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Domains of Practice: Relationship to Part II of the American Board of Health Physics Certification Examination

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INTRODUCTION

Five domains of practice constitute the majority of professional activities of certified health physicists (PES83, DE88). These domains of practice include measurements, regulations and standards, facilities and equipment, operations, and education and training. A listing of typical activities in each of these domains appears in the Appendix.

The American Board of Health Physics (ABHP) designed Part II of the 1987 written examination to cover these identified domains of practice at approximately the same weights as identified by the Professional Examination Service survey conducted for the ABHP in 1983. As a result each question appearing in the ABHP Comprehensive Examination 31, Part II, had domain weight assignments. The sum of the five domain weight assignments totaled 100% for each question.

At this point the basis of this study can be postulated. A measure of the candidates' ability in each of the domains of practice can be determined from scores for each question given the assigned weights. This information could be provided to candidates who were unsuccessful in passing the examination to assist them in strengthening performance in the affected domains for a subsequent examination attempt.

The remainder of this paper will discuss the determination of domain weight assignments, the model to be employed, the resulting hypothesis, methods to test the model, and the results. Discussion of the results and conclusions will serve to finish this study.

DOMAIN WEIGHT ASSIGNMENT

Selection of questions for Examination 31, Part II, (comprehensive certification) included determination of domain weight assignments. To accomplish this determination, each member of the question reviewing team was asked to provide their assessment of domain weights for each question. Team members were provided with the list of typical activities in each domain (Appendix). The only restriction imposed was that the sum of weights must equal 100%.

The question reviewing team included members from the following entities within the ABHP: the Board of Directors, the Comprehensive Certification Panel of Examiners, and the Power Reactor Panel of Examiners. Each member was familiar with the concept. The reviewing team numbered over 30 people with a wide range of professional expertise.

There was not unanimity of agreement on weight assignments for each question among members of the reviewing team. An important assumption was invoked at this juncture: the best estimate of the "true" domain weight assignment for each question is the average of the individual weights from all members. These weight assignments are presented in Table 1. Table 2 provides a description of the topics of each of these questions.

Table 1. Domain Weight Assignments for American Board of Health Physics Examination 31, Part II, Comprehensive Certification.

Question	Weights (%)				
	Measurement	Regulations and standards	Facilities and equipment	Operations	Education and training
1	31	10	28	4	27
2	38	11	11	6	34
3	49	18	15	17	1
4	36	10	24	24	6
5	48	5	36	8	3
6	38	52	5	3	2
7	66	2	27	2	3
8	38	21	31	9	1
9	35	21	20	22	2
10	29	23	27	18	3
11	42	12	39	6	1
12	32	15	33	12	8
13	23	23	32	19	3

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THE MODEL

The model employed for this discussion assumes the candidates' ability in each of the domains transcends the boundary of a particular question; i.e., an 80% capability in one domain (e.g., measurements) would be the same for all questions in which that domain is present. Since each candidate answers 10 questions, the multiple regression solution to these 10 questions in five unknowns would yield estimates of the candidates' capability in each of the five domains. This measure of capability in identified domains of practice may be more informative than the test score itself.

A mathematical representation of the model follows:

$$S_i = V_i \sum_{j=1}^{5} C_j D_{ij} \qquad (1)$$

Table 2. Topics of Questions.

Question	Topic
1	Population exposures to radon
2	Biological effects of ionizing radiation--multiple choice
3	Low-level activity in sewage plant influent
4	^{137}Cs implant--multiple layer shield
5	Activation of steel light fixture
6	ICRP Publication 30--multiple choice
7	Ionization chambers--multiple choice
8	PWR iodine reduction calculation
9	Optimization--multiple choice
10	Respiratory protection and ALARA
11	^{85}Kr dispersion--e.g., stack height calculation, etc.
12	Dose to fetus from fluoro unit
13	LSA radiation waste shipment

After: American Board of Health Physics Examination 31 (1987).

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where:

S_i = Score obtained for the"i"th question

V_i = Point value of the "i"th question

C_j = Candidates' capability in the"j"th domain

D_{ij} = Domain weight for the "j"th domain in the "i"th question (Table 1).

Three observations should be made at this juncture:

1. The candidate's capability, C_j, in a particular domain should meet the following restriction: $O \leq C_j \leq 1.0$.
2. There is no constant present in Equation 1.
3. The sum of domain weight assignments for a particular question totals 100%.

RESULTS

The model was tested by solving the multiple equations represented by Equation 1. The candidate's score for each question taken was substituted into Equation 1. The system of equations was then solved for the C_i values using the stepwise regression routine contained in Microstat* Release 2.09 on an IBM PC.**

Stepwise regression was chosen to allow the selection of only those variables that are statistically significant in explaining the observed variations of the data. The F to enter and the F to remove values were the program default values of 3.0. Thus, the resulting equation selected could have no domains represented to all five domains represented. Figure 1 indicates the various combinations of domains selected for 46 cases.

Several of the figures that follow provide a box and whisker plot to indicate the range of the variable of interest. The box portion of the plot represents the range of the 25th to the 75th percentile; the line through the midportion of the box represents the median value. The lines extending from the top and bottom of the box represent the minimum and maximum values, respectively. The number in parentheses represents the number of cases.

The results of the stepwise regression calculations were especially interesting in light of the first two observations about the model (previous section). The values for C_j for a particular candidate did not meet the restriction of ranging between 0 and 1 (Figure 2). Values greater than 1 and less then 0 (negative values) were observed. In almost all cases the constant in the resulting equation was not 0. Further discussion of these two anomalies will be provided in the next section.

The multiple R^2 of the resulting regression equations ranged from 0 (no regression) to >0.9 (Figure 3). The results from 55 candidates provided 53 cases with significant regressions ($R^2 > 0$). Only two cases were best represented by the average value of the score.

The 53 cases in which the regression was statistically significant were further subdivided into two groups. The demarcation between these two groups was arbitrarily chosen as $R^2 \geq 0.50$. This demarcation provides a group in which more than 50% of the observed variation can be attributed to (i.e., explained by) the indicated regression equation. This group included 46 of the 53 cases. The remaining 9 cases (7 + 2) will not be discussed further. Figure 4 is a pie chart with these three categories represented.

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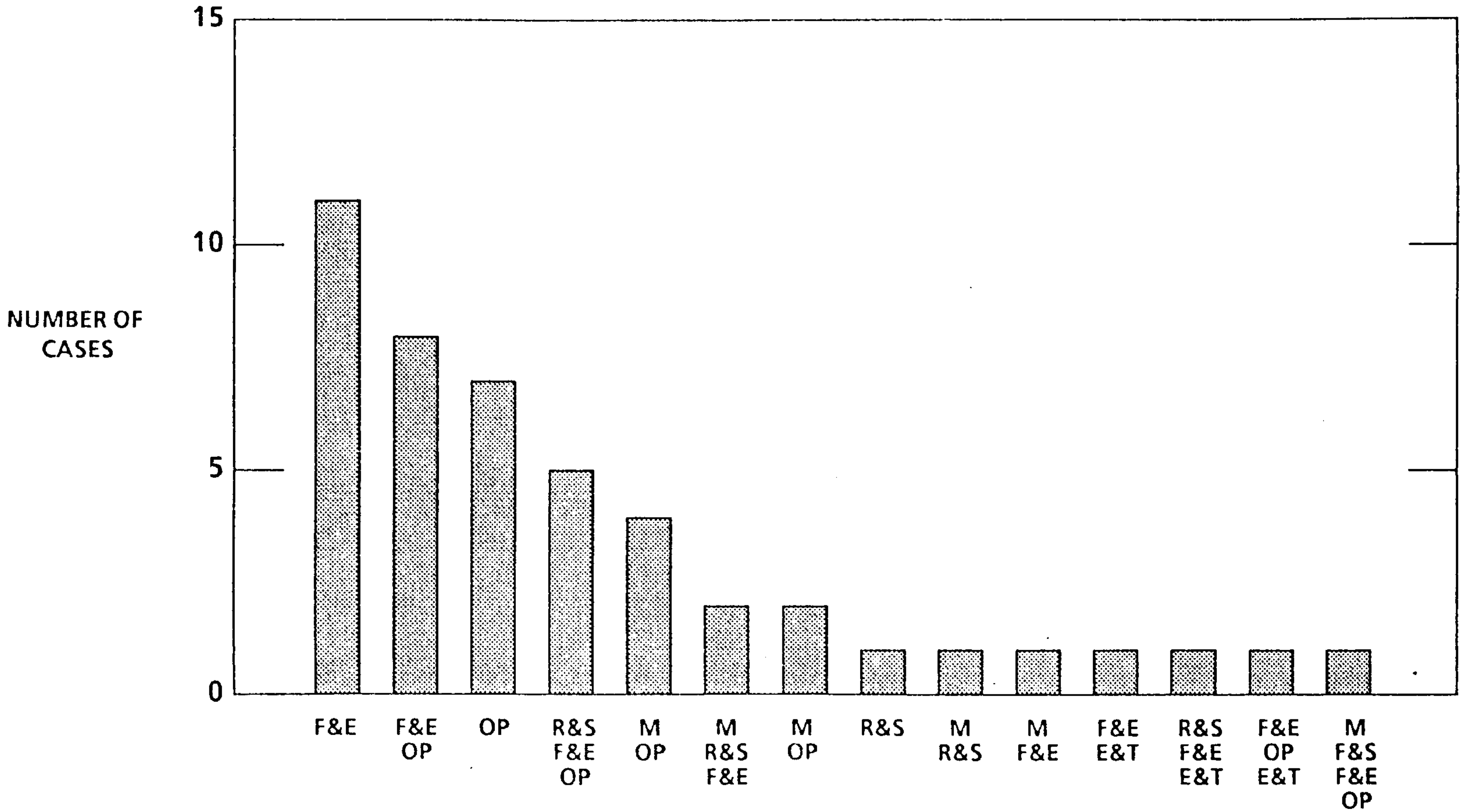

Figure 1. Combinations of Domain Constants.

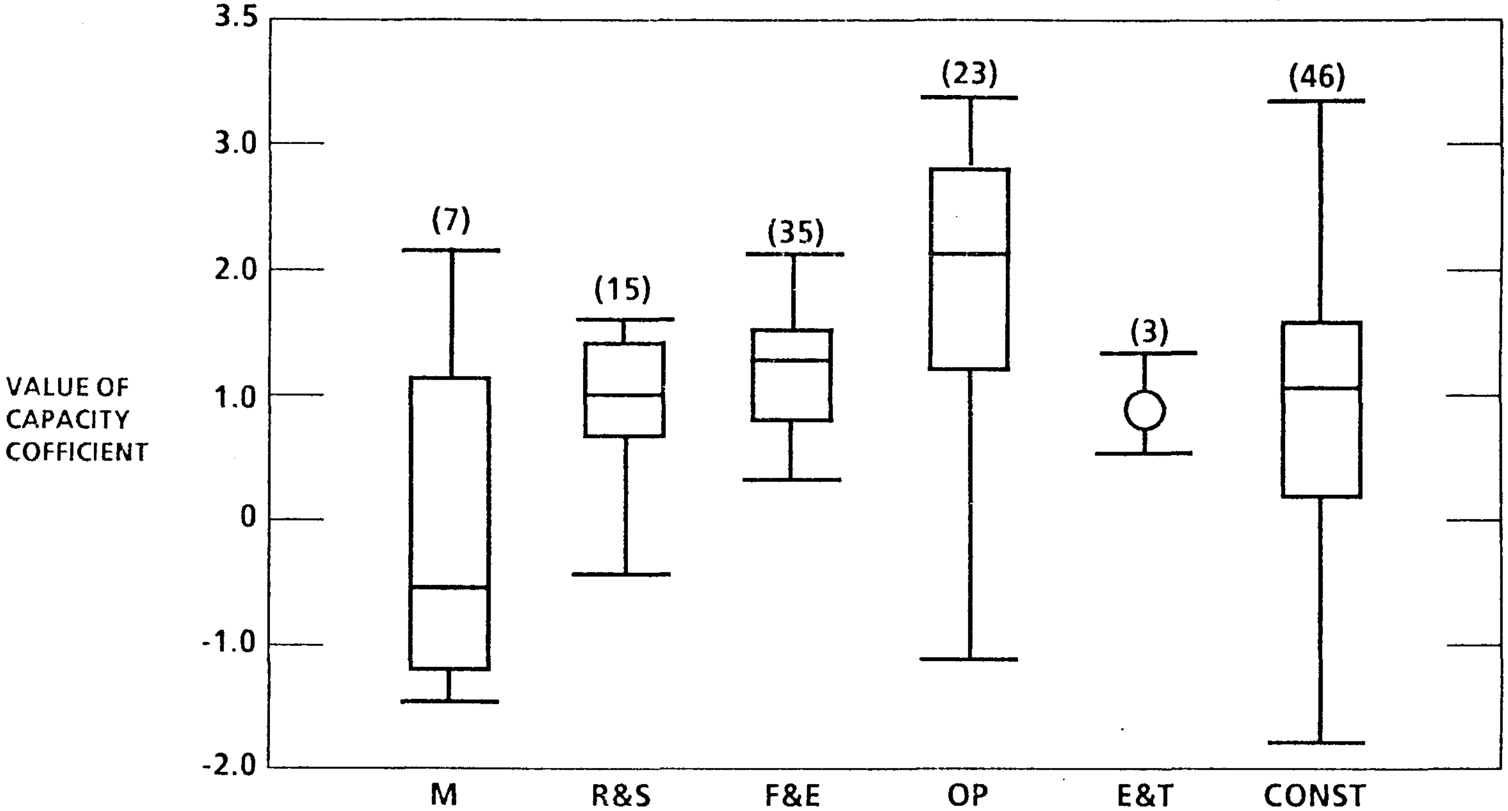

Figure 2. Candidates Capability Range of Domain Coefficients ABHP Examination 31 (1987).

PS88 3320-6

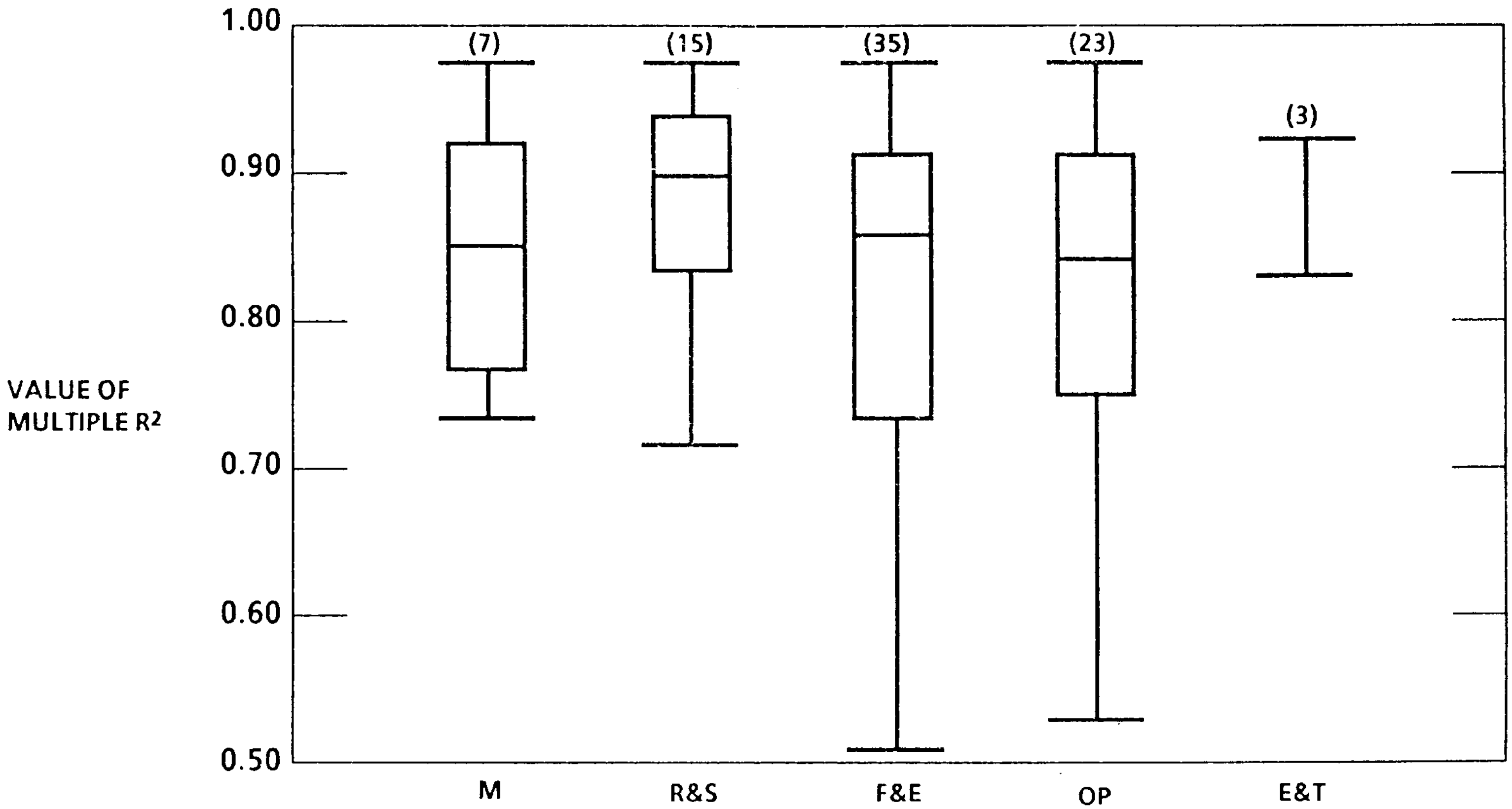

Figure 3. Range of Multiple R^2 Values for Domain Coefficients.

PS88 3320-7

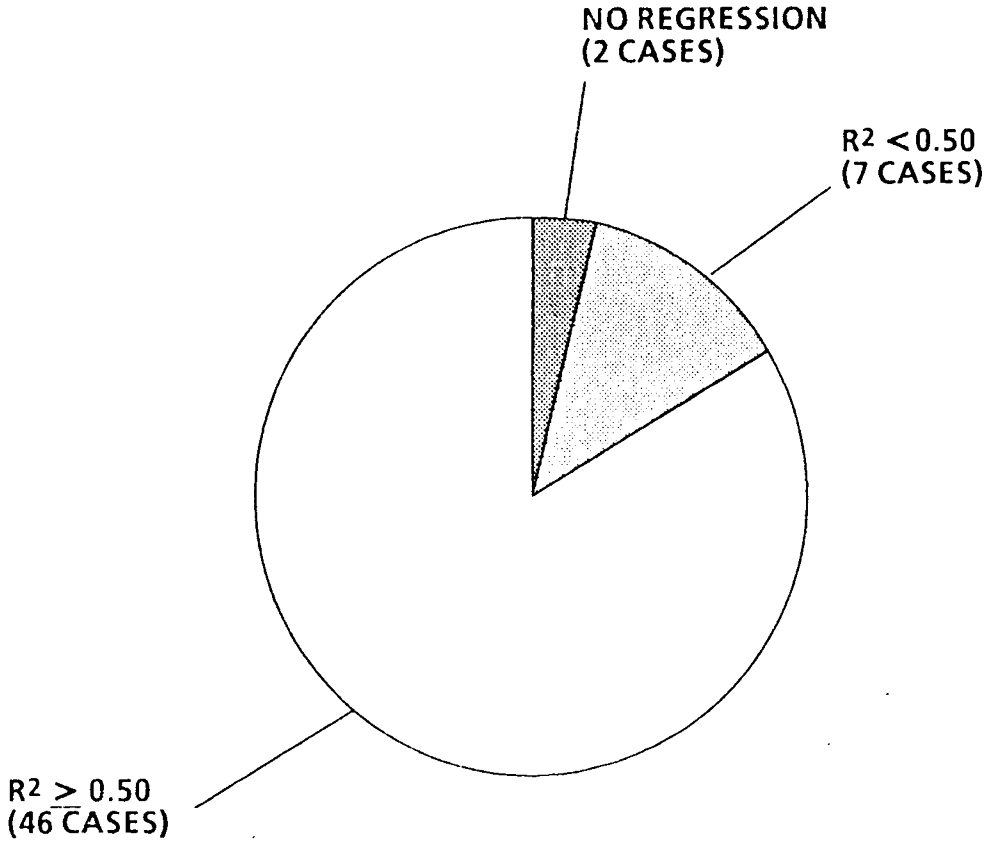

Figure 4. Distribution of Multiple R^2 Values.

PS88 3320-8

DISCUSSION

Inferring candidates' capability in the five domains of practice from their respective test scores and the assigned domain weights appears to be statistically valid. In 46 of the 55 cases (83%) the resulting regression equation could account for more than 50% of the observed variation. Three anomalies were present. The first anomaly concerns the inclusion of only one or two domains in most of the resulting regression equations. Several explanations may be plausible:

1. The implicit assumption of independence between predictor variables in multiple linear regression was not met; e.g., in a case where the facilities and equipment domain was selected as the predictor variable in the "best" regression equation, another domain such as operations or regulations and standards may be highly correlated with the selected variable. This would be consistent with the expected expertise of a health physicist specializing in facility-related health physics responsibilities; this individual should be knowledgeable in operations, regulations, and standards pertaining to facility operations.

2. There was not a sufficient range of a particular domain weight present over the questions selected to provide a basis for estimating a predictor variable for that domain (DR81). Experimental design methods that would prevent this defect were not employed in this situation.

3. Selection of a stepwise regression routine as opposed to selecting a "full-model" (all five domains) regression routine limited the number of domains selected. A full-model routine will provide estimates of all predictor variables. The standard error of estimates for some of these predictor variables may be so large that a value of 0 for that variable cannot be ruled out.

The second anomaly concerns the fact that the values of the predictor variables fall outside the 0 to 1 range. This is reasonable when only one or two variables are selected. A value greater than unity implies that contributions from other domains (possibly correlated) are included. The explanation of negative predictor variables is not so easily interpreted. If a positive value is interpreted as a degree of ability in a particular domain, is a negative value to be interpreted as a degree of disability in that domain?

The third anomaly concerns the presence of a constant term in the prediction equation. The proposed model would require a value of 0 for this term. In most cases its value is not 0. One explanation is that the constant term represents a general knowledge of, or ability in, the domains not represented in the selected equation. There is also the problem of relating negative values of the constant. Again, would this represent a general disability in the unspecified domains?

Constraints placed on the range of values for acceptable predictor variables (ranging from 0 to 1) and requiring all domains to be represented is worth investigating. There are techniques available for performing such estimates (DI86). This avenue was not investigated in this study.

A final comment on the nature of the weight assignments for each domain in each question. As indicated previously, there was a wide variation in the values assigned to these weights by each member of the review team. This implies large coefficients of variation in the values reported in Table 1. An implicit assumption in regression analysis is the precision of the independent predictor variables (DR81). When the precise domain weights are not known, additional uncertainties are added to predictions. These uncertainties were not considered in this study.

CONCLUSIONS

The determination of five domain weights for each question on Part II of the ABHP Comprehensive Certification Examination 31 allowed estimation of candidates' ability in some of the five domains. Over 80% of the cases resulted in a statistically significant regression equation with a multiple R^2 greater than 0.50. The results from a stepwise regression procedure did not follow the postulated model in its entirety. In the majority of cases one or two domains were all that were selected to explain the variation in a candidate's score on each of the 10 questions taken. In addition the predictor variables for the domains selected fell outside the model specified ranges of 0 to 1 in many cases. Thus, the original goal of measuring a candidate's ability in each of the five domains was not fully met.

Based on the encouraging regression relationships, the pursuit of these relationships should be continued, especially for future ABHP examination results. The following two avenues of approach should be investigated:

1. A least-squares estimation procedure that allows specification of constraints on the predictor variables

2. The process for determination of domain weights for each question and strives to reduce uncertainties in these estimates.

The final goal of these determinations would be to have the ability to report back to individual candidates their scores for each question and an indication of their performance in the domains of importance in the practice of health physics.

ACKNOWLEDGEMENTS

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REFERENCES

DR81, N. R. Draper and H. Smith, 1981, *Applied Regression Analysis*, 2nd edition, John Wiley & Sons, New York.

DI86, C. H. Distenfeld and R. J. Vallem, 1986, "A Composite Empirical and Analytical Method to Predict the Magnitude of Surface Contamination in Semi-Accessible Areas," in *Health Physics Considerations in Decontamination and Decommissioning*, Proceeding of the Nineteenth Mid-Year Topical Symposium of the Health Physics Society, Knoxville, Tennessee.

DE88, D. H. Denham and R. L. Kathren, "*The Changing Emphases in Health Physics,*" PNL-SA-14719, Pacific Northwest Laboratory, Richland, Washington.

PES83, Professional Examination Service, 1983, "Domains of Practice of Certified Health Physicists," Report to American Board of Health Physics.

APPENDIX A

DOMAINS OF PRACTICE

Typical Activities for Consideration in the
American Board of Health Physics
Certification Examination

1. Measurement (M)--30% weighting--typical activities.

   - Specify methods.
   - Assess surface contamination.
   - Present data and reports.
   - Assess internal deposition and calculate dose.
   - Measure airborne radioactivity level.
   - Collect and analyze environmental media.
   - Quantitate radiation fields in workplaces.
   - Measure external dose received by workers.
   - Collect and analyze samples.

2. Regulations and Standards (RS)--16% weighting--typical activities.

   - Assure operations are conducted ALARA.
   - Maintain license.
   - Assure proper response to emergencies.

3. Facilities and Equipment (FE)--24% weighting--typical activities.

   - Determine shielding requirements.
   - Determine potential environmental impacts.
   - Determine containment and ventilation requirements.
   - Review current and proposed operations and engineering control.
   - Perform hazards analysis and risk assessment.
   - Specify warning and access control system.
   - Specify instrumentation for measuring radiation and radioactivity.
   - Specify equipment for remote handling.
   - Specify protective equipment and clothing.

4. Operations and Procedures (OP)--18% weighting--typical activities.

   - Review current and proposed operations and recommend radiation controls.

5. Education and Training (ET)--12% weighting--typical activities.

   - Provide for training and development of personnel.
   - Educate and inform the public.