Selection of medical students: a controlled experiment

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OBJECTIVES We aimed to discover, through a controlled experiment, whether cognitive and non-cognitive assessment would select higher-achieving applicants to medical school than selection by lottery.

METHODS We carried out a prospective cohort study to compare 389 medical students who had been admitted by selection and 938 students who had been admitted by weighted lottery, between 2001 and 2004. Main outcome measures were dropout rates, study rate (credits per year) and mean grade per first examination attempt per year. Study rates in the 4 pre-clinical years of medical school were used to categorise students' performance as average or optimal.

RESULTS Pre-admission variables did not differ between the two groups. The main outcome of the selection experiment was that relative risk for dropping out of medical school was 2.6 times lower for selected students than for lottery-admitted controls (95% confidence interval 1.59–4.17). Significant differences between the groups in the percentage of optimally performing students and grade point average for first examination attempts were found only in the 2001 cohort, when results favoured the selected group. The results of the selection process took into account both the assessment procedure involved and the number of students who withdrew voluntarily.

CONCLUSIONS This is the first controlled study to show that assessing applicants' non-cognitive and cognitive abilities makes it possible to select students whose dropout rate will be lower than that of students admitted by lottery. The dropout rate in our overall cohort was 2.6 times lower in the selected group.

KEYWORDS Netherlands; *school admission criteria; *schools, medical; cohort studies; *education, medical, undergraduate; *students, medical; humans.

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INTRODUCTION

Because the number of applicants to medical school exceeds the number of places available, the selection of students is internationally widespread. Various national and local procedures are used.[1,2] The literature on selection shows that selection procedures tend to be based on two different principles: selection of those students who perform best, or selection of well-defined subgroups.

Various methods are used to identify best-performing students, including: undergraduate grade point average (uGPA) scores; pre-admission grades in specific basic science subjects; the Medical College Admission Test (MCAT); the Scholastic Assessment Test (SAT); interviews; written submissions, and psychological tests.[3–7] Ideally, the validity of these different methods should be tested using a control group of randomly admitted students. However, such control groups are not available because admission procedures select overall cohorts per academic year. As a surrogate, correlations are therefore sought either between the scores of the selection method (or methods) and performance at medical school, or between these scores and the outcome of medical licensing examinations. Recent reviews of the literature by Salvatori[8] and McGaghie[9] have shown that the uGPA has a moderate predictive value for subsequent academic performance, with correlations of 0.40–0.50. Similarly, the MCAT has an acceptable predictive value for pre-clinical performance, obtaining correlations of 0.31–0.54 with GPAs in Year 3 of medical school.[10,11] All other selection methods, including interviews (which are widely used[12]), have low correlations with academic performance.[8]

It is much easier to verify the efficiency of the second method of selecting students, which is by subgroup, categorised, for example, on the basis of age group, ethnicity, social background or educational background (such as those defined by university graduates versus school leavers). Comparisons of such selected groups with controls admitted under the conventional admission method show no significant difference in performance in medical school or subsequent medical practice.[13–15]

Some authors believe that selection processes overall very much resemble a lottery, and that the random selection of students for admission ultimately results in levels of student achievement similar to those produced by any of the existing selection procedures.[5,6,16] However, it has also been shown that certain characteristics, such as ability, motivation, ambition and conscientiousness, have, at the very least, a moderately positive bearing on student achievement.[17,18]

In the Netherlands, central selection takes place on the basis of a lottery that is weighted for academic attainment. In recent years it has become obvious that a pre-university education GPA (pu-GPA) of ≥ 8 (on a scale of 1–10, where 1 = poor and 10 = excellent) has a high predictive value for student achievement.[19] It has also become accepted that individual characteristics play some part in study success.[20] Since 1999, students with a pu-GPA ≥ 8 have therefore had unrestricted direct access to medical school, and medical schools have been allowed to select a maximum of 50% of their students on the basis of characteristics other than pu-GPA.

This situation presented a unique environment in which to perform an experiment in which a selection procedure could be designed, implemented and compared with the weighted lottery procedure. In the 2001–2002 academic year, we therefore started a selection experiment. The underlying hypothesis was that if, through their extracurricular activities, students display greater ability, motivation or ambition to achieve than their peers, they will not only perform better at medical school, but will continue to do so afterwards.

The objective of this experiment was to use controlled techniques to determine whether a combination of selection steps, based on the assessment of cognitive and non-cognitive abilities, would lead to the admission of students whose achievement in medical school would turn out to surpass that of students who had been selected by weighted lottery. This paper presents the first results of this experiment (i.e. those collated after 4 years of applying these selection steps).

METHODS

Admission of students

Pre-university education in the Netherlands lasts 6 years. Final examinations cover a number of subjects, four of which (biology, physics, chemistry and mathematics) are obligatory for admission to medical school. The GPA achieved in the final examinations is based on a combination of school examinations and state examinations, with each accounting for 50%. To graduate from pre-university education and enter the lottery procedure, the candidate must attain a pu-GPA of ≥ 5.5 (on a scale where 1 = poor and 10 = excellent).

Since 2001–2002, there have been options for admission to medical school through a local selection procedure (S-group), through the national lottery system (L-group), and through unrestricted direct access (D-group) (Fig. 1). To qualify for unrestricted direct access, an applicant must have a pu-GPA of ≥ 8. All other applicants have to take part in the weighted lottery, in which the chance of selection rises along with the pu-GPA. There are four different lottery categories defined as: 7.5 ≤ pu-GPA < 8.0; 7.0 ≤ pu-GPA < 7.5; 6.5 ≤ pu-GPA < 7.0, and 5.5 ≤ pu-GPA < 6.5. The ratio by category for admission by lottery is, respectively, 9 : 6 : 4 : 3. After selection by lottery, and if enough places are available, applicants are assigned to the medical school of their first choice. Applicants who take part in the lottery can also choose to apply using a local selection procedure, which precedes the lottery.

Selection procedure at Erasmus MC Medical School

For logistical reasons in 2001, the maximum number of students to be selected was set at 15% of the maximal admissible number of 276. In 2002 it was set at 30% of 335, and in 2003 and 2004 at 50% of 410.

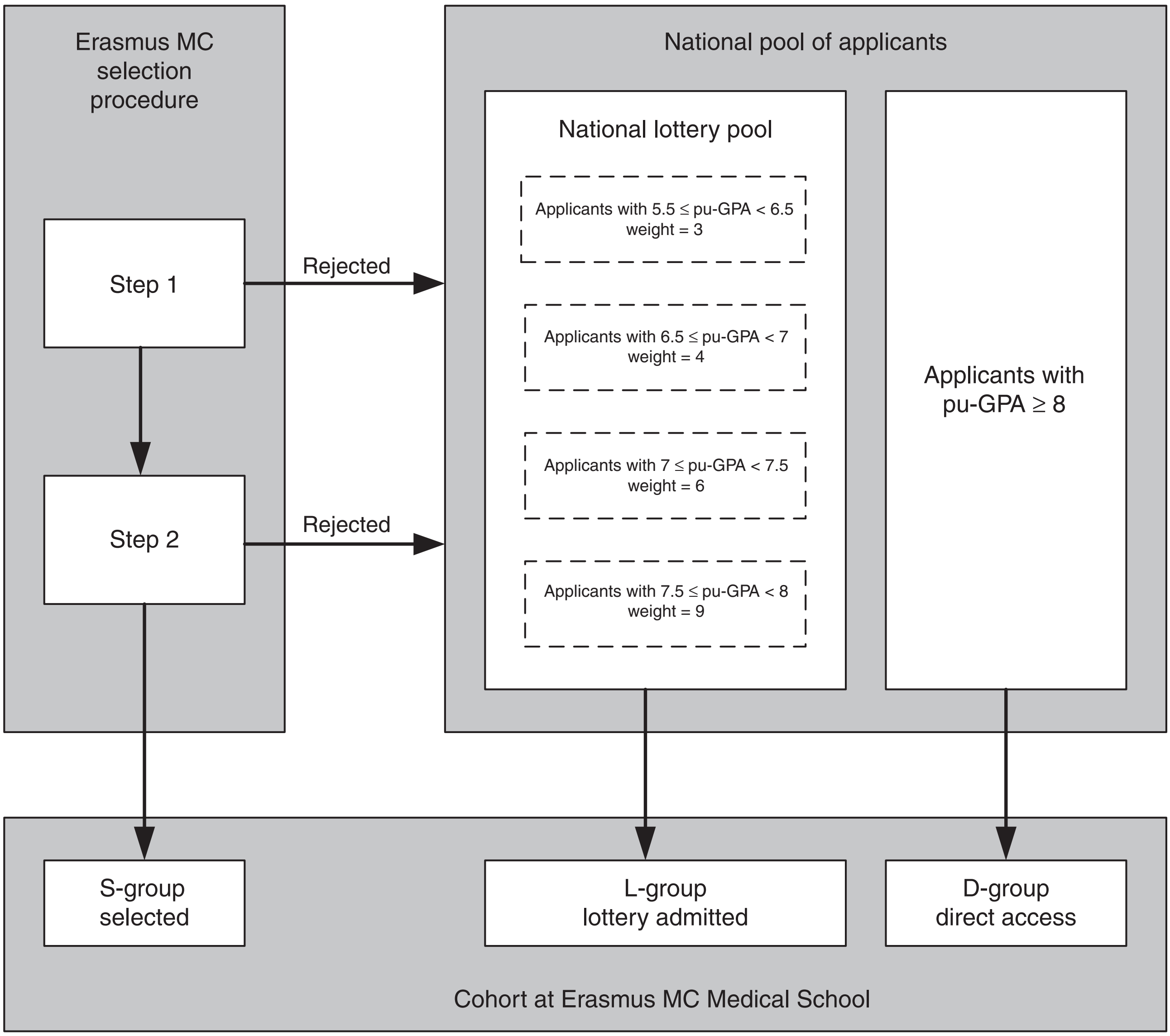

Figure 1 Diagram showing the parallel selection and lottery procedures at Erasmus MC Medical School, Rotterdam. pu-GPA = pre-university grade point average

A two-step procedure was designed. In the first step, applicants were assessed according to the quality and extent of their extracurricular activities before application. Only activities that had lasted for ≥ 2 years and had been carried out during the 3 years immediately prior to application were taken into account.

These activities were divided into five categories:

1. activities in health care;
2. activities in management and organisation;
3. activities related to a talent (such as music, sport or science);
4. (extracurricular) academic education, and
5. additional pre-university education.

Applicants specified their extracurricular activities on a structured application form. The provision of evidence such as letters of recommendation and references to support their statements was mandatory. Per category, a minimum quality level was determined beforehand. If the activity met the quality criteria, the extent of that activity was calculated in hours per year; a minimum of 160 hours per year over 2 consecutive years was required. The total number of hours over 2 years was recoded into an individual score, and a ranking established. Except in 2001, all applicants who were ranked above the mean in the first step of selection were invited to proceed to the second. In the first academic year, a fixed number of 60 applicants were invited for the second selection step.

The second step consisted of five cognitive tests on a medical subject. These were performed over 4 consecutive days at Erasmus MC Medical School and contained questions on logical reasoning, scientific thinking, epidemiology and pathology, anatomy and philosophy. Three tests consisted of multiple-choice questions and two of open-ended questions. Applicants were scored per test using a scale of 1–10, where 1 = poor and 10 = excellent. A score of ≥ 5.5 was considered satisfactory. To be selected for admission, a student needed to pass four of five tests and achieve an average score across the five tests of ≥ 5.5.

Criteria for student achievement

The current medical curriculum at Erasmus MC consists of a 4-year pre-clinical phase followed by a 2-year clinical phase. The pre-clinical phase includes five modules, each lasting 2–6 weeks, as well as 6 thematic blocks each lasting 15–19 weeks, and electives amounting to a total of 29 weeks. Between them, the modules and thematic blocks include 29 examinations. Each examination qualifies the candidate for a fixed number of credits under the European Credit Transfer System (ECTS). One credit equals 28 hours of study; the study load per year is 60 credits.

We had no minimum requirements for the number of credits per year. However, it has been shown that 96% of the students at Erasmus MC who failed to obtain 60 credits by the end of the first 2 years of study failed to complete medical education.[21] Such students were therefore considered as dropouts. For the remaining students, achievement was specified by study rate (number of credits per year) and GPA at the first examination attempts per year. The credits and grades were derived from the university student administration system.

Statistical analysis

Four consecutive cohorts were entered into the study. Each cohort was followed for at least 2 years. The pre-admission variable 'gender' was analysed using chi-squared statistics with Mantel–Haenszel test for stratification by year of entrance and weighted lottery category. Analysis of covariance (ANCOVA) was used for comparisons of age, and a *t*-test was used to compare pu-GPA between both groups.

As approximately 50% of our students obtain the maximum of 60 credits each year, the use of study rate as a parameter for achievement leads to a non-normal distribution of the population. This non-normal distribution is increased by the identification of dropouts. Students were therefore divided into three categories: dropouts with < 60 credits after 2 years of study; optimal performers with the maximum study rate of 60 credits after each year, and average performers with a study rate of < 60 credits per year. A Mantel–Haenszel stratification test was used for comparisons between selected and lottery-admitted groups concerning dropouts and optimal and average performers. The strata were year of entrance at medical school and weighted lottery category. Grade point averages in both groups were compared using student *t*-tests.

Data were derived from the university student administration systems, recorded in EXCEL 2003 workbooks and analysed using SPSS for Windows Version 15.0.[22]

RESULTS

Selection procedure: quantitative aspects

Table 1 shows the different stages of the selection procedure that led 8.1% students to be selected in 2001, 13.4% in 2002, 21.1% in 2003 and 21.1% in 2004. The sizes of these components are also shown. The number of applicants increased from 393 in 2001 to 736 in 2004. The total number of places available increased from 275 in 2001 to 410 in 2003 and subsequent years.

In 2001 and 2002, we limited the maximum number of students admitted by selection for logistical reasons. After the first assessment in 2001, this led to the rejection of an aberrantly high percentage of applicants. In the remaining 3 years, a mean of 44.5% of registered applicants was rejected. In 2003 and 2004, selection was performed according to the strict criteria described in the Methods section. About a quarter of the initial applicants withdrew voluntarily before the first selection step. Furthermore, each year approximately 9% of the applicants did not respond to the invitation to enter the next phase.

Table 2 shows the sizes of the D-, S- and L-groups per cohort. As the goal of the experiment was to investigate whether a procedure could be developed to select students who would perform better than those admitted by weighted lottery alone, we compared only selected and lottery-admitted groups (S- and L-groups).

Pre-admission variables

Pre-admission variables per cohort are shown in Table 3. Overall, 65% of the S-group consisted of women, compared with 60.5% of the L-group. After controlling for year of entrance and weighted-lottery category, we found that this difference was non-significant ($\chi^2[1] = 3.01$, $P = 0.083$).

Mean age, adjusted for year of entrance and weighted-lottery category, was 19.69 years in the S-group and 19.34 years in the L-group. The S-group was 4.1 months older, which was significant ($F[1, 1259] = 9.960$, $P = 0.002$). However, the partial $r = 0.08$, which was very low. Although both covariances were significant, their effect sizes were very low: year of entrance was $t(1259) = -2.740$, $P = 0.006$, $r = 0.26$; weighted-

Table 1 Quantitative aspects of the selection procedure

	Cohort				
	2001	2002	2003	2004	Total
Procedure	*n** (%)[†]	*n** (%)[†]	*n** (%)[†]	*n** (%)[†]	*n** (%)[†]
Central registration	393	536	622	736	2287
Withdrawn before first step	109 (27.7)	172 (32.1)	135 (21.7)	195 (26.5)	611 (26.7)
Step 1	284 (72.3)	364 (67.9)	487 (78.3)	541 (73.5)	1676 (73.3)
Rejected	216 (55.0)	153 (28.5)	172 (27.7)	230 (31.3)	771 (33.7)
Invited to participate in step 2	68 (17.3)	211 (39.4)	315 (50.6)	311 (42.3)	905 (39.6)
Withdrawn before second step	14 (3.6)	19 (3.5)	47 (7.6)	16 (2.2)	96 (4.2)
Step 2	54 (13.7)	192 (35.8)	268 (43.1)	295 (40.1)	809 (35.4)
Rejected	13 (3.3)	87 (16.2)	91 (14.6)	113 (15.4)	304 (13.3)
Selected	41 (10.4)	99 (18.5)	176 (28.3)	181 (24.6)	497 (21.7)
Withdrawn/lottery admitted elsewhere	9 (2.3)	28 (5.2)	45 (7.2)	26 (3.5)[‡]	108 (4.7)
Selected group	32 (8.1)	71 (13.2)	131 (21.1)	155 (21.1)	389 (17.0)

* Number of applicants who participated in a particular step of the procedure
[†] Percentage of centrally registered candidates
[‡] Withdrawn only

Table 2 Cohort composition

	2001	2002	2003	2004	Total
Cohort	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Total cohort	272	332	405	403	1412
D-group	19 (7.0)	19 (5.7)	20 (4.9)	27 (6.7)	85 (6.0)
S-group	32 (11.8)	71 (21.4)	131 (32.3)	155 (38.5)	389 (27.5)
L-group	221 (81.2)	242 (72.9)	254 (62.7)	221 (54.8)	938 (66.4)

D-group = direct access group; S-group = selected group; L-group = lottery group

Table 3 Pre-admission variables: gender; mean age, and mean pre-university grade point average

		2001 (SD)	2002 (SD)	2003 (SD)	2004 (SD)
Gender, % female*	S-group	71.9	74.6†	60.3	63.2
	L-group	61.5	58.3	56.3	66.5
Mean age, years†	S-group	20.82 (2.40)*	20.05 (2.35)	19.85 (2.77)	19.31 (1.75)
	L-group	19.79 (2.07)	19.67 (2.43)	19.48 (1.92)	19.37 (2.04)
Mean pu-GPA, *Z*-score	S-group	− 0.23 (0.82)	− 0.12 (0.83)	− 0.18 (0.81)	− 0.16 (0.81)
	L-group	− 0.16 (0.81)	− 0.15 (0.85)	− 0.10 (0.85)	− 0.13 (0.88)

* Significantly higher than corresponding L-group ($t[251] = 2.569$, $P = 0.011$)
† Significantly more than corresponding L-group ($\chi^2[1] = 6.25$, $P = 0.012$)
SD = standard deviation; D-group = direct access group; S-group = selected group; L-group = lottery group; pu-GPA = pre-university grade point average

lottery category was $t(1259) = 9.402$, $P = 0.000$, $r = 0.08$.

For each year of entrance, pu-GPAs were transformed into *Z*-scores. The pu-GPA was − 0.17 for the S-group and − 0.14 for the L-group ($t[1261] = -0.568$, $P = 0.570$). Adjusting for year of entrance revealed no different means.

Student achievement per cohort

Table 4 shows the achievements of the S- and L-groups specified as dropouts, optimal study rate and GPAs at the first examination attempts. Four cohorts were included in the study. All cohorts had a minimum follow-up of 2 years and two had a follow-up of 4 years. A Mantel–Haenszel stratification test showed a highly significant difference between the percentage of dropouts in the S- and L-groups ($\chi^2[1] = 14.68$, $P = 0.000$). The S-group had a relative risk for dropout 2.58 times (95% confidence interval [CI] 1.59–4.17) lower than that of the controls. The percentages of optimally performing students in both groups were almost identical and did not statistically differ in any of the 2002–2004 cohorts. By contrast, the percentages in the two groups in the 2001 cohort did differ, but this was statistically significant only in the second year ($\chi^2[1] = 4.17$, $P = 0.041$). After stratification for year of entrance and lottery category with Mantel–Haenszel chi-squared tests, the S-group did not outperform the L-group in terms of optimal performance in any of the academic years.

Finally, there were no significant differences between the two groups in GPAs at the first examination

Table 4 Achievement in the selected and lottery groups

Cohort		2001 n (%)	2002 n (%)	2003 n (%)	2004 n (%)	Statistics RR*	95% CI	P
Dropouts								
	S-group	2 (6.3)	2 (2.8)	11 (8.4)	9 (5.8)	2.58	1.59–4.17	0.000
	L-group	45 (20.4)	27 (11.2)	37 (14.6)	31 (14.0)			
Optimal performance								
After	S-group	22 (73.3)	52 (75.4)	72 (60.0)	96 (65.8)	1.31	0.98–1.75	0.065
1 year	L-group	110 (62.5)	143 (66.5)	125 (57.6)	121 (63.7)			
After	S-group	23 (76.7)	46 (66.7)	40 (33.3)	81 (55.5)	1.18	0.89–1.56	0.244
2 years	L-group	100 (56.8)*	147 (68.4)	77 (35.5)	95 (50.0)			
After	S-group	14 (46.7)	32 (46.4)	40 (33.3)	–	0.90	0.64–1.26	0.532
3 years	L-group	71 (40.3)	109 (50.7)	87 (40.1)	–			
After	S-group	13 (43.3)	26 (37.7)	–	–	1.38	0.84–2.26	0.206
4 years	L-group	48 (27.3)	78 (36.3)	–	–			

Cohort		2001 n	GPA	SD	2002 n	GPA	SD	2003 n	GPA	SD	2004 n	GPA	SD
Mean grades													
Year 1	S-group	30	6.78†	0.88	69	6.48	0.81	120	6.24	0.66	146	6.18	0.64
	L-group	176	6.29	0.80	215	6.42	0.74	217	6.22	0.64	190	6.25	0.72
Year 2	S-group	30	6.63	1.12	69	6.59	0.83	120	5.91	0.75	145	5.99	0.75
	L-group	167	6.29	0.88	215	6.44	0.83	217	5.98	0.71	182	6.10	0.77
Year 3	S-group	30	6.38	1.03	66	6.49	0.73	109	6.08	0.81	–	–	–
	L-group	175	6.20	0.76	213	6.30	0.81	206	6.06	0.73	–	–	–
Year 4	S-group	30	6.33	1.03	68	6.32	0.93	–	–	–	–	–	–
	L-group	170	6.03	0.89	203	6.25	0.82	–	–	–	–	–	–

* Significantly more than corresponding percentage of optimals in the L-group ($\chi^2[1] = 4.20$, $P = 0.040$)
† Significantly higher than corresponding GPA in the L-group ($t[204] = 3.04$, $P = 0.003$)
RR = relative risk, calculated on the basis of the Mantel–Haenszel common odds ratio estimate, stratified for year of entrance and lottery category; 95% CI = 95% confidence interval; S-group = selected group; L-group = lottery group; GPA = grade point average; SD = standard deviation

attempts, except in the 2001 cohort during the first academic year.

DISCUSSION

In 2001, a controlled experiment was instigated to investigate whether medical students selected on the basis of a combination of non-cognitive extracurricular activities and cognitive abilities would perform significantly better in medical school than students admitted by lottery.

Although there was no evidence for the existence of methods that might select students who would perform better in medical school, there were several reasons for this experiment.[6] One major reason was the co-existence in the Netherlands of a central weighted lottery with a local selection system. This provided a unique environment in which to perform controlled experiments. Another important reason was that, in the absence of a selection system of proven efficacy, a lottery system should not be accepted as a valid solution. Both the lottery and this unproven procedure have been described as unfair to medical school applicants, as neither includes any truly objective criteria for predicting future performance.[23]

Our choice of selection criteria was based on the hypothesis that pre-university students who have distinguished themselves from their peers in their extracurricular activities, but not in higher GPAs, might have characteristics that will lead them to perform better in medical school than controls admitted on the basis of a lottery. Because no literature was available to support this, we felt that a second selection step, based on cognitive abilities, might be needed.[23,24] Selection on the basis of pu-GPA was not allowed.

The main outcome of the selection experiment in four consecutive cohorts was the finding that the relative risk for dropping out of medical school was 2.6 times lower in selected students than in controls admitted by lottery. Except in the 2001 cohort, there were no significant differences between the percentages of students who performed optimally in either group. In the 2001 cohort, there were differences in all academic years, although this reached statistical significance only in the second academic year. Similarly, neither were there any significant differences during the first academic year between the S- and L-groups in terms of GPAs achieved at first examination attempts, with, once again, the exception of the 2001 cohort. It seems reasonable to postulate that the outcome of our selection was a product mainly of the procedure, but also, to a certain extent, of self-selection by the applicants themselves, the latter because some applicants were rejected and some withdrew voluntarily throughout the entire course of the selection procedure. Means of 47% of applicants were rejected and 35.6% withdrew. Eventually, 17% were selected. The majority of applicants who withdrew (26.7%) did so before the start of the first step of the assessment after they had received the application form. Of the remaining 9%, approximately half withdrew because the lottery had allocated them a place at another medical school, which they then accepted.

The differences we observed in student achievement could not be explained by the pre-admission characteristics 'gender' and 'pu-GPA'. Although selected students were significantly older (by 4 months), this is unlikely to be a reasonable explanation. So how can we explain why a highly significant decrease in dropout rate was not accompanied by differences in GPA at the first examination attempt or by differences in the 'optimal' and 'average' study-rate categories? The most likely explanation is that our selection process excluded most of the potential dropouts who would normally have been admitted under the lottery procedure.

Students at risk of dropping out have three main characteristics: relatively low performance in pre-university education;[25,26] lower prior qualifications for academic study, and poorer social integration at university.[27–29] Retrospective analysis at our medical school seems to indicate that students who are at risk of dropping out fall into three groups, consisting of: those who lack both motivation and ability; those with high motivation but inefficient study methods, and able students who get off to a slow start.[30] Future comparisons of dropouts in the S- and L-groups may provide information about the type of potential dropouts who are excluded by the selection procedure.

In future research we will analyse qualitative aspects of the selection procedure and also the applicability of the procedure to other medical schools and other academic programmes, such as those in law and economics. As well as comparing the performances of the S- and L-groups during clinical rotations, we will also compare levels of participation in extracurricular activities at medical school and seek to determine whether a higher level of participation in extracurricular activities in pre-university students, such as in 2001, is related to better achievements in study rate and GPA.

In conclusion, this is, to our knowledge, the first study to show that it is possible to select students who will perform better in the pre-clinical phase of medical school than their lottery-admitted controls. In this study, our main finding was that the dropout rate in these students was 2.6 times lower than in lottery-admitted students. We believe that these data may provide a starting point for examining the relationships between personal characteristics and academic achievement.

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