Medical school selection criteria and the prediction of academic performance

Evidence leading to change in policy and practice at the University of Queensland

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ABSTRACT

Objective: To assess how well prior academic performance, admission tests, and interviews predict academic performance in a graduate medical school.

Design, setting and participants: Analysis of academic performance of 706 students in three consecutive cohorts of the 4-year graduate-entry medical program at the University of Queensland.

Main outcome measures: Proportion of academic performance during the medical program explained by selection criteria, and correlation between selection criteria and performance. Selection criteria were grade point average (GPA), GAMSAT (Graduate Australian Medical School Admissions Test) score, and interview score. Academic performance was defined as overall total in all examinations combined, in first and fourth year examinations, and in individual written, ethics and clinical components.

Results: Selection criteria explained 21.9% of variation in overall total score, falling from 28.2% in Year 1 to 17.7% in Year 4. This was highest for the written examination in Year 1 (30.5%) and lowest for the clinical examination in Year 4 (10.9%). GPA was most strongly correlated with academic performance (eg, for overall score, partial Spearman's correlation coefficient [pSCC], 0.47; $P < 0.001$), followed by interviews (pSCC, 0.12; $P = 0.004$) and GAMSAT (pSCC, 0.07; $P = 0.08$). The association between GPA and performance waned from Year 1 to Year 4, while the association between interview score and performance increased from Year 1 to Year 4.

Conclusion: The school's selection criteria only modestly predict academic performance. GPA is most strongly associated with performance, followed by interview score and GAMSAT score. The school has changed its selection process as a result.

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Selection of students into medical school is a high-profile, contentious, and high-stakes exercise. Selection typically serves two distinct purposes: to reduce the large number of otherwise qualified and capable applicants to match the number of places available, and to enrol students thought most likely to succeed in what is an arduous program of study and to subsequently become effective members of the profession.

In Australia, most medical schools use a combination of prior academic performance (prior degree grade point average [GPA] for graduate-entry programs), performance on a specific admissions test (GAMSAT [Graduate Australian Medical School Admissions Test]) and an interview or other psychometric technique.[1] There is little consistency between schools in the combination of, or the weight given to, each component in the decision-making process.[1] Similar variation in practice has been reported from the United Kingdom.[2] A systematic review[3] indicated that prior academic performance is the best predictor of subsequent academic performance and that interviews add little to the selection process. There is only very limited published literature on the value of GAMSAT.

Amid concerns that the selection process for the University of Queensland MB BS program may not be optimal, the School of Medicine reviewed selection as part of the regular process of quality assurance. This article reports on the relationship between the school's selection criteria (combination of GPA, GAMSAT and interview) and subsequent student performance during the medical program.

METHODS

The MB BS program at the School of Medicine, University of Queensland, is Australia's largest, admitting 375 students in 2007. This is a 4-year graduate-entry program, and entry is based on selection according to an initial hurdle of attaining a GPA of 5 or more in any prior degree (any Masters or PhD degree is deemed as meeting this requirement). Final ranking and an offer of a place is based on a combination of GAMSAT and interview scores (Box 1).

GAMSAT is a written examination developed by the Australian Council for Educational Research with the consortium of graduate-entry medical schools,[1] and was designed to assess the capacity of students to undertake high-level intellectual studies in a demanding course. It evaluates the nature and extent of abilities and skills gained through prior experience and learning, including the mastery and use of concepts in basic science as well as the acquisition of more general skills in problem solving, critical thinking, and writing.[1] GAMSAT Section 1 focuses on reasoning in humanities and social sciences, Section 2 focuses on written communication, and Section 3 on reasoning in biological and physical sciences.

The interview is semistructured and is conducted by a pair of academic and/or medically qualified members of staff. The interview is designed to assess selected personal attributes considered appropriate to a career in medicine, including the ability to communicate, cognitive style, cooperativeness, evidence of active participation, motivation to practise medicine, open-mindedness, self-confidence, stable self-identity, and ability to contribute to the health services in Australia. All interviewers undergo formal training, which includes a didactic presentation, detailed written material and video presentations of actual interviews from previous years. Prospective interviewers are required to achieve a predefined standard on trial interviews before being accepted onto the panel. Interviewers are also required to undergo biennial recertification based on their ratings of videotaped interviews. Before each daily interview session, interviewers are briefed once more on

1 Selection process used at the School of Medicine, University of Queensland

Step 1. Grade point average (GPA) "hurdle": students must meet a minimum GPA to be considered for admission. This minimum GPA was 4.5 at the start of the study period and increased to 5.0 during the study.

Step 2. Students with an eligible GPA must score a minimum of 50 in each of the three sections of GAMSAT (Graduate Australian Medical School Admissions Test), and are then ranked on their total GAMSAT score, to receive an offer of interview.

Step 3. Students are interviewed by a pair of interviewers using a structured interview schedule, and marked independently. The pair of interviewers compare scores at the end of the interview and calculate an average score.

Step 4. The interview score and the GAMSAT scores are combined, and used to create a final ranking which determines whether an offer of a place is made. ◆

the essential components of the interview. Interviewers are required to independently rate the eight distinct applicant attributes before conferring with the co-interviewer to arrive at final individual ratings for each attribute. Interviewers rate each attribute according to a calibrated yardstick for that attribute. The 16 individual ratings generated by this process are averaged to produce a final mark. If sufficient agreement between interviewers is not achieved, a different pair of interviewers reinterview the applicant.

Students in the MB BS program take examinations midway through and at the end of Year 1 and Year 2, and (at the time of this study) at the end of Year 4.

For the purpose of our analyses, we used scores obtained in all examinations in all 4 years of the program combined (we called this the overall total score), Year 1 examinations, and Year 4 examinations. We did this to explore the relationship between selection criteria and total academic performance, performance shortly after entry to the program, and performance at the end of the program, respectively. We also used scores in the three major components of the Year 1 and Year 4 assessments, namely the clinical examination, the ethics examination, and the written examination. Year 2 results were similar to Year 1 results (data not shown).

We studied three consecutive, complete student cohorts (2001–2003 entry years) comprising 706 students, over the 4-year MB BS program.

Statistical analysis

Descriptive statistics were calculated for each cohort and its corresponding academic year, and for all cohorts combined. Normal distribution was checked for each study variable and the assumption of normality was upheld. Scatter plots, both unadjusted and Lowess (locally weighted scatterplot smoothing), were compared to determine whether relationships were linear (they were found to be essentially linear).

Correlation between the outcome measure (student academic performance) and selection criteria was calculated using Spearman's correlation coefficient (SCC). Partial correlation coefficients (pSCC) were also calculated, thereby adjusting the reported correlation coefficient for any one of the three selection criteria for the effect of the other two.

Multiple linear regression was performed for each outcome variable with all variables included. The clustering effect of interviewer pairs was also accounted for (the difference from the non-cluster analysis was marginal). Analysis of parameter estimates was performed using an exchangeable correlation which models the similarity in clusters. Standard coefficients with 95% confidence intervals, standard errors, P values, and R^2 values are tabulated. In addition,

2 Student characteristics, 2001–2003

	Total 2001–2003	2001	2002	2003
Student characteristic	Number (%)	Number (%)	Number (%)	Number (%)
Total	706	226	217	263
Sex				
Female	340 (48.2%)	117 (51.8%)	99 (45.6%)	124 (47.2%)
Male	366 (51.8%)	109 (48.2%)	118 (54.4%)	139 (52.8%)
Age group (years)				
20–25	212 (30.1%)	21 (9.3%)	76 (35.0%)	115 (43.7%)
> 25	494 (69.9%)	205 (90.7%)	141 (65.0%)	148 (56.3%)
Country of birth				
Australia	583 (82.6%)	182 (80.5%)	182 (83.9%)	219 (83.3%)
Other	123 (17.4%)	44 (19.5%)	35 (16.1%)	44 (16.7%)
Academic background				
Biological science	453 (64.2%)	144 (63.7%)	153 (70.5%)	156 (59.3%)
Health professional	152 (21.5%)	48 (21.2%)	43 (19.8%)	61 (23.2%)
Other	101 (14.3%)	34 (15.1%)	21 (9.7%)	46 (17.5%)
Highest degree				
Bachelor	584 (82.7%)	184 (81.4%)	180 (82.9%)	220 (83.7%)
Higher degree	122 (17.3%)	42 (18.6%)	37 (17.1%)	43 (16.3%)
First degree university				
University of Queensland	441 (62.5%)	133 (58.9%)	151 (69.6%)	157 (59.7%)
Other	265 (37.5%)	93 (41.2%)	66 (30.4%)	106 (40.3%)
Residency				
Rural	95 (13.5%)	34 (15.0%)	26 (11.9%)	35 (13.3%)
Urban	597 (84.5%)	190 (84.1%)	184 (84.8%)	223 (84.8%)
Overseas	14 (2.0%)	2 (0.9%)	7 (3.2%)	5 (1.9%)
Language spoken at home				
English	662 (93.8%)	215 (95.1%)	202 (93.1%)	245 (93.2%)
Not English	44 (6.2%)	11 (4.9%)	15 (6.9%)	18 (6.8%)
Source of students				
Domestic	690 (97.7%)	223 (98.7%)	210 (96.8%)	257 (97.7%)
International	16 (2.3%)	3 (1.3%)	7 (3.2%)	6 (2.3%)

standardised coefficients (β values) are presented to show the relative independent contribution of the predictor variables. Bonferroni corrections were applied to all analyses to account for the multiple comparisons.

We calculated that, with a sample size of 706, with α set at 0.05 and with β set at < 0.2 (80%), we had 98% power to test a null hypothesis of no correlation between selection criteria and academic performance, with the alternate hypothesis being a correlation between 15% and 20%. Statistical significance was set as $P < 0.05$. SAS version 9.1 (SAS Institute, Cary, NC, USA) was used for analysis.

Ethics approval

Ethics approval was provided by the University of Queensland Ethics Committee. No funding was sought for this study.

3 Summary of study variables

	No.*	Mean	SD	Minimum	Maximum
Outcome variables					
Overall total	706	68.9	7.1	27.4	84.3
Year 1 total	703	64.6	7.4	30.0	83.6
Year 4 total	649	71.1	5.6	30.4	86.8
Year 1 clinical exam	692	67.1	7.3	36.6	87.0
Year 4 clinical exam	646	65.1	8.4	36.5	88.3
Year 1 written exam	703	63.0	8.1	24.4	82.3
Year 4 written exam	646	68.4	4.9	54.1	81.8
Year 1 ethics exam	703	71.7	8.2	37.0	90.8
Year 4 ethics exam	646	72.2	7.4	43.9	90.5
Predictor variables					
GPA at first degree	586	5.5	0.7	4.0	7.0
Interview score	706	7.5	0.6	5.1	9.4
GAMSAT total	706	66.2	4.1	48.0	83.0
GAMSAT Section 1	706	63.0	5.1	50.0	85.0
GAMSAT Section 2	706	63.0	7.1	44.0	88.0
GAMSAT Section 3	706	69.5	7.4	46.0	100.0

Overall total = combined scores from all examinations in all 4 years of the medical program. GPA = grade point average. GAMSAT = Graduate Australian Medical School Admissions Test. * Number of students. ◆

RESULTS

Student characteristics

The three student cohorts had similar characteristics and were balanced in sex, mostly aged over 25 years, and of Australian birth (Box 2). Most (64.2%) had a biological science background, and 17.3% had a previous degree higher than Bachelor level. Most students had done their previous study at the University of Queensland. Box 3 shows the values associated with all study variables; the number of subjects in Year 4 is different to Year 1 because of variation in the number of students admitted to the program in each year.

Relationships between selection criteria and student performance

Combined selection criteria

From the multivariate model (Box 4), the three selection criteria (GPA, GAMSAT and interview score) combined explained 21.9% of variation in student performance across all 4 years for the three cohorts combined. This variation fell from 28.2% in Year 1 to 17.7% in Year 4. This explanation of variation was highest for the written examination in Year 1 (30.5%) and lowest for the clinical examination in Year 4 (10.9%). The explained variation in performance fell from Year 1 to Year 4 for overall, written examination and clinical examination scores, but not for the ethics examination, in which it increased slightly (Box 4).

Individual selection criteria

GPA was consistently significantly (and independently) associated with performance in each cohort (data not shown), each examination, and each examination component (Box 4). β Values fell from Year 1 to Year 4 for each examination, but were consistently higher for the total and the written examination, than for the clinical and the ethical examinations in turn.

Consistent with the above results, the correlation coefficients for GPA with each examination and its component were significant. Further, the partial correlation coefficients changed little, and remained significant (Box 5).

β Values for interview scores were consistently lower than those for GPA (except for Year 4 clinical examination) (Box 4), indicating that GPA is relatively more important in explaining variation in academic performance. For overall examination score, the β value for interview score is about three times lower than that for GPA (both are significant).

Interestingly, the β values for interview score increased substantially from Year 1 to Year 4 for each examination, showing that the predictive value of interview performance is higher for academic performance at the end of the medical program. Consistent findings are displayed in Box 5 for unadjusted and adjusted correlation coefficients.

Adjusted correlation coefficients for GAMSAT total score (Box 5) were consistently close to or lower than the values for interview score, and only reached significance for the Year 1 total and written examination. This is different from the unadjusted coefficients, which, while still modest in absolute values, did reach significance in several cases.

Similarly, β values for GAMSAT total score are close to zero, except for Year 4 clinical examination (Box 4). GAMSAT section scores are also mainly close to zero or of small absolute value, and only reach significance for Year 4 ethics examination (Section 1) and Year 4 clinical examination (Section 2; negative association).

Box 6 shows the associations between each selection criterion and the overall total academic performance.

DISCUSSION

Our findings confirm, and importantly extend, the existing literature on factors that are associated with academic performance in medical school, and hence that may have value in the selection of students.[3] Our results show that the selection criteria we (and many other schools) use predict about 20% (ranging from about 10% to 30%) of student academic performance (as measured by examination), depending on year within the program and examination component.

The largest and most recent systematic review on this topic concluded that prior academic performance accounted for 23% of variance in undergraduate medical performance,[3] a figure consistent with our findings. It is important to stress therefore that most variation in academic performance is not explained by selection criteria and is presumably a consequence of both intrinsic personal factors and the effect of the teaching itself.

4 Regression modelling of the relationship between selection criteria and academic performance

		Total examination score		Clinical examination		Written examination		Ethics examination	
	Overall total	Year 1	Year 4	Year 1	Year 4	Year 1	Year 4	Year 1	Year 4
GPA of first degree (coeff [95% CI])	3.72 (3.04 to 4.41)	4.26 (3.52 to 4.99)	2.84 (2.17 to 3.49)	3.38 (2.62 to 4.14)	2.12 (1.18 to 3.06)	4.56 (3.78 to 5.34)	2.99 (2.39 to 3.59)	3.02 (2.03 to 4.00)	2.33 (1.37 to 3.30)
SE (β)	0.35 (10.71)	0.38 (11.30)	0.34 (8.41)	0.39 (8.74)	0.48 (4.42)	0.39 (11.47)	0.31 (9.79)	0.50 (6.00)	0.49 (4.74)
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Interview score (coeff [95% CI])	0.95 (0.34 to 1.56)	0.65 (0.00 to 1.30)	1.35 (0.73 to 1.96)	0.88 (0.13 to 1.63)	3.23 (2.26 to 4.21)	0.66 (–0.03 to 1.37)	0.79 (0.23 to 1.36)	0.93 (0.01 to 1.85)	2.20 (1.22 to 3.18)
SE (β)	0.31 (3.08)	0.33 (1.95)	0.31 (4.30)	0.38 (2.32)	0.49 (6.51)	0.36 (1.86)	0.29 (2.77)	0.47 (1.98)	0.50 (4.40)
P	0.001	0.05	< 0.001	0.02	< 0.001	0.06	0.01	0.05	< 0.001
GAMSAT total (coeff [95% CI])	–0.69 (–2.06 to 0.68)	–0.54 (–1.92 to 0.84)	0.14 (–1.42 to 1.14)	–0.12 (–1.71 to 1.47)	2.17 (0.22 to 4.11)	–0.26 (–1.71 to 1.18)	–0.82 (–1.99 to 0.34)	–0.63 (–2.56 to 1.29)	–1.47 (–3.25 to 0.31)
SE (β)	0.69 (–0.99)	0.70 (–0.77)	0.65 (–0.22)	0.81 (–0.15)	0.99 (2.18)	0.74 (–0.36)	0.59 (–1.38)	0.98 (–0.64)	0.91 (–1.61)
P	0.32	0.44	0.83	0.88	0.03	0.72	0.17	0.52	0.11
GAMSAT Section 1 (coeff [95% CI])	0.17 (–0.15 to 0.49)	0.11 (–0.22 to 0.44)	0.14 (–0.19 to 0.48)	0.09 (–0.30 to 0.48)	–0.48 (–0.97 to 0.01)	0.01 (–0.33 to 0.36)	0.28 (–0.01 to 0.57)	0.28 (–0.19 to 0.75)	0.68 (0.23 to 1.13)
SE (β)	0.16 (1.06)	0.17 (0.65)	0.17 (0.82)	0.19 (0.43)	0.25 (–1.90)	0.18 (0.77)	0.15 (1.91)	0.24 (1.15)	0.23 (2.95)
P	0.29	0.51	0.41	0.66	0.06	0.94	0.06	0.25	< 0.001
GAMSAT Section 2 (coeff [95% CI])	0.26 (–0.09 to 0.61)	0.17 (–0.19 to 0.52)	0.05 (–0.27 to 0.36)	–0.02 (–0.43 to 0.39)	–0.54 (–1.04 to –0.04)	0.09 (–0.27 to 0.46)	0.24 (–0.06 to 0.54)	0.353 (–0.14 to 0.86)	0.39 (–0.05 to 0.84)
SE (β)	0.18 (1.47)	0.18 (0.91)	0.16 (0.28)	0.21 (–0.10)	0.25 (–2.12)	0.19 (0.50)	0.15 (1.59)	0.26 (1.40)	0.23 (1.73)
P	0.14	0.36	0.78	0.92	0.03	0.62	0.11	0.16	0.08
GAMSAT Section 3 (coeff [95% CI])	0.42 (–0.27 to 1.11)	0.44 (–0.26 to 1.13)	0.02 (–0.62 to 0.66)	0.17 (–0.64 to 0.98)	–0.99 (–1.97 to –1.99)	0.36 (–0.37 to 1.09)	0.46 (–0.12 to 1.04)	0.25 (–0.72 to 1.22)	0.67 (–0.22 to 1.55)
SE (β)	0.35 (1.19)	0.36 (1.22)	0.32 (0.06)	0.41 (0.41)	0.49 (–1.99)	0.37 (0.96)	0.29 (1.54)	0.49 (0.51)	0.45 (1.48)
P	0.24	0.22	0.95	0.68	0.05	0.34	0.12	0.61	0.14
R^2	21.9%	28.2%	17.7%	16.8%	10.9%	30.5%	22.8%	11.9%	15.1%

Overall total = combined scores from all examinations in all 4 years of the medical program. GPA = grade point average. coeff = coefficient. SE = standard error of β. GAMSAT = Graduate Australian Medical School Admissions Test. ◆

The systematic review[3] also concluded that further studies on the value of the interview are needed, and indicated that, in the studies reviewed, interviews seemingly added little or nothing to the selection process. At best, they were associated with only weak to modest independent prediction (0.11–0.14) of performance. In our study, the interview was correlated with overall total examination performance and performance in each Year 4 component (Box 6), but only at modest levels. The high levels of statistical significance (low *P* values) reflect the large dataset we studied, and it is important to focus on the absolute value of the adjusted correlation coefficient when interpreting our findings. For the interview, these ranged from 0.05 to 0.22, and were consistently substantially lower than the adjusted coefficients for GPA, except for Year 4 clinical and ethics examination performance, in which they were similar.

Although widely used in Australia, and now used by some schools in the UK and Ireland, there is only limited literature on the value of GAMSAT in predicting medical school performance. A PubMed search identified only two studies (one that is 10 years old and outlines a rationale for GAMSAT, and a second that explores association with clinical reasoning skills in a small sample of students). There are many more articles that validate the North American equivalent, the Medical College Admission Test.[4] Our data indicate that GAMSAT is poor in predicting academic performance; all of the adjusted correlation coefficients (Box 6) for GAMSAT total score are close to zero. These are the first published data on the validity of GAMSAT in an entire student cohort. Our findings suggest that GAMSAT may have only limited value in predicting academic performance.

An exploratory meta-analysis showed that the predictive power of interviews for academic success was only 0.06, and for clinical success (after graduation) was 0.17, indicating a modest effect.[5] Part of the reason for this may be that interviews are inherently unreliable. The authors of a literature review and empirical study called into doubt the fairness of interviews as a highly influential component of an admissions process.[6] We acknowledge that the interview process we used may, in and of itself, have influenced the results of our analysis. For example, the training and standardisation that we sought may have limited the ability to discriminate between candidates. However, the data in Box 3 indicate that a

5 Correlation (unadjusted and partial) between academic performance and selection criteria

	Overall total	Total examination score		Clinical examination		Written examination		Ethics examination	
		Year 1	Year 4	Year 1	Year 4	Year 1	Year 4	Year 1	Year 4
GPA in first degree									
SCC	0.50	0.50	0.35	0.39	0.20	0.50	0.44	0.24	0.17
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
pSCC	0.47	0.45	0.36	0.35	0.18	0.45	0.41	0.26	0.19
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Interview score									
SCC	0.07	0.02	0.15	0.00	0.16	−0.03	0.06	0.08	0.18
P	> 0.99	> 0.99	0.01	> 0.99	< 0.001	> 0.99	> 0.99	> 0.99	< 0.001
pSCC	0.12	0.05	0.15	0.06	0.22	0.06	0.11	0.05	0.19
P	0.004	0.2	< 0.001	0.2	< 0.001	0.2	0.01	0.2	< 0.001
GAMSAT total score									
SCC	0.20	0.25	0.06	0.16	0.07	0.28	0.18	0.07	0.03
P	< 0.001	< 0.001	> 0.99	< 0.001	> 0.99	< 0.001	< 0.001	> 0.99	> 0.99
pSCC	0.07	0.11	−0.01	0.05	0.06	0.14	0.018	0.01	0.04
P	0.08	0.01	0.7	0.2	0.2	0.01	0.05	0.9	0.3

GPA = grade point average. SCC = Spearman's correlation coefficient (unadjusted). pSCC = partial Spearman's correlation coefficient (adjusted for the other two of the three variables). GAMSAT = Graduate Australian Medical School Admissions Test. ◆

wide range of scores was attained in our interviews, and our results are consistent with those previously reported.[3]

Another important limitation is that our analysis only included students with a relatively high GAMSAT score (mean, 66.2) and so our findings do not test the whole range of GAMSAT scores. Nevertheless, this is a "real world" use of GAMSAT and our findings should be interpreted in that light. A strength of our study is that we examined a range of selection criteria in association with each other, not in isolation (which is a problem in many previously published studies examining individual components of the selection process[3]).

One stated desire of a selection process is to seek to include non-academic, non-cognitive factors. It is important to acknowledge that academic ability and other key (non-cognitive) attributes are not necessarily inversely correlated,[7] or mutually exclusive. Indeed, there is evidence that the two are positively correlated.[8] Selecting on academic performance alone, or predominantly, may in fact also lead to the admission of students with attractive non-cognitive attributes.

We acknowledge that other approaches to selection do exist or are being developed, such as the Personal Qualities Assessment[9] and the Multiple Mini-Interview.[10] These methods may have value, but need to be formally assessed in longitudinal studies. We also acknowledge that selection criteria may influence the learning behaviour of potential applicants (such as studying particular material in preparation for GAMSAT, which may then influence future performance at medical school); this may be seen as a useful or useless influence. Further, the "threat" of an interview may dissuade some potential applicants (such as those with inherently poor communication skills) from even applying to medical school.

Our findings are not merely of academic interest. Our judgement from these data is that GPA is the strongest and most defensible (although not perfect) performance predictor, that interviews add only a small amount, and that GAMSAT has little predictive value. As a result, the school has removed the interview from its selection process. We will diligently monitor the effect of changes to our selection criteria on performance in our medical program, and will report our experience in the future.

COMPETING INTERESTS

None identified.

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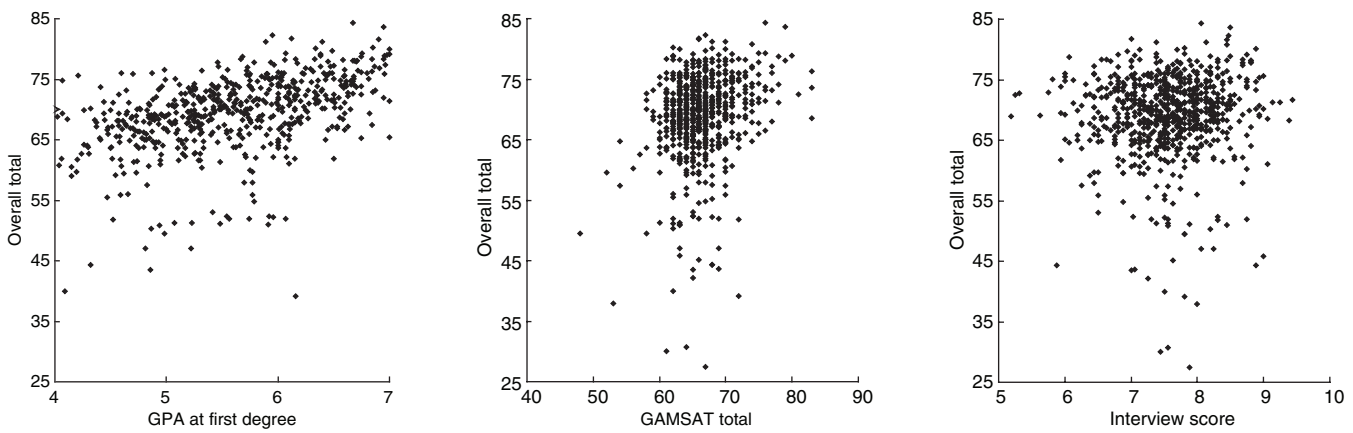
6 Scatter plots for overall total score against grade point average (GPA), Graduate Australian Medical School Admissions Test (GAMSAT) total score, and interview score



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