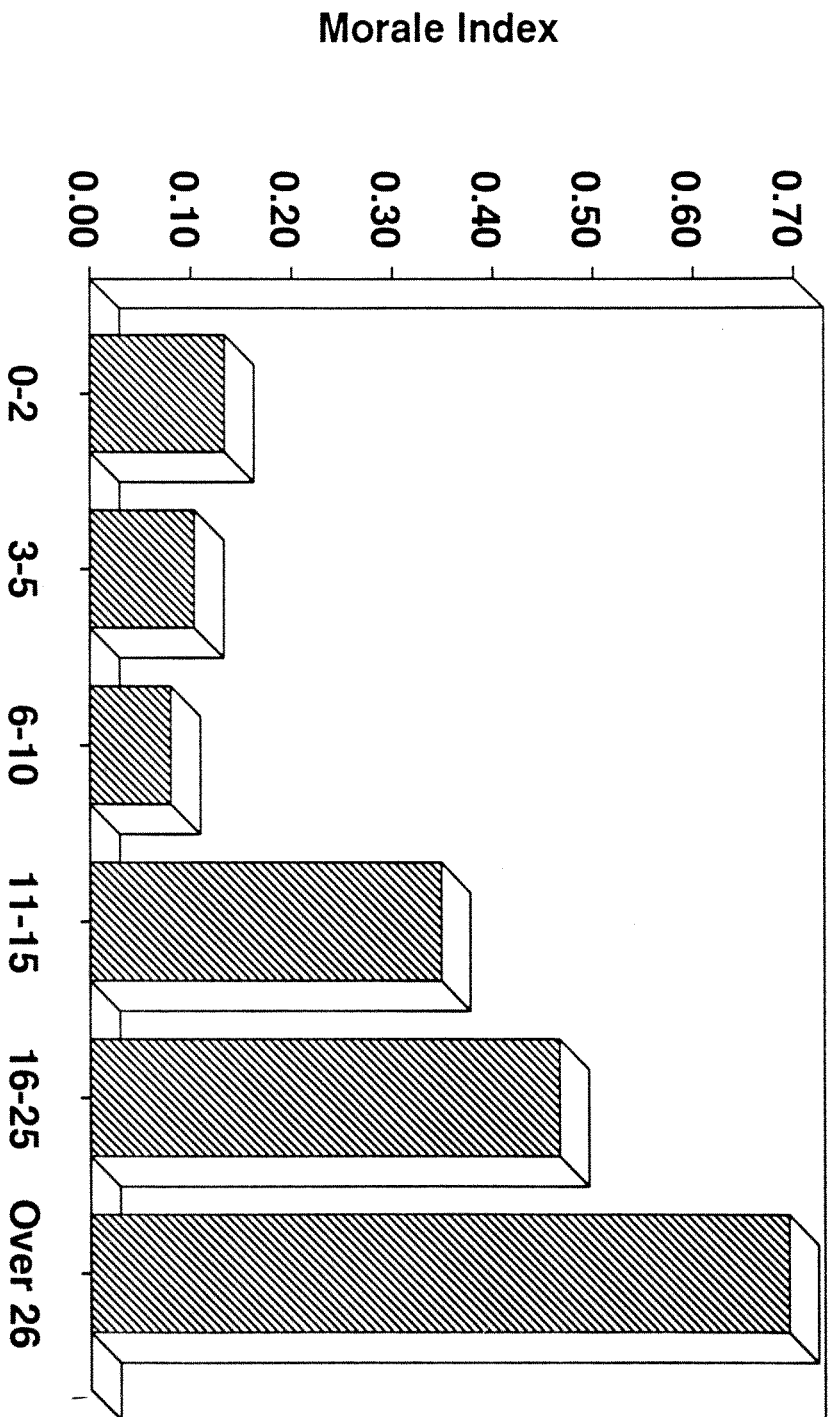
Morale Index and Job Classification



Morale Index and Organization Type



*Morale Index and Years of Service
with Present Employer*



*How the Use of Written Procedures
Affects the Quality of Analytical Results*

