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Psychometric Analysis and Validity of the Medical College Admission Test at the Aga Khan University

by

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Abstract

Objectives: The purpose of the study was to 1) determine the effectiveness of admission criteria used by the Aga Khan University Medical College for predicting students' performance during medical school, and 2) to identify a parsimonious model for admission decisions that is most predictive of students' performance using latent variable path analysis.

Method: The data of three cohorts of students (n=276) admitted in the years 2003, 2004 and 2005 was obtained from the AKU Registrar's Office and the AKUMC Examination Cell. Progress of the three cohorts during medical school was followed longitudinally through years one to five. Psychometric analysis of the admission and medical school measures was done to gather evidence of reliability and validity Descriptive statistics were computed and sub models were run for each of the dependent variable. Factor analysis for identification of latent variables and linear regression analysis using backward regressions models was done to determine the relationship between the independent and dependent variables. Structural equation modeling was used to study latent variable path models assessing the impact of the independent variables on dependent variables.

Results: English language was shown to be the only predictor in the regression model for clinical reasoning and decision making (F=14.92, p =<0.001). A three factor structure was identified for predicting validity of admission decisions for achievement in medical school employing Maximum Likelihood (ML) estimations (n=112). Fit indices: χ^2 (21) = 59.70, p =<.001 CFI=.873; RMSEA = 0.129; SRMR = 0.093

Conclusion: A three factor model of aptitude for medicine, science knowledge and achievement in medical school was the most theoretically coherent model for predictive validity of admissions at AKUMC. The written tests of cognitive ability used for admission and progress during medical school had adequate validity, but measures of non cognitive ability need further improvement. Admission favors applicants from the British system of education. Prior attainment and scores on science subtest of the admission test predict performance in the first two years of medical school. The performance of written tests of clinical reasoning and decision making are best predicted by the scores on the English language subtest while being a female predicts better performance in assessment of clinical skills.

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Dedication

I dedicate my thesis to all my teachers, mentors and role models who have consciously and unconsciously helped in making me the person and the professional that I am today.

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List of Abbreviations

A –level	Advanced Level
AAMC	American Association of Medical Colleges
AchMS	Achievement in Medical School
AGFI	*Adjusted Goodness of fit index*
AKU	Aga Khan University
AKUMC	Aga Khan University Medical College
AKUMC-AT	Aga Khan University Medical College Admission Test
AM	Aptitude for Medicine
BMAT	Biomedical Admission Test
BS	Biological Sciences
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Indexes
CIV	Construct Irrelevant Variance
CRDM	Clinical Reasoning and Decision Making
CS	Clinical Skills
CU	Construct Under Representation
DIT	Defining Issues Test
EFA	Exploratory Factor Analysis
F	Factor (latent variable)
GAMSAT	Graduate Australian Medical School Admission Test
GAMSAT	Graduate Australian Medical School Admission Test
GCSE	General Certificate in Secondary Education
GPA	Grade Point Average
KBBS	Knowledge of Basic Biological Sciences
LASSI	Learning and Study Strategies Inventory

LVPA	Latent Variable Paths Analysis
MBBS	Bachelor of Surgery and Bachelor of Medicine
MCAT	Medical College Admission Test
MCC	Medical Council of Canada
MCCQE	Medical Council of Canada Qualifying Examinations
MCQ	Multiple Choice Questions
ML	Maximum Likelihood
MMI	Multiple Mini Interviews
NBME	National Board of Medical Examination
OSCE	Objective Structured Clinical Examination
O – level	Ordinary Level
PA	Prior Attainment
PB	Professional Behavior
PC	Personal Characteristics
PCAT	Pharmacy College Admission Test
PS	Physical Sciences
RMSEA	Steiger's Root Mean Square Error of Approximation
SAT	Scholastic Achievement Test
SCAF	Student Continuous Assessment Form
SEM	Structural Equation Modeling
SJT	Situational Judgement Tests
SK	Science Knowledge
SPSS	Statistical Package for Social Sciences
SRMR	*Standardized Root Mean-Square Residual*
UGPA	Undergraduate Grade Point Average
UK	United Kingdom

UKCAT	United Kingdom Clinical Aptitude Test
US	United States
USMLE	United States Medical Licensing Examination
V	Variable
VR	Verbal Reasoning
WGCTA	Watson-Glaser Critical Thinking Appraisal
WS	Writing Sample
Y1	Year one of medical school
Y2	Year two of medical school
Y3	Year three of medical school
Y4	Year four of medical school
Y5	Year five of medical school

CHAPTER I – INTRODUCTION

Background

The purpose of the selection process for any educational program is to select from a group of applicants those who have the maximum potential to complete the respective education and graduate as competent professionals for the kind of work they are expected to perform with the appropriate professional behaviours.[1] For the study of medicine it means that the medical school admissions committee identifies students with a potential to complete medical studies and to be a good doctor. This is a very important task for a profession which is demanding both during study and practice and has a great social responsibility as its graduates are expected to deal with issues related to life and death.

Selection procedures and criteria for entry into medical schools vary across countries. Most of the studies available are from Canada and the United States (US) with relatively fewer studies of medical school admission criteria from Europe, Australia and other parts of the world. Selection in medical schools in Canada and the US are partly based on scores on a standardized Medical College Admissions Test (MCAT) and undergraduate grade point average (UGPA), quality of undergraduate medical institution, referral letters, personal statements and interviews.[2,3,4,5] In the United Kingdom (UK) until recently the criteria used by medical schools include prior attainment as an indicator of academic ability, insight into medicine, extracurricular activities and interests, personality, motivation, and linguistic and communication skills. [6,7] Australian medical schools use the Graduate Australian Medical School Admission Test (GAMSAT) for selecting students.[8,9,10]

Demonstration of the validity of selection decisions is essential as it means that the students offered admissions were considered to be most suitable for the study of medicine as opposed to those not selected. This necessitates the undertaking of validation studies in order to justify the use of assessments for decisions that have a long-term effect on the personal and professional lives of the students as well on the health work force and quality of health care.[11]

Demonstration of effectiveness of the selection process has been studied by correlating factors considered for admission with scholastic performance during medical school,[8,11,12,13] at licensing examination[4,14,15,16] and residency education.[17] There are few studies that have gone beyond residency into actual practice. Longitudinal studies are recommended to study the validity of the admission decisions based on medical practice and career satisfaction.[18] The factors traditionally considered for selecting medical students included prior academic attainment, knowledge of science subjects, and reasoning skills (verbal and quantitative).[16,19] Over the years, however, there has been increasing realization of the role of non-cognitive attributes that are considered important for the functioning of a medical student and future physician.[2,20] Many instruments are being used ranging from non-structured informal interviews to semi-structured panel interviews[21] and highly structured multiple mini interviews.[22]

The most reported validity evidence is associations between various screening methods used at the time of admission which include but are not limited to admission test,[23] interview,[2] personality inventories,[19] intelligence tests, situational judgement vignettes[24], personal statements[5] and referral letters[25] and success in medical school and licensingf examinations[1].

Performance on measures of Scholastic performance

The first reports of a medical college admission test (MCAT) came from the US where the Moss Scholastic Aptitude Test was introduced in 1928 to assess suitability of applicants for the study of medical education and to provide an objective measure to select medical students. However this test was critiqued for assessing recall of factual knowledge and its limited breadth. The Moss test was first revised in 1946 by the American Association of Medical Colleges (AAMC) and renamed as the Medical College Admission Test in 1948.[26] Since then the MCAT has been revised four times; the second time in 1962 with the inclusion of general knowledge, then in 1977 with increasing emphasis on science knowledge and lastly in 1991 with inclusion of a subtest that included a writing sample. The current MCAT has four sections: 1) The physical sciences section is intended to assess problem solving ability in general chemistry and physics; 2) the biological sciences section is intended to do the same for organic chemistry and biology; 3) the writing sample section requires the composition of two essays, intended to measure candidates' ability to develop a central idea,

[1] These are also called as outcome variables or criterion variables. In this report I will refer to them as dependent variables

synthesize concepts, and present those ideas cohesively, logically, and with correct use of grammar and syntax and 4) the Verbal Reasoning section consists of approximately seven passages, each followed by 5–7 questions, whose correct response requires the candidate to understand, evaluate and apply the information and arguments provided.[19,27] These versions of MCAT have been compared for predictive validity. In many earlier studies the relationship of MCAT with first two years of medical education have been reported and earlier studies had shown that MCAT science section was an adequate predictor of performance in the pre clinical years.[12] Studies conducted later showed that MCAT and undergraduate grade point average in science subjects together had better correlations with performance in the first two years as well as of scores on the National Board of Medical Examination (NBME) Part I than any one of the variables independently.[2,27,28]

Table I: Historical development of the MCAT from 1948 to 2011 (Adapted from Callahan, et al. 2010)[13]

	Pre 1978	1977 – 1991	Post 1991
Science achievement	+		
Science problem solving (composite score derived from Biology, Chemistry and Physics subtests)		+	
Biological sciences			+
Physical sciences			+
Verbal ability	+		
Skill analysis reading		+	
Verbal reasoning			+
Writing sample			+
Quantitative ability	+		
Skills analysis: Quantitative		+	
General information	+	+	

Studies of association with assessment of clinical knowledge showed that the post 1977 version of the MCAT total and subtest scores on general knowledge, and skill analysis (verbal and quantitative) significantly predicted scores on NBME Part II examination as well as locally prepared tests of clinical knowledge.[8] Further studies have consistently demonstrated that MCAT scores and UGPA (science) effectively predict performance on the United States Medical Licensing Examination (USMLE) Step 1 and its predecessor NBME part I with validity coefficients ranging from $r = .39$ to $.63$.[14]

Current studies on the reliability and predictive validity of MCAT also support earlier reports that the MCAT is a good predictor of performance in medical school and also on the USMLE Step 1 (examination of Basic science knowledge), Step 2 (examination of clinical knowledge) and Step 3 (examination of clinical skills).[29] The predictive validity increases when MCAT scores are combined with undergraduate science GPA.[27,30] A meta analysis of 23 studies shows that the MCAT predictive validity for total and subtest scores have large to medium effect sizes (r values based on Cohen's D) for assessment of basic science and clinical knowledge and skills but moderate predictive validity for performance on licensing examinations[16]. Callahan[13] reports that verbal ability subtest scores have higher validity coefficients for performance on NBME Part II./USMLE Step 2 and Part III/Step 3.

Reports of association of demographic variables with outcome measures have studied sex, age and ethnicity. Some studies have shown no significant association between sex and academic performance[12] while others[13] have reported larger validity coefficients on the MCAT for women than men in predicting Part III/Step 3 performance. Relationship of academic performance to age of students has been reported to be negative.[12] Studies of race and ethnicity as predictors of academic performance in medicine have been equivocal.[31,32]

Although the MCAT has been studied for its association with performance in medical school and in licensing examinations, there are few studies that look at the complete assessment process including observed variables for aptitude for medicine, achievement in medical school and demographic /personal characteristics and determine their relationship with measures of achievement in medicine.

Context of this study

Study of validity of selection decisions are easier in countries where there are centralized national level admissions and licensing examinations due to availability of standardized measures of assessment and a large pool of applicants in a variety of medical schools. Lack of a standardized uniform national level examination for admission to medical school or for licensing purposes, poses a problem since the study is limited to one school with limited sample of students and assessment methods that vary. Pakistan is one such country without national level entry and licensing examinations for the study of medicine. Admission in medical schools has been traditionally offered based on the scores obtained in high school (grade 12) in physics, chemistry and biology as well as non science subjects including literature, vocabulary and grammar in English and Urdu (official and national languages respectively). The cut off score for selection in medical schools would vary every year based on the highest percentage achieved in the pre-medical science examinations and the number of available seats. An admission test was introduced for the first time in Pakistan in 1983 with the starting of the Aga Khan University (AKU), the first medical university to be established in the private sector in Pakistan.[33] With time and the opening up of many more private sector medical and general universities in the country the practice of using admission tests has caught on. Entry tests are now conducted by the respective provincial governments for selection of students in public sector medical colleges under their administrative control. The private sector medical colleges however, are allowed to conduct their own entry tests.[34] Medical College admission tests, in Pakistan, are developed by organizations/ institutions with varying capacity of technical expertise in item construction. The written tests are largely one-best answer type of multiple choice questions with no systematic studies of validity and reliability. Only three studies could be found that provide some evidence for predictive validity. Systematic psychometric analyses and validity studies are therefore required.

Selection process at AKU

The applicant pool for AKU medical college (AKUMC) comes from within and outside of Pakistan. It is the first medical university in Pakistan to use admission tests and hence has a history of using quality assurance procedures for test construction and analysis. Trained and qualified item developers are used to construct the various examinations. About 2500 to 3500 applicants write the test for admission to 100 seats at AKUMC every year. Detail of selection process is provided in Appendix A, however a brief introduction of the procedures is given below.

1. Admission test comprising of 180 multiple choice questions of one best-answer type to assess the applicants' knowledge of Biology (40 questions), Chemistry (40 questions), Physics (40 questions), Math problems (20

questions) and English comprehension (40 questions). The questions aim to assess understanding of the concepts relevant to the study of medicine and are targeted at the high school level. A sample of an admission test provided to the applicants is in Appendix B.

2. Top 350 – 400 scorers of the admission test are invited for the interviews (using a ratio of 3.5 interviewees per medical college seat). The cutoff level varies from year to year. Two separate interviewers use a structured format to interview each student. Each interview lasts for about 30 minutes. The interview is intended to assess initiative, leadership potential relevant to available opportunities, independent thinking, maturity relevant to age, motivation for medicine, communication skills, adaptability, socio-cultural awareness, awareness of health issues, ethics and extracurricular interest considered relevant to the practice of medicine. The *Interview Guide* is in Appendix C.
3. Students are given an opportunity to submit their curriculum vitae and are required to support their claims with appropriate evidence. They write about their awards, honors, extracurricular activities, work experience etc. They are also asked to provide two letters of references.
4. An admission committee of 12 members, including the Dean of the medical college who heads the committee, reviews the information of each short listed candidate provided by the Registrar's office. The committee members are selected from within AKU faculty, other academic institutions, community

leaders and representatives of the Aga Khan Foundation. The members rate each candidate on a scale of 1-4 on the information provided consisting of demographic profile, schools attended, academic record of secondary and post secondary education, score on admission test, ratings and comments given by the two interviewers, salient features of referral letters, leadership positions during academics, voluntary work undertaken and other notable academic and extra-curricular achievements. The ratings are given individually by the admission committee members and the sum of the ratings is expressed as a percentage in the final rank ordered list for admission.

Statement of the Problem

Rahber, et al.[33] reported that AKU medical college admission test (AKUMC-AT) predicted scholastic performance in the first years of medical college and an association between the system of prior education (Pakistani or British) and academic ability. Given the importance of decisions based on admissions tests, much more psychometric work is required. The present study therefore extends and provides more comprehensive psychometric analysis and investigation of the validity evidence for the AKU admissions process and may also help in identifying components of the AKUMC selection process that are more predictive of students' performance during medical college and will be useful in improving the selection process at AKU.

Research Objectives

The purpose of the present study was to gather evidence for the validity of decisions made on the basis of medical college admission criteria used by AKU. The main objectives were to study the evidence for predictive validity of criteria used by AKUMC for selecting students and to identify a parsimonious model for selecting students that best predicted performance in medical school. A structural equation model incorporating these variables was proposed and tested.

Chapter II contains a review of studies on predictive validity of admission criteria in medical education, and a brief discussion on validity and structural equation modeling technique. Chapter III outlines methods used in the descriptive, exploratory and structural equation model analyses of the data. Chapter IV presents the results of the psychometric, exploratory and structural equation modelling analyses. Chapter V summarizes the findings and provides a discussion of the results in the context of medical education over the past four decades, the strengths and limitations of the study, and the conclusions. Appendix A- G provide information on the admission process and detailed tables of psychometric, exploratory and latent variable path analysis (LVPA).

CHAPTER II – LITERATURE REVIEW

This chapter is organized into six sections: 1) a brief discussion on the theory of validity especially predictive validity, 2) a review of structural equation modeling (SEM) as a statistical tool to test latent variable path analysis (LVPA) for predicting validity of the admission criteria, 3) effectiveness of measures used for determining the predictive validity of decisions relating to admission in medical school, 4) psychometric concerns in studies of predictive validity, 5) summary of literature review, and 6) research questions and proposed model for this study.

Theory of Validity

Assessments have become a hallmark of the quality of any educational system. With greater understanding of learning and developments in the field of psychometrics, assessors and test developers have been held accountable for the inferences that are made on the basis of the assessment scores. This has led to validation exercises in assessment and educational assessors are required to adduce validity evidence for the assessments.[11] The classical publication by Cronbach and Meehl[35] identifies all validity as construct validity and that the validity of decisions depends providing evidence that the instrument is able to actually measure what it is supposed to measure.[36] This depends upon the items that make up the instrument that is the content and the cognitive process that the particular assessment is trying to gauge· Thus validity is in essence the degree to which evidence and theory support the interpretations of test scores for the proposed uses of tests for the specific group of test takers and the purpose of the test.[37]

Sources of validity evidence

The sources of evidence[37] include i) evidence of the content representativeness of the test materials, ii) the response process, iii) the internal structure of the assessment, iv) correlation of assessment scores to other measures, and v) the consequence of assessment scores for students. The standards of educational measurement[38] recommended use of various sources since strong evidence from one source does not preclude the need to seek evidence from other sources since different decisions may place differential emphasis on one (or more) source/s of evidence as opposed to others and not all sources of data or evidence are required for all assessments.

The sources for evidence required are briefly discussed below

<u>Evidence for content validity</u> is obtained from test blueprint or test specifications which ideally describe the subcategories and sub-classifications of content and specifies precisely the proportion of test questions in each category and the cognitive level expected to be assessed by those questions. The test specifications are reflective of the emphasis placed on content considering how essential and /or important it is for the level of student being assessed and the desired level of cognitive ability. Therefore while checking for validity evidence the researcher correlates the level of cognitive ability presumably assessed by the questions included in the test with the desired level as specified. The number

of questions and their technical appropriateness also provides evidence for content-related validity.

Evidence regarding the response process is gathered by providing evidence that all sources of error which may be associated with the administration of the test are minimized to the maximum possible. This includes evidence regarding accuracy of response keys, quality control mechanisms of data obtained from the assessments, appropriateness of methods used to obtain a composite score from scores received from different types of assessments and the usefulness and the accuracy of the score reports provided to examinees.

Evidence for internal structure is determined by statistical relationship between and among other measures of the same or different but related constructs or traits. The psychometric characteristics required as evidence under this head include difficulty and discrimination indices, reliability and /or generalizability coefficients..

Evidence regarding relationship of assessment scores to scores on other variables requires a study of the scores obtained on a measure against an existing, older measure with well known characteristics that is the extent to which the scores obtained on one test relate to performance on a criterion which is usually another test. The two tests can be administered in the same time period (concurrent validity) or the second may be administered at some future time (predictive validity).[11]

Evidence regarding the impact of assessment on examinees or evidence of consequential validity of the instrument seeks to determine the decisions made on the basis of assessment score and the impact of assessments on teaching and learning. The consequences of assessments on examinees, faculty, patients and society are enormous and these consequences can be positive or negative, intended or unintended.

Threats to validity evidence

The two main threats faced by validity evidence are construct under representation (CU), and construct irrelevant variance (CIV). CU can be due to under-sampling (few questions, few stations, few observations), biased sampling or a mismatch of sample to domain and low reliability of scores/ratings. CIV refers to systematic error introduced by variables unrelated to the construct being measured. Such can happen if there are flawed/too easy/too hard items, cheating, and variability within and between assessors.[39]

Predictive Validity

Predictive validity is the degree to which a test can predict how well a person will perform on a measure of the domain of interest (outcome) in the future. This outcome measure can be a test for example standardized licensing examination or a performance measure such as patient satisfaction ratings during practice.[36] If the tests do not correlate this demonstrates that the tests are measuring distinct constructs. When considering predictive validity one of the most important steps is to define the constructs that have to be assessed and then select the most appropriate measure for assessment.

Structural Equation Modeling

Structural equation modeling (SEM) is a statistical approach which purports to develop an understanding of complex phenomenon which governs human behaviour and is used to measure underlying hypothetical constructs (latent variables) and their interrelationships.[40,41] Since these constructs are not directly observable hence the relationships between observed variables and latent variables has to be construed by developing hypotheses leading to theories. SEM provides a framework that allows researchers to study hypothesized underlying structural relationships between latent variables or constructs by integrating three key components: path analysis, factor analysis, and the development of estimation techniques for model fit.[41] There are two main goals of SEM; 1) understand the pattern of correlation between a set of variables and 2) explain as much of their variance as possible with the model specified by the researcher. The researcher tries to determine the extent to which the hypothesized (theoretical) model is supported by empirical data. If the data is inconsistent with the model, that is, the data does not support the theoretical model, then the researcher may modify or develop other theoretical models and test them (thus the model fits the data). Various models may be tested to discover a model which makes theoretical sense, and has reasonable statistical correspondence to the data. Thus SEM tests theoretical models using scientific method of hypothesis testing to advance our understanding of the complex relationships of constructs.[42]

SEM is becoming popular in educational research since it is a theory strong approach which allows for the analysis of hypothesized relationships between latent constructs which is not possible by traditional statistical methods.[40,43] It partials out the measurement error from multiple (not so reliable) indicators and hence models error free relationships and can be used for a number of research designs.[44] By subsuming Confirmatory Factor Analysis and Path Analysis it allows for higher order understanding of complex phenomenon through development of measurement and structural models.[42,45] These confirmatory methods provide researchers with a comprehensive means for assessing and modifying theoretical models and offer great potential for furthering theory development.[42,46]

I selected SEM for statistical analysis in this study since this is considered a theory strong approach and I was trying to establish a relationship between the latent variables 'aptitude for studying medicine', 'prior scholastic attainment' and 'achievement in medicine' as demonstrated by performance on measures in medical school in the light of current theories . These variables are not directly observable or measurable and are inferred on the basis of data gathered from a set of indicator variables that can be observed and measured. The observed variables were further categorized into independent (admission criteria) and dependent/outcome variables (scores on assessment in medical school).

Procedures for SEM

There are six basic steps of SEM which are iterative because problems at a later stage may require a return to an earlier one.

Model specification: a hypothetical model is developed using all available relevant theory, research and information. Available information is used to decide which variables to include and which variables not to include in the theoretical model and depict the relationship between them. The exclusion of important variables or inclusion of unimportant variables will produce implied models that are misspecified.[47]

Model identification; requires the researcher to identify the unique values for the parameters of the specified model. Depending on the available information a model may be said to be over, under or just identified. A model is over-identified if the information known (that is variance and covariance) is more than that which needs to be estimated (parameter estimation, measurement errors) while if the unknown exceeds the known the model is under-identified.[41]

Model estimation; the researcher has to obtain estimates for each parameter specified in the model (using computer programs) that produce the implied matrix $\sum$ such that the parameter values yield a matrix as close as possible to *S* (sample covariance matrix of the observed variables). This determines how well the model fits the sample data. The estimation process involves the selection of a particular fitting function (Maximum Likelihood, Least squares) to minimize the difference between $\sum$ and S using available fitting functions and multiple iterations until the best parameter estimation is obtained.[48]

Testing model fit; this step is to determine the extent to which the theoretical model is supported by the obtained sample data. Various fit indices are available and used estimating goodness of fit between the hypothesized model and sample data. This is assessed by finding parameter values of a model that best fits the data - a procedure called parameter estimation. [49] Two types of indices are used: absolute and comparative. Absolute fit indices compare observed (sample) versus expected (population) variances and covariances. *Chi-square i*s a good example of an absolute fit index.[49] If the observed and expected variances and covariances are in perfect agreement then the Chi-square index is zero. A non significant Chi-square indicates a good fit while a significant Chi-square index means that the observed matrix differs significantly from the expected yielding a poor fit. However, Chi-square is likely to be significant with large sample size and as SEM requires a large sample size it has to be interpreted cautiously and in conjunction with other indicators. Chi-square can be used to compare two alternate models where a non significant Chi-square suggests that the two models are not significantly different from each other.[50] Other absolute indices commonly used are *Adjusted Goodness of fit index (AGFI)* which ranges from 0.0 to 1.0, *Standardized Root Mean-Square Residual (SRMSR)* which represents the average standardized discrepancy between observed and model implied relations across all parameter estimates.[40] A value below 0.08 indicates good fit. *Steiger's Root Mean Square Error of Approximation (RMSEA)* is a related index which adjusts for a model's complexity i.e. number of paths estimated in the model.[40] Fewer estimated paths (parsimonious model) increase the RMSEA fit. A perfect fit will yield an RMSEA of zero. Scores <0.08 are considered to be adequate while a value below 0.05 indicates good fit.[50] Comparative Fit Indices (CFI) compare the model fit to an alternative model, such as the null model which has no path linking the variables. Scores can range from 0 to 1.0 an index of 0.90 or higher indicates a good fit between the model tested and the data.[43,49]

Model modification; this is often needed when the initial fit of the proposed theoretical model is not acceptable. A subsequent step is to modify the model and evaluate the new modified model. Model modification should be done on theoretical grounds which can be supported.[44]

Predictive validity of admission decisions in medical school

Predictive validity evidence on admission is gathered by determining the association between measures at the time of admission (independent /predictor variables) with measures of performance during medical, in licensing examinations, during residency and in practice (dependent/criterion/outcome variables). In the following section I have listed the independent and dependent variables reported in literature followed by a discussion on the effectiveness of the measures to guide in developing a parsimonious model for admissions at

AKUMC. Both academic and non academic variables have been used to predict the validity of decisions made for selecting student into medical school.

Independent Variables: Academic

These include Performance on admission test including total scores and subtest scores and indicators of prior scholastic achievement specifically, overall undergraduate grade point average (GPA) in science as well as in other (non science) subjects or their equivalent such as scores /grades reflective of prior attainment. Other information that is considered includes number of withdrawn, repeated and incomplete courses appearing on the transcript. Institutional quality where undergraduate studies have been completed determined either by the scores on tests of scholastic achievement or by locally developed rankings of institutional quality.

Independent Variables: Non Cognitive

These include personality traits assessed by Interviews, psychological tests and inventories, and situational Judgment tests. Demographic variables including sex, age, race and socioeconomic background are also considered by institutions which are aspiring for diversity among their students.

Dependent Variables:

The dependent variables studied include performance during medical school (scores on assessment in pre clinical and clinical years), scores on national licensing examination of applied basic and clinical knowledge, clinical decisions making and clinical skills as well as performance during residency.

Academic difficulty resulting in either delayed graduation or withdrawal or dismissal from medical school is also studied for determining the predictive validity of the admissions criteria.

Effectiveness of the Academic variables

MCAT total score

Traditionally admissions in medical schools have been based on prior educational attainment and MCAT scores. Studies of predictive validity have reported on the correlations and validity coefficients of MCAT for performance on the National Board of Medical Examination (NBME) Parts I, II and III which have been later replaced by the United States Medical Licensing Examinations[3,4,5,12] (USMLE) Step 1, 2 and 3 either independently or along with medical school grade point average (GPA)[51,52,53] and matriculation scores.[54] Canadian studies have employed medial school GPA and the scores on Medical Council of Canada Qualifying Examinations (MCCQE). [55] Studies in UK have used grades in A-level subjects and performance in United Kingdom Clinical Aptitude Test (UKCAT)[52] and Biomedical Admission Test (BMAT)[6,7] while studies from Australia have reported use of Graduate Australian Medical School Admission Test (GAMSAT) as independent academic variables.[9,10]

There is a large body of literature on the predictive validity of MCAT reporting on the validity coefficients for the revisions that have taken place with varying reports. The correlation coefficient between preadmission criteria and performance on tests of basic science knowledge using the modified MCAT after 1977 has been reported to range from r = .29 to .66 which is similar to values reported for admission tests in business, law and graduate schools. [23] The MCAT version of 1978 was reported to have low predictive validity for medical school performance (r = 0.39 with 95 % CI 0.21 – 0.54) while moderate (r = 0.60 with 95% CI, 0.50 – 0.67) for the licensing examination.[3] Swanson et al[27] found validity coefficients of r = 0.49 and 0.51 of MCAT versions of 1977-1991 and post 1991 for Part I/Step 1. Julian[23] reported a high validity coefficient for post 1991 version of MCAT ranging from r =.60 for USMLE Step 1 to 0.49 for Step 2 and Step 3. Callahan et al [13] studied the predictive validity of three versions of MCAT for NBME Part I/USMLE Step 1, Part II/Step 2 and ratings for clinical competence in the first year of residency. They report that the validity coefficient for Part I/Step1 remained around r = 0.45, $p<.01$ for all three versions of MCAT, while a decline was observed in the validity coefficients for MCAT versions in predicting Part II/Step 2 from r = 0.47 for pre 1978 version to r = 0.42 – 0.40 for the 1978 version and r = 0.37 for the 1991 version. Validity coefficients for the MCAT versions in predicting Part III/Step 3 remained near r = 0.30.[13]

UK has recently introduced admission tests for entry in medical schools and validity studies are underway. Studies reported by UK have used A- level grades, and UKCAT scores as the independent variables while Year 1 and 2 examinations as the dependent variable.[52] This test was first administered in 2006 and early reports show that the scores had a non significant but positive correlation with knowledge or performance scores in year 1 at the two medical schools included in the study with r= 0.106, $p > 0.05$. Biomedical Aptitude Test (BMAT) introduced at the University of Cambridge, the University of Oxford, Imperial College London and University College London has shown that the scores on science sections predict first class performance in both year 1 and year 2 examination correlating better with year 1 scores (r = 0.26 to 0.45) than with year 2 scores (r = 0.18 to 0.26).[6] GAMSAT used by Australian medical schools for admission in graduate studies has also shown incremental validity for predicting performance as early as in Year 1 of medical school and explains about 17% of variance in Year 1 grades.[9,56] A study of predictability of AKU admission test showed a significant association between admissions test scores and subject scores in the Bachelor of Surgery and Bachelor of Medicine (MBBS) Part I examinations administered at the end of first year of medical college. [33]

Undergraduate GPA

Undergraduate GPA has been studied for its predictive validity for performance in medical school. Weiss[54] reported matriculation scores to be the most effective and the only consistent predictor in his study. However, most of the studies demonstrate moderate validity coefficients for performance in early years in medical school ranging between r = 0.4 - 0.6 as well as on the NBME Part I /USMLE Step 1 which improves when undergraduate medical school GPA are added to the equation.[13,14] Swanson[27] reported an increase of r = .04 in the validity coefficient when UGPA was added to the scores on MCAT. Vancouver[28] found the composite MCAT score and undergraduate science GPA to be predictive for NBME Part I scores. Another study which looked at the relationship between MCAT scores, UGPA and performance on medical school examinations in years 1 and 2 as well as NBME Part I reported that the MCAT scores predicted the NBME scores better than the medical school grades while the UGPA was better at predicting medical school grades than NBME part I.[55] This may be because of method affect of the measurement as both MCAT and NBME use long examinations with multiple choice questions while assessment during medical school uses other methods to assess the students.[57] The UGPA correlates lower with the Part II scores than the MCAT total scores and locally prepared third year examinations of clinical problem solving also correlated moderately with the MCAT scores.[8] In UK grades obtained in the General Certificate in Secondary Education (GCSE) Advanced level (A –level) which can be considered in lieu of UGPA have shown to have long term predictive validity for studies in medicine. [58] Another study of predictive validity of an admission test offered by Karachi Medical and Dental College in Pakistan reported that the admission test scores had significantly positive weak correlation with professional examinations at the end of second ($p < 0.01$) and third ($p < 0.01$) year.[59] Combining the high school scores increased the predictive validity for the performance of students on professional examination at the end of first ($p < 0.05$), second ($p < 0.05$) and third ($p < 0.05$) years. Thus concluding that admission test scores combined with high school cores were weak positive predictors of performance in the first three years of medical college.

MCAT Subtest scores

Of the subsets of USMLE, the biological sciences subset has been reported to be the best predictor of medical school performance in the preclinical years (r = 0.32 95% CI, 0.21 – 0.42) and the USMLE Step 1 (r = 0.48 95% CI, 0.41 – 0.54).[14] Chemistry subtest scores have been found to be the most predictive for first and second year GPA as well as for the NBME Part I scores while science problem solving and skill analysis (reading) best predicted pharmacology and behavioural science scores.[14] Brooks[14] reported predictive validity coefficient ranging from .36 to .57 when the best predictor for each criterion variable was considered. The MCAT scores demonstrated validity coefficients ranging from .03 to .47 with scores in clinical years with the chemistry and science problems having the highest correlation (r = .43) and reading skills having the lowest (r = .22). A study to investigate the best fit for a hypothesized model of medical students' diagnostic or clinical reasoning skills using the MCAT subset scores on verbal reasoning, physical sciences, biological sciences and writing sample, undergraduate average GPA (UGPA) at admission, basic science achievement in the first two years, clinical performance in the single clerkship year, and Medical Council of Canada (MCC) Part I test concluded that the MCAT and UGPA correlated highly (r = .77) with the performance in medical school in the basic sciences years (Y1 and Y2) and that science knowledge and achievement in medical school function as independent latent variable measures of clinical reasoning skills.[55]

Physical Sciences scores (MCAT-PS) demonstrate a moderately strong correlation that decreases as the student moves further in medical school. Biological Sciences (MCAT-BS) shows a strong correlation with Part I/Step 1 and first two years of medical school GPA but gradually decreases over the year. Writing Sample (MCAT-WS) has failed to demonstrate any positive correlations with performance in medical school. The scores on Verbal Reasoning (MCAT-VR) demonstrate moderately strong correlations that improve over the years since admission in medical school.[60] Reports from UK have shown that of the subjects examined at GCSE A-levels examination grades in biology and chemistry have been shown to have low predictive validity for performance in medical schools.[61]

These results are most likely because both admission and licensing examinations measure the cognitive domain using multiple choice questions hence there is a better correlation in these scores than the medical college examinations which assess the domains of clinical skills and behaviours. Another reason could be that the admission tests assess the funds of knowledge in the basic science subjects which is also the focus of studies in the first two years on medical school leading to a good correlation. On the other hand MCAT scores have low correlations with clerkship ratings and NBME Part II/USMLE Step 2 and

3. This is most likely because the constructs being assessed are different as well as the instruments that are used for assessment vary.

Measures of Non cognitive factors

Personality assessment

Interviews

Interviews have been under criticism for their subjectivity but the face validity of interviews and the traditional importance attached to them have been the main impetus to continue with the interviews. They are considered to be helpful in gathering information about the applicants and verifying information that has already been provided[2] but a meta analysis of selection interviews[62] concluded that interviews have little or no value in predicting academic achievement. Kreiter and Yin[63] found low-to-moderate reliability with 17–27% of rating variance attributable to applicant differences. They demonstrated that applicants should have multiple interviews, each rated by multiple raters to achieve internal reliability of $\alpha = 0.60$. Structured interviews with many interviewers have shown to have a higher reliability; increasing from 0.23 for one interviewer to 0.73 with nine independent interviewers.[64] Training of interviewers has reported to result in improved inter-rater reliability. Moderate reliability ($\alpha = 0.49 - 0.47$) has been reported for interviews conducted by three to four interviewers after three hours of training.[31] High inter-rater reliability has been reported after four hours of training and regular training thereafter.[65,] Richards, et al. [66] have reported a reliability of .91 within and .90 between two ratings given by two panel of interviewers on video recordings of the same admission interviews without any training. It has been reported that knowledge of interviewee's performance on measures of cognitive ability and their demographic characteristics influences the ratings.[31] Although interviews have non committal contribution it has been recommended personality factors and predictor variables with improved validity should supplement MCAT.[20,67,68] There is a need to have a better understanding of the constructs defined to be important for medical professionals [20,69] and develop instruments able to measure them effectively. Multiple Mini Interviews (MMI) have been developed in the light of the above reported[22] issues with interviews with a reliability of α = 0.65 and a correlation of r = 0.43 (p < 0.05) on an OSCE type examination conducted in postgraduate education and r = 0.35 (p < 0.05) in an undergraduate examination with MMI administered 5 years prior to the licensing examination.[22] The MMI has consistently shown statistically significant, practically relevant, positive predictive correlations with future performance.[22,70,71] It has also shown sustained incremental correlation coefficients with increasing time from medical school admission, more than GPA and MCAT. However, these conclusions have been reported on small studies and larger studies are needed to confirm the findings.

In addition to the number of interviewers, none or poor interviewer training, and poorly structured interviews, low reliability of interviews could also be because the applicants for interview are selected after the initial admission tests which increases the homogenous nature of the group posing a greater challenge in differentiating between them and decreasing the probability of wide differences in their subsequent performance.[72] While the increasing correlation of MMI with outcome assessments during clerkship and national licensure examination could be ascribed to a shift from assessment of cognitive towards non-cognitive domains in later years.[73]

Personality tests and inventories

Personality tests - used as an adjunct to other admission criteria - have not demonstrated predictive validity for performance in medical school. Market[17] studied the incremental validity of three non cognitive tests for medical school academic achievement. Three tests namely Rotter Locus of Control, Adjective Checklist, and Student Orientation Survey added very little (r=.04) to the validity coefficient of MCAT for first-year medical school GPA. A similar study conducted on Pharmacy students [74] showed that non traditional test scores from Learning and Study Strategies Inventory (LASSI), Defining Issues Test (DIT), and Watson-Glaser Critical Thinking Appraisal (WGCTA) showed at best marginal predictive ability. The empathy scales on California Psychological Inventory (CPI) negatively correlated with the scores in knowledge based written tests (r= -.36), but positively correlated with the clinical and communication skills scores.[75] Studies are underway utilizing mixed methods for assessment of non cognitive factors. A multimodal approach "MOR" which utilized interviews, standardized patients and questionnaires to assess personal skills, interpersonal skills, judgement and decision making is being studied. Initial results have shown good psychometric qualities of the assessment methods and weak positive correlation (.01 - .15) with scores on cognitive assessment.[76] Report from the 'rainbow project' has shown that scores from the tests used for predicting grades on test of scholastic achievement (SAT) complemented and increased the validity[77] coefficients for SAT I, II and III by 10% to 24.8%.

The use of personality tests has problems of homogeneity of the group of students, issues with self reporting and the number of constructs being assessed in one instrument. A high internal consistency on personality inventories should be interpreted cautiously as similar but faulty answers to the items on the questionnaire could lead to a high reliability but is not desirable.[19]

<u>Situational judgements tests</u>

Situational judgement tests (SJT) are a recent introduction in the medical school admission process. Multiple vignettes are presented to the applicants and they are asked their perspective on it, or how they would deal with the situation etc. The aim of the vignettes is to assess the interpersonal skills, ethical stance and decision making skills of the students.[76] Written SJT where a candidate has to select from a list of responses have been reported to correlate better with scores on cognitive assessment than video based SJTs where the candidate has to express the responses verbally. Scores on video SJTs correlate better with scores later in medical education.[24] This may be because written tests assessing cognitive abilities are generalizable to other tests of cognition [19].

Demographic variables

Variety of students demographic variables including ethnicity, age and gender have been studied with different validity coefficients for the subgroups.[78] Studies conducted on pharmacy students have found that when demographic variables of age and gender are added to quantitative variables of PCAT and academic performance no significant differences were found in first year GPA[79] only two studies have reported age to have a marginal affect at best.[78] Study by Anderson[12] reported that although it was generally perceived that female students score higher their study did not support that perception. However Shaw[31] has reported that applicant's gender accounted for the largest variance in the interview scores with women interviewees receiving higher ratings regardless of the gender of the interviewers. But he has not reported on the variance in performance that could be accounted to sex.

Letters of reference and personal statements

Other components that are reviewed by admission committees, but have not been reported to be assigned considerable importance are personal statement, referrals letters and extra-curricular interests. These include letter of evaluation from undergraduate advisors, faculty members, pre medical committees, community leaders, research sponsors, and/or employers; involvement in and the nature of non health-related extracurricular activities during undergraduate or graduate education; involvement in and quality of health related work experience; state of legal residence; and breadth and difficulty of undergraduate course work.[51] There are varying reports of the validity of referral letters with some studies reporting no correlation between what was written to performance[2,80] but found to have predictive validity for performance in residency and residency rankings.[25] The subjectivity of the referral letters could be one of the reasons for its not having validity for more objective assessments.[19] Personal statements although reviewed by admission committees have not been reported to be effective for predicting future performance in medical education. The ratings given to personal statements may be affected by rater bias as well as non standardized presentation of the contents in the personal statements which makes it difficult to assess. Experience in writing statements as well as expert input in writing could lead to additional errors in the ratings[2]. Kulatunga-Moruzi and Norman[5] have reported moderate inter-rater reliability coefficient of $\alpha = 0.45$ for the ratings by assessors of personal statements.

Psychometric concerns

The limitations that are found in studies of predictive validity are manifold and have to be given due consideration in making any judgements about these factors. Measurement method has been identified as one of the factors that effects correlations.[57,73] It has been hypothesized that MCAT total scores as well as subtests scores and UGPA correlate better with NBME Part I and II scores as well as medical school performance during years 1 and 2 since they use the same or similar methods for assessment namely one best multiple choice questions. However these correlations decrease for NMBE Part III and medical school scores for the clinical years since the assessment is also done of professional attributes, clinical skills and communication using rating scales and patient based examinations rather than MCQs.

Another issue of concern is that of range restriction which leads to an underestimated validity coefficient since the students selected in medical schools are similar in characteristics than those not admitted leading to restricted variability.[3,8,17,63,81] Use of limited ratings or pass /fail criteria and grading instead of a wide rating system limits the amount of information on medical school performance and do not provide the variability required for differentiating between students.

Another problem encountered is the presence of many different criteria and their relative weights in the admission process, there is a mix of subjective and objective criteria ultimately leading to a decision based on a global judgement that is made by the admission teams.[62] In many situations low scores on one or more of the admissions criteria is compensated by a high score on another component. This poses a problem in determining predictive validity of the various components.

Another major factor that could be considered leading to low correlations between independent and outcome variables is the shift of emphasis during assessment over the years of medical studies from recall and interpretation of knowledge to problem solving and clinical reasoning and an increased emphasis on non-cognitive variables.[19] The relative stability of validity coefficients reported for the MCAT-VR compared to MCAT-PS and MCAT-BS could be a result of a combination of factors. One factor may be that verbal reasoning is less context-bound, so correlations with future performance remain unaffected as the context changes. Another may be that it spans cognitive and non-cognitive domains and therefore remains relevant, even as assessment measures in clerkship and on national licensing examinations shift from cognitive towards non-cognitive domains.[16]

Summary of the literature review

The literature review indicates that no 'one' selection method adequately predicts performance throughout the continuum of medical education. Use of a multifaceted approach is therefore recommended. New methods need to be developed and assessed for their contribution to selection of medical students and that other variables that complement the MCAT need to be studied for identifying selection methods, which have a greater validity coefficient for clinical knowledge and medical practice since that is the ultimate aim of educating medical students.[82] UGPA and MCAT scores on the science subtest have demonstrated moderate correlations with performance in basic science examinations during early years of medical school as well as in national licensing examinations assessing basic science knowledge (NBME Part I/USMLE Step 1). Scores on subtests of science knowledge and verbal reasoning have been found to have a moderate validity coefficient for performance during clinics and in examinations assessing clinical knowledge (NBME Part II/USMLE Step 2) and scores on MCAT subtests of verbal reasoning and writing samples demonstrate a moderate to low validity coefficient for performance in residency education and assessment of clinical skills (NBME Part III/USMLE Step 3). This gives credibility to all the components of the current MCAT as all the three criteria are important for the practice of medicine.

It also transpired that although many medical schools encourage students from less advantaged communities and rural populations to apply, however, there are less number of students admitted from these areas and it may just be that the admission criteria are biased and favour a certain group of students.[83]

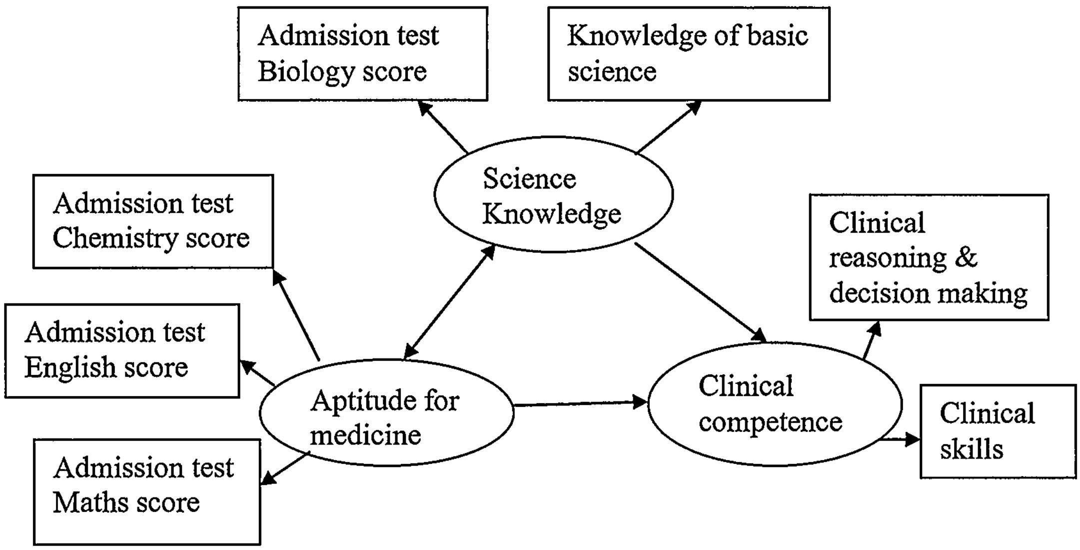
Research Questions

As stated in Chapter 1, the main research question of this study is "what is the effectiveness of admission process at AKU for selecting the most appropriate students for the study and practice of medicine?" Several specific questions were proposed

1. What is the effectiveness of AKUMC-AT total and subtest scores for predicting students' performance during medical school?
2. Which of the admission criteria are able to identify students who are clinically competent?
3. How effective are the interviewers rating and selector's votes in predicting performance in medical school?

4. Can we identify a parsimonious model of admission that is most predictive of students' performance?

Proposed Model



A model based on the study reported by Donnon and Violato[55] was proposed whereby medical students' clinical competence (as demonstrated by aggregate scores on clerkship written examination that assess clinical reasoning and problem solving and aggregate scores on clinical science examinations) is a function of their aptitude for medical school and basic science achievement, and that clinical reasoning and decision making and clinical skills contribute independently to the clinical competence (achievement) of the medical students while aptitude for medicine and science knowledge correlate with each other.

The proposed structural model consists of three factors (latent variables) denoted later as 'F' and a measurement model with twelve observed variables denoted as 'V'. The three factors with their respective observed variables are listed below.

F1 = Science knowledge measured by:

V1 (admission test subtest scores in Biology)

V2 (scores on knowledge of basic science test at the end of first two years of medical school)

F2 = Aptitude for medicine measured by:

V3 (admission test subtest scores in Chemistry)

V4 (admission test subtest scores in Math problem)

V5 (admission test subtest scores in English comprehension)

F3 = Clinical competence:

V6 (scores on assessment of clinical reasoning and decision making)

V7 (scores on assessment of clinical skills)

CHAPTER III – METHODS

Participants

The data of three cohorts of students (n=276) admitted in the years 2003, 2004 and 2005 at AKUMC graduating in 2008, 2009 and 2010 respectively was obtained from two offices; the AKU Registrar's Office and the AKUMC Examination Cell. The participant numbers decreased in the final analysis due to students who either did not join or withdrew (n=17) in the first year of the program. Records of 259 students were initially included, which further decreased since 32 student records were incomplete for the AKU medical college admission test (AKU-MCAT), interview ratings, selectors' votes and /or subsequent scores on medical school examinations. Scores for medical school examinations for all assessments were not available for students considered ineligible to sit the examination (due to low attendance or failing the continuous /end-of-clerkship assessment) or if they were away on electives. These students then sat the examinations with the next cohort of students. The results of such students were included from the records of subsequent examination, if available. Scores were not available for students from the graduating class of 2010 who had not taken the examinations. The total number of records included in final analysis thus comprised 227 cases.

Measures

Independent Variables

Admissions data of three cohorts was provided anonymously by the Registrar's Office with medical school registration numbers to facilitate combining of data from two different sources. The information provided included demographic information about the students (age, sex, place of permanent residence, system of education[2]), their AKUMC-AT total scores, subtest scores in biology, physics, chemistry, math problems and English comprehension, evidence of prior attainment interviewer ratings and percent ratings given by the members of the admissions committee.[3]

Dependent variables

The data on dependent variables consisted of scores on medical school examinations during the five years of education. These included two end-of-the-year examinations (in Year 1 and Year 2) of applied knowledge in BBS and clerkship scores in six main disciplines (General Surgery, Internal Medicine, Family Medicine, Obstetrics & Gynaecology, Paediatrics and Psychiatry). The clerkship scores consisted of two components

1. Test of clinical reasoning and decision making (CR&DM) using multiple choice questions conducted at the end of the clerkship in each discipline. All

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[2] Students applying to AKU come from two different systems of education; the Pakistani (Matric) system in which students sit the examinations for secondary school certificate (SSC- grade 10) and higher secondary certificate (HSC- grade 12) and the British system comprising General Certificate of Secondary Education (GCSE) ordinary (O) level (grade 11) and advanced (A) level (grade 13) examinations.

[3] Please refer to Appendix A for a detailed description of the admission process and criteria.

of the test items use clinical vignettes and are directed towards assessment of the students' reasoning and decision making skills.

2. Assessment of clinical skills (CS) based on observed assessments using long cases, objective structured clinical examination (OSCE) and called as end of clerkship (EOC) examination
3. Continuous assessment of professional behaviours using students continuous assessment forms[4] and log books.

Data Analysis

1. Descriptive analysis of all the variables in the data set using Statistical Package for Social Sciences (SPSS) version 17 for windows by SPSS incorporated.
2. Psychometric analysis of the assessment instruments using ITEMAN (tm) for 32-bit Windows, Version 3.6 (c) 1982 - 1998 by Assessment Systems Corporation of the following:
   a. Admission tests
   b. Examinations of applied basic science knowledge (linear addition of MCQ examination scores administered at the end of Years 1 and 2)
   c. Examination of Clinical Reasoning and Decision Making (linear addition of MCQ test scores, which are administered at the end of the clerkship period in six disciplines)
   d. Assessment of Clinical Skills (linear addition of scores from the CA forms and EOC examinations in six disciplines)

[4] Please refer to the continuous assessment form at Appendix3

3. An analysis of variance (ANOVA) to determine dis/similarities between the three cohorts
4. Exploratory data analysis using half of the records (randomly divided into two using SPS)
    a. Correlation between observed variables for the following:
        i. Personal characteristics such as age, gender, socio economic status (proxy indicator being system of education),
        ii. prior attainment (points awarded by the AKUMC admission committee on the basis of O level results and number of A grades at Advanced Level GCSE),
        iii. aptitude for medicine
            1. objectives assessment - total score and subtests scores AKUMC-AT
            2. subjective judgment - interview ratings and selectors' votes, (the interview ratings were given in grades from A-D on a 4 point alphabet scale which was converted to a numerical scale for analysis purposes as A=4, AB=3.5, B=3, BC=2.5, C=2, CD=1.5, and D=1.
        iv. Knowledge of basic biological sciences (BBS)
        v. Clinical reasoning and decision making (CR&DM)
        vi. Clinical skills.
        vii. Professional behaviors

b. Exploratory factor analysis to identify the latent variables that were assessed using the admissions and examination data

c. Regression analysis to identify the predictors of success using backward linear regression

5. Testing of a model of latent variable path analysis (LVPA) for predictive validity on the other half of the data using the window- based structural equation modeling software EQS (A Structural equation program, multivariate software Inc. Copyright by PM Bentler. Version 6.1 (C) 1985 - 2010 (B97).

Steps in testing LVPA model using SEM

The relationship between observed and latent variables was construed on the basis of literature and exploratory analysis of half of the data using multivariate correlations, linear regression and factor analysis. Alternate models were derived and tested for best fit using the EQS software.

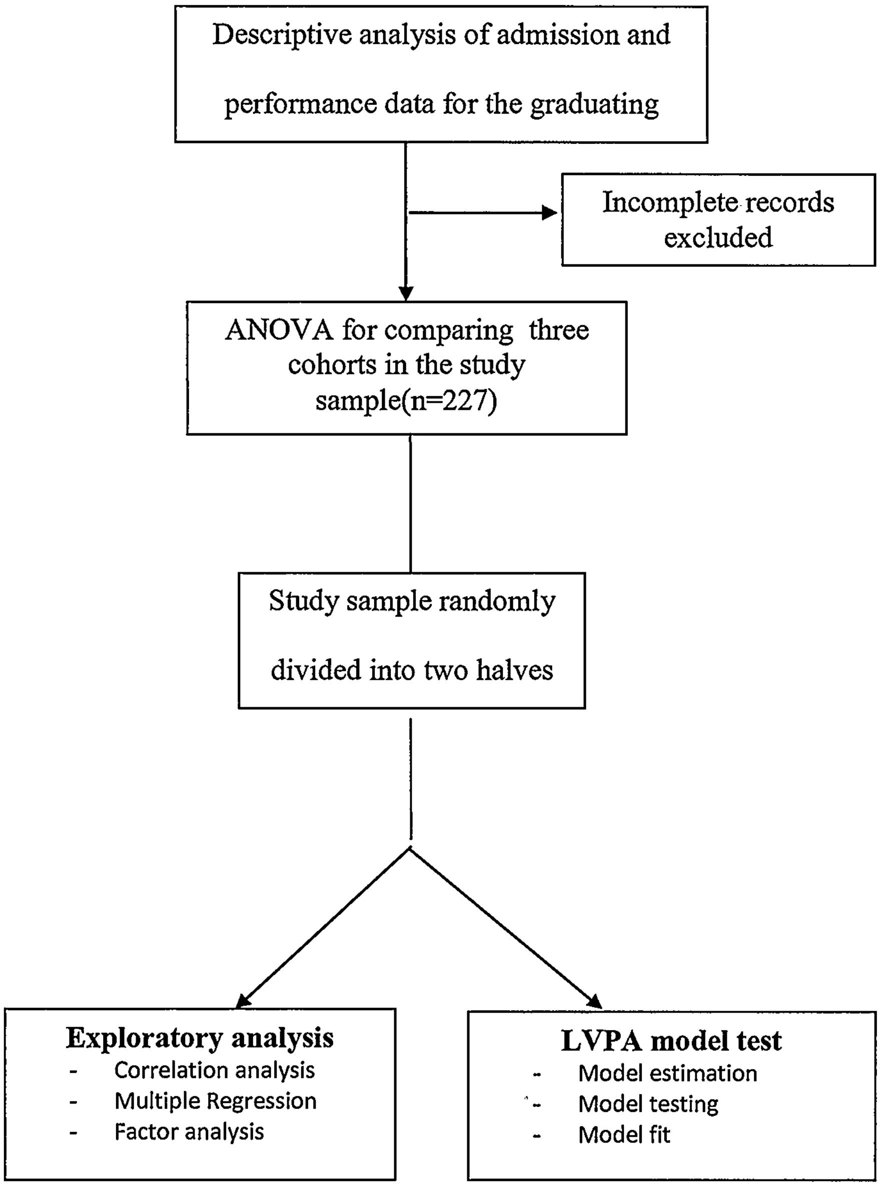
For the initial LVPA model I used nine (9) observed variables and three (3) latent variables. According to SEM guidelines there should be at least 10 cases for one variable (Kline 1991) and ideally I should have had a minimum of 120 cases. However, of the total of 227 cases, 115 were used in exploratory analyses and 112 for testing the model fit which created a limitation for analysis. Model was modified and retested to discover the one model that made theoretical sense, and had reasonable statistical correspondence to the data.

Summary of Analyses

1. Students' data set was removed if the information on categorical variables were incomplete, if the students did not join or withdrew within the first two years of medical school.
2. Of the 276 students offered admission in AKU in the years 2003, 2004 and 2005 a total of 227 were included in the study based on completeness of data
3. Psychometric analysis of the admission and medical school measures was done using ITEMAN to gather validity evidence for using them further in analysis
4. Analysis of variance was done to compare the three cohorts
5. Exploratory analysis was done on half of the data set (randomly split). Descriptive statistics were computed and sub models were run for each of the outcome variable. To determine the relationship between the independent and dependent variables the following two steps were taken.
    a. Factor analysis for identification of latent variables
    b. Linear regression analysis using stepwise and backward regressions models
6. LVPA model was developed and tested using EQS software. Fit of three measurement models was first determined individually and once a good fit was obtained for each then the structural model was tested.
7. Model was re-specified and tested for best fit.

A flow chart of data analyses is given in Figure 2 below.

Figure 2: Flow Chart of Data Analysis



CHAPTER IV: RESULTS

This Results chapter is organized into four sections 1) descriptive analysis of the observed variables used in the study, which includes frequency distribution, mean and standard deviations 2) psychometric analysis of the admission test and assessments administered during medical education at the local (medical school) level, 3) exploratory analysis including exploratory factor analysis, and backward linear regression analysis and 4) latent variable path analysis which consists of descriptive statistics, Pearson product-moment correlations and structural equation models comparisons. Summary tables are inserted within the text here while complete data tables for all analyses are provided in the appendices D – G.

Descriptive analysis

Descriptive statistics for each year of the study for students admitted at AKUMC in 2003, 2004 and 2005 for each observed variable (independent and dependent) are presented in this section. The number of students varied overtime because 1) the number of seats in medical college increased to 100 for the class admitted in 2005, 2) a total of 21 students from those offered admission during 2003, 2004 and 2005 did not join or withdrew from the program within the first two years, and 3) students considered ineligible to take examination or who were away on electives. Thus, a total of 40 records were excluded from the final analysis (exploratory and testing of LVPA model). Table 2 shows the number of students admitted and withdrew.

Table 2: number of students admitted and graduated in the period studied

Year admitted (N)	Withdrew	Year graduated (N)
2003 (88)	12	2008 (76)
2004 (88)	3	2009 (77)
2005 (100)	6	2010 (84)

Demographic variables

Data regarding age was available for 212 students and the result is representative of the general trend of younger students in medical colleges in Pakistan with 97.6% of students aged 20 years or less with 83.8% between the ages of 18 and 19 years. Four students were 16 years of age at the time of application. Two applicants aged 23 and 25 years did not join the program. .

Almost half of the students were females (50.8%); Majority (83.1%) of students were from within Pakistan, with only six of thirteen international students who were offered admissions joining the program. Of the Pakistani students 74.73% had mentioned their permanent residence in provincial capitals while the rest in cities that were either industrial hubs or near to the capital cities.

Educational Background

A stable and incremental trend was seen in the number of students from British system of education (63% of those admitted in 2003 to 87% in 2005) with both GCSE Ordinary level (O-level) and Advanced level (A-level) certificates while 4-7% of those admitted studied in a mixed system with either GCSE O level followed by higher secondary education in the Pakistani system or with initial education in the Pakistani system followed by GCSE A levels in the British system. Only seven percent of the students had studied throughout in the Pakistani system of education.

Prior attainment

GCSE O level scores are converted into points by the admissions office which are then considered by the admissions committee. GCSE A – level grades in the subjects of Biology, Chemistry and Math /Physics are considered. Table 3A gives the descriptive statistics for both. The mean points on performance in O level examinations ranged from 9-19 points with a mean of 10.9 $\pm$ 1.89. The maximum number of A-grades that were submitted to the admissions office were four (22% of students) while 3 students who got admission did not have a single A grade in the subjects of biology, chemistry, physics and math.

Performance in AKUMC admission criteria

AKUMC-AT scores were not available for 40 students; these were students who were exempted from the admission test in lieu of Scholastic Aptitude Test (SAT) or of MCAT and applicants who had written the AKUMC-AT in the previous year but could not get admitted and had reapplied.

The interviewer ratings are given on a seven-point alphabetical scale. These were converted to seven-point numerical ratings where A=4, AB=3.5, B=3, BC=2.5, C=2, CD = 1,5 and D=1. The ratings of the two interviewers had poor inter-rater reliability (r= 0.06). The admission committee ratings that were a percentage of composite of individual ratings by the members were skewed to the right (mean = 94.33). Table 3 shows the analysis of the admission criteria for all three years.

Table 3: Descriptive statistics of the AKUMC Admission Test Total and Subtest Scores, Interview Ratings and Prior Attainment

A: Descriptive statistics on performance on the subtest sections of AKUMC Admission Test					
Class of	Physics	Chemistry	Biology	Math	English
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
2008	24.41 (4.35)	28.87 (2.87)	27.21 (2.75)	4.62 (1.02)	18.14 (1.67)
2009	27.59 (3.15)	27.76 (3.52)	29.23 (3.66)	14.51 (2.71)	30.63 (3.39)
2010	29.44 (2.52)	29.86 (2.91)	26.02 (3.17)	16.30 (2.29)	33.94 (2.08)

B: Descriptive statistics on interview ratings, prior attainment and ratings by members of the admission committee				
Class of	Interview rating	Points in O levels	# of A grades in A- level	Admission Committee Ratings
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
2008	6.64 (.79)	10.1 (2.21)	3.09 (1.31)	97.9 (4.60)
2009	6.38 (0.91)	10.60 (2.21)	2.83 (1.08)	89.28 (6.8)
2010	6.56 (1.04)	9.97 (1.71)	2.76 (.593)	94.70 (5.1)

C: Descriptive data of the total AKUMC-AT				
Class of	Number of examinees	Mean	SD	Cronbach Alpha
2008	2376	73.291	17.709	0.91
2009	3171	89.252	22.033	0.93
2010	3391	90.973	22.954	0.93

One-way Analysis of Variance

One-way Analysis of Variance (ANOVA) was used to test for differences in the dependent variables among the three groups admitted in the three years (2003 – 2005). Table 4 shows that the scores on all the variables differed significantly across the three groups with $F\,(2,\ 230) = 136.73$, $p < 0.001$ for KBBSY1, $F\,(2,\ 232) = 5.771$, $p < 0.01$ for KBBSY2, $F\,(2,\ 226) = 4.393$, $p < 0.001$ for CRDM, $F\,(2,\ 233) = 4.393$, $p < 0.05$ for CS, and $F\,(2,\ 230) = 52.846$, $p < .001$ for PB.

Table 4: ANOVA (Effect of Year of Graduation on the dependent variables)

	Df	F	Sig.
Basic Science Knowledge year 1	2, 230	136.73	.000
Basic Science Knowledge year 2	2, 232	5.771	.004
Clinical Reasoning and Decision Making	2, 226	4.393	.000
Clinical Skills	2, 223	4.393	.014
Professional Behavior	2, 230	52.846	.000

Psychometric analysis

An analysis of examinations administered to the classes of 2008, 2009 and 2010 was done using ITEMAN. Tables 5 and 6 give summary findings of the item analysis of total AKUMC-AT and assessments during medical school. The detailed item analysis report of admission test administered in 2004 is in appendix E. A brief description of the findings on item analysis is given below.

Admission Test

The admission test had a total of 180 multiple choice questions to be attempted in 2 ½ hours. The test had a reliability of $\alpha \leq .90$ for the three years studied which fulfills the requirements for a reliable test. Cronbach alpha, mean score and standard deviations for admission test scores are given in table 5a for the tests administered in 2003, 2004 and 2005 (Class of 2008, 2009 and 2010 respectively).

Written test for Knowledge of Basic Biological Sciences (KBBS)

This comprised of two papers administered at the end of years one and two. Each comprising of 160 – 170 multiple choice questions of one best type in the subjects of anatomy, physiology, biochemistry, pharmacology, pathology, microbiology and community health sciences

Written test for Clinical Reasoning and Decision Making

Clinical knowledge is assessed through multiple choice questions and structured orals targeted at assessing application of clinical knowledge, clinical reasoning and decision making skills. The assessment is conducted upon completion of each of the six clerkships. An analysis of the questions papers administered in the three years in the six clerkships is given below. Except for Psychiatry all had moderate to good reliability (internal consistency) with Cronbach alpha ranging from .54 to .75 and a mean difficulty of higher than 0.62. Since the written assessment of knowledge in the six disciplines over the three years seemed to be similar (except in Psychiatry which had a low reliability and standard deviation) a pooled total knowledge score of clinical knowledge without psychiatry was created for the purpose of further analysis.

Assessment of professional behaviour and skills

Professional behaviours (PB)

The mean continuous assessment ratings of professional behaviors assessed by using Student Continuous Assessment Form (SCAF)[5] during clinical clerkship in six disciplines (surgery, medicine, family medicine, obstetrics and gynecology, pediatrics and psychiatry) ranged from 36.5 to 53.5. Table 5 shows the analysis of the scores. The lowest mean scores were in EM followed by ObG in year four and the highest in Medicine in year five. This difference could be ascribed to the faculty's expectations from the students in the different years. The internal consistency of scores from CA forms as calculated by Cronbach's alpha was 0.48.

Clinical skills

The clinical skills are assessed upon the completion of each clerkship. period. These assessments are not uniform across the specialties with a variety

[5] SCAF is in Appendix D

of methods including Objective Structured Clinical Examination (OSCE), short cases and long cases. The short and long cases are conducted in the wards and ambulatory clinics while the OSCEs use standardized patients (SPs), both real patients with physical findings as well as healthy individuals who are trained by the faculty in their roles. The OSCE stations use a nested design and range from 10 – 16 stations depending on the availability of the observers. Structured checklists are used for assessing the students' performance on these stations which includes history taking skills, physical examination skills, counseling skills with some stations on reasoning process for dealing with ethical dilemmas.

Table 5: Descriptive analysis of the written examinations administered during the five years of medical school

A) Applied Basic Sciences at the end of years 1 and 2 of medical

	End of year 1 examination			**End of year 2 examination**		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**
N of Items	159	179	174	166	160	166
Number of Examinees	84	85	93	88	84	94
Mean	113.08	135.44	108.70	113.32	109.88	116.83
Std. Dev.	10.07	15.45	11.76	14.56	10.55	8.782
Alpha	0.80	0.90	0.81	0.88	0.81	0.70

B) Descriptive analysis of the examination of clinical reasoning and decision making at the end of clerkship during years 3-5 of medical school

	Surgery			**Medicine**			**Family Medicine**		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
N of Items	100	100	100	100	100	100	100	100	100
# Examinees	82	80	87	82	80	87	82	79	87
Mean	66.24	64.98	70.25	63.15	78.28	71.75	72.65	75.58	74.51
Std. Dev.	6.98	7.22	5.85	7.53	5.61	6.96	6.49	4.89	4.92
Alpha	0.67	0.72	0.61	0.74	0.67	0.74	0.65	0.58	0.55
	Obstetrics and Gynecology			**Pediatrics**			**Psychiatry**		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
N of Items	100	100	100	100	100	100	30	30	29
# Examinees	82	88	85	81	84	86	80	87	87
Mean	67.62	74.40	71.06	69.05	75.60	80.70	24.66	24.44	22.13
Std. Dev.	5.89	5.67	5.70	6.64	4.49	5.37	2.46	1.85	1.66
Alpha	0.60	0.61	0.62	0.71	0.54	0.67	0.44	0.42	0.31

Table 6: Descriptive analysis of the assessment of clinical skills and professional behaviors during clerkships

A) Assessment of professional behaviors						
	ObGyn	**Psych**	**Paeds**	**Surgery**	**Medicine**	**Fam Med**
N	255	254	255	250	251	249
Mean	40.92	48.72	51.92	52.84	53.56	53.46
SD	8.82	3.38	3.72	3.23	2.44	4.51
Min	24.63	41.00	41.45	41.65	44.65	42.00
Max	60.00	60.00	62.56	61.86	59.80	65.09
B) Assessment of Clinical Skills						
	ObGyn	**Psych**	**Paeds**	**Surgery**	**Medicine**	**Fam Med**
N	253	254	255	250	251	249
Mean	14.59	13.76	17.60	22.45	20.55	21.46
SD	1.71	1.79	2.67	2.64	1.58	2.03
Min	8.25	8.80	10.50	15.73	16.52	12.33
Max	19.13	17.00	24.00	28.76	24.77	25.74

Correlation

Pearson product moment correlations matrix of the observed variables is in Appendix F. The findings show that female sex had a weak to moderate positive and significant correlation with all the dependent variables. Ratings by admission committee and interview ratings generally had negative correlations with other variables. However, both were moderately and significantly correlated (r=.426, *p*< .001). Total number of As in GCSE (A-level) was weakly positive and significantly correlating with scores on knowledge in BBS (KBBS). Subtest scores in AKUMC-AT math problem and English comprehension sections had moderate positive and significant correlation with scores on clerkship examination of CR&DM and clinical skills (r= 0.44 and 0.36 respectively, *p*<.001) while scores on math problems and English comprehension strongly correlated (r=.93, *p*<.001) with each other. Scores on subtest of biology correlated moderately with KBBS scores (r=.30, *p*<.001). Scores on CRDM and Clinical Skills (aggregate of scores on clinical skills and continuous assessment) also correlated strongly (r=.53, *p*<.001). Table 7 shows the results of the correlations between AKU-MCAT sub test and total scores and prior attainment with performance on medical school examinations.

Table 7: Correlation coefficients of scores on the AKUMCAT with knowledge of basic and biological sciences, clinical reasoning and decision making, and clinical skills

AKU-MCAT sub test scores	Basic and Biological Science	Clinical reasoning &decision making	Clinical skills
Biology	**.374****	.025	.038
Chemistry	-.040	.083	-.143*
Physics	.101	.312**	-.070
Math problem	.159*	**.390****	-.013
Verbal reasoning	.215**	**.434****	-.050
Total AKU-MCAT scores	.206**	**.425****	-.022
O-level points	.080	-.101	-.099
Number of As in A level	.194*	.084	.020

The correlations of AKUMC-AT total score with scores on basic science examinations at the end of the first two years were low to moderately positive. The highest correlation of basic science scores was with the biology subtest scores ($r = 0.37$; $p < .001$). Correlation of physics and chemistry subtest score were low and not significant. However, the total science, math problem and English comprehension scores had weak but significantly correlations ($r = 0.15$ to $r=0.22$, $p <0.05$). While there are many statistically significant correlations between admission test scores and the measures of clinical reasoning and decision making; the correlations were small in size, the largest accounting for no more than 45% of the variance. Scores on math problem and English comprehension had significant and high correlations with total clinical examination scores ($r = 0.41$ and 0.45 respectively). Total AKU MCAT scores correlated significantly and moderately with total scores of clinical knowledge test ($r=.49$; $p < .001$).

Total AKU-MCAT scores correlated positively with the year 2 and total basic science scores as well as all clinical subtest scores except psychiatry ranging from $r = 0.22 - 0.54$ ($p <.001$). Knowledge of BBS significantly and moderately correlated with scores of clinical knowledge.

The points awarded by the Admissions Office for performance in GCSE O-level examinations had weak correlations with scores on assessment of basic sciences and clinical science knowledge. There was slight improvement in coefficients for basic science and clinical sciences with number of A grades obtained in GCSE A-level examinations, the largest accounting for only 19% of variance between the two measures. The two indicators of prior scholastic achievement negatively and significantly correlated with each other (r = 0.223; p <.001).

Exploratory Factor Analysis (EFA)

Exploratory factor analysis was performed on 50% of the records (n=118). Principal components extraction with Varimax rotation were used to decompose the correlation matrix shown in Appendix G. Two exploratory factor analyses were performed. The first one using all 38 variables (age, sex, achievement in GCSE O level, grades in GCSE A level, interview ratings, ratings given by admission committee members, five subtest scores on AKUMC-AT, assessment of CRDM in six specialties, clinical skills scores in nine specialties and scores on SCAF in nine specialties). Eleven factors were identified explaining 71.44% of the variance with the data converging in 32 iterations.

A second factor analysis was performed by linear addition of the written assessments of clinical knowledge in the six disciplines named clinical reasoning decision making skills (CRDM). The assessment of clinical skills and professional behaviours were also linearly added and labelled clinical skills. Six factors were identified explaining 69.30% of the variance in the data. The rotation converged in five iterations. Item loadings of less than 0.4 were suppressed. For items loading on two factors, the choice to include on one factor was based on logical appropriateness. The item loadings for the factors are given in table 8.

Table 8. Factor Loadings, Eigen values, and percentages of explained variances from Principal Component Analysis with a Varimax Rotation (n=115)

	Factors				
	Aptitude for medicine	Achievement in medical school	Science knowledge	Prior attainment	Personal Characteristics
Sex					**.802 (PC)**
O level scores				**.435 (PA)**	
A level grades			**.634 (PA)**	-.487	
Interview ratings					-.597
Ratings by admission committee					
Subtest scores in Chemistry	**.674 (AM)**				.434
Subtest scores in Physics				**.812 (AM)**	
Subtest scores in Biology			**.715 (SK)**		
Subtest scores in Math	**.984 (AM)**				
Subtest scores in English	**.947 (AM)**				
Scores in Basic Science examination			**.767 (SK)**		
Assessment of clinical sciences	.433	**.683(AchMS)**			
Assessment of Clinical skills		**.858(AchMS)**			
Eigen values	2.69	1.98	1.69	1.35	1.24
% of Variance	19.25	14.17	12.07	9.67	8.87

AM= Aptitude for Medicine, AchMS=Achievement in Medical School, SK= science knowledge, PA= prior attainment, PC= personal characteristics

Multiple Regression Analysis

Admission scores, prior attainment, interview ratings and ratings given by the admission committee were regressed on scores of basic science knowledge, clinical reasoning and decision making, clinical skills and professional behaviours to examine which factors could provide a stronger prediction of the different elements of achievement in medical school. These regressions were calculated for sex, total and subtest scores on AKUMC-AT, GCSE O-level points, number of A grades in GCSE A-levels examination and aggregate interview ratings of the two assessors. Table 9 shows the Standardized Regression Coefficients, P-values, and adjusted R-Square values for predicting performance on assessment of biological and basic sciences, clinical reasoning and decision making and clinical skills using prior attainment, personal characteristics and subtest scores on AKUMC-AT for 50% random sample of graduates (n=115). Results of a step-wise regression analysis are reported in tables 10-12 separately for each dependent variable. Performance in A level as demonstrated by number of A grades obtained in GCSE examination and admission subtest scores in biology significantly entered the regression equations for performance on assessment of basic sciences at the end of the first two years. The regression was a poor fit (R^2_{adj} = 16%) but the overall relationship was significant ($F_{2,77}$ = 8.29, $p < .01$). With other variables held constant, the performance on test of knowledge of basic biological science had negative correlation with subtest scores in English comprehension, physics and interview ratings. The score on KBBS decreased by

0.67 for one score increase in English comprehension, by 0.24 for one score increase in physics and by 0.88 for increase in interview rating. Subtest scores in English comprehension were the best predictors for performance in assessment of clinical reasoning and decision making with the R^2_{adj} = 22% and a significance relationship ($F_{1,76}$ = 22.49, p <.001). The relations remained significant with the addition of admission subtest scores in chemistry and female sex but the F value decreased ($F_{2,75}$ = 8.333, p <.001). Performance on assessment of clinical skills was best predicted by female sex and admission subtest scores in English comprehension with R^2_{adj} = 27% and a significant relationship ($F_{2,75}$ = 15.11, p <.001). None of the other independent variables entered the equation significantly..

Table 9: Stepwise regression analysis for basic biological sciences knowledge, clinical reasoning & decision making skills and clinical skills using prior attainment, personal characteristics and subtest scores on AKUMC-admission test

	Predictor variables	*b*	SE *b*	β	*P*	R^2
KBBS*	A grades in GCSE A level examination	4.80	2.26	.22	<.05	
	subtest score in biology	1.91	0.57	.35	<.01	.156
CRDM**	Subtest scores in English	1.95	0.41	0.48	<.001	.218
CS ***	Female sex	14.68	4.08	0.35	<.01	
	Subtest score in English	1.10	0.27	0.39	<.001	.268

* Knowledge of Basic Biological Sciences
** Clinical Reasoning and Decision Making
*** Clinical Skills

Table 10: Stepwise regression analysis for assessment of biological and basic sciences using prior attainment, personal characteristics and subtest scores on AKUMC-AT

Model	**Predictor variables**	***B***	**SE *b***	**β**	***P***	**R^2**
1	A grades in GCSE A level examination	4.80	2.26	.22	.038	
	subtest score in biology	1.91	0.57	.35	.001	.156
2	A grades in GCSE A level	5.01	2.25	.23	.029	
	subtest score in chemistry	1.00	0.66	.16	.132	
	subtest score in biology	1.76	0.57	.32	.003	.170
3	Female sex	3.58	3.81	.09	.350	
	A grades in GCSE A level	4.96	2.25	.227	.031	
	subtest score in chemistry	1.11	0.66	.161	.128	
	subtest score in biology	1.72	0.57	.311	.004	.169
4	Female sex	3.73	3.83	.10	.33	
	A grades in GCSE A level	4.87	2.26	.22	.035	
	subtest score in chemistry	1.07	0.66	.17	.110	
	subtest score in biology	1.69	0.58	.30	.005	
	Subtest score in English	-0.20	0.25	-.08	.440	.164
5	Female sex	3.72	3.83	0.10	.335	
	A grades in GCSE A level	4.50	2.31	0.20	.055	
	subtest score in chemistry	1.00	0.67	0.15	.142	
	subtest score in biology	1.64	0.58	0.29	.006	
	Subtest score in math	0.82	0.92	0.25	.372	
	Subtest score in English	-0.78	0.70	-0.32	.267	.162
6	Female sex	3.85	3.87	0.10	.323	
	A grades in GCSE A level	4.42	2.33	0.20	.062	
	subtest score in chemistry	1.01	0.68	0.16	.141	
	subtest score in biology	1.62	0.59	0.29	.008	
	Subtest score in math	0.76	0.94	0.23	.432	
	Subtest score in English	-0.73	0.72	-0.29	.308	
	Interview ratings	-0.78	2.05	-0.04	.703	.152
7	Female sex	3.40	4.08	0.09	.408	
	A grades in GCSE A level	4.41	2.34	0.20	.064	
	Subtest score in physics	-0.28	0.66	-0.05	.710	
	subtest score in chemistry	1.04	0.69	0.17	.134	
	subtest score in biology	1.66	0.60	0.30	.007	
	Subtest score in math	0.77	0.95	0.24	.421	
	Subtest score in English	-0.68	0.73	-0.27	.356	
	Interview ratings	-0.88	2.08	0.05	.675	.142
8	Female sex	3.44	4.17	0.09	.412	
	A grades in GCSE A level	4.44	2.44	0.20	.073	

	GCSE O level scores	0.09	1.51	0.01	.953	
	Subtest score in physics	-0.25	0.67	-0.05	.715	
	Subtest score in chemistry	1.035	0.71	0.16	.148	
	Subtest score in biology	1.66	0.61	0.30	.009	
	Subtest score in math	0.76	0.98	0.24	.439	
	Subtest score in English	-0.67	0.76	-0.27	.376	.130
	Interview ratings	-0.88	2.09	-0.05	.677	

Table 11: Stepwise regression analysis for assessment of clinical reasoning and decision making skills using prior attainment, personal characteristics and subtest scores on AKUMC-AT

Model	**Predictor variables**	***b***	**SE *b***	**β**	***p***	**R^2**
1	Subtest scores in English	1.95	0.41	0.48	.000	0.218
2	Subtest score in chemistry	1.16	1.07	0.11	.279	
	Subtest scores in English	1.89	0.41	0.46	.000	0.220
3	Female sex	6.84	6.24	0.11	.277	
	Subtest score in chemistry	1.21	1.07	0.12	.259	
	Subtest scores in English	1.87	0.41	0.46	.000	0.222
4	Female sex	7.16	6.27	0.12	.257	
	Subtest score in chemistry	1.37	1.09	0.13	.212	
	Subtest scores in biology	-0.78	0.97	-0.08	.424	
	Subtest scores in English	1.85	0.41	0.46	.000	0.218
5	Female sex	7.55	6.30	0.12	.234	
	Subtest score in chemistry	1.37	1.09	0.13	.211	
	Subtest scores in biology	-0.88	0.98	-0.09	.368	
	Subtest scores in English	1.84	0.42	0.45	.000	
	Interview ratings	-2.89	3.20	-0.09	.369	.217
6	Female sex	6.81	6.38	0.11	.289	
	GCSE O level scores	-1.88	2.30	-0.09	.418	
	Subtest score in chemistry	1.59	1.12	0.15	.161	
	Subtest scores in biology	-0.81	0.98	-0.09	.410	
	Subtest scores in English	1.79	0.42	0.44	.000	
	Interview ratings	-2.87	3.21	-0.92	.373	.213
7	Female sex	6.94	6.41	0.11	.282	
	A grades in GCSE A level	2.59	3.95	0.07	.513	
	GCSE O level scores	-1.56	2.36	-0.72	.511	
	Subtest score in chemistry	1.63	1.13	0.16	.154	
	Subtest scores in biology	-0.89	0.99	-0.09	.373	
	Subtest scores in English	1.19	0.42	0.45	.000	
	Interview ratings	-2.58	3.25	0.08	.431	.206
8	Female sex	7.19	6.46	0.12	.269	
	A grades in GCSE A level	3.13	4.10	0.08	.448	
	GCSE O level scores	-1.34	2.42	-0.06	.582	
	Subtest score in chemistry	1.71	1.15	0.16	.141	
	Subtest scores in biology	-0.88	1.00	-0.09	.382	
	Subtest scores in math	-0.82	1.60	-0.16	.608	
	Subtest scores in English	2.41	1.22	0.59	.052	
	Interview ratings	-2.93	3.34	-0.09	.383	.198
9	Female sex	7.05	6.88	0.11	.310	
	A grades in GCSE A level	3.11	4.15	0.08	.456	
	GCSE O level scores	-1.35	2.44	-0.06	.583	

	Subtest score in physics	-0.70	1.10	-0.01	.950	
	Subtest score in chemistry	1.71	1.16	0.16	.144	
	Subtest scores in biology	-0.86	1.03	-.09	.404	
	Subtest scores in math	-0.81	1.63	-0.15	.619	
	Subtest scores in English	2.41	1.24	0.59	.055	
	Interview ratings	-2.96	3.39	-0.09	.386	.186

Table 12: Stepwise regression analysis for assessment of clinical skills using prior attainment, personal characteristics and subtest scores on AKUMC-AT

Model	**Predictor variables**	***B***	**SE *b***	**β**	***p***	**R^2**
1	Female sex	14.68	4.08	0.35	.001	
	Subtest score in English	1.10	0.27	0.39	.000	.268
2	Female sex	15.18	4.08	0.36	.000	
	Subtest score in biology	-0.78	0.61	-0.13	.206	
	Subtest score in English	1.08	0.27	0.38	.000	.274
3	Female sex	15.75	4.08	0.38	.000	
	Subtest score in biology	-0.87	0.61	-0.14	.159	
	Subtest score in English	1.07	0.27	0.38	.000	
	Interview rating	-2.86	2.10	-0.13	.178	.283
4	Female sex	15.22	4.13	0.36	.000	
	O level scores	-1.30	1.45	-0.09	.373	
	Subtest score in biology	-0.79	0.62	-0.13	.203	
	Subtest score in English	1.05	0.27	0.37	.000	
	Interview rating	-2.87	2.11	-0.13	.178	.281
5	Female sex	15.16	4.12	0.36	.000	
	O level scores	-1.67	1.48	-0.11	.265	
	Subtest score in chemistry	0.80	0.72	0.11	.266	
	Subtest score in biology	-0.89	0.62	-0.14	.156	
	Subtest score in English	1.00	0.28	0.36	.001	
	Interview rating	-2.86	2.10	-0.13	.178	.283
6	Female sex	14.99	4.14	0.36	.001	
	O level scores	-1.81	1.50	-0.12	.233	
	Subtest score in chemistry	0.76	0.72	0.11	.295	
	Subtest score in biology	-0.92	0.62	-0.15	.146	
	Subtest score in math	0.67	0.98	0.18	.499	
	Subtest score in English	0.53	0.75	0.19	.483	
	Interview rating	-2.52	2.17	-0.12	.251	.278
7	Female sex	15.71	4.39	0.38	.001	
	GCSE O level scores	-1.77	1.51	-0.12	.247	
	Subtest score in physics	0.36	0.70	0.07	.606	
	Subtest score in chemistry	0.70	0.73	0.10	.341	
	Subtest score in biology	-1.00	0.64	-0.16	.129	
	Subtest score in math	0.62	0.99	0.17	.533	
	Subtest score in English	0.46	0.77	0.16	.555	
	Interview rating	-2.39	2.20	0.11	.280	.270
8	Female sex	15.74	4.42	0.38	.001	
	A grades in GCSE A level	0.99	2.54	0.04	.699	

	GCSE O level scores	-1.16	1.58	-0.11	.310	
	Subtest score in physics	0.37	0.70	0.07	.600	
	Subtest score in chemistry	0.71	0.74	0.10	.341	
	Subtest score in biology	-1.01	0.65	-0.16	.125	
	Subtest score in math	0.54	1.02	0.15	.596	
	Subtest score in English	0.52	0.79	0.19	.513	
	Interview rating	-2.32	2.22	-0.11	.300	.261

Confirmatory Analysis using Structural Equation Modeling

Figure 3 is the model based on theory of achievement and performance and on the findings of the exploratory analysis to better reflect the hypothesized directionality and relationship of the proposed latent constructs, science knowledge, aptitude for medicine and clinical competence, with clinical competence being demonstrated by scores on assessment during medical school. A Correlation matrix created from the data is in table 13. A three factor model was developed and was fitted to the data using EQS software. The remainder of the 50% random sample (n =112) was used for this purpose.

The three factors in the model consisted of

F1 = Science knowledge measured by:

V1 (admission test subtest scores in biology)

V2 (scores on knowledge of basic science test at the end of first two years of medical school)

F2 = Aptitude for medicine measured by:

V3 (admission test subtest scores in chemistry)

V4 (admission test subtest scores in math problem)

V5 (admission test subtest scores in English comprehension)

F3 = Clinical competence:

V6 (scores on assessment of clinical reasoning and decision making)

V7 (scores on assessment of clinical skills)

Variable 8 (number of A grade in the A-level GCSE) and V9 (Sex) were independent variables (added in the model as a result of the findings of the exploratory analysis) hypothesized to affect science knowledge (F2) and achievement in medical school (F3) respectively.

The equation for the three measurement models are given below.

V1=1*F1+E1;

V2=1*F1+E2;

V3=1*F2+E3;

V4=1*F2+E4;

V5=1*F2+E5;

V6=1*F3+E6;

V7=1*F3+E7;

V8=1*F2+E8;

V9=1*F3+E9;
/Covariances
F1,F2=*;
F2,F3=*;
F1,F3=*,

Table 13: Correlation matrix of the variables in the sample used for structural equation modelling

	Sex	Total A grades - GCSE A level	Subset score in admission subtest				KBBS	CRDM	CS
			Chem	Bio	Math	VR			
Sex	1								
Total A grades - GCSE A level	.090	1							
Admission subtest score in chemistry	-.113	-.141	1						
Admission subtest score in biology	.046	.125	.043	1					
Admission subtest score in math	.242*	-.107	.004	.048	1				
Admission subtest score in VR	.199*	-.107	.016	.073	.864**	1			
KBBS	.079	.057	-.145	.357**	.205*	.199*	1		
CRDM	.170	.028	.018	.077	.389**	.427**	.424**	1	
CS	-.268**	.097	.058	.117	-.293**	-.244*	.300**	.461**	1

(Sex = female sex, chem. = chemistry, bio = biology, math = mathematics, VR = verbal reasoning, KBBS = knowledge of basic biological sciences, CRDM = clinical reasoning and decision making, CS = clinical skills)

Model 1

Figure 3 shows the three latent variables with respective parameters estimates and goodness of fit index, values for CFI, SRMR and RMSEA. The model converged in 13 iterations, The standardized solution provided significant positive factor loadings for number of A grades in GCSE A level examination and subtest scores in the biology (.41 and .21 respectively, p<.05). the factor loadings for knowledge of basic & biological sciences and English comprehension were 1.0.The is done by the computer program in an attempt to maximize the fit of the model to the data and is an artefact of measurement. In this ML model fit, the theoretical structure of the model was not supported with the existence of negative covariance between the latent variables of science knowledge with both aptitude for medicine and clinical competence. This did not make logical sense as research in clinical decision making acknowledges the use of basic science knowledge in the reasoning process.[84]

Clinical reasoning and decision making and clinical skills had positive and significant estimates of .92 and .67 for the latent factor clinical competence. Female sex was positive correlated with clinical competence.

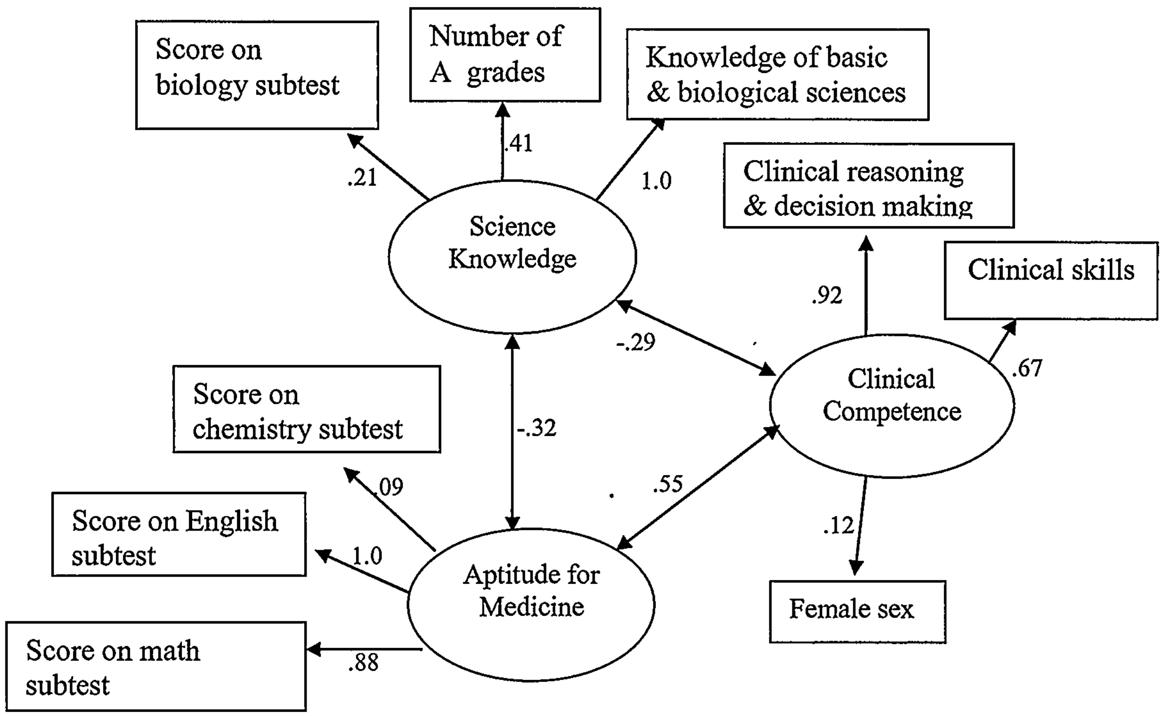


Figure 3: Structural Equation Model for predictive validity of admission criteria for achievement in medicine based on the knowledge encapsulation theory employing Maximum Likelihood (ML) estimations (n=112). Fit indices: χ^2 (21) = 74.57, p =<.001; CFI=.824; RMSEA = 0.152; SRMR = 0.096

Model 2

The model was re -specified (Figure 4) with clinical reasoning loading on both science knowledge and clinical competence based on studies by Donnon et al[60] and Patel et al.[84] In this ML model fit, the theoretical structure and model is supported with the existence of covariance between the latent variables of science knowledge, and aptitude for medicine. The model converged in 12 iterations. The combination rules of cut-off score values are achieved for the CFI at .873 which is lower than the recommended value for the criteria set for robustness and non-robustness conditions with N = 200 and values of SRMR at .093 and RMSEA at .129, and a $\chi^2_{(21)} = 59.70$, $p < .001$ which is smaller than that of the earlier model $\chi^2_{(21)} = 74.57$, $p =<.001$

No other model came close to the fit indices reached by the alternate model 2 and hence I have taken this to be my final model as factors that are effectively demonstrating predictive validity for the AKU medical college admission criteria. In addition this study also supports the theory of two distinct domains of basic science and aptitude for medicine as an indicator of clinical competence.

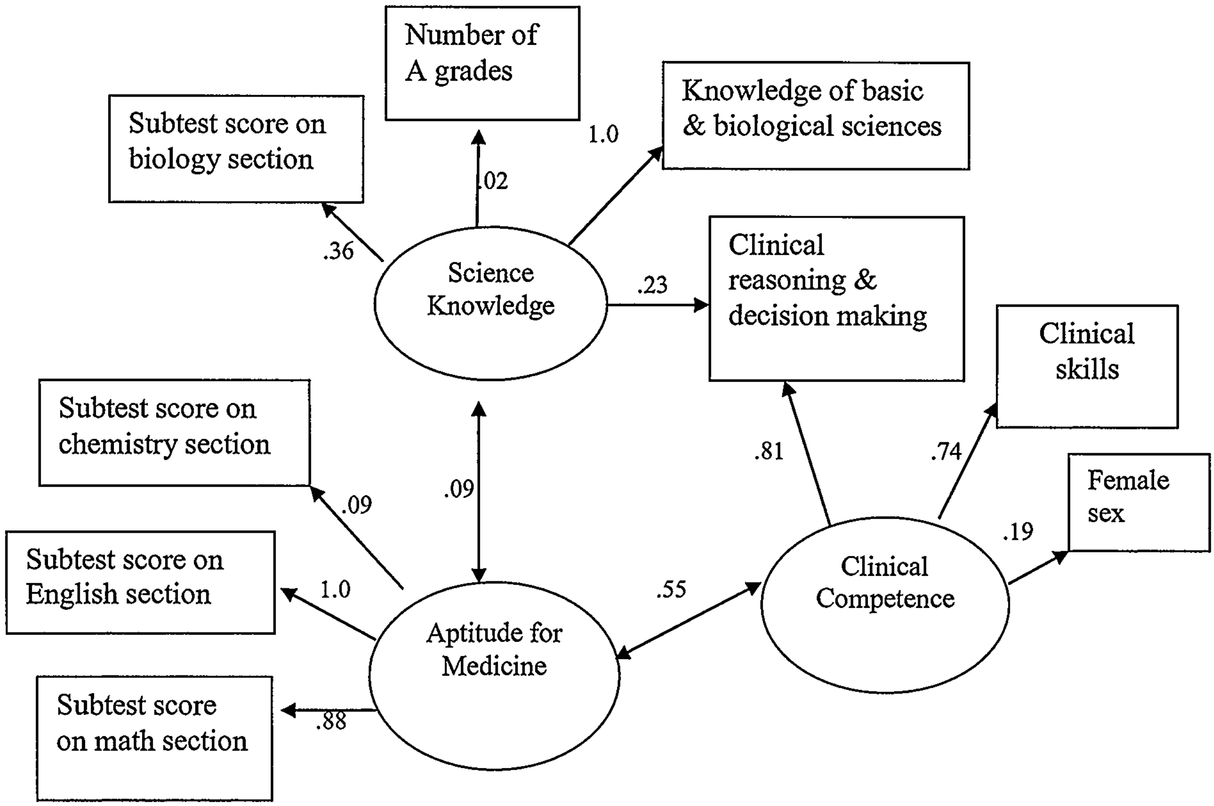


Figure 4: Alternate Structural Equation Model for predictive validity of admission criteria for achievement in medicine employing Maximum Likelihood (ML) estimations (n=112). Fit indices: χ^2 (21) = 59.70, p =<.001; CFI=.873; RMSEA = 0.129; SRMR = 0.093

CHAPTER V: DISCUSSION

This study was aimed at assessing the predictive validity of the AKU medical college admission criteria. A descriptive analysis of the categorical and quantitative data was conducted. Since there are no published reports of the psychometric quality of AKU admission test as well as the examinations and assessments that are conducted throughout the duration of years of medical study, I also examined all the tests and examinations used as independent or dependent variables in this study for their psychometric quality.

Main findings

1. A three factor model of aptitude for medicine, science knowledge and achievement in medical school was the most theoretically coherent model for predictive validity of the admissions tests conducted by AKU during 2003, 2004 and 2005.
2. Subtest scores in biology, chemistry, math problems and English comprehension of the AKUMC-AT, being a female and the number of A grades obtained in GCSE A-level examinations were predictors of performance on assessment of achievement during medical school.
3. Number of A grades in GCSE A level examination and subset score in biology are moderately but significantly positive predictors (R^2=15%) of good performance in assessment of basic sciences during the first two years of medical school.

4. Subtest score in English comprehension is a positive significant predictor (R^2=22%, F=14.92, p =0.000). of success on assessment of clinical reasoning and decision making.
5. Subset score in English comprehension and being female are predictors (R^2 =27%) of success on assessment of clinical skills during the clerkships in medical school
6. The assessment of non cognitive variables using (partially structured) interviews demonstrated low (equal to zero) reliability (r=.06) and did not enter any equation for predictive validity
7. Basic science knowledge and achievement in medical school which is an indicator of clinical competence function as independent latent variables in the measures of clinical reasoning and decision making skills

Predictive Validity

The SEM cutoff criteria used to evaluate structural model fit indices for the final model tested supported a three factor model of medical students Aptitude for Medical Studies, Basic Science Knowledge and Achievement in Medical School. These findings are in similar to that of in which they studied 589 students' performance on assessment of clinical reasoning skills.[55] They got higher cutoff values for SEM model (CFI = .905, SRMR= .054, RMSEA = .105) than my study most likely because they had a larger sample size and used standardized licensing examination as their measure in addition to school level assessment, while in this study the sample size was smaller (n=112) and the measures were all at the school level. These findings support the theoretical structure of clinical reasoning skills development that supports the independent influence of basic science knowledge and clinical competence.[84] This model, in addition to supporting the distinct domains theory for basic sciences and achievement in medical school also suggests the independent influence of each on clinical knowledge.

Prior attainment as demonstrated by the number of A-grades obtained in the GCSE A –level examinations predicted performance on test of basic sciences (β = .22, p <0.05) with a correlation coefficient of (r = .20). The correlation decreased with the progression in later years. This is similar to findings reported by other studies.[19,33,54,61,85]

The AKUMC-AT and its sub scores were predictive of performance in the medical school similar to findings from other studies. Total AKUMC-AT scores correlated better with scores on clinical reasoning and decision making than with basic science attainment (r = .43 and .22 respectively). Similar finding has been reported by Yates and James[86] who report low predictive value of total UKCAT score for performance in the first two years but found subtest scores to be predictive for different subjects studied. Other studies have[30,51,57] found total MCAT scores to be better predictors for performance in the first two years in medical school. This difference could be attributed to data coming from one school using locally developed test in my study as well as to differences in the curricula being used in the different medical schools. Scores on admission subtest of biology predicted the scores on basic science examination ($\beta = .35$, $p < .01$) and is in consonance with correlation coefficient reported in other studies.[87,88] Regression models showed that scores on English comprehension predicted scores on assessment of clinical reasoning and decision making and clinical skills. This is similar to findings of MCAT where VR has been shown to be a better predictor of success in step 2 and step 3 examinations and clerkship ratings. This finding also similar to studies of predictive validity of clinical reasoning skills.[55,60] Low correlation coefficients have been reported in predictive validity studies due to range restriction[27] and a homogenous group of students who ultimately get admitted in medical school. Correction for restriction of range was not applied in this study since SEM is a robust technique using raw data for analysis.

Prior attainment and total AKUMC-AT scores had lower and negative correlations with measures of clinical skill ($r = .02$ and $-.05$ respectively). Similar findings have been reported by other researchers with a plausible explanation that this difference may be due to assessment of different constructs and also effect measurement instruments used.[57,88] The assessment in the first two years is mostly focused on knowledge while in the later years it tends to emphasize assessment of clinical reasoning. The effect of measurement instrument[57] is also a likely explanation since the written assessments comprise of long tests using Multiple Choice Questions (MCQs) while the assessment of clinical skills is mainly done wither by OSCEs or semi structured long cases while that of professional behaviours is done using behaviourally anchored rating scales which are very subjective in assessment.

Sex was identified as a predictor for clinical skills with female students showing academic superiority. This has also been reported in other studies. Where female students have better scores on admission test as well as in medical school courses.[81,89,90] A possible reason could be that admission tests and written assessment has more to do with knowledge whereas clerkship ratings assess professional attributes and clinical performance.

Interviews ratings and ratings by the admissions committee did not enter any regression equation for prediction of achievement in medical school and have low or negative correlation with other independent variables. The ratings by the two interviewers had poor correlations (α =.06) This is in agreement with findings of most of the studies assessing the role of interviews[2,91]except those which have used examiner training or highly structured interviews with many interviewers.[21,22,63] The most likely reason could be that the interviewers are not trained adequately. Only one orientation session is held once a year but this is apparently not enough. Increasing the number of interviewers, structuring the interviews and including current students as interviewers could improve the reliability of scores.[21,22,91,92]

A significant finding of my study is that the students getting admitted in AKUMC are very similar in respect to age, system of prior education (80-85% from the British GCSE system). Although AKU aspires to be an all inclusive institution and conducts outreach programmes activities to attract potential applicants from remote and underprivileged areas the admitted students' demographic profile does not lend itself to this desire. Policy changes are being proposed and new models being tested to increase the diversity of the medical schools.[68,93]

Psychometric analysis of the measurement methods used for testing aptitude (admission test) and achievement in medicine.

For validity of decisions made on the basis of measurement it is important that the measurement instruments are reliable.[37,94] The AKU admission test had a mean score of 73.19 $\pm$ 17.7, 89.25 $\pm$ 22.03 and 90.97 $\pm$ 22.95 (a maximum total score of 180) for the test administered in 2003, 2004 and 2005. There is increase in the mean score over the three years. One of the reasons for this observation could be better prepared students. Many educational centres offer coaching services to applicants of medical school. Studies reporting the effect of these coaching services were reviewed by McGaghie et al.[95] who found minor improvement in scores. However, they recommended increased rigor in these studies. The admission test had an internal reliability (Cronbach alpha) of greater than 0.91 in all three years. This provides some degree of validity evidence for decisions made on the basis of the AKUMC admission test. Other measures of validity evidence for admission test were not available and hence cannot be commented on.

The tests use in the assessment of basic science knowledge and clinical reasoning and decision making in the six clinical disciplines also showed moderate to good reliability during the three years studied. Evidence for content, constructs assessed and internal structure demonstrated that the examinations comprised of well designed MCQs to certify course /clerkship with high internal reliability measures, as are the standardized tests administered for MCAT and USMLE/MCC licensure examinations.

Structural Equation Modeling

For the structural equation model the major finding were that:

1. The three measurement models independently provided good fit indices.
    a. Latent variable *knowledge of science subjects* with measureable variable being subtest scores in Biology subtest of the AKUMC admission test and of Basic Sciences in years 1 and 2 of medical school with a CFI = 1.000
    b. Latent variable *aptitude for medicine* as measured by admission subtest scores on Chemistry, Math problems and English comprehension with a CFI = 1.000
    c. Latent variable for *achievement in medicine* as demonstrated by scores on examinations of clinical reasoning and decision making and assessment of clinical skills with a CFI = .97

2. The number of A grades obtained in GCSE A level examination and sex were identified as independent variables affecting the latent variable Science Knowledge and Achievement in Medicine respectively.
3. A hypothesized three factor structural model of medical student *science knowledge, aptitude for medicine* and *achievement in medicine* provided a theoretically fitting model for the data with a CFI of = .873, RMSEA = .129, SRMR = .093; the latent variables aptitude for medicine covariates with and achievement in medicine with a coefficient of .56 while with the latent variable science knowledge with a coefficient of .09
4. All other variations of model gave lower CFI none exceeding the above value.

Limitations of the study

My study also faced similar problems reported in earlier studies namely restriction of range,[19,82,88] method effect[57] and use of limited grades or ratings used in medical schools, I was faced with a unique problem of not having a standardized licensing examinations similar to the United States Medical Licensing Examination (USMLE) or the Medical Council of Canada Qualifying Examinations (MCCQE) to use as a criterion. Therefore, I had to use the AKU institutional examinations as the dependent variable. This would raise questions about the validity of conclusions made on the basis of this study. Although most of AKU graduates take the USMLE but that data was not obtainable for the three cohorts studied since the institutions did not have the permission from the students to obtain data from National Board of Medical Examiners (NBME). Another major limitation is that the data (that was not gathered by me individually and was handed to me by the respective departments) was incomplete and much information was missing. A third limitation was of data attrition due to students offered admission not joining or leaving the program in the first two years. Fourth limitation was that I could not go further backward in time because AKUMC had initiated the 'new curriculum' using PBL as a main instructional strategy within a clinical presentation curriculum in 2002 (class of 2007) which was the first year and a lot of changes and adjustments were made while that cohort of students passed through medical school. Fifth limitation is the variability in the process of clinical assessment of students during clerkship. This has only been identified as a result of this study that different disciplines assign different weights to the components of clinical assessment and utilizes differing procedures which created a problem in combining scores.

Strengths

To my knowledge no such study has been reported from South Asia where all the admission criteria and the measures of achievement in medical school (as an indicator of clinical competence) have been studied. Second this study uses three cohorts of students from one medical school and follows them throughout their period of medical education to provide data stability. Third the performance data is not limited to assessment of declarative knowledge using paper and pencil tests but includes assessment of professional behaviours and clinical skills which are important elements of achievement in medical school (as an indicator of clinical competence). Fourth, complex and advanced statistical analyses (for example correlation, regression, EFA and SEM) have been utilized to study the research question and test the hypothesized model.

Future directions

The data gathered from the three cohorts studied although supports the model but not with the recommended fit index needed. This could be because of less than optimal sample size and errors of measurement in the instrument used to collect data from the students. Hence this study could be considered as an exploratory study to be confirmed using larger sample size and robust measurement instruments.

The value of the various admission criteria for predicting medical competence beyond the undergraduate years is still debateable. The admission test has demonstrated predictive validity for performance on measures of knowledge but innovative methods are being developed and predictive validity evidence is being gathered for measures of non-cognitive abilities and performance in practice.

The role of English comprehension ability as a predictor of success in medical school needs to be studied further to determine if this can be generalized to other institutions within and outside the country or is it unique to AKU.

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APPENDIX - A

Information for AKU admissions test 2008-09

Admission to the MBBS program is based on merit and potential for leadership. This is assessed through several criteria including scholastic achievements, achievements in extra-curricular and co-curricular activities, participation in social work, productive use of time and other experiences indicating potential for leadership. These criteria cumulatively form the sole basis for admission. Applicants must be able to demonstrate competence in English comprehension and expression, both written and verbal, as the medium of instruction is English.

Academic Requirements for Eligibility: (For candidates applying from Pakistan and overseas)

Applicants prepared in Urdu or English medium institutions, in Pakistan or overseas, who have successfully completed Higher Secondary School Education or are graduates and meet the eligibility criteria may apply. Applicants must present qualifications, which are appropriate to the system of education in which they have been prepared. The College has no preference for a particular type of preparation and qualification.

Applicants from Pakistan and overseas, who have pursued diverse curricula and present different qualifications, are evaluated in comparison with others presenting the same or similar qualifications. During evaluation, No attempt is made to relate achievements in diverse educational systems to a numerical equivalent of the qualification in Pakistan.

Pakistani system of education - Higher Secondary School Certificate

An achievement of at least 65% in the HSC pre-medical examination is essential for applying to the Medical College.

British or equivalent Advanced Level Certificates of Education

At the Ordinary Secondary School level, applicants should have completed at least six subjects including English, biology, chemistry and physics. Official O-Level certificate with grades must accompany the application.

At the Advanced Level of the General Certificate of Education or equivalent, three subjects are required with a minimum grade “B” in each of the three subjects. The subjects must include chemistry, biology and physics.

The requirements for applicants presenting Scottish, West African or East African Certificates of Advanced Level Education are similar.

The SAT II will not be acceptable as a substitute for the Advanced Level grades.

For provisional applicants, the short listing, interviews and ranking by the Admission Committee will take place on a provisional basis while the 'A' level grade / scores are awaited.

Canadian or American High School Certificates

Applicants must present evidence of satisfactory completion of Higher Secondary School with a minimum cumulative GPA of 3.25 or 85% or grade 'B'.

It is required for applicants to have studied biology, chemistry and physics at the Higher Secondary School level (grade 9 through 12).

Applicants are also required to submit SAT II in three or more subjects. The subjects must include biology, chemistry and physics. The minimum eligibility score for each of the three SAT II subjects is 700.

The above requirements are also applicable to candidates having completed two years in college/university.

Candidates may submit three required Advanced Placement (AP) subjects in lieu of the three required SAT II subjects. The minimum eligibility score is a '4' in each of the three subjects. A combination of SAT II and AP is not acceptable. The University will not accept AP in lieu of the SAT II subjects after the 2008 admission cycle.

For provisional applicants, the shortlisting, interviews and ranking by the Admission Committee will take place on a provisional basis while the SAT II or AP scores and HSC transcript is awaited. The Admission Test consists of five components: biology, chemistry, physics, mathematics and English. It consists of questions designed to test recall of factual information, application of knowledge, deduction and problem-solving ability.

Admission test content

The Admission Test is based upon the current syllabi of the Boards of Higher Secondary Certificate Education in Pakistan for chemistry, biology and physics and the Boards of Secondary Education for mathematics. The English language section tests competency in the English language. Applicants should note that minimum or even very high Admission Test scores only fulfil eligibility requirements and may not be competitive during the later stages of evaluation. University will accept the SAT I in lieu of the AKU Admission Test. The eligibility requirement for SAT I is a combined score of 1250 (using critical reading and mathematics only). Candidates who are graduates from overseas are required to write the Medical College Admission Test (MCAT) administered by the American College Testing Services in Iowa. Minimum eligibility requirement is a combined score of 24. Overseas graduates are not eligible to write the AKU Admission Test.

Stage 1

The University shortlists applicants on the basis of a cumulative index determined on the basis of the applicant's Secondary School Certificate achievement and the AKU Admission Test. The achievements in the Admission Test or its equivalent will weigh heavily in shortlisting applicants for interviews. Shortlisted applicants are invited for interviews. The College limits the number of applicants to be interviewed to those who have a reasonable chance of being selected for admission.

Those whose cumulative scores are borderline, but whose origins, education or a significant period of residence or work experience has been in rural or under- privileged areas may also be invited for interviews.

Interviews

Each applicant meets two interviewers, who are experienced evaluators, separately for approximately half an hour each. Interviewers look specially for those personal attributes one would wish to find in a caring physician. The purpose of the interview is to assess a variety of attributes, including integrity, motivation for and interest in medicine, maturity, social and cultural awareness, knowledge of health issues in developing nations, initiative and leadership potential.

Selection

Data based on criteria used during the earlier stages of evaluation, as well as the applicant's achievements in extra curricular and co-curricular activities are compiled for each shortlisted applicant. Decisions for admission are made by an Admissions Committee in line with the objectives of the Medical College. The decisions of the Admissions Committee are based upon the profile of each candidate's scholastic achievements, work experience, interests, leadership potential, and strengths and weaknesses relative to other shortlisted candidates. Admissions are granted to those applicants who display maximum promise and potential. A deliberate effort is made to select meritorious students from diverse backgrounds. This is in the belief that diversity amongst students greatly enriches the educational experience. The University has a provision to train those students for an additional year, before joining the MBBS year I, who qualify for admission, but are found deficient in certain skills, including English language.

APPENDIX - B

Aga Khan UniversityMedical College
Admission Test
Information for Applicants

Admission Test Centre

- Date and venue of the Test has been indicated in the brochure/prospectus and on the admit card.
- Applicants should indicate on Centre of their choice in the space provided in the application form.
- In case the admit card does not reach on time, applicant is advised to write the Test at a convenient Centre with a photocopy of the application form for identification
- Applicants should note that the Admission Test will be administered at a Centre only if there are sufficient candidates.

Test Structure

- The duration of the Test is 2 hours
- All questions are compulsory.
- The test paper comprised the following sections:

Biology	:	Multiple choice questions	30
Chemistry	:	Multiple choice questions	30
Physics	:	Multiple choice questions	30
Mathematics	:	Multiple choice questions	20
English	:	Multiple choice questions	40

The university has not authorized any publication or preparatory classes for this Test.

- Applicants are advised not to guess answers. Each correct answer in the biology, chemistry and physics session receives on point. Omitted questions do not get any point. One-fourth of a point is subtracted for incorrect responses. For Mathematics each correct answer receives point 0.5; one fourth of point is subtracted for tow incorrect responses. There is no negative marking in the English section.

The Answer Sheet

- The Test will be answered on a single, printed answer sheet. This answer sheet is scored by a computer.
- All answers must be marked in pencil.
- The answer sheet is extremely sensitive. Be absolutely sure before marking an answer; make a dark mark. If you wish to change the answer, erase completely and then make a new mark. If the computer reads tow marks, it will record a zero.

Aga Khan University
Medical College Admission Test
Specimen Paper

Biology

Q.1 A member network of channels which transports materials in a cell is called:

A. Mitochondria
B. Lysosomes
C. Endoplasmic reticulum
D. chromatin reticulum

Q.2 Insects resist desiccation because of:

A. The nature of their cuticle
B. Their small size
C. Tracheal method of breathing
D. Their excretion of urea

Q.3 In the black, bread mold, the hyphae that absorb nutrients and penetrate the bread are known as:

A. Sporangiophores
B. Stolons
C. Rhizoids
D. Cametangia

Q.4 Measles, smallpox and influenza are all

disease caused by:

A. Fungi
B. Protozoa
C. Viruses
D. Bacteria

Chemistry

Q.5 What volume of earbon dioxide would be produced if 5 liters of propane, C_3H_3 were burnt in air according to the following equation:

$$C_3H_3+50_2=H_2O+3CO_2$$

A. One liter
B. Three liters
C. Fifteen liters
D. Thirty liters

Q.6 Which of the following when added to pure water. will increase its pH:

A. NH3
B. HI
C. HBr
D. CH1

Q.7 The empirical formula of a liquid compound is $C_2\,H_{12}\,O_6$ to find molecular formula, it is necessary to know the:

A. Boiling point of the compound
B. Density of the compound
C. Relative molecular mass of the compound
D. Percentage composition of the compound

Q. 8 Isotopes have the same:

A. Electron structure
B. Mass number
C. Number of neutrons
D. Physical properties

Physics

Q.9 Which of the following was is not an example of a transverse wave:

A. Radio waves
B. Sound waves
C. X-rays
D. Waves in the sea

Q.10 Which of the following principle is true for electromagnetism

A. A wire carrying a current produces a magnetic field
B. A wire moving in a magnetic field has and EMF induced in it.
C. A wire carrying a magnetic field, experiences a force
D. A changing magnetic field through a coil produces an induced EMF in the coil.

Q.11 Heating a magnet will:

A. Weaken its magnetic field
B. Strengthen its magnetic field
C. Reverse its polarity
D. Have no effect

Q.12 What is the magnitude of the acceleration for the object shown below?

A. $2.5 m/s^2$
B. $3.0 m/s^2$
C. $9.8 m/s^2$
D. $12 m/s^2$

Mathematics

Q.13 if tow similar triangles have base in the ratio of 2:3, what is the ratio of their areas:

A. 1:1
B. 2:3
C. 4:6
D. 4:9

Q.14 In a group of 80 children, there are 22 more girls than boys. How many girls are there in the group:

A. 36
B. 44
C. 48
D. 51

Q.15 if pqr=O, prs=O and rst=1, which of the following must equal 0:

A. p
B. q
C. r
D. s

Q. 16 Which would result in the largest number:

A. 10^2+30^2
B. 10^4
C. (19x21)+ (29x31)
D. 25x36

English

Read the Following passage and answer the questions below:

Dropping cholesterol

1 Reducing cholesterol has become the mantra of doctors and patients alike. Over the last decade clinical trials have shown that a drop in cholesterol levels slows the growth of arterial blockages and reduces heart attacks among patients with a high risk of heart disease. But orchestration that drops with drugs has been controversial; several studies suggested that such drugs increase the risk of death form cancer and suicide. Even as they lower the death rate from heart attacks.

Now a study by a team of Scandinavia researchers shows that a member of new class of cholesterol lowering drugs has the benefits without the drawbacks. The treatment reduces the number of fatal heart attacks by more than 40% without raising the death rate due to other factors.

Q. 17 Why has the use of drugs to control

cholesterol level been controversial?

A. The drugs are linked to increased risk of death form other factors.
B. The growth of arterial blockages slows down as theirs drugs reduce cholesterol level
C. Patients face a high risk heart disease as a side effect of these drugs.
D. the death rate from heart attacks remain unchanged

Q.18 Patients with a high risk of heart disease would benefit.

A. From the use of controversial drugs.
B. From a number of new drugs with some draw backs.
C. If their cholesterol level dropped.
D. If orchestras were less controversial.

Q.19 Use the given text in (I) to select the most appropriate choice in meaning the word "orchestrating" in line 6

A. Changing
B. Arranging something in order
C. Re-Arranging something
D. Putting aside

Q.20 If I _________ enough money, I would go around the world
A. had
B. have
C. has
D. could

Q. 21 The boy explained the reason for coming late___________ detail
A. for
B. with
C. in
D. by

APPENDIX - C

The Aga Khan University
Medical College: Interview Evaluation Form

Applicant's Name: ____________________ Application #: _________ Time: ______
(*Starting time)*

Scale for rating A-D: See definitions on page 4
A: Excellent; **AB**: Between Excellent and Above Average**; B**: Above average; **BC**: Just short of being Above Average; **C**: Average**; CD**: Just short of being Below Average; **D**: Below average

Personal Information: *Is the candidate currently studying (i.e. HSC completed and in another medical college/ institution or completing HSC this year); number of siblings; parents background; etc.*

Initiative: *Is the individual involved with multiple tasks? Did the candidate start anything new? Are there examples of being creative? How does the candidate spend free time? What are his/her activities at home? Evidence of diversity of interest: Is the candidate involved in extra-curricular activities (other than academic)*

Please circle one box						
A	AB	B	BC	C	CD	D

Leadership Potential (relevant to available opportunities): *Evidence of playing a leadership role in family/school/community; at what level? Are there any examples in candidate's life?*

Please circle one box						
A	AB	B	BC	C	CD	D

Independent thinking *What kind of decisions has the candidate been taking? eg: at home for other siblings or for himself/herself etc?*

Please circle one box						
A	AB	B	BC	C	CD	D

Maturity (relevant to age): *How does the candidate assess himself/herself? What are the 3-4 deficiencies in the candidate that he/she feels he/she needs to improve to become a better person? How does the candidate manage stress?*

Please circle one box						
A	AB	B	BC	C	CD	D

Candidate's Motivation, Interest and Commitment to the Medical Profession: *what does the candidate think are the qualities required for a good physician? Is there motivation for AKU or MBBS? Why has he/she chosen AKU? What are the backup options?*

Please circle one box						
A	AB	B	BC	C	CD	D

Adaptability, Tolerance and Respect for Others: *Is the candidate flexible? Is the candidate of an adaptable nature, with good interpersonal skills, at ease with all sorts of people? Does the candidate respect others irrespective of their economic, cultural and religious status? Is there compassion for others? What kind of friends does the individual have? What is the level of tolerance? Has candidate been part of a work project team? Is candidate a social, team, 'people person' or prefers to remain alone? What is the candidates understanding of a patient/doctor relationship? Would the candidate be able to deal with male and female patients with ease with doing examinations in later years?*

Please circle one box						
A	AB	B	BC	C	CD	D

Socio-cultural Awareness: *Is the candidate aware of the social and cultural issues with respect to his/her own personal environment?*

Please circle one box						
A	AB	B	BC	C	CD	D

Awareness about Health issues: *Is the candidate aware of the health care issues relevant to developing countries in general and Pakistan in particular?*

Please circle one box						
A	AB	B	BC	C	CD	D

Work Experience (with respect to available opportunities): *Has the candidate been involved in any paid or voluntary, social or community work? eg: Girl guide/boy scout, giving tuitions etc. Are these related to school / college or on own initiative? For how long?*

Please circle one box						
A	AB	B	BC	C	CD	D

About Academic Integrity: *What are candidates views on academic honesty? Does the candidate feel it is okay to be dishonest, as the society around demands that? If she/he has cheated in school or college, will she/he do it again? Having been involved in school/College and repenting is not the same as a 'so what if I did attitude.'*

Awareness of AKU and its programmes: *Is the candidate aware of AKU and its programmes. Is there awareness about AKU process and admission criteria?*

Please circle one box						
A	AB	B	BC	C	CD	D

Impression on Personality	**Please use rating scale as given on page 1 of this form**			
Comprehension*				
Expression*				
Confidence Level*				

*assessment should not be influenced by competence in English

Overall Assessment: Comments: *These should relate to the candidate. Comparison with peers should be made if relevant*

A:	**Excellent:** *Exceptional candidate.*	
AB:	**Between Excellent and Above Average:** *Just short of being excellent*	
B :	**Above average:** *Impressed you with thinking process. Was genuinely interested in medicine. Would benefit from the professional experience at AKU.*	
BC:	*Just short of being Above Average*	
C:	**Average:** *No distinguishing qualities. May have potential.*	
CD:	*Just short of being Below Average*	
D:	**Below average:** *Below a level that would be expected of others in their peer group. May not be suitable for medical profession.*	

Final rating

II ***The following questions should be answered after the overall evaluation and should not in any way influence your overall rating.***

1. Interview conducted in Urdu ______ English _______ Both _______
   Please rate the candidate's competency in the English language:

*1 **Excellent** (Fluent communication)*	
*2 **Above average** (Communicates fluently with minimum errors in accuracy)*	
*3 **Average** (Communicates but not fluently and makes frequent errors)*	
*4 **Below average** (Communicates with much difficulty and makes a lot of language errors or may not be able to speak at all)*	

(For foreign students state their competence in Urdu: ________________________

2. Have you observed the candidate to have any physical disability? Do you think the disability will be a hindrance to the candidate in performing duties as a Doctor. **(Please do not ask any questions relating to this).**

3. Do you recommend the candidate for the Preparatory Year Programme? If yes, please state reasons. *(This is for students from underprivileged areas and who have studied in Government schools and have demonstrated themselves to be sufficiently academically endowed. This programme requires students to attend a 9 month preparatory course at AKU. Candidates are reassessed at the end of the preparatory programme. Admission to AKU after the programme is NOT guaranteed).*

Name of Interviewer: ____
(Please Print)

Department: ________________________ Date: ________________

APPENDIX – D

THE AGA KHAN UNIVERSITY MEDICAL COLLEGE, KARACHI

CLERKSHIP - STUDENTS CONTINUOUS ASSESSMENT (years 3 – 5)

FROM ________________ TO ________________

	COMPETENCY	UNSATISFACTORY	SATISFACTORY	GOOD	EXCELLENT
PROFESSIONALISM					
A	PROFESSIONAL AND ETHICAL BEHAVIOR	Consistently demonstrates irregularity in attendance. Demonstrates irresponsible behaviour or unethical behaviour or has been dishonest.	Demonstrates punctuality, altruism, compassion, integrity. Is a reliable member of the health care team. Is appropriately dressed and respects the views and interests of the patient and patient's family.	Consistently demonstrates punctuality, altruism, compassion, integrity. Is a reliable and efficient member of the health care team. Respects the views and interests of the patient and patient's family.	Demonstrates excellence in professional and ethical behaviour by going beyond the call of duty.
B	INTERPERSONAL SKILLS	Consistently demonstrates poor communication skills; unable to deal with difficult patients or issues; can be hostile or antagonistic.	Demonstrates effective communication; tends to avoid difficult encounters.	Communicates appropriate information clearly, comprehensively; able to identify and address the needs of others.	Displays team leadership qualities; successfully deals with difficult situations without antagonizing others.
REPORTER					
C	KNOWLEDGE (BASIC AND CLINICAL)	Consistently demonstrates lack of using clinical knowledge to define priorities in diagnosis and management of clinical problems.	Usually demonstrates reasonable fund of knowledge making accurate diagnosis and reasonable differential diagnosis.	Consistently demonstrates reasonable fund of knowledge making accurate diagnosis and reasonable differential diagnosis. Treatment plan appropriate for level.	Exceptional knowledge base; complete differential diagnosis for complex cases, comprehensive management plans.
D	HISTORY TAKING	Histories consistently incomplete, illogical or inappropriate.	Includes most of the relevant issues which are accurate. Somewhat disorganized approach.	Elicits most suitable historical points. History complete, accurate and organized	Histories address a broad differential diagnosis, adjusts style to clinical situation; able to acquire relevant information in difficult scenarios.
E	PHYSICAL /MENTAL STATE EXAMINATION	Examination consistently incomplete or inappropriate; lacks ability to elicit findings.	Includes most of the relevant findings; sometimes over- or under-inclusive.	Examination complete, accurate and demonstrates depth in clinical acumen.	Examinations address a broad differential; elicits subtle findings; uses advanced diagnostic maneuvers.
F	WRITTEN RECORDS AND NOTES	Consistently continues to omit key details; notes disorganized.	Notes include most of the relevant information; somewhat disorganized.	Well organized; clear, legible; consistently includes important information.	Exceptionally clear and concise documentation fulfilling medico legal requirements.
G	ORAL PRESENTATION SKILLS	Demonstrates difficulty in presenting data in a logical order; incomplete and superficial data presentation.	Usually presents essential information reasonable well.	Presents information clearly; in an organized manner; occasional minor omissions.	Consistently presents relevant information precisely and in a logical manner, with confidence.

COMPETENCY		UNSATISFACTORY	SATISFACTORY	GOOD	EXCELLENT
INTERPRETER					
H	INTERPRETIVE SKILLS / DIAGNOSTIC ABILITY	Consistently fails to justify/demonstrate clinical reasoning	Able to justify/demonstrate clinical reasoning for common clinical problems.	Able to justify/demonstrate clinical reasoning for most of the clinical problems	Always evidence based in justifying/ demonstratating clinical reasoning
I	CLINICAL JUDGEMENT	Actions and explanations consistently lack understanding of underlying medical reasoning; difficulty in arriving at decisions.	Usually makes use of information available with occasional difficulty in arriving at decisions.	Formulates available information well and makes sound clinical decisions.	Consistently accurate evaluation of all available data; makes good clinical decisions without delay.
MANAGER					
J	CONTINUITY OF CARE / RESPONSIBILITY	Consistently demonstrates unreliability; has failed to assure ongoing patient care, does not complete assigned tasks	Basically reliable; may occasionally loose track of patients; usually follows up with assigned tasks.	Reliable; keeps up to date with developments in his / her patients with minimal prompting; always follows up with assigned tasks	Exceptionally reliable; complete awareness of his/her patients; always contributes more in addition to the assigned tasks
EDUCATOR					
K	SELF-DIRECTED LEARNING / INITIATIVE / MOTIVATION	Consistently demonstrates lack of interest in learning; does not attempt to fill in gaps in knowledge base or procedural skills.	Interested in learning; may require direction from others in acquisition of knowledge.	Reads around interesting or difficult cases	Keenly interested in learning; often follows up on cases; good self-directed learning skills.
L	EDUCATES THE PATIENT	Consistently demonstrates inability to educate the patient about the management plan, possible complications and preventive measures	Able to educate the patient regarding the management plan and complications.	Always educates the patient regarding the management plan, possible complications, preventive measures and alternate treatment options.	Always educates the patient regarding the management plan, treatment options, possible complications and preventive measures. Customizes a plan according to patient circumstances and preferences

- *In order to successfully complete the clerkship, students will have to attain a satisfactory in demonstration of Professional and Ethical Behaviour.*
- *Written comments are necessary under a separate letterhead, in either case if a student demonstrates unsatisfactory or excellent performance.*

__NOTE:__ Attributes which are not assessed during the rotation should be marked NA (NOT ASSESSED) or (NOTAPPLICABLE) depending upon the objectives of the rotation.

OVERALL SCORE: ______________

__COMMENTS ON OVERALL PERFORMANCE:__

____

____

____

____

____

____

____

Feed back given to student: Y _____ N _____ **Signature of Consultant / Team** ____________________________

APPENDIX - E

Item Analysis Report

Item Analysis Report of Admission Test 2004					
Item #	Proportion Correct	Proportion Wrong	Difficulty	Discrimination	Point -Biserial
1	0.31	0.69	0.31	-0.18	0.15
2	0.86	0.14	0.86	0.27	0.32
3	0.41	0.59	0.41	0.23	0.2
4	0.80	0.20	0.80	0.23	0.24
5	0.44	0.56	0.44	0.23	0.3
6	0.33	0.67	0.33	0.34	0.31
7	0.13	0.87	0.13	-0.01	-0.01
8	0.76	0.24	0.76	0.31	0.29
9	0.81	0.19	0.81	0.32	0.33
10	0.6	0.4	0.6	0.4	0.33
11	0.54	0.46	0.54	0.19	0.16
12	0.56	0.44	0.56	0.41	0.33
13	0.72	0.28	0.72	0.3	0.27
14	0.13	0.86	0.13	-0.11	-0.12
15	0.55	0.45	0.55	0.17	0.15
16	0.26	0.74	0.26	0.21	0.19
17	0.17	0.83	0.17	0.12	0.13
18	0.22	0.78	0.22	0.13	0.12
19	0.18	0.82	0.18	0.12	0.14
20	0.42	0.58	0.42	0.23	0.2
21	0.51	0.49	0.51	0.48	0.39
22	0.05	0.95	0.05	-0.07	-0.13
23	0.75	0.25	0.75	0.04	0.06
24	0.86	0.14	0.86	0.29	0.34
25	0.54	0.46	0.54	0.58	0.46
26	0.24	0.76	0.24	0.33	0.32
27	0.83	0.17	0.83	0.12	0.14
28	0.5	0.5	0.5	0.34	0.28
29	0.69	0.31	0.69	0.35	0.31
30	0.78	0.22	0.78	0.09	0.1
31	0.13	0.87	0.13	0.12	0.15
32	0.08	0.92	0.08	-0.16	-0.22
33	0.61	0.39	0.61	0.28	0.24
34	0.55	0.45	0.55	0.5	0.4
35	0.43	0.57	0.43	0.42	0.35

Item #	Proportion Correct	Proportion Wrong	Difficulty	Discrimination	Point -Biserial
36	0.71	0.29	0.71	0.41	0.37
37	0.69	0.31	0.69	0.24	0.22
38	0.45	0.55	0.45	0.16	0.14
39	0.92	0.08	0.92	0.16	0.26
40	0.41	0.59	0.41	0.47	0.41
41	0.83	0.17	0.83	0.11	0.12
42	0.27	0.73	0.27	0.08	0.09
43	0.59	0.41	0.59	0.14	1.2
44	0.48	0.52	0.48	-0.03	-0.02
45	0.4	0.6	0.4	0.18	0.15
46	0.1	0.9	0.1	-0.01	0
47	0.42	0.58	0.42	0.12	0.12
48	0.09	0.91	0.09	0.05	0.08
49	0.28	0.72	0.28	0.31	0.28
50	0.84	0.16	0.84	-0.03	0
51	0.31	0.69	0.31	0.12	0.12
52	0.86	0.14	0.86	0.24	0.27
53	0.24	0.76	0.24	0.17	0.16
54	0.66	0.34	0.66	0.39	0.34
55	0.74	0.26	0.74	0.35	0.35
56	0.91	0.09	0.98	0.15	0.22
57	0.34	0.66	0.34	0.27	0.23
58	0.63	0.37	0.63	0.37	0.3
59	0.24	0.76	0.24	0.24	0.23
60	0.33	0.67	0.33	0.24	0.21
61	0.44	0.56	0.44	0.26	0.21
62	0.67	0.33	0.67	0.32	0.28
63	0.47	0.53	0.47	0.52	0.41
64	0.24	0.76	0.24	0.15	0.16
65	0.18	0.82	0.18	-0.02	0
66	0.51	0.49	0.51	0.22	0.2
67	0.3	0.7	0.3	0.41	0.37
68	0.78	0.22	0.78	0.41	0.4
69	0.82	0.18	0.82	0.18	0.2
70	0.58	0.42	0.58	0.46	0.37
71	0.73	0.27	0.73	0.32	0.3
72	0.49	0.51	0.49	0.41	0.32

Item #	Proportion Correct	Proportion Wrong	Difficulty	Discrimination	Point -Biserial
73	0.49	0.51	0.49	0.15	0.13
74	0.49	0.51	0.49	0.59	0.47
75	0.84	0.16	0.84	0.25	0.28
76	0.03	0.97	0.03	-0.06	-0.14
77	0.61	0.39	0.61	0.4	0.34
78	0.78	0.22	0.78	0.42	0.4
79	0.46	0.54	0.46	0.37	0.31
80	0.82	0.18	0.82	0.26	0.27
81	0.61	0.39	0.61	0.5	0.41
82	0.22	0.78	0.22	0.14	0.13
83	0.52	0.48	0.52	0.55	0.44
84	0.37	0.63	0.37	0.49	0.41
85	0.59	0.41	0.59	0.35	0.29
86	0.55	0.45	0.55	0.48	0.38
87	0.52	0.48	0.52	0.56	0.43
88	0.5	0.5	0.5	0.52	0.41
89	0.66	0.34	0.66	0.37	0.33
90	0.56	0.44	0.56	0.54	0.54
91	0.45	0.55	0.45	0.45	0.37
92	0.36	0.64	0.36	0.47	0.37
93	0.5	0.5	0.5	0.35	0.29
94	0.67	0.33	0.67	0.44	0.38
95	0.61	0.39	0.61	0.52	0.43
96	0.21	0.79	0.21	0.02	0.03
97	0.78	0.22	0.78	0.36	0.36
98	0.73	0.27	0.73	0.54	0.49
99	0.19	0.81	0.19	0.31	0.33
100	0.36	0.64	0.36	0.45	0.37
101	0.16	0.84	0.16	0.19	0.21
102	0.71	0.29	0.71	0.35	0.35
103	0.32	0.68	0.32	0.25	0.23
104	0.41	0.59	0.41	0.32	0.27
105	0.36	0.64	0.36	0.02	0.02
106	0.68	0.32	0.68	0.28	0.26
107	0.48	0.52	0.48	0.49	0.39
108	0.63	0.37	0.63	0.57	0.46
109	0.5	0.5	0.5	0.43	0.35
110	0.78	0.22	0.78	0.2	0.2

Item #	Proportion Correct	Proportion Wrong	Difficulty	Discrimination	Point -Biserial
111	0.6	0.4	0.6	0.49	0.4
112	0.3	0.7	0.3	0.17	0.16
113	0.32	0.68	0.32	0.37	0.32
114	0.32	0.68	0.32	-0.04	-0.03
115	0.52	0.48	0.52	0.48	0.38
116	0.61	0.39	0.61	0.41	0.35
117	0.32	0.68	0.32	0.13	0.1
118	0.36	0.64	0.36	0.27	0.24
119	0.27	0.73	0.27	0.17	0.16
120	0.09	0.91	0.09	0.08	0.14
121	0.51	0.49	0.51	0.55	0.43
122	0.46	0.54	0.46	0.28	0.22
123	0.23	0.77	0.23	0.42	0.41
124	0.84	0.16	0.84	0.34	0.36
125	0.07	0.93	0.07	-0.02	-0.02
126	0.61	0.39	0.61	0.36	0.29
127	0.75	0.25	0.75	0.45	0.39
128	0.45	0.55	0.45	0.51	0.41
129	0.52	0.48	0.52	0.47	0.37
130	0.51	0.49	0.51	0.59	0.46
131	0.38	0.62	0.38	0.72	0.58
132	0.57	0.43	0.57	0.72	0.58
133	0.23	0.77	0.23	0.41	0.41
134	0.6	0.4	0.6	0.49	0.39
135	0.15	0.85	0.15	0.27	0.32
136	0.37	0.63	0.37	0.51	0.44
137	0.72	0.28	0.72	0.4	0.36
138	0.18	0.82	0.18	0.27	0.28
139	0.08	0.92	0.08	0.07	0.1
140	0.31	0.69	0.31	0.11	0.1
141	0.87	0.13	0.87	0.25	0.29
142	0.26	0.74	0.26	-0.06	-0.06
143	0.59	0.41	0.59	0.45	0.36
144	0.45	0.55	0.45	0.34	0.28
145	0.52	0.48	0.52	0.42	0.33
146	0.88	0.12	0.88	0.26	0.34
147	0.38	0.62	0.38	0.22	0.18

Item #	Proportion Correct	Proportion Wrong	Difficulty	Discrimination	Point -Biserial
148	0.31	0.69	0.31	-0.04	-0.04
149	0.58	0.42	0.58	0.2	0.16
150	0.46	0.54	0.46	0.5	0.4
151	0.71	0.29	0.71	0.44	0.38
152	0.57	0.43	0.57	0.62	0.49
153	0.45	0.55	0.45	0.43	0.35
154	0.91	0.09	0.91	0.17	0.26
155	0.71	0.29	0.71	0.51	0.44
156	0.97	0.03	0.97	0.07	0.17
157	0.62	0.38	0.62	0.46	0.38
158	0.86	0.14	0.86	0.29	0.35
159	0.47	0.53	0.47	0.53	0.42
160	0.41	0.59	0.41	0.26	0.22
161	0.74	0.26	0.74	0.49	0.45
162	0.64	0.36	0.64	0.55	0.45
163	0.61	0.39	0.61	0.52	0.42
164	0.41	0.59	0.41	0.6	0.48
165	0.75	0.25	0.75	0.51	0.48
166	0.64	0.36	0.64	0.68	0.54
167	0.69	0.31	0.69	0.43	0.38
168	0.24	0.76	0.24	0.01	0.01
169	0.59	0.41	0.59	0.61	0.49
170	0.52	0.48	0.52	0.53	0.43
171	0.57	0.43	0.57	0.23	0.19
172	0.39	0.61	0.39	0.24	0.19
173	0.39	0.61	0.39	0.06	0.05
174	0.28	0.72	0.28	0.11	0.1
175	0.38	0.62	0.38	0.45	0.38
176	0.47	0.53	0.47	0.35	0.28
177	0.33	0.67	0.33	0.16	0.13
178	0.43	0.57	0.43	0.5	0.41
179	0.5	0.5	0.5	0.16	0.13
180	0.3	0.7	0.3	0.24	0.21

Item Total Statistics AKU Admission Test 2004

number of questions	180
Number of examinees	3171
Mean score	89.25
Variance	485.46
Standard Deviation	22.033
Skewness	-0.04
Kurtosis	-0.42
Minimum score	17
Maximum score	147
Median score	89
Alpha	0.93
SEM	5.824
Mean Difficulty	0.49
Mean item-total	0.265
Mean Biserial	0.35
Maximum score (low)	75
N (lower group)	857
Minimum score (high)	103
N (higher group)	891

Difficulty and discrimination analysis (N=180)*

Difficulty index	Difficult ≤ .29	Moderate .30 - .80	Easy >.80
Number of items	35	127	18

Discrimination index	Inverse discrimination	Poor 0.0-0.19	Acceptable 0.2 – 0.29	Good 0.3 – 0.39	Excellent <4.0
Number of items	14	40	33	26	67

* Using Ebel's guidelines

APPENDIX - F

Correlation coefficients of all variables for all cases in the data set (n=227)

	sex	age	system of education	total As	agg_inter view	Ad com ratings	tot_phy	tot_chem	tot_bio	tot_math	tot_eng
Sex	1										
Age	.020	1									
Educ system	-.027	-.172*	1								
total As (A)	.027	-.179*	.089	1							
agg_interview	-.068	.099	-.085	-.238**	1						
Ad C Ratings	-.045	-.099	-.037	.108	.302**	1					
tot_phy	.338**	-.046	-.003	-.027	-.105	.207*	1				
tot_chem	-.011	.029	.100	-.131	-.073	.255**	.348**	1			
tot_bio	-.057	.050	.041	.147	-.120	-.146	.069	-.016	1		
tot_math	.180*	.192*	-.017	.076	-.171*	-.068	.506**	.143	-.077	1	
tot_eng	.195*	.185*	-.003	.012	-.087	-.099	.512**	.080	-.068	.897**	1
grandtot	.222**	.155	.019	.031	-.163	.001	.737**	.355**	.162	.892**	.895**
tot_1A	-.041	-.038	.031	.154	-.043	-.235**	-.093	-.034	.431**	-.140	-.149
tot_1B	.146	-.038	.065	.286**	-.129	-.202*	.140	.053	.400**	.220**	.260**
tot_Med	.143	.103	-.029	.031	-.111	-.080	.313**	.149	.129	.513**	.540**
tot_Obg	-.039	.090	.088	.037	.083	-.025	.162	.039	.043	.247**	.340**
tot_Peds	.005	.030	.000	.040	-.113	-.014	.245**	.085	-.150	.434**	.470**
tot_Psy	.112	-.071	.046	.078	.026	.149	-.014	.071	-.026	-.100	-.139
tot_Surg	-.015	-.062	.020	.042	.034	.194*	.121	.138	-.155	.133	.191*
tot_FM	.026	.027	.083	-.055	.030	.081	.220**	.152	.037	.214*	.275**
CA_SUR_3	.024	-.009	.095	-.146	.072	.092	.178*	.051	-.192*	.150	.201*
CA_med_3	.033	-.007	-.035	-.098	-.122	-.061	.166	.038	.134	.199*	.209*
CA_FM_3	-.184*	-.044	-.030	-.131	.077	.097	-.099	-.086	.134	-.337**	-.346**
CA_ObG_4	.045	.065	-.030	-.048	-.069	.134	.428**	.181*	-.307**	.647**	.676**
CA_Psych_4	-.182*	-.013	.033	-.027	.013	-.003	-.081	.078	.218**	-.288**	-.252**
CA_Peds_4	-.006	.097	-.030	.010	-.060	-.095	.122	.056	-.117	.686**	.670**
CA_CHS_4	-.079	.076	-.045	.040	-.048	.026	.009	-.128	.009	.134	.105

CA_SUR_5	-.187*	-.019	.124	-.060	.079	-.061	.009	-.074	.238**	.023	.037
CA_Med_5	-.137	.040	.071	.015	.056	.146	-.213*	.068	.024	-.344**	-.334**
CA_FM_5	-.183*	.081	-.054	.111	.022	.087	-.019	-.090	-.071	-.020	-.027
CA_EM_5	-.183*	-.078	.166	-.089	-.090	.064	.048	.131	-.054	-.068	-.002
OSCE_surg_3	-.145	-.123	-.022	.031	-.131	-.059	-.057	.080	.113	-.129	-.165
OSCE_ObG_4	-.302**	-.134	.048	.153	.008	.050	-.244**	-.087	.163	-.370**	-.338**
OSCE_Psych_4	-.123	-.054	-.060	-.017	.112	.090	-.037	.009	-.089	-.088	-.059
OSCE_Peds_4	.136	.134	.034	-.051	-.084	-.032	.417**	.179*	-.113	.700**	.751**
OSCE_Surg_5	-.203*	-.050	-.065	.014	-.072	-.044	-.167	-.086	.184*	-.278**	-.275**
OSCE_Med_5	-.005	-.064	-.031	.013	.037	.152	.083	.067	-.152	.061	.127
OSCE_FM_5	-.222**	.035	-.039	.095	-.003	.022	-.253**	-.029	.147	-.318**	-.360**
OSCE_EM_5	-.144	.042	.024	-.159	.037	.051	-.184*	-.014	.107	-.273**	-.239**
EOC_CHS_4	-.042	-.073	.039	-.023	.089	.009	-.065	-.106	.192*	-.157	-.156

	grandtot	tot_1A	tot_1B	tot_Med	tot_Obg	tot_Peds	tot_Psy	tot_Surg	tot_FM	CA_SU3	CA_me3	CA_FM3
sex	.222**	-.041	.146	.143	-.039	.005	.112	-.015	.026	.024	.033	-.184*
age	.155	-.038	-.038	.103	.090	.030	-.071	-.062	.027	-.009	-.007	-.044
Edu system	.019	.031	.065	-.029	.088	.000	.046	.020	.083	.095	-.035	-.030
total As in A	.031	.154	.286**	.031	.037	.040	.078	.042	-.055	-.146	-.098	-.131
agg_interv	-.163	-.043	-.129	-.111	.083	-.113	.026	.034	.030	.072	-.122	.077
ratings	.001	-.235**	-.202*	-.080	-.025	-.014	.149	.194*	.081	.092	-.061	.097
tot_phy	.737*	-.093	.140	.313**	.162	.245**	-.014	.121	.220**	.178*	.166	-.099
tot_chem	.355**	-.034	.053	.149	.039	.085	.071	.138	.152	.051	.038	-.086
tot_bio	.162	.431**	.400**	.129	.043	-.150	-.026	-.155	.037	-.192*	.134	.134
tot_math	.892**	-.140	.220**	.513**	.247**	.434**	-.100	.133	.214*	.150	.199*	-.337**
tot_eng	.895**	-.149	.260**	.540**	.340**	.470**	-.139	.191*	.275**	.201*	.209*	-.346**
grandtot	1											
tot_1A	-.057	1										
tot_1B	.321**	.620**	1									
tot_Med	.556**	.261**	.566**	1								
tot_Obg	.297**	.262**	.471**	.682**	1							

tot_Peds	.411**	.046	.242**	.516**	.438**	1						
tot_Psy	-.094	.159	.258**	.337**	.349**	.217*	1					
tot_Surg	.157	-.120	.109	.445**	.424**	.381**	.227**	1				
tot_FM	.290**	.134	.319**	.601**	.551**	.501**	.312**	.532**	1			
CA_SUR_3	.158	-.104	-.008	.200*	.153	.222**	.139	.363**	.263**	1		
CA_med_3	.240**	.035	.184*	.330**	.198*	.140	.006	.289**	.318**	.100	1	
CA_FM_3	-.288**	.325**	.004	-.071	.095	-.057	.112	.008	.100	.146	.071	1
CA_ObG_4	.609**	-.463**	-.125	.374**	.195*	.361**	.008	.396**	.275**	.356**	.165	-.221**
CA_Psych_4	-.176*	.218*	.131	-.055	.044	-.037	.228**	.049	.037	.095	.074	.252**
CA_Peds_4	.560**	-.148	.127	.419**	.231**	.417**	-.053	.161	.184*	.092	.156	-.296**
CA_CHS_4	.075	-.017	.044	.162	.045	.022	.116	.072	.121	.138	.153	.174*
CA_SUR_5	.062	.363**	.298**	.270**	.198*	.089	.069	.067	.224**	.184*	.071	.305**
CA_Med_5	-.307**	.135	.039	.045	.097	.083	.253**	.198*	.222**	.091	-.017	.140
CA_FM_5	-.055	-.153	-.003	.106	.145	.203*	.163	.336**	.205*	.244**	.192*	.194*
CA_EM_5	.001	-.173*	-.130	-.028	.043	.124	.061	.236**	.133	.054	-.052	.116
OSCE_sur3	-.096	.145	.098	.013	-.108	-.044	.112	.010	.052	.005	.192*	.164
OSCE_Ob4	-.326**	.440**	.296**	.137	.328**	.098	.213*	.182*	.303**	-.066	.071	.407**
OSCE_Psy4	-.083	-.131	-.114	.031	.088	.071	.178*	.228**	.132	.057	.080	.094
OSCE_Ped4	.698**	-.130	.255**	.575**	.435**	.537**	-.091	.335**	.420**	.235**	.262**	-.250**
OSCE_Sur5	-.242**	.372**	.216*	.137	.241**	.008	.244**	.154	.211*	.130	.185*	.411**
OSCE_Me5	.081	-.048	.206*	.410**	.355**	.377**	.411**	.608**	.458**	.346**	.209*	.054
OSCE_FM5	-.313**	.326**	.163	.016	.089	-.055	.192*	.106	.045	-.064	.120	.255**
OSCE_EM5	-.230**	.103	.129	.018	.137	-.035	.187*	.287**	.270**	.066	.218*	.222**
EOC_CHS4	-.122	.325**	.224**	.085	.106	.040	.176*	.035	.104	-.035	.159	.358**

	CA_ObG4	CA_Psyc4	CA_Peds4	CA_CHS4	CA_SUR5	CA_Med_5	CA_FM_5	CA_EM_5	OSCE_S3	OSCEOG4
Sex	.045	-.182*	-.006	-.079	-.187*	-.137	-.183*	-.183*	-.145	-.302**
age	.065	-.013	.097	.076	-.019	.040	.081	-.078	-.123	-.134
Educ sys	-.030	.033	-.030	-.045	.124	.071	-.054	.166	-.022	.048
total As in A	-.048	-.027	.010	.040	-.060	.015	.111	-.089	.031	.153
agg_int	-.069	.013	-.060	-.048	.079	.056	.022	-.090	-.131	.008
Ad C ratings	.134	-.003	-.095	.026	-.061	.146	.087	.064	-.059	.050
tot_phy	.428**	-.081	.122	.009	.009	-.213*	-.019	.048	-.057	-.244**
tot_chem	.181*	.078	.056	-.128	-.074	.068	-.090	.131	.080	-.087
tot_bio	-.307**	.218**	-.117	.009	.238**	.024	-.071	-.054	.113	.163
tot_math	.647**	-.288**	.686**	.134	.023	-.344**	-.020	-.068	-.129	-.370**
tot_eng	.676**	-.252**	.670**	.105	.037	-.334**	-.027	-.002	-.165	-.338**
grandtot	.609**	-.176*	.560**	.075	.062	-.307**	-.055	.001	-.096	-.326**
tot_1A	-.463**	.218*	-.148	-.017	.363**	.135	-.153	-.173*	.145	.440**
tot_1B	-.125	.131	.127	.044	.298**	.039	-.003	-.130	.098	.296**
tot_Med	.374**	-.055	.419**	.162	.270**	.045	.106	-.028	.013	.137
tot_Obg	.195*	.044	.231**	.045	.198*	.097	.145	.043	-.108	.328**
tot_Peds	.361**	-.037	.417**	.022	.089	.083	.203*	.124	-.044	.098
tot_Psy	.008	.228**	-.053	.116	.069	.253**	.163	.061	.112	.213*
tot_Surg	.396**	.049	.161	.072	.067	.198*	.336**	.236**	.010	.182*
tot_FM	.275**	.037	.184*	.121	.224**	.222**	.205*	.133	.052	.303**
CA_Sur3	.356**	.095	.092	.138	.184*	.091	.244**	.054	.005	-.066
CA_med3	.165	.074	.156	.153	.071	-.017	.192*	-.052	.192*	.071
CA_FM3	-.221**	.252**	-.296**	.174*	.305**	.140	.194*	.116	.164	.407**
CA_Ob4	1									
CA_Psy4	-.250**	1								
CA_Peds_4	.509**	-.266**	1							
CA_CHS_4	.235**	.035	.048	1						
CA_SUR_5	.037	.207*	.060	.248**	1					
CA_Med_5	-.171*	.248**	-.175*	.078	.189*	1				
CA_FM_5	.101	.059	-.049	.124	-.053	.090	1			

CA_EM_5	.220**	.046	-.006	.083	.103	.157	.077	1		
OSCE_sur3	-.189*	.192*	-.081	-.039	-.004	.124	.004	.018	1	
OSCE_Ob4	-.271**	.119	-.292**	.078	.198*	.219**	.185*	.131	.185*	1
OSCE_Psy4	.091	.094	-.075	.096	-.085	.254**	.243**	.091	.079	.072
OSCE_Pd4	.540**	-.172*	.639**	-.040	.073	-.188*	.000	.094	-.085	-.155
OSCE_Sur5	-.191*	.137	-.187*	.091	.174*	.241**	.279**	-.003	.142	.427**
OSCE_Me5	.308**	.065	.131	.051	.113	.281**	.241**	.255**	.069	.200*
OSCE_FM5	-.388**	.325**	-.267**	.118	.135	.226**	.176*	-.046	.190*	.424**
EOC_CHS4	-.208*	.370**	-.072	.398**	.162	.168*	.148	.013	.146	.256**

	OSCE_Psych_4	OSCE_Peds_4	OSCE_Surg_5	OSCE_Med_5	OSCE_FM_5	OSCE_EM_5	EOC_CHS_4
sex	-.123	.136	-.203*	-.005	-.222**	-.144	-.042
age	-.054	.134	-.050	-.064	.035	.042	-.073
Educ sys	-.060	.034	-.065	-.031	-.039	.024	.039
total As	-.017	-.051	.014	.013	.095	-.159	-.023
agg_interv	.112	-.084	-.072	.037	-.003	.037	.089
Ad C ratings	.090	-.032	-.044	.152	.022	.051	.009
tot_phy	-.037	.417**	-.167	.083	-.253**	-.184*	-.065
tot_chem	.009	.179*	-.086	.067	-.029	-.014	-.106
tot_bio	-.089	-.113	.184*	-.152	.147	.107	.192*
tot_math	-.088	.700**	-.278**	.061	-.318**	-.273**	-.157
tot_eng	-.059	.751**	-.275**	.127	-.360**	-.239**	-.156
grandtot	-.083	.698**	-.242**	.081	-.313**	-.230**	-.122
tot_1A	-.131	-.130	.372**	-.048	.326**	.103	.325**
tot_1B	-.114	.255**	.216*	.206*	.163	.129	.224**
tot_Med	.031	.575**	.137	.410**	.016	.018	.085
tot_Obg	.088	.435**	.241**	.355**	.089	.137	.106
tot_Peds	.071	.537**	.008	.377**	-.055	-.035	.040
tot_Psy	.178*	-.091	.244**	.411**	.192*	.187*	.176*
tot_Surg	.228**	.335**	.154	.608**	.106	.287**	.035

tot_FM	.132	.420**	.211*	.458**	.045	.270**	.104
CA_SUR3	.057	.235**	.130	.346**	-.064	.066	-.035
CA_med_3	.080	.262**	.185*	.209*	.120	.218*	.159
CA_FM_3	.094	-.250**	.411**	.054	.255**	.222**	.358**
CA_ObG_4	.091	.540**	-.191*	.308**	-.388**	-.173*	-.208*
CA_Psych4	.094	-.172*	.137	.065	.325**	.267**	.370**
CA_Peds_4	-.075	.639**	-.187*	.131	-.267**	-.116	-.072
CA_CHS_4	.096	-.040	.091	.051	.118	-.022	.398**
CA_SUR_5	-.085	.073	.174*	.113	.135	.154	.162
CA_Med_5	.254**	-.188*	.241**	.281**	.226**	.246**	.168*
CA_FM_5	.243**	.000	.279**	.241**	.176*	.285**	.148
CA_EM_5	.091	.094	-.003	.255**	-.046	.245**	.013
OSCE_Sur3	.079	-.085	.142	.069	.190*	.125	.146
OSCE_Ob4	.072	-.155	.427**	.200*	.424**	.304**	.256**
OSCE_Psy4	1						
OSCE_Pd4	-.084	1					
OSCE_Sur5	.100	-.204*	1				
OSCE_Me5	.258**	.274**	.275**	1			
OSCE_FM5	.208*	-.203*	.287**	.056	1		
OSCE_EM5	.150	-.019	.471**	.332**	.296**	1	
EOC_CHS4	.000	-.167*	.301**	.079	.271**	.218**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

a. Listwise N=139

APPENDIX – G

Exploratory Analysis
Correlation coefficients of 50 % of the random sample for all observed variables in the study (n=118)

	Sex	# As A- level	Inter scores	Ad comm. ratings	tot_phy	tot_chem	tot_bio	tot_math	tot_eng	KBBS	CRDM	CS
Sex	1											
# As in A level	-.019	1										
Interview scores	-.056	-.148	1									
Admiss Comm rating	-.158	.208	.426**	1								
tot_phy	.206*	.007	-.167	.046	1							
tot_chem	-.038	-.056	-.090	.086	.177	1						
tot_bio	-.082	.020	-.132	-.065	.133	.091	1					
tot_math	-.002	.044	-.173	-.173	.598**	.096	.072	1				
tot_eng	-.018	-.057	-.117	-.156	.580**	.085	.003	.926**	1			
KBBS	-.056	.161	-.193*	-.338**	.071	.213*	.304**	.146	.071	1		
CRDM	-.133	.051	-.060	-.057	.234*	.219*	-.037	.391**	.440**	.386**	1	
CS	-.411**	.076	.017	.260**	.176	.049	-.177	.337**	.355**	-.052	.548**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).