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Graduate-Entry Medical Student Variables that Predict Academic and Clinical Achievement

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A hypothetical model was formulated to explore factors that influenced academic and clinical achievement for graduate-entry medical students completing their third year of university studies. Nine latent variables were considered including the students' background, previous successes with their undergraduate and postgraduate studies and their assessed ability to study graduate-entry medicine based on their scholastic aptitude and their interview selection scores. The academic and clinical achievement of 99 graduate-entry medical students were estimated by measuring their performance on two separate assessment procedures, a 150 item multiple choice examination and a 20 item objectively structured clinical evaluation (OSCE) test. These two assessments were taken across two years (to include two student groups) and were equated using Rasch scaling procedures. Models identifying causal pathways leading to academic and clinical achievement were tested using Partial Least Squares Path Analysis (PLSPAT). The study's results suggest that medical student achievement can be predicted by variables, which account for 6 to 22 per cent of the variance of scores that assess academic achievement and clinical performance at the third year level respectively. The most significant predictors and those which had direct influence on graduate-entry medical student achievement were: (a) student gender, undergraduate grade point average scores, type of undergraduate studies undertaken, and where those studies were carried out that were related to the OSCE scores, and (b) whether or not the graduate-entry medical students had pursued other studies prior to undertaking the medical course and age that were both negatively related to achievement on the multiple choice examination. Measures of performance at interview and student scores for GAMSAT that were used in the selection process were not related to the performance outcomes assessed.

Rasch scaling, partial least squares analysis, graduate-entry, medical students, scholastic aptitude, scores, interview selection

INTRODUCTION

Three Australian university medical schools (Flinders University in South Australia, the University of Queensland and the University of Sydney) just over ten years ago changed their traditional six year conventional undergraduate medical course to a four year graduate-entry medical program on the grounds that they wanted to broaden the academic basis for student admission and acknowledge the student's past performance in tertiary education (Aldous, Leeder, Price, Sefton and Tuebner, 1997). Another catalyst for the change was a widely held perception that secondary school results on their own did not allow university faculties to identify the potential students most motivated and suited to medical studies. There were demographic

inconsistencies also, with universities tending toward accepting metropolitan students rather than rurally based students into their medical programs (Field and Gordon, 2000). Other forces were pressing for the need to change the way Australian medical education was being managed. Medical science and technology were advancing at a rapid rate, giving rise to avenues of medical treatment that were unheard of before. Simultaneously, public expectations were also changing with patients wanting to be more informed and have greater engagement in their own treatment. In order to satisfy these demands and expectations while simultaneously wishing to prepare future medical practitioners more effectively, the graduate entry medical program was devised. Its charter was to help instil in medical students a commitment to lifelong learning, where the students make a greater contribution towards their own learning, become more self directed and employ a problem based approach to learning (Wing, 2003).

This paper examines whether different graduate-entry medical student characteristics could be used to predict academic and clinical achievement in the third year (penultimate year) of medical studies. Graduate-entry medical students are assessed in their knowledge, their skill acquisition and apply their abilities to medical reasoning to clinical scenarios using two different but related assessment methods: completion of a 150 item multiple choice examination paper, and the successful execution of 20 different clinical skills scenarios, called OSCEs (Objectively Structured Clinical Evaluation).

Figure 1 gives, in diagrammatic form, the path model for the latent variables shown in oval-shaped boxes with the directions of hypothesized causal influence being shown by the path arrows. Since several of the latent variables were not directly observable, the manifest variables used to observe the latent variables are shown in Figure 1 as rectangular boxes. Not all possible causal paths are shown in Figure 1, and only those hypothesized to be of sufficient magnitude to have recognizable influences are drawn. However, it should be noted that in testing the model, all possible causal pathways were examined.

With reference to Figure 1, it is hypothesized that achievement in the student's third year of medical study (latent variable 10) is directly influenced by the student's capacity at interview (latent variable 9) and overall achievement in undergraduate studies (GPA) (latent variable 6) and involvement in post-graduate study (latent variable 7). It is also hypothesized that achievement could be indirectly influenced by the student's age (latent variable 2) as students who held post-graduate awards would be older than students who held an undergraduate degree only. Latent variable numbers 4 and 5 (place and type of undergraduate study) are thought to influence medical student achievement indirectly, particularly through scores obtained at interview given by the assessors of the interviews. In order to obtain a sufficient numbers of students for sound analyses this study had to employ two cohorts (students commencing in 1998 and 1999 depicted as latent variable 3) and it was argued that this variable would not have a direct influence on achievement but could influence the student's aptitude test score (latent variable 8) and interview score (latent variable 9) because it was assumed that aptitude tests and interviewing procedures for course admission could change from year to year.

It was argued that factors influencing student success in medicine would be best tested by employing a path analysis model, involving latent and manifest predictor variables. It was further hypothesized that any variability in performance in Year 3 of the medicine course could be attributed to differences in variance associated with these predictor variables.

BACKGROUND TO THE STUDY

While there is very little information cited in the literature about medical student characteristics and admission to graduate medical programs, there is a great deal of literature examining the

different factors that explain the undergraduate medical students' ability to achieve both in multiple choice examinations and in the clinical setting.

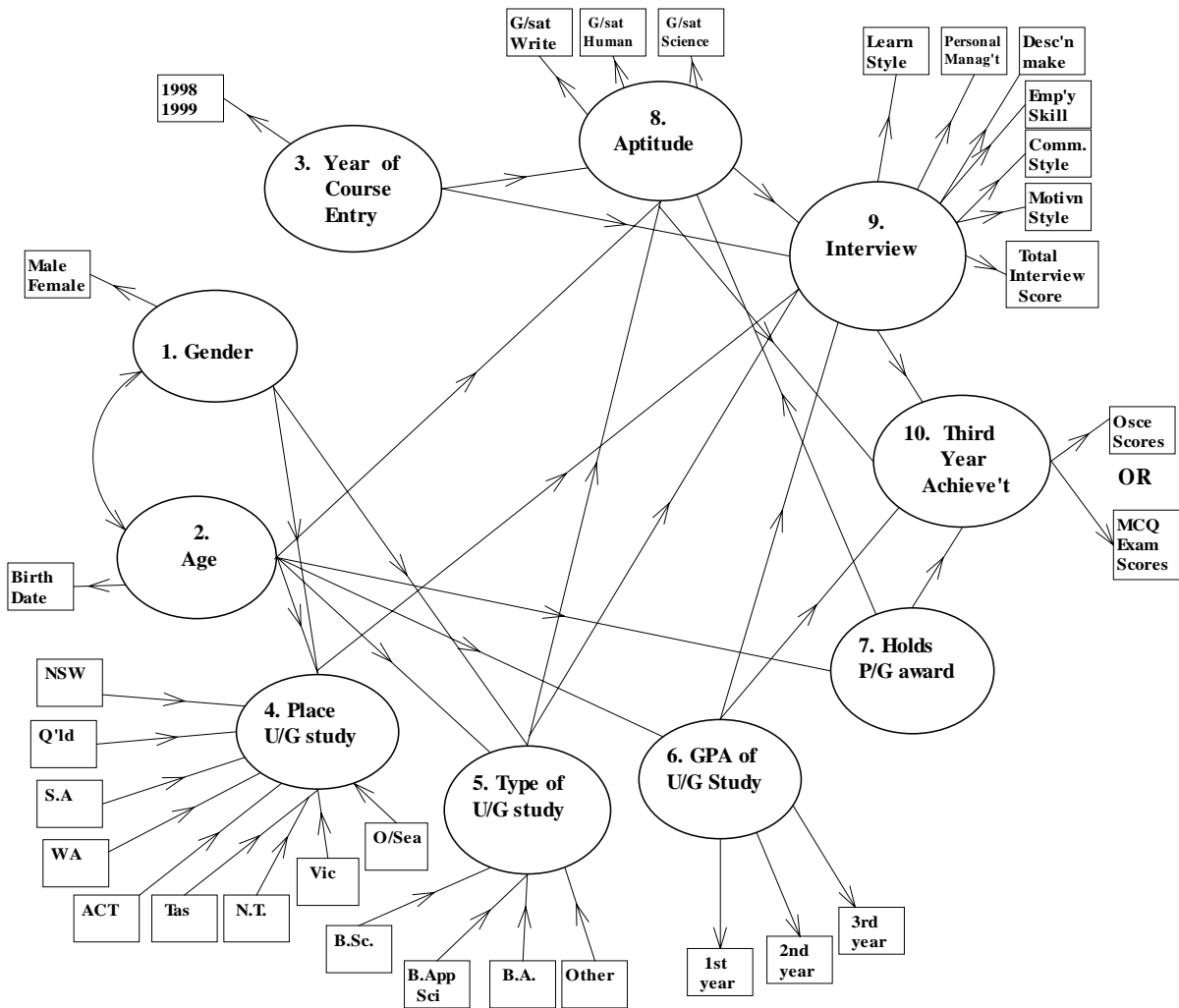


Figure 1. Predicted relationships between manifest and latent variables to achievement in the graduate entry medical program.

Different psychological tests have been used to predict medical student achievement. Psychiatric assessment of medical students has been used as a determinant of success in graduating from medical school but has proved to be unreliable particularly when involving such variables as the student's personality, interest and attitudes (Aldrich, 1987). However, when combined with a profile at course entry involving student's success in a previous degree, achievement at high school and grade point average such tests might be useful, as predictors of success in the non-clinical aspects of medical studies (Green, Peters and Webster, 1993; Hoschl and Kozeny, 1997; Shen and Comrey, 1997).

The medical student's age has been found to have effects both for gaining access to medical courses and for defining achievement during the medical program. Older students in several studies, did less well in reasoning in the sciences and tended to be graded with lower scores at the beginning of their courses, up to and including the first year of their medical studies (Aldous, Leeder, Price, Sefton and Tuebner, 1999; Huff and Fang, 1999; Kay, Pearson and Rolfe, 2002). Medical student ratings as given by their clinical supervisors were not significantly influenced by student age, yet another recent English study suggested that the older and mature aged medical students did achieve better overall, when compared to their younger counterparts (Rolfe, Pearson, Powis, and Smith, 1995; James and Chilvers, 2001).

Student gender seems to have some influence on medical student achievement also. Scores achieved by male students on medical course admission tests for GAMSAT (Graduate Australian Medical School Admissions Test) were higher than those achieved by female medical student applicants (Ramsbottom-Lucier, Johnson, and Elam, 1995; Aldous, Leeder, Price, Sefton and Teubner, 1999; Chaput de Saintonge and Dunn, 2001). While on course, female medical students were seen generally to be at a greater risk of experiencing difficulties with their studies compared to their male counterparts (Huff and Fang, 1999). However, if female medical students already possessed an honours degree while undertaking their medical courses, problems with achievement were less likely (James and Chilvers, 2001).

There has been much debate about the advantages of using grade point average scores (GPA) as a determinant for medical course access. GPA scores are said not to be consistent determinants of success in the early years of undergraduate medical studies (Blue, Gilbert, Elam and Basco, 2000). However, matriculation and higher undergraduate science scores were better predictors of success for the very beginning medical students' achievement (Hall and Stocks, 1995; James and Chilvers, 2001) and for predicting the student's eventual access to a medical specialty area on graduation (Pringle, and Lee, 1998). Used on their own, GPA scores are not considered to be consistent predictors for medical course achievement especially for students who came from cultural minority groups (Lynch and Woode, 1990), or for students who used English as a second language (Chan-Ob and Boonyanaruthee, 1999), or for predicting medical students' ability to interact with patients, or of estimating their performance requiring clinically related skills (Hall and Stocks, 1995; Poussaint, 1999; Reede, 1999).

The Graduate Australian Medical School Admissions Test (GAMSAT) modelled on the North American Medical College Admissions Test (MCAT) seeks to evaluate medical student abilities and skills developed through prior experience and learning. This includes the student's understanding of basic science, general problem solving skills, critical thinking skills and writing ability (ACER, 1998). One recent Australian study showed that male applicants scored more highly on GAMSAT in reasoning in the humanities and reasoning in the sciences than female medical students, and that older students did less well in reasoning in the sciences. However, improvement in written communication occurred with age (Aldous, Leeder, Price, Sefton, and Teubner, 1997).

The type of first degree studies undertaken by students has been found to have a strong influence on GAMSAT performance particularly for arts and social science students who did well with reasoning in the GAMSAT humanities test and written communication, and with science degree students doing better in reasoning in the GAMSAT physical sciences test. Honours students did better overall on GAMSAT scores than students holding just the bachelor degree (Aldous, Leeder, Price, Sefton, and Teubner, 1997). Although much research has been done into factors influencing performance in traditional medical school courses, very little research has been undertaken into the examination performance of students in graduate entry medical programs.

METHODS OF INVESTIGATION AND ANALYSIS

Participants

A retrospective sample of 99 (consisting of two groups of 51 and 48 students) Australian graduate entry medical students who had completed their third year of medical studies was chosen for this research study. The two groups of students who were selected for the study, comprised those who commenced their four-year graduate medical program in 1998 (occasion 1) and those who started a year later in 1999 (occasion 2). Just over half of the medical students were males (57%) and with an age range from 23 years to 47 years of age (mean, 29 years and sd 6.0).

Upon commencement of a medical course, the predominate undergraduate degree held by students (62%) was a science degree, followed by an applied science degree (22% of students) and with a Bachelor of Arts award accounting for 12 per cent of the student group. Four students held other qualifications such as a Bachelor of Engineering. Well over half of the group held postgraduate degrees (62%) in addition to their undergraduate qualifications. Most students gained their initial qualifications in South Australia (40%) followed by Victoria (16%), New South Wales (12%), with Queensland, Western Australia and Tasmania having almost equivalent but small numbers of students. Very small numbers of students came from the Northern Territory, the Australian Capital Territory and from Australian students obtaining their undergraduate degrees overseas.

Data Collection

With full recognition of confidentiality issues, information about student admission variables was obtained from past student records. Admission scores obtained for the study's use included the Graduate Australian Medical School Admissions Test (GAMSAT) scores for applicants, their grade point average scores achieved in their undergraduate studies and the student's interview scores obtained prior to course admission.

Student achievement information in their third year of medical studies was gained from a retrospective audit of student records documenting results on a 150 multiple-choice examination, which tested different aspects of medicine in various domains including obstetrics and gynaecology, surgery, paediatrics and general practice. In addition the scores recorded in a 20 task objectively structured clinical evaluation (OSCE) were obtained. The foci of these so-called clinically simulated tasks included history taking, counselling skills, pharmacological understanding, physical examination practices and clinical dexterity in medical procedures in several medical domains. It should be noted that some of the multiple choice examinations and the objectively structured clinical evaluation tasks differed between the two occasions, but as some common items were used on both occasions, this allowed for the equating of the instruments over both time periods.

Data Analysis

As the student scores obtained for both the multiple choice examination and the OSCE assessments were estimated using classical test theory (or true-score theory), any analysis of those student test scores is confined to information about item difficulty and item discrimination and some overall estimate of the test's reliability. This feature has serious limitations (Yen and Edwardson, 1999) in equating scores over time. These problems can be overcome by the use of item-response theory (Rasch scaling analysis) which allows an estimation of the student's underlying ability to be undertaken by examining the student's performance on a set of test items, after allowance has been made for the difficulty of the item and how well the items are matched to the student's ability level (El-Korashy, 1995; Ludlow and Haley, 1995). The program used for this part of the analysis was done using the RUMM software (Andrich, Luo and Sheridan, 2001).

As previously mentioned, the items of the multiple choice examinations and the OSCE assessments differed over the two years in which the study was conducted, and the sets of scores needed to be equated before the analysis could proceed. Data from the two different medical student examinations were therefore combined, as there were sets of common items linking the tests together over two occasions (Wright, 1993; Luo, Seow, and Chew, 2001). The analysis provided a calibration, standard error and fit statistic for every student and all test items involved in the testing. Misfitting items were eliminated in the calibrations (Andrich, Sheridan and Luo, 1998). However, since a weak correlation between the students' scores arising from the multiple-choice examination to the clinical assessments was obtained ($r=+0.30$). It was not possible to combine the two different types of scores to form a single outcome measure.

After test equating was completed, the Partial Least Squares Path Analysis (PLSPAT 3.01) program (Sellin, 1990) was used to test the separate models of variables that were hypothesized to influence academic achievement and clinical performance in medicine at third year level. The analysis would predict and identify which relationships between the variables and achievement might or might not exist (Noonan, and Wold, 1985). The PLSPAT procedure is highly appropriate for analysing and predicting relationships between educational data as it can deal with data that are not normally distributed and that would be excluded in other analytical approaches. Additionally, PLSPAT can deal with relatively small numbers of cases and yet remain very robust especially in situations where not all the relevant variables are known to be normally distributed or where the relationship between the latent variables (theoretical constructs) and the manifest variables are unknown or speculative (Falk, 1987). PLSPAT is also the modelling method of choice as it can account for influences hypothesized to act by using causal models because it is clearly impossible to administer randomised controlled conditions to assess causality in such educational settings (Keeves, 1988). In the presentation of the findings of the analyses of the data collected in this study, the estimated path models are shown in diagrammatic form with only a brief discussion of the procedures involved in their estimation. However, only the causal paths of particular interest in the prediction of medical student performance are discussed although a more detailed report has been prepared for consideration of interested readers (Blackman, 2004).

RESULTS

Multiple-Choice examination

Figure 2 shows the estimated path model for the prediction and explanation of the multiple-choice examination scores.

The effects of educational status of the medical student

The variable that describes whether or not a student entered medicine course with an award greater than an ordinary undergraduate degree (LV7) has a negative pathway (-0.19) on the achievement variable for the multiple-choice examination. This co-efficient indicates that the post-graduate group did significantly worse in the multiple-choice examination than students holding only an undergraduate award.

The effects of the age of the medical student and success

With respect to the relationship between the age and achievement of the multiple-choice examination, it can be seen that a negative path co-efficient (-0.16) exists between age and the achievement variable. This indicates that the younger students did significantly better on the multiple-choice achievement test than did older students.

These are the only two variables that are estimated to influence directly the multiple choice examination scores, and a large residual path of 0.97 (representing unexplained variance) is recorded for the achievement variable (LV10) in Figure 2, since only six per cent of the variance of this outcome is explained.

Clinical assessment scores

Figure 3 shows the estimated path model for the prediction and explanation of the objectively structured clinical examination scores.

The effects of GPA scores

With reference to Figure 3 it can be seen that the grade point average scores obtained by students in their undergraduate studies (LV6) has a direct influence on their subsequent achievement on the clinical assessment tasks. A positive path coefficient exists between these two variables (0.17) which indicates that students with higher grade point averages in their undergraduate studies overall achieve at a higher level on the clinical examination in their third year of medical studies. The loadings for the GPA scores obtained in the first (0.88) second (0.92) or third years (0.78) of study are an indication that there is little difference between the contributions to OSCE performance made by the different years of prior study.

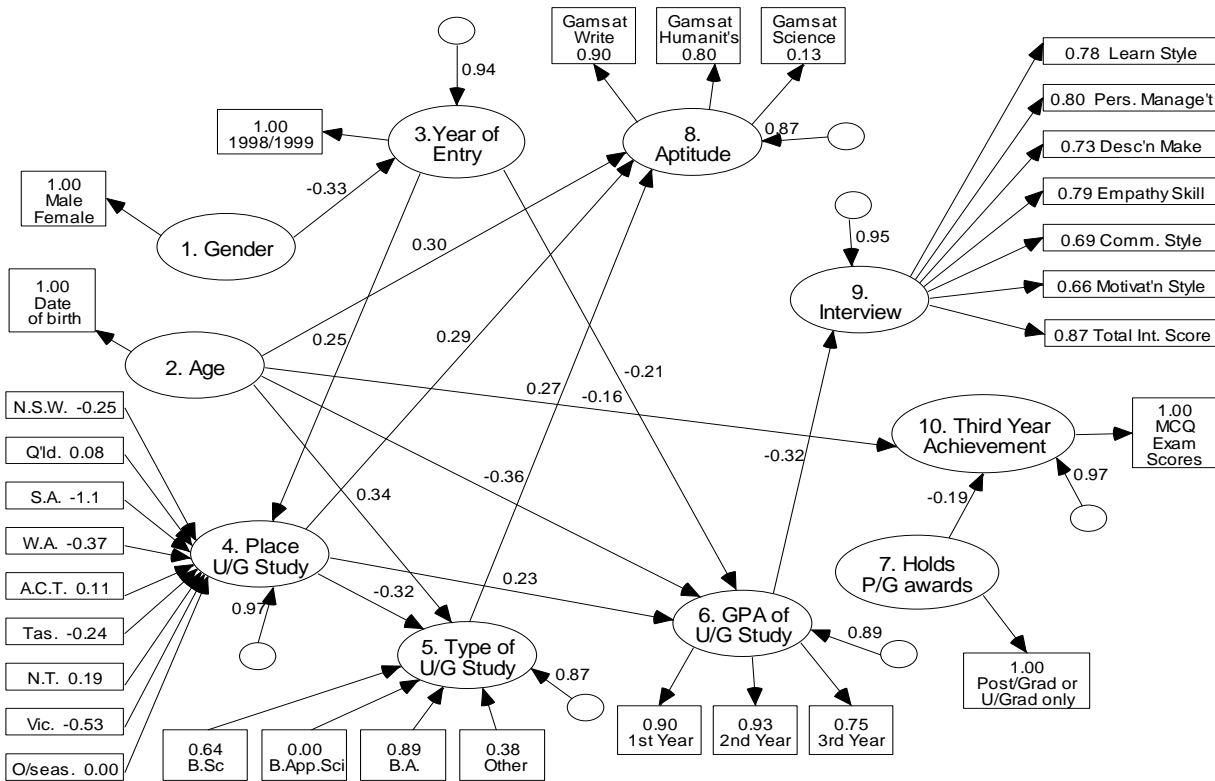


Figure 2. Final model for predicting achievement in the multiple-choice medical examination

The effects of the type of undergraduate studies

A path co-efficient of 0.21 exists between the clinical examination variable and the variable that describes the type of undergraduate study (LV5) taken by the student prior to entering medical studies. A positive pathway indicates that students with a science type of undergraduate degree (0.85) achieve better than students with an Arts degree (0.71), any other degree (0.40) or an applied science degree (0.0). Graduate entry medical students who held an applied science degree were coded as zero and employed as a dummy variable in the analysis. Students who held degrees in applied science did significantly worse than other students in particular clinical examination tasks involving history taking, interpretation of objective medical data and the specific management of external fixation devices to limb fracture.

The place of undergraduate studies undertaken

Between the achievement variable and the variable associated with where students undertook their undergraduate studies (LV4), a path co-efficient of 0.25 is recorded. This positive pathway suggests that students from certain undergraduate study sites did better than others in their

medical examinations. This is particularly true for students who studied for their undergraduate degrees in Western Australia (-0.10) and South Australia (-0.56) who ha significantly lower clinical examination scores compared to their counterparts who studied in Queensland (0.49).

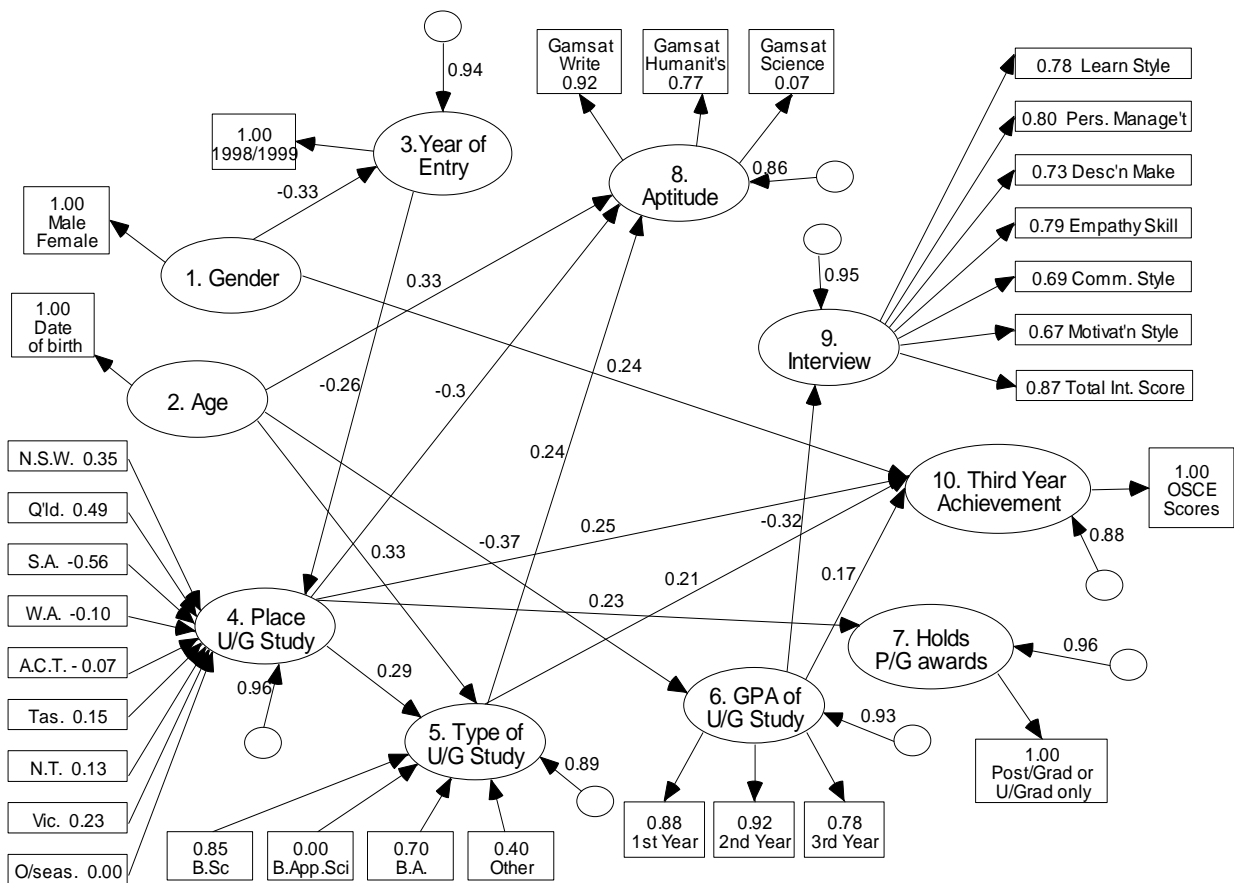


Figure 3. Final path model for factors influencing achievement clinical medical examination

The effects of gender on undergraduate students

A positive path co-efficient exists between the student gender variable (LV1) and the achievement variable (0.24). This indicates that female students did better than male students overall in their clinical assessments. A residual path of 0.88 exists after the effects of these four variables on the OSCE scores have been estimated, since 22 per cent of the variance of the outcome variable was explained.

Discussion

Gender and achievement

Although there were more male students in the 1998 group than female medical students and more female students than male students in the 1999 group, gender was not a significant predictor of achievement in the multiple-choice examination, but it was for achievement in the clinical assessments.

It is difficult to provide a strong explanation for the clinical achievement difference in favour of female students without further study. However, it might arise because the content of some of the OSCEs could favour female students over male students. Differential item functioning (using Rasch scaling) of the OSCE assessments did show that female students did significantly better than male students on certain clinical content areas such as infection management and paediatric

assessment. Alternatively, clinical ability might differ between female and male students because of what the OSCE examination was actually asking the medical student to do (namely, counselling and interpreting data) and hence female students might be more successful than the male students with respect to particular affective or psychomotor skills. It could also be due to the fact that female students interact differently with their learning environments than do male students and that motivation for clinical achievement differs according to whether the student is female or male (Chaput De-Saintonge, and Dunn, 2001).

Student age and achievement

A significant negative co-efficient exists between the multiple choice examination variable only, and the medical student's age. This finding indicates that older students are less successful than younger students when taking the multiple-choice examination. This finding is consistent with other studies that have found that older student did less well in reasoning in the sciences (Aldous, Leeder, Price, Sefton, and Teubner, 1997) and were more at risk of having difficulties with academic work in general (Huff, and Fang, 1999). In terms of clinical performance, however, age was not a significant predictor with one study suggesting rather that the clinical achievement of older students was influenced significantly by when the clinical experience was offered. (Ramsbottom-Lucier, Johnson, and Elam, 1995).

Place of undergraduate study and achievement

The graduate-entry medical program is offered in South Australia, Sydney and Brisbane and students involved in this study who were from New South Wales and Queensland would have been able to apply to gain access to their own State's graduate medical program but instead came to South Australia to study. While students from Queensland and New South Wales achieved higher scores in their clinical assessments, further study is required to examine how students in other schools of graduate-entry medicine are performing.

Type of undergraduate award and achievement

It was hypothesized that the type of initial degree that the student possessed would only indirectly influence achievement. It was thought that this variable would have its strongest influence on the interview and GAMSAT scores. It has been historically acknowledged that students with high scores in science type topics traditionally do well in medicine and this model has shown such a relationship exists since those students with a science degree perform better than students with an arts degree or another degree except an applied science degree. Students with an applied science degree do noticeably worse than their counterparts with other degrees.

GPA scores and achievement

This study has shown that GPA scores are significant predictors of the clinical focus examination. This pathway was predicted in the initial hypothesis and this finding concurs with other studies that acknowledge that undergraduate GPA scores can predict medical school performance (Blue, Gilbert, Elam, and Basco, 2000).

Post-graduate award status and achievement

Medical students who hold awards in addition to their undergraduate degree are not achieving as well as medical students who hold an ordinary degree in the multiple choice examination model. This was not predicted in the initial hypothesis, which proposed that such students would achieve better scores as a result of their further studies. One reason for this negative co-efficient could be that the multiple-choice method differed significantly from the way the students were assessed when they undertook their own post-graduate studies, whereas students who held an ordinary

degree only, were more likely to have had recent experience with written examinations, possibly including the multiple choice format.

GAMSAT scores and achievement

The GAMSAT scores in this study do not have any direct or indirect influence on student achievement in medical studies. The GAMSAT scores are influenced by the student age, where they undertook their studies and the type of undergraduate studies previously undertaken, but the continued GAMSAT scores as such, are not able to predict clinical or multiple choice examination performance. This is a consequence of the fact that the different components of GAMSAT do not combine effectively together and should be separated in further analyses and subsequent studies.

Success at interview and achievement

This study has been unable to identify a significant link between medical course achievement and scores obtained from a pre-course interview that was initially hypothesized. Admission performance has been linked to achievement in undergraduate medicine but only for the first year of medical studies according to Hall and Stocks, (1995). There is much debate about whether an interview should form part of the medical student admission process (Smith, 1991), whether the interview panels are accurate in their assessment of medical student applicants (Owen, Hayden, and Connors, 2002) and whether interviews should actually be linked to other admission testing processes (Edwards, Maldano, and Calvin, 1999). The seven domains used for student selection in this study are working well together as a construct to derive a combined score for course admission. A continuing effort to develop objective criteria for interview screening would appear to be required, especially if this process could further identify the medical students' capacity for working in a team and detect levels of student self-confidence (Powis, Neame, Bristow, and Murphy, 1988; Powis, 1998).

CONCLUSION

Differences in the achievement of graduate-entry medical students during their third year assessment can be explained by different student variables, depending on the type of graduate entry medical student assessment used. Undergraduate grade point average scores seems to be a significant indicator for predicting clinical achievement, the student's gender, the type of undergraduate studies undertaken and where they studied previously, and all have a direct influence of the clinical achievement variable. Examination scores are directly, but negatively influenced by the age of the student and whether or not they had undertaken further studies in addition to their undergraduate award. While interview and GAMSAT scores on there own, do not add to the explanation of student achievement in this study, they are themselves strongly influenced by other student variables particularly those related to the student's previous study. Most predictors of performance in college and medical school leave relatively large amounts of variance of performance unexplained, because a highly selected sample of students is under investigation with greatly reduced variance. Traditional estimates using school records, GPA scores, information about ethnicity and gender, result in prediction equations with a maximum of 30 per cent of variance explained, (McGanny and Ganoo, 1995). Further studies to increase the predictability of achievement scores could arise from the inclusion of additional variables such as the student's specific ethnic group, types of clinical experience undertaken and other non-cognitive student factors, such as study habits, self image, degree of family support, as well as other non-academic activities, such as employment, hobbies and length of time in commuting to clinical learning areas. A mutli-level analysis which could simultaneously explore not only student variables but also learning institution variables (such as class sizes, timetabling, teaching

and learning practices) could also be employed to measure prediction and explanation of achievement in graduate-entry medicine.

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