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Original Research

Interim identification of "at risk" students: A predictive model

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ABSTRACT

Objective: Identifying and supporting students who are academically at risk are an essential part of medical education. This study considers how well aspects of previous performance predict academic performance in the current year and whether it is possible to use a combination of previous and current performance to identify students who are academically "at risk" in the current year. **Methods:** Regression analysis was used to investigate how previous academic performance influences current performance in medical students at a mid-point in their studies (year 4 of 7). To identify students who are academically "at risk" in the current year a risk prediction model was developed on the basis of a combination of current and past performance variables. **Results:** Cumulative grade point average and previous failures were identified as significant macro-level predictors of performance, and in addition several subject-by-subject level predictors were identified as independently significant. This risk prediction model accurately predicted "at risk" students, with a high degree of sensitivity and specificity, as shown by the non-progression of 88% of the students who were identified as being 'at risk'. **Conclusions:** By considering the academic content of courses, the development of transferable skills and how recently a course was taken, it is possible to accurately predict academic performance. It is possible to identify students who are academically "at risk" by developing a predictive model using a combination of current and previous variables. Therefore, non-completion rates in medical schools could be reduced through the timely introduction of specific and targeted remedial interventions for "at risk" students.

KEY WORDS: Academic performance, at risk, progression, medical education

INTRODUCTION

In medical colleges all over the world, students seek admission from diverse academic and socio-economic backgrounds. Applicants have varying levels of aptitude to study medicine. Mastery of the course content alone does not ensure success in the field of medicine. In addition to the cognitive factors, being a competent medical professional also requires compassion, empathy, a sense of professionalism, and commitment to the profession of medicine. Training in a medical school should consider how best to foster these attributes during the prolonged years of instruction that a medical student undergoes in order to ensure that medical graduates are fit for purpose [1].

Admission to medical school is keenly contested the world over and authorities use a variety of screening procedures to select the applicants who are best suited for the limited number of seats available. Quite often, selection criteria include the candidates' secondary school performance, standardized admissions tests or interviews [2,3]. Some medical schools are known to employ extensive screening tests for identifying desirable personality traits of the candidates, before the selection is made [4]. In other countries, including Oman, entrance to medical school is prescribed at a national level without the individual colleges having a role in student selection.

It is well-known that medical education is resource-intensive in nature. It is very important to ensure that entrants to medical school complete the course on time and commence the practice of medicine. Strategies, to minimize non-progression and non-completion rates, are essential for both the assurance of quality and to ensure resource efficiency. It may be necessary to introduce a systematic approach to identifying students who may require additional remedial help. This academic surveillance involves the process of predicting the academic performance of the students and identifying the students who may have problems in coping with the strenuous academic tasks involved in the study of medicine. If such "at-risk" students are identified early during their career, it may be possible to take adequate measures to help them to achieve their targets by providing additional guidance and appropriate mentoring [5]. It is vital that any such identification of "at-risk" students is made early enough for intervention to be efficacious [6]. These "educational interventions" could avert undesirable failure or progression rates in medical schools [7]. Students who, unfortunately, are not able to cope with the demands of the profession can then be redirected into other more suitable

branches of the allied health sciences. Not only will this allay financial loss to the student and the institution, it will also ensure minimal loss of time for the student who might otherwise waste valuable years trying to pursue a course of study with minimal likelihood of success.

The focus of most of the research on predicting the success of students has been on admission to medical school. As such it results in the exclusion of applicants who are considered to be less likely to succeed. Few studies have directly addressed interim, in the course, prediction of at-risk students [7]. It is the identification and support of this group of students, enrolled but at risk of non-completion, that is the focus of this research.

There is a variety of pre-admission variables that have been shown to be useful in the prediction of academic performance [8,9]. Results from one such study, from Prague, suggest that variables chosen from the assessment domains of high school performance, written entrance examination, admission interview, and personality traits may be significant predictors of academic success during the first 3 years of medical study [2]. Similar studies from the Arabian Gulf region have also shown a predictive relationship between grade point average (GPA), academic performance and the need for additional academic support [10,11]. Recently, Abdini and Dom [12] used a highly sophisticated artificial intelligence tool (Adaptive Neuro Fuzzy Inference System) to predict preclinical performance, showing that high-school and pre-university performance are important determinants for students' selection to medical school. In Iran, medical school admissions are based on a nationwide Konkoor examination held on a competitive basis. However in a recent survey, the Konkoor score alone or in combination with high school GPA, have shown to be poor predictors of medical students' academic performance [13]. In an attempt to pick out the cognitive predictors of students' success in medical school, the post-high school scores in Science and Biology were found to be the most significant predictors [14]. It was interesting to note that though the top scorers in these two tests were successful, those with lower scores are not inevitably bound to fail. In a recent report from United Arab Emirates Shaban and McLean [15] have demonstrated that by data archiving and analysis it may be possible to correlate the preadmission grades with the academic performance of the medical studies during their 6 year study period.

That the predictive validity of the MCAT ranges from small to medium [16] shows that there are a variety of other non-cognitive factors that must be contributing to medical school outcomes [9,17]. As a result, some medical school admissions procedures involve assessment of these non-cognitive factors [18]. It is clear that while pre-admissions prediction of success has been useful in can only provide a partial picture into the reasons for success or failure. Taking a longer-term view of the student experience, beyond admission, is recommended [19] as a way of gaining better understanding of these issues.

Data involving the predicting of academic success of at risk students has not been previously reported for medical students from Oman. In this context, it was thought worthwhile to investigate the predictive value of a cluster of cognitive and non-cognitive variables of enrolled medical students part way through their studies. There are two research questions addressed; (i) which cognitive and non-cognitive factors are most predictive of academic performance? (ii) can these factors be used to generate a model that can be used to identify students who are considered academically "at risk" at a mid-point in their medical studies?

METHODS

One cohort of 94 students took part in the study. All students were enrolled in the 4th year of a 7-year medical program, which leads to the award of Doctor of Medicine in a private medical college in Oman. This is one of only two medical colleges in Oman and is a private higher education institute specializing in the training of medicine and pharmacy. The program is taught entirely in the English language and graduates students with a US-style medical degree as a result of an academic partnership with a well-established US medical school.

For the cognitive factors data from three different time periods were used: (i) Data from secondary school (ii) previous performance in foundation and premedical studies (iii) performance in current courses. The data from school included exit grades by subject and the students admissions rank, which is determined by national authorities. The data from foundation and premedical studies included course grades for the previous 3 years, as well as the cumulative GPA and the number of courses failed. In addition to the grades from the current courses in each semester, students were invited to attend a short interview to determine non-cognitive factors. One of the variables arising from this interview was a measure of how motivated the student is to study medicine and become a physician. A structured interview involving 11 questions was used to generate a 10-point scale of motivation for medicine.

Part 1: Identifying the Factors that are Predictive of Current Academic Performance

A linear logistic regression analysis was performed [20], where the end of current year grades, weighted by course credit hours, was the dependent variable and data from previous performance at school and in premedical studies were the independent variables. Initially, this was done using global variables such as cumulative GPA, number of fails and average school ranking. If one of these global variables was significant then an additional *post-hoc* regression analysis was done using the individual components of the global variable, such as the course-by-course grades.

Part 2: Using Predictive Factors to Identify Students who are Considered Academically "at Risk"

To identify "at risk" students in the current year, a combination of current and past performance variables were used. The subjects, identified in Part 1, which were most predictive of performance contributed 50% to the model of risk and the

grades for semester 1 courses in the current year contributed the other 50%. The resulting model was used to identify academically "at risk" students.

Ethical approval for this study was granted by the Institutional Research Review Board and individual consent was obtained from students for their participation in the study.

RESULTS

Part 1: Identifying the Factors that are Predictive of Current Academic Performance

The end of year course grades for 94 students was used as the dependent measure. These grades comprised the weighted average of the course grade, weighted by the credit hours for each course.

The target variables used in the initial linear regression analysis were the cumulative GPA on entry into the current year, the number of failed courses in previous years, average school leaving grades, and the motivation for medicine score. This initial forward stepwise linear regression showed that these target variables accounted for a significant amount of the variance at the end of year grades, with an adjusted $R^2 = 0.611$. The two variables that were independently significant (at $P < 0.05$) were cumulative GPA (77%) and the number of failed courses (23%). The other variables (school leaving grades and the motivation for medicine) did not contribute powerfully to the model.

Since the cumulative GPA accounted for such a large proportion of the predictive model, a further regression analysis was carried out for the individual subjects. The individual subject grades, from the previous 3 years were used to predict overall grades at the end of the 4th year. Since 11 subjects are used as independent variables in this regression with only 94 students, a Bonferroni correction has been applied. The subject grades in these courses accounted for a significant amount of the variance, adjusted $R^2 = 0.667$. Four out of these 11 subjects, accounted for 82% of the predictive value of the model [Table 1]. These were biology (year 3), problem-based learning, biology (year 2) and psychology. It should be noted that some of these subjects, such as PBL and psychology carried very few credit hours yet still had significant predictive value.

Part 2: Using Predictive Factors to Identify Students who are Considered Academically 'at Risk'

A risk prediction index was generated [Figure 1] where 50% of this index was based on weighted averages of the grades from the subjects that contributed significantly to performance, obtained from the aforementioned regression analysis. The remaining 50% of the prediction index was comprised of the grades for subjects in the current year. On the basis of this students, were ranked according to this index and the bottom 25 students were considered to be "at risk." Of these 25 students, 4 students passed the year and progressed,

Table 1: Results of regression analysis with premedical courses as predictors of performance at the end of the students first year of preclinical medicine (year 4). The four significant contributors to the predictive model are shown with the power of their contribution and their significance

Subject	Adjusted R^2	Significance
Biology (year 3)	0.40	$P<0.001$
Problem based learning	0.26	$P<0.01$
Biology (year 2)	0.16	$P<0.05$
Psychology	0.12	$P<0.05$

The following subjects did not contribute significantly to the model: English, mathematics, chemistry, physics, information technology

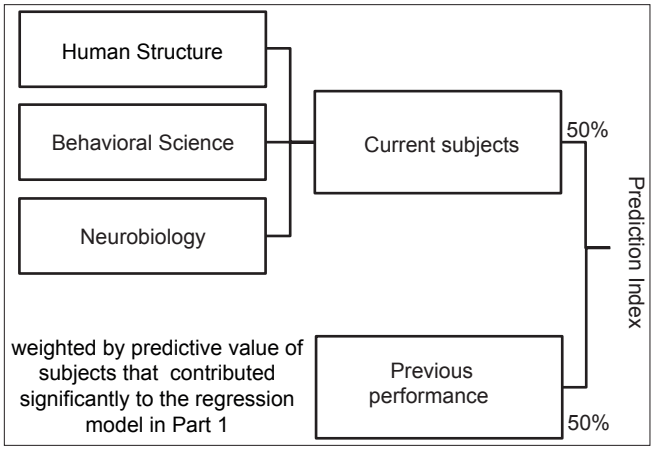

Figure 1: Generation of the 'at risk' index. Half of the index is determined by the weighted grades of previous courses and the other half is determined by performance on the courses already completed in semester 1 of the current year

21 students (88%) had to repeat courses and were delayed by 1 year in their studies. There were also 2 students who were not identified as being at risk who failed the year. While the numbers are too small to perform analysis it is worth noting that 3 of the 4 "at risk" students who passed the year came voluntarily to a second interview to discuss study skills with an academic advisor, whereas only 4 of the 22 'at risk' students who failed made use of this remedial opportunity.

DISCUSSION

It is possible to predict academic performance on the basis of a student's previous performance. In the global regression analysis it was the cumulative GPA and the number of previous fails that was most predictive of future performance. That cumulative GPA and the number of previous failures are predictive of future performance is in agreement with the literature [2,10]. These represent the most recent information on academic performance. Thus, there is a recency effect, such that school leaving grades, from 3 years previously, had little predictive value. This is further confirmed in the subject-by-subject regression analysis in which the most important factors were the 2 most recent subjects. Subjects taken in previous years contributed little to the model. While cumulative GPA is widely used in academia as a composite global picture of a student's academic performance, these findings suggest that the cumulative GPA may not be the

most useful measure when trying to predict future performance as it does not take into account how recently the various subjects were taken. This is especially important for students on long programmes of study (7 years in this case), where cumulative GPA reflects subjects taken several years previously.

It was clear from the subject-by-subject regression analysis that some previous subjects confer more predictive power than others. For this cohort of students, it was their biology and PBL grades from the previous year that contributed most to the predictive model. These were only 2 of the 6 subjects taken by students in the previous year. Thus, there are some subjects that, although they must be passed for progression, are not predictive of future performance. It is likely that some subjects are "threshold" subjects, such that students must reach a certain standard in that subject to progress, but excelling in that subject is not predictive of future performance in medical school [5]. For example, proficiency in English is essential for completion of a medical degree taught entirely in English [21], but being excellent (supra-threshold) in English does not suggest the person will excel in medicine. Likely candidate threshold subjects include; English language, Information Technology, Mathematics and Physics. It is pleasing that these subjects do not contribute significantly to the model, as this non-significance suggests that this cohort of students has reached an appropriate threshold of understanding in these subjects.

The subjects which do predict future performance are strikingly different. Some are academically rigorous, such as Biology, and provide the theoretical underpinning of the future studies of anatomy and physiology. This is in contrast to problem-based learning, what also contributes significantly, despite bearing only one credit hour. The PBL course is not content driven, but rather aims to build students' skills in problem-solving. Thus subject-specific content and the development of learning skills seem to both be important in determining academic success.

One the basis of these findings we propose that there is a triad of components that are most likely to influence predictions of future performance in medicine: (i) specific content, (ii) skill development and (iii) recency [Figure 2].

Non-academic factors, such as motivation for studying medicine, did not significantly contribute to the prediction of a student's performance. It should be noted that motivation for medicine was assessed at a voluntary interview with faculty

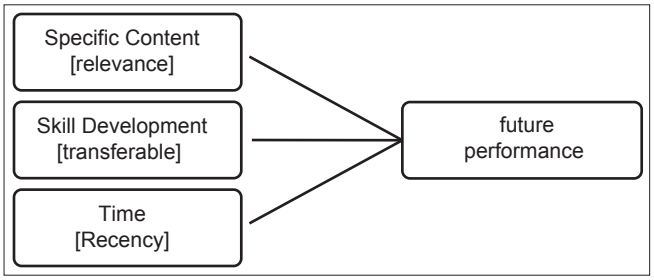

Figure 2: Triad of components that are important in predicting future performance

that was attended by only 19% of the students. Being a self-selected sample, it is likely that the students who completed the interview were homogeneous, being the more motivated and self-directed students. Future studies, which involve a wider range of students, may be more useful in investigating the role of motivation for studying medicine in predicting academic performance.

One of the main aims of this study was to identify students who are academically "at risk". These students were in the 4th year of their degree and so the predictive model was made on the basis of the previous performance (weighted by the outcome of a regression analysis) and current performance. This predictive model accurately predicted 'at risk' students, with a high degree of sensitivity and specificity. The fact that 88% of the students who were identified to be 'at risk' were delayed by a year could be considered as an indication that the model is a valid tool for predicting the academic performance of the students. A model like this is bound to give 'surprises'. Two students who were not considered to be 'at risk' failed the year. In addition four of the 'at risk' students managed to progress to the next year. Of these four, three had come for interviews with one of the authors as an academic advisor. Although the numbers are low it is tempting to suggest that these academic interventions, by way of advice on coping mechanisms and study skills, were effective as interventions that lifted students out of the "at risk" designation.

The need to identify students who may not be able to go successfully through the academic schedule of the medical curriculum within the stipulated timeframe has attracted academic attention [15], including from the Arabian Gulf region [22]. Studies at Nottingham suggested that 10-15% of the medical student intake was likely to fail completely or are likely to face crucial problems academically [23,24]. This is to be viewed as a serious problem since, apart from the concerned students, it affects the faculty and society as a whole. Medical education globally is supported heavily by public funding; hence non-completion in medical schools involves high societal cost. The medical curriculum is labor intensive and demands lots of time and effort from the students. These foregoing factors confirm the importance of identifying 'at risk' students early during the course of study so that they can be helped. If these students are unable to cope with the challenges, in spite of remedial measures, it becomes the responsibility of the stakeholders to make an effort to guide these students towards other streams of education, which are less demanding and where they are more likely to be successful in making a career for themselves. Successful early intervention will enhance student learning and decrease causes of frustration [6]. It is likely that both the risk factors and any efficacious interventions will be context dependent and must be contextualized to fit the cultural and psychosocial nature of the cohort [25].

This study has been conducted at only one medical college and with only one cohort of students, and while it would be useful to replicate and broaden this study, we recommend that the triad of components that predict academic success at an interim stage of study (core content, skills, and recency) can

be contextualized and used in many other medical colleges to identify students who are academically "at risk." In the current setting, this model accurately predicted "at risk" students, with a high degree of sensitivity and specificity. If this approach is adopted as a part of routine academic monitoring and paired with effective remediation, then it could lead to reduced attrition rates in medical schools.

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