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Kulkarni, Sanat; Parry, Jayne; Sitch, Alice

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An assessment of the impact of formal preparation activities on performance in the University Clinical Aptitude Test (UCAT): a national study

Sanat Kulkarni, Jayne Parry* and Alice Sitch

Abstract

Background: Previous studies have shown performance in the University Clinical Aptitude Test (UCAT) to be associated with measures of candidate socio-economic advantage such as parental occupation and type of school attended. It is possible that access to preparation support and materials may in part explain these associations. In this paper we determine whether use of formal preparation resources is associated with higher UCAT scores and whether differences in use of preparation resources exist between socio-demographic groups.

Methods: After completing the 2017 UCAT UK school-leaver candidates ($n = 14,332$) were asked to answer a questionnaire regarding their use of official UCAT and commercial resources, school-based support, and time spent preparing. Multiple linear and logistic regression models were used to evaluate the associations between preparedness, demographic characteristics and UCAT performance.

Results: Five thousand, four hundred thirty-nine (38%) candidates responded to the questionnaire. Use of freely available UCAT official practice tests, paid commercial materials, attendance at school-based preparation courses and spending more time preparing were significantly associated with higher UCAT scores. Candidates who were from less deprived backgrounds and attending independent or grammar schools were significantly more likely to use paid commercial materials and spend longer preparing.

Conclusions: Reported use of preparation resources varies between candidates from different socio-demographic backgrounds and is associated independently with performance in the UCAT. Increasing the availability of freely available resources may mitigate some of these differences.

Keywords: UCAT, Preparation, Coaching, Widening access, Selection

Introduction

There is growing use of psychometric aptitude tests by universities to assist in the selection of future medical students. Use of these tests enables medical schools to assess candidate attitudes and potential future

professional behaviour, and also overcomes two existing challenges in assessing cognitive ability: (i) continued grade inflation in school-leaving examinations [1] (which historically have formed the basis for medical schools to assess candidate academic ability) which limits attempts to differentiate between applicants, and (ii) the socio-demographic patterning of performance in these examinations and which may hinder institutional efforts to widen access to medicine [2, 3].

*Correspondence: J.M.Parry.1@bham.ac.uk

Institute of Applied Health Research, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK



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Table 1 Deciles of total UKCAT score in 2014, 2015 and 2017 (NB. 2016 is excluded as the decision making section was not used operationally that year) [5]

Decile	2017	2015	2014
1st	2230	2210	2180
2nd	2340	2330	2310
3rd	2420	2410	2380
4th	2480	2470	2450
5th (mean score)	2540	2540	2510
6th	2600	2600	2570
7th	2670	2660	2630
8th	2750	2740	2710
9th	2860	2840	2820

Table 2 Proportion of candidates in each SJT Band in 2015, 2016 and 2017 [5]

	Band 1	Band 2	Band 3	Band 4
2017	28%	42%	21%	9%
2016	26%	44%	22%	9%
2015	24%	45%	22%	9%

The most widely used aptitude test in the UK is the University Clinical Aptitude Test (UCAT; previously the UK Clinical Aptitude Test (UKCAT)). Introduced in 2006 it is now used by the majority of UK medical schools as part of their student selection processes. The UCAT is a computer-based test and is delivered on behalf of the UCAT Consortium by Pearson VUE at designated test centres throughout the UK. Applicants to the medical schools using the UCAT sit the test before they make their application to medical school and can only make one attempt at the test in each annual university application cycle [4].

The UCAT comprises four cognitive subsections (verbal reasoning, quantitative reasoning, abstract reasoning, and decision making) and situational judgement test (SJT) [4]. Each cognitive section is scored separately on a scale ranging from a minimum of 300 to a maximum of 900, resulting in a total score ranging from 1200 to 3600. The SJT component is marked separately with students being placed into four Bands in which Band 1 is the best performance. Details of the distribution of total scores by decile and the proportion of students in each SJT Band for test cycles 2014–2017 are shown in Tables 1 and 2 [5].

There is no consensus as to how medical schools should use the UCAT in selection and a variety of approaches exist whereby UCAT scores are used separately or integrated with other metrics to shortlist

candidates for interview and/or to determine whether an offer is made [6].

Although the UCAT uses constructs which are designed to be less affected by socio-demographic factors than historical predictors of academic ability [4], studies have suggested that the inherent biases associated with the school examinations taken by UK school leavers (pupils from White and professional social-class backgrounds and attending independent or academically selective ('grammar') schools tend to do best) also exist for UCAT performance albeit the biases may be reduced [6]. Further, males have been shown to perform better than females on the cognitive components of the UCAT [2, 7–11] with the reverse noted for the SJT element [10, 11].

The reasons for this socio-demographic patterning of performance in the UCAT are not completely clear. We have previously suggested that access to preparation support and materials may in part explain the associations with measures of social advantage [6]. The UCAT Consortium provides free-to-use preparation resources on their website; these include practice tests, practice questions for each subsection, a candidate preparation toolkit and an official guide to the test [4]. Schools, aware that the UCAT is a key element in selection for medical degree programmes, may also include advice and practice for the UCAT as part of wider measures they have in place to support pupils to make successful applications [9]. UCAT candidates also have access to an increasing number of commercially-produced practice materials and courses which provide participants with test-taking strategies and access to a large, highly realistic bank of questions typically at a significant cost [8, 9]. Estimates concerning the use of commercial courses or materials vary with one study reporting that 20% of students attended a fee-paying course [9] whilst other studies in Australia, where a similar admissions test was used, suggest a prevalence of over 50% [12, 13].

In this paper we report a study in which we linked candidates' responses to a questionnaire-based survey designed to elicit information on their preparation to their performance in the 2017 sitting of the UCAT. Specifically we sought to determine whether (i) formal preparation, including use of free and paid-for preparation resources, is associated with higher UCAT scores, and (ii) the demographic characteristics of those using preparation resources and whether use of preparation resources differs between socio-demographic subgroups. We limited our analyses to candidates aged 16–20 years because we wished to focus on the experience of school pupils and recent school leavers rather than graduates.

Methods

All UK-resident candidates who sat the UCAT in 2017 were invited to participate in the study. Candidates aged under 16 years or who were aged 21 years and older were subsequently excluded from the study population to leave a sub-population we termed 'school leavers' (aged 16–20 years). Upon completion of the test candidates were directed to a brief on-screen questionnaire which was preceded by a statement regarding the research and a tick-box in order to gain consent. The questionnaire was created by the research team, informed by previous literature [8, 9] and comprised five questions regarding candidates' engagement with school/college-based support, use of the official UCAT preparation materials, use of free-to-access and of paid online commercial materials, and an estimate of total time spent preparing for the test (see Additional file 1: Appendix 1). Whilst we acknowledge that books are a commonly used preparation resource, we believed these were unlikely to be used as a candidate's primary resource. As such, the survey focused on online materials which are typically more up-to-date and reflective of the current test content and layout. Candidates were able to decline to participate at any point and could exit the UCAT without prejudice.

Construction of dataset

When candidates complete their online registration form to secure a place to sit the UCAT they provide the following demographic information: date of birth, gender, ethnicity, parental occupation, nationality, and school/college details. Additionally, they are invited to consent to the use of this personal information and data relating to their UCAT performance by researchers to build further the evidence-based underpinning use of the test in selection. The demographic, test performance and preparation survey data of all candidates

consenting to participate in research were linked to create a pseudo-anonymised dataset which was made available to the research team via the University of Dundee Health Informatics Centre's safe haven.

Data collection

Socio-demographic characteristics

Candidate age was calculated as on September 1 2018 using reported date of birth. Ethnicity was self-defined using the full Census classification and then categorised before release to the research team as Asian, Black, White, Mixed or Other. Candidates selected their school type from a drop-down list as either: Sixth Form or Further Education College, Comprehensive, Independent or Fee Paying Private, Grammar or Other. Information on parental occupation was used to derive the National Statistics Socio-economic Classification (NS-SEC) for each student in accordance with the Government method of calculation [14]. The NS-SEC is a measure of socioeconomic status with a scale ranging from 1 to 5; 1 is the least deprivation whilst 5 is the most deprived. Additionally, information was available on whether a candidate had been awarded a bursary by UCAT (candidates in financial need who meet specific criteria are eligible for a bursary covering the full test fee).

UCAT performance

Individual sub-section and total UCAT scores were provided for each candidate.

Previous attempts at the UCAT

It is possible that some candidates choose to have a 'practice run' at the UCAT, sitting the test in the year prior to making their application for medical school, so as to familiarize themselves with the process. This approach may be considered a form of preparation and we recorded the number of times, if any, the candidate had taken the test previously.

Table 3 Preparedness categories and how they were derived

Preparedness Category	Derivation Method
School-based preparation course	Reported having specific preparation sessions at school or college
Official UCAT Tests	Reported using the official UCAT Timed Practice Tests
Other official UCAT resources	Reported using any of the: UCAT official app, official guide or question tutorials in the Candidate Preparation Toolkit
Free commercial materials	Reported using any free commercial preparation materials
Paid commercial materials	Reported using any paid commercial preparation materials
Attempt number > 1	Having a UCAT attempt number of 2 or more
Time spent preparing	Coded according to their response to question 5 on a scale from 'Did not prepare' to '40 + hours' of preparation

Self-reported preparation methods and time

Using the responses to the questionnaire six binary categories of preparedness were created (see Additional file 1: Appendix 2 and Table 3). It was not deemed appropriate to combine these to create a single variable to indicate if students were prepared or unprepared.

Statistical analyses

Using a conservative estimate of a standard deviation of 300 in total UCAT score (based on UCAT data [5]), to detect a difference in UCAT score between preparedness groups of only 40 points, 1463 participants are required in each group (2926 in total) for 95% power and 5% significance. For reference, a difference of 80 points equates to moving from the 5th to 6th decile rank in total UCAT scores. The data collected provides over 5000 participants meaning the study is adequately powered.

All statistical analysis was conducted using Stata 15 (StataCorp LP, College Station, TX, USA). Descriptive statistics of the candidate demographics and their UCAT results were reported in terms of responders and non-responders. Chi-squared tests were conducted for the categorical and binary variables whilst independent t-tests and Mann Whitney U tests were conducted for the continuous variables, as appropriate.

In order to determine (and confirm previously described) associations between the demographic variables and UCAT performance, a multiple linear regression model was constructed with UCAT score as the outcome and gender, ethnicity, NS-SEC, school type, bursary status and attempt number as covariates. Inclusion in this aspect of the analysis was not dependent on responding to the questionnaire as all data used were routinely collected by the UCAT Consortium. A binary logistic regression model was fitted with SJT Band 1 or 2 (compared to SJT Band 3 or 4) as the outcome and the same covariates as above.

A multiple linear regression model was then fitted to investigate the association between total UCAT score (outcome variable) and each of the preparation categories, using the same covariates as above. Logistic models were fitted to investigate the association between the preparedness categories and performing well or badly on the SJT component of the test (SJT Band 1 or 2 (better performance) compared to SJT Band 3 or 4 (poorer performance) with the same covariates as above.

Binary logistic regression models were constructed, using each of the preparedness categories as an outcome and participant characteristics as covariates. Based on UCAT guidance, preparation time was categorised into those who had reported spending more than 20 h and those who had reported spending less than this.

Whilst p -values < 0.05 are often considered statistically significant, we would urge the reader to exercise caution when interpreting the results of the significance tests given the number of tests conducted and the resulting increased risk of type 1 error; we also encourage readers to look at the magnitude of differences between groups with corresponding confidence intervals given the large sample size.

Research ethics statement

Ethical approval for this study was provided by the University of Birmingham Ethics Committee (ERN_17-0521).

Results

In 2017 14,332 UK-resident candidates aged 16–20 years sat the UCAT of whom 5,439 (38%) responded to the preparedness questionnaire (Fig. 1).

Respondent Characteristics and Preparation

Compared to non-responders, respondents were more likely to be younger, female, of White ethnicity, of higher socioeconomic status, have attended a sixth form/further education college or comprehensive school, and were less likely to have received a bursary for the test (Table 4). Although statistically significant, the absolute magnitude of differences in socio-demographic characteristics between responders and non-responders was small, due to the large sample size. For instance, the mean difference in age between responders and non-responders, whilst statistically significant, was 18 days. Responders also performed better than non-responders in the test overall, and in each subsection, with the exception of the abstract reasoning component (Table 5). A significantly greater proportion of respondents achieved an SJT Band 1 or 2 compared to Band 3 or 4 ($p = 0.025$) and were taking the test for the first time.

Among responders ($n = 5439$), 877 (16.1%) reported attendance at a school-based preparation course, 4434 (81.5%) reported using the official UCAT practice tests and 3047 (56%) reported using paid commercial materials (Table 6). Only 34 (0.6%) respondents reported not spending any time preparing for the test whilst 1320 (24.3%) prepared for over 40 h (Table 7).

Socio-demographic factors and UCAT performance

The results of the multiple linear regression model, constructed using all candidates who were UK residents and aged 16–20 years and with non-missing values ($n = 13,016$), indicate that candidates who are male, attend grammar or independent or private fee-paying schools, were of White ethnicity or of higher socioeconomic background perform significantly better on the

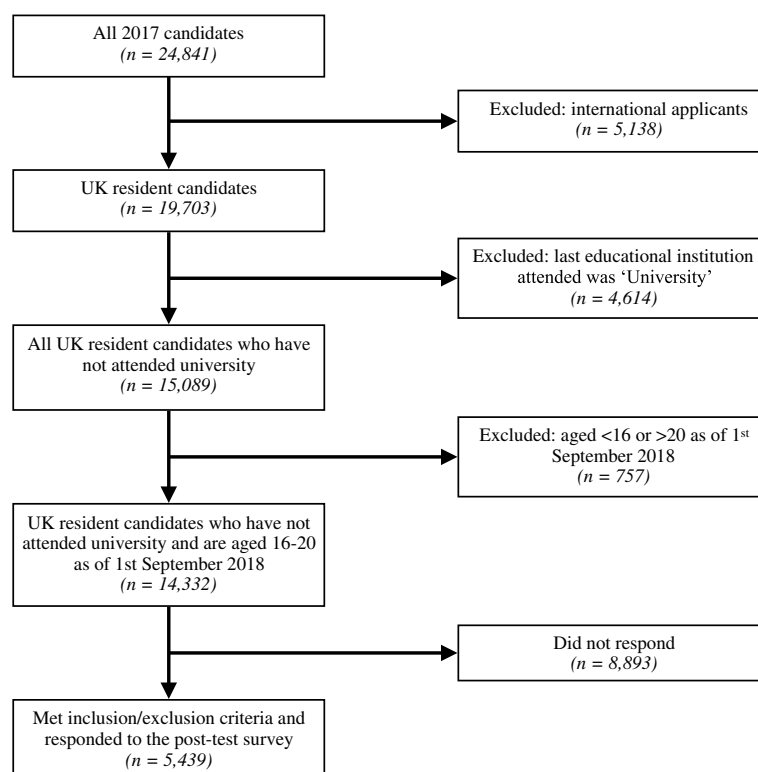


Fig. 1 Derivation of study sample

test (Table 8). Further test subsection analyses can be found in Additional file 1: Appendix 3.

A binary logistic regression model (Table 9), with the Band 1 or 2 (better performance) in the SJT component as the outcome (compared to Band 3 or 4), showed that males were significantly less likely to achieve the top two Bands (Band 1 or 2) than females. Those from independent, grammar and comprehensive schools were significantly more likely to be placed in the top two Bands compared to those attending a sixth form or college. Candidates of Asian and Black ethnicities performed significantly worse than those of White ethnicity. Candidates from more deprived backgrounds performed significantly worse than those from least deprived backgrounds. Students who were retaking the test were significantly more likely to obtain a Band 1 or 2; further analysis with Band 4 as the outcome variable showed similar results (Additional file 1: Appendix 4).

Impact of preparation on UCAT performance

Use of the freely available official UCAT timed practice tests was associated with greatest impact on test performance (MD = 67.77, 95% CI: 52.01 to 83.53; $p < 0.001$) (Table 8). Attendance at a

school-based preparation course (MD = 36.66, 95% CI: 20.25 to 53.07) or using paid commercial materials (MD = 37.65, 95% CI: 24.81 to 50.49) also significantly improve test performance ($p < 0.001$ for both). Overall UCAT performance improved as the time spent preparing increased (see Fig. 2). When evaluating subsections of the UCAT, performance appeared to increase with greater preparation time categories for the abstract reasoning and quantitative reasoning subsections only; for other subsections performance seems to plateau at moderate levels of preparation. Differences in scores between those who retook the test, used paid commercial materials or spent longer preparing, compared to those who did not, were largely observed in the abstract reasoning and quantitative reasoning subsections (Additional file 1: Appendix 5). Attendance at a school-based preparation course and studying for over 20 h for the test were both found to be significantly associated with achieving a Band 1 or 2 in the SJT (Table 9). Moreover, the socio-demographic patterns in UCAT performance seen using all eligible candidates such as better performance by males or those of White ethnicity, remain despite adjustment for preparedness in our model.

Table 4 Demographic characteristics of the study population in terms of responders and non-responders

	Responders (<i>n</i> = 5439 (38.0)) N (%)	Non-responders (<i>n</i> = 8893 (62.1)) N (%)	All (<i>n</i> = 14,432) N (%)	<i>p</i> -values
Mean age (SD)	18.66 (0.59)	18.71 (0.61)	18.69 (0.60)	< 0.001
Gender				< 0.001
Male	1967 (36.2)	3494 (39.3)	5461 (38.1)	
Female	3472 (63.8)	5399 (60.7)	8871 (61.9)	
Ethnicity				< 0.001
<i>White</i>	2609 (48.0)	3851 (43.3)	6460 (45.1)	
<i>Asian</i>	1816 (33.4)	3505 (39.4)	5321 (37.1)	
<i>Black</i>	521 (9.6)	670 (7.5)	1191 (8.3)	
<i>Mixed</i>	288 (5.3)	441 (5.0)	729 (5.1)	
<i>Other</i>	205 (3.8)	426 (4.8)	631 (4.4)	
NS-SEC				0.024
1	4160 (76.5)	6543 (73.6)	10,703 (74.7)	
2	213 (3.9)	302 (3.4)	515 (3.6)	
3	80 (1.5)	182 (2.1)	262 (1.8)	
4	212 (3.9)	381 (4.3)	593 (4.1)	
5	364 (6.7)	580 (6.5)	944 (6.6)	
Missing	410 (7.5)	905 (10.2)	1315 (9.2)	
SCHOOL				< 0.001
<i>Sixth Form/ Further Education College</i>	2689 (49.4)	4376 (49.2)	7065 (49.3)	
<i>Comprehensive</i>	705 (13.0)	944 (10.6)	1649 (11.5)	
<i>Grammar</i>	1006 (18.5)	1843 (20.7)	2849 (19.9)	
<i>Independent/Private Fee Paying</i>	958 (17.6)	1636 (18.4)	2594 (18.1)	
<i>Other</i>	80 (1.5)	94 (1.1)	174 (1.2)	
Missing	1 (0.0)	0 (0.0)	1 (0.0)	
BURSARY				0.014
Bursary received	584 (10.7)	1075 (12.1)	1659 (11.6)	
No bursary received	4855 (89.3)	7818 (87.9)	12,673 (88.4)	

P-values for the chi-squared tests are presented except for age where an independent t-test was conducted. Unless stated, there was no missing data for the variables. Missing data was not used in chi-squared calculations

Use of preparation materials and time taken to prepare, and candidate characteristics

Males were significantly less likely to report using the official UCAT practice tests, using free commercial materials or to prepare for more than 20 h for the test than females (see Tables 6 and 7). Compared to those at sixth form or college, students attending grammar and independent schools were significantly more likely to report attendance at a school-based preparation course with odds ratios of 1.50 (95% CI: 1.22 to 1.85, $p < 0.001$) and 3.02 (95% CI: 2.49 to 3.65, $p < 0.001$) respectively. Similarly, those attending independent or grammar schools were significantly more likely to use the official UCAT tests, paid commercial and to prepare for more than 20 h for the test compared to those attending sixth forms or colleges.

Students of Asian or Black ethnicity were significantly more likely to have reported attending a school-based preparation course, using free commercial materials or spending more than 20 h preparing for the test compared to those of White ethnicity. Compared to White students, those of Asian ethnicity were significantly more likely to use paid commercial resources.

Candidates in most socio-economically deprived quintile were significantly less likely to use the official tests, use paid commercial materials or prepare more than 20 h for the test compared to the least deprived (those with an NS-SEC of 1). Students in receipt of a bursary were significantly less likely to report using paid commercial materials or to prepare for more than 20 h for the test compared to those who had not received a bursary.

Table 5 UCAT total and sub-section scores for responders and non-responders

	Responders	Non-responders	All	p-values
Mean total UCAT score (SD)	2590 (243)	2566 (230)	2575 (235)	< 0.001
Mean abstract reasoning score (SD)	639 (85.4)	638 (82.1)	638 (83.4)	0.372
Mean verbal reasoning score (SD)	583 (79.1)	571 (74.5)	575 (76.5)	< 0.001
Mean decision making score (SD)	658 (54.0)	651 (52.8)	654 (53.4)	< 0.001
Mean quantitative reasoning score (SD)	710 (92.9)	706 (90.7)	707 (91.6)	0.003
SJT Band (N (%))				0.025
1 or 2	4057 (74.6)	6482 (72.9)	10,539 (73.5)	
3 or 4	1382 (25.4)	2411 (27.1)	3793 (26.5)	
UCAT Attempt Number (N (%))				< 0.001
1st	5056 (93.0)	8072 (90.8)	13,128 (91.6)	
2nd or more	383 (7.0)	821 (9.2)	1204 (8.4)	
Test Type (N (%))				0.419
UCAT	5254 (96.6)	8542 (96.1)	13,796 (96.3)	
UCATSEN	178 (3.3)	338 (3.8)	516 (3.6)	
UCATSA	4 (0.1)	8 (0.1)	12 (0.1)	
UCAT50	3 (0.1)	5 (0.1)	8 (0.1)	

P-values are shown for the independent t-tests (for UCAT and subsection scores) and chi-squared tests (for categorical variable) were conducted to identify differences between responders and non-responders

Discussion

Our analysis indicates that use of the official UCAT materials, use of paid commercial materials, attendance at school-based preparation courses and spending more time preparing are all associated with better performance on the cognitive components of the test. A dose-response relationship was observed for the increasing time spent preparing with no apparent ceiling of effect. Statistically significant differences in the use of these preparation resources were identified between different socio-demographic groups and those from differing school types.

With regards to the SJT component, spending more time preparing for the test was a significant predictor of better performance but the findings indicate no evidence of an association between use of specific preparation resources and performance with the exception of attendance at school-based preparation courses. One explanation for this finding may be that because SJT performance correlates with personality traits such as conscientiousness [15, 16], those spending longer preparing for the test are more likely to be conscientious candidates and will therefore inherently perform better on this component.

Our findings reiterate the socio-demographic patterning reported in UCAT and SJT performance by others [2, 6–8, 10, 11]. We note also that candidates in receipt of UCAT Consortium bursaries perform significantly worse on the test.

Our data suggest that candidates using preparation resources perform better in the test, an observation which concurs with the literature on the Undergraduate Medicine and Health Sciences Admissions Test (UMAT) used in Australia [12, 13]. Two questionnaire-based studies by Lambe et al. have previously investigated the impact of modes of preparation on self-reported UCAT performance [8, 9]. The first study found that increased preparation time correlated with higher test scores [8] whilst the second noted that those who used UCAT-provided practice tests performed 67 points better than those who did not (95% CI: 22.6 to 110.3, $p < 0.001$) [9]. Further interpretation of these observations is compromised by absence of information on socio-demographics of respondents and non-respondents [8, 9]. In contrast to our study, Lambe et al. did not identify a significant difference in UCAT performance between those who had attended school or commercial courses and those who had not. However the reported use of paid commercial coaching resources and school-based preparation courses by their participants was markedly lower than that reported in our study (9% commercial and 7% school-based versus 56% and 16% respectively) [8, 9].

Our analysis suggests that the differences in UCAT scores associated with preparedness can largely be attributed to better performance in the abstract reasoning and quantitative reasoning subsections which appears to echo the findings from the equivalent sections of the UMAT [12, 13]. In our subsection analysis, only performance in

Table 6 Demographic characteristics by preparedness category. Below are binary logistic regression models with each of the preparedness categories (with the exception of retaking) as the outcome variables and demographic variables as covariates. The reference category for each variable has an odds ratio of 1. Significant results with negative direction of effect have been shaded red whilst significant results with positive direction of effect have been shaded green

	School-based preparation course N (%) Odds ratio (95% CI); p-value	Official UCAT Tests N (%) Odds ratio (95% CI); p-value	Other official UCAT resources N (%) Odds ratio (95% CI); p-value	Free commercial materials N (%) Odds ratio (95% CI); p-value	Paid commercial materials N (%) Odds ratio (95% CI); p-value	Attempt number >1 N (%)
All	877 (16.1)	4434 (81.5)	3654 (67.2)	4717 (86.7)	3047 (56.0)	383 (7.0)
GENDER						
Male	352 (17.9) 1.15 (0.98 to 1.35); 0.083	1572 (79.9) 1.37 (1.08 to 0.92); 0.002	1203 (61.2) 0.69 (0.61 to 0.78); <0.001	1667 (84.8) 0.73 (0.62 to 0.86); <0.001	1132 (57.6) 1.02 (0.91 to 1.15); 0.740	165 (8.4)
Female	525 (15.1) 1	2862 (82.4) 1	2451 (70.6) 1	3050 (87.9) 1	1915 (55.2) 1	218 (6.3)
SCHOOL						
Sixth Form/ Further Education College	337 (12.5) 1	2139 (79.6) 1	1902 (70.7) 1	2320 (86.3) 1	1312 (48.8) 1	192 (7.1)
Comprehensive	46 (6.5) 0.48 (0.34 to 0.67); <0.001	598 (84.8) 1.37 (1.08 to 1.74); 0.011	511 (72.5) 1.06 (0.87 to 1.29); 0.556	594 (84.3) 0.99 (0.77 to 1.26); 0.915	375 (53.2) 1.34 (1.13 to 1.61); <0.001	40 (5.7)
Grammar	190 (18.9) 1.50 (1.22 to 1.85); <0.001	830 (82.5) 1.24 (1.01 to 1.51); 0.036	615 (61.1) 0.68 (0.58 to 0.80); <0.001	881 (87.6) 1.08 (0.86 to 1.36); 0.500	687 (68.3) 2.08 (1.77 to 2.45); <0.001	70 (7.0)
Independent/Private Fee Paying	295 (30.8) 3.02 (2.49 to 3.65); <0.001	797 (83.2) 1.26 (1.03 to 1.55); 0.027	576 (60.1) 0.63 (0.53 to 0.74); <0.001	857 (89.5) 1.48 (1.16 to 1.90); 0.002	631 (65.9) 2.12 (1.80 to 2.51); <0.001	69 (7.2)
Other	9 (11.3) 0.98 (0.48 to 2.00); 0.966	69 (86.3) 1.60 (0.81 to 3.14); 0.175	50 (62.5) 0.78 (0.48 to 1.28); 0.325	64 (80.0) 0.82 (0.45 to 1.53); 0.539	41 (51.3) 1.15 (0.72 to 1.84); 0.554	11 (13.8)
Missing	0 (0.0)	1 (100.0)	0 (0.0)	1 (100.0)	1 (100.0)	1 (100.0)
ETHNICITY						
White	384 (14.7) 1	2159 (82.8) 1	1785 (68.4) 1	2194 (84.1) 1	1366 (52.4) 1	143 (5.5)
Asian	324 (17.8) 1.33 (1.12 to 1.59); 0.001	1461 (80.5) 0.91 (0.77 to 1.08); 0.277	1176 (64.8) 0.87 (0.75 to 0.99); 0.041	1629 (89.7) 1.81 (1.47 to 2.21); <0.001	1158 (63.8) 1.85 (1.61 to 2.12); <0.001	168 (9.3)
Black	88 (16.9) 1.46 (1.11 to 1.92); <0.05	404 (77.5) 0.81 (0.63 to 1.04); 0.103	365 (70.1) 1.00 (0.80 to 1.26); 0.986	467 (89.6) 1.87 (1.34 to 2.62); <0.001	249 (47.8) 1.01 (0.82 to 1.25); 0.895	29 (5.6)
Mixed	44 (15.3) 0.97 (0.68 to 1.39); 0.860	241 (83.7) 0.99 (0.71 to 1.38); 0.957	197 (68.4) 0.95 (0.73 to 1.25); 0.725	245 (85.1) 1.00 (0.71 to 1.42); 0.985	149 (51.7) 1.01 (0.78 to 1.30); 0.949	21 (7.3)
Other	37 (18.1) 1.43 (0.94 to 2.17); 0.097	169 (82.4) 1.26 (0.81 to 1.96); 0.310	131 (63.9) 0.79 (0.57 to 1.11); 0.179	182 (88.8) 1.48 (0.91 to 2.41); 0.113	125 (61.0) 1.95 (1.39 to 2.73); <0.001	22 (10.7)
NS-SEC						
1	720 (17.3) 1	3419 (82.2) 1	2761 (66.4) 1	3620 (87.0) 1	2388 (57.4) 1	262 (6.3)
2	23 (10.8) 0.72 (0.46 to 1.13); 0.153	173 (81.2) 0.94 (0.65 to 1.34); 0.719	160 (75.1) 1.33 (0.96 to 1.83); 0.087	183 (85.9) 1.03 (0.68 to 1.54); 0.898	107 (50.2) 0.93 (0.70 to 1.23); 0.594	16 (7.5)
3	8 (10.0) 0.67 (0.32 to 1.43); 0.304	69 (86.3) 1.41 (0.74 to 2.70); 0.294	59 (73.8) 1.20 (0.72 to 2.00); 0.482	67 (83.8) 0.79 (0.43 to 1.45); 0.445	44 (55.0) 1.07 (0.68 to 1.69); 0.771	12 (15.0)
4	28 (13.2) 0.79 (0.52 to 1.20); >0.05	164 (77.4) 0.78 (0.56 to 1.09); 0.147	149 (70.3) 1.10 (0.81 to 1.51); 0.529	179 (84.4) 0.77 (0.52 to 1.14); 0.185	106 (50.0) 0.76 (0.60 to 0.96); 0.021	17 (8.0)
5	51 (14.0) 0.82 (0.59 to 1.14); 0.240	279 (76.7) 0.74 (0.56 to 0.97); 0.028	250 (68.7) 0.98 (0.77 to 1.26); 0.882	311 (85.4) 0.77 (0.55 to 1.07); 0.115	182 (50.0) 0.76 (0.60 to 0.96); 0.021	27 (7.4)
Missing	47 (11.5)	330 (80.5)	275 (67.1)	357 (87.1)	220 (53.7)	49 (12.0)
BURSARY						
No bursary received	802 (16.5) 1	3955 (81.5) 1	3223 (66.4) 1	4216 (86.8) 1	2768 (57.0) 1	338 (7.0)
Bursary received	75 (12.8) 1.08 (0.81 to 1.45); 0.581	479 (82.0) 1.21 (0.93 to 1.58); 0.149	431 (73.8) 1.26 (1.01 to 1.58); 0.044	501 (85.8) 0.82 (0.62 to 1.09); 0.167	279 (47.8) 0.81 (0.66 to 0.99); 0.039	45 (7.7)
Constant for binary logistic regression model	0.13 (0.11 to 0.15); <0.001	4.54 (3.91 to 5.26); <0.001	2.82 (2.49 to 3.21); <0.001	5.71 (4.84 to 6.73); <0.001	0.80 (0.71 to 0.90); <0.001	

Please note that only candidates with non-missing values were included within the regression analysis

Table 7 Demographic characteristics by time spent preparing for the test. Binary logistic regression model with preparing > 20 h as the outcome variable and demographic variables as covariates as the final column. The reference category for each variable has an odds ratio of 1. Missing values not included in chi-squared tests or regression analysis. Significant results with negative direction of effect have been shaded red whilst significant results with positive direction of effect have been shaded green

	Did not prepare N (%)	0-10 hours N (%)	11-20 hours N (%)	21-30 hours N (%)	31-40 hours N (%)	40+ hours N (%)	p-value	Preparing >20 hours OR (95% CI); p-value
All	34 (0.6)	451 (8.3)	1082 (20.0)	1357 (25.1)	1163 (21.5)	1320 (24.4)		
GENDER							<0.001	
Male	19 (1.0)	202 (10.3)	416 (21.3)	503 (25.7)	403 (20.6)	411 (21.0)		0.72 (0.63 to 0.81); <0.001
Female	15 (0.4)	249 (7.2)	666 (19.3)	854 (24.7)	760 (22.0)	909 (26.3)		1
SCHOOL							<0.001	
Sixth Form/ Further Education College	22 (0.8)	254 (9.5)	586 (21.9)	674 (25.2)	553 (20.7)	587 (21.9)		1
Comprehensive	5 (0.7)	43 (6.2)	160 (23.0)	163 (23.4)	147 (21.1)	178 (25.6)		1.21 (1.00 to 1.47); 0.052
Grammar	5 (0.5)	65 (6.5)	147 (14.7)	261 (26.1)	240 (24.0)	284 (28.3)		1.59 (1.33 to 1.91); <0.001
Independent/Private Fee Paying	2 (0.2)	84 (8.8)	176 (18.5)	236 (24.8)	206 (21.6)	248 (26.1)		1.26 (1.06 to 1.50); 0.010
Other	0 (0.0)	5 (6.3)	13 (16.3)	22 (27.5)	17 (21.3)	23 (28.8)		1.78 (1.01 to 3.13); 0.045
Missing	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)		
ETHNICITY							<0.001	
White	6 (0.2)	230 (8.8)	610 (23.5)	669 (25.7)	537 (20.7)	549 (21.1)		1
Asian	20 (1.1)	132 (7.3)	296 (16.4)	444 (24.6)	390 (21.6)	521 (28.9)		1.68 (1.44 to 1.95); <0.001
Black	4 (0.8)	53 (10.3)	78 (15.2)	122 (23.8)	125 (24.4)	131 (25.5)		1.57 (1.24 to 1.91); <0.001
Mixed	3 (1.1)	19 (6.6)	58 (20.0)	79 (27.5)	65 (22.7)	63 (22.0)		1.27 (0.95 to 1.68); 0.102
Other	1 (0.5)	17 (8.4)	40 (19.7)	43 (21.2)	46 (22.7)	56 (27.6)		1.55 (1.07 to 2.23); 0.019
NS-SEC							0.005	
1	21 (0.5)	324 (7.8)	806 (19.5)	1035 (25.0)	923 (22.3)	1030 (24.9)		1
2	1 (0.5)	19 (9.0)	45 (21.3)	61 (28.9)	39 (18.5)	46 (21.8)		0.98 (0.72 to 1.31); 0.881
3	3 (3.9)	12 (15.4)	20 (25.6)	14 (18.0)	11 (14.1)	18 (23.1)		0.51 (0.32 to 0.81); 0.004
4	2 (1.0)	21 (10.0)	48 (22.8)	55 (26.1)	38 (18.0)	47 (22.3)		0.75 (0.55 to 1.01); 0.061
5	5 (1.4)	38 (10.5)	76 (20.9)	92 (25.3)	68 (18.7)	84 (23.1)		0.74 (0.58 to 0.95); 0.018
Missing	2 (0.5)	37 (9.1)	87 (21.5)	100 (24.7)	84 (20.7)	95 (23.5)		
BURSARY							<0.001	
No bursary received	29 (0.6)	382 (7.9)	947 (19.6)	1213 (25.1)	1061 (22.0)	1195 (24.8)		1
Bursary received	5 (0.9)	69 (11.9)	135 (23.3)	144 (24.8)	102 (17.6)	125 (21.6)		0.77 (0.62 to 0.95); 0.016
Constant								2.06 (1.82 to 2.34); <0.001

Note that only 5407 participants reported the time they spent preparing hence all percentages are calculated out of this value

Table 8 Multiple linear regression model with total UCAT score as the outcome and preparedness categories and demographic variables as covariates. The third and fourth columns show the multiple linear regression model with total UCAT score as the outcome and demographic variables as covariates using all included candidates (i.e. responders and non-responders) and does not therefore adjust for preparedness

Variable	Mean difference in UCAT score including preparedness variables (95% CI)	p-value	Mean difference in UCAT score using all eligible candidates (95% CI)	p-value
Gender				
Female	0		0	
Male	52.78 (40.27 to 65.28)	< 0.001	48.36 (40.75 to 55.96)	< 0.001
School type				
Sixth Form/Further Education College	0		0	
Grammar	112.57 (96.00 to 129.14)	< 0.001	112.00 (102.14 to 121.87)	< 0.001
Independent/ Private Fee Paying	94.21 (77.03 to 111.40)	< 0.001	100.32 (90.01 to 110.63)	< 0.001
Comprehensive	16.17 (-2.73 to 35.08)	0.094	27.22 (15.08 to 39.36)	< 0.001
Other	-47.10 (-96.64 to 2.44)	0.062	-25.56 (-59.99 to 8.88)	0.146
Ethnicity				
White	0		0	
Asian	-103.87 (-118.07 to -89.67)	< 0.001	-77.05 (-85.55 to -68.56)	< 0.001
Black	-205.29 (-227.34 to -183.24)	< 0.001	-178.50 (-192.96 to -164.04)	< 0.001
Mixed	-55.71 (-82.72 to -28.69)	< 0.001	-38.62 (-55.59 to -21.64)	< 0.001
Other	-129.34 (-163.71 to -94.98)	< 0.001	-103.81 (-123.68 to -83.93)	< 0.001
NS-SEC				
1	0		0	
2	-22.40 (-52.40 to 7.59)	0.143	-17.20 (-36.35 to 1.96)	0.078
3	-50.98 (-99.39 to -2.56)	0.039	-65.66 (-92.05 to -39.27)	< 0.001
4	-50.55 (-80.58 to -20.52)	0.001	-74.20 (-92.27 to -56.13)	< 0.001
5	-64.52 (-88.82 to -40.21)	< 0.001	-71.98 (-87.08 to -56.87)	< 0.001
Second or more than second attempt of UCAT	66.64 (42.69 to 90.60)	< 0.001	46.77 (33.07 to 60.47)	< 0.001
School-based preparation course	36.66 (20.25 to 53.07)	< 0.001		
Official UCAT Tests	67.77 (52.01 to 83.53)	< 0.001		
Other official UCAT resources	-1.24 (-14.12 to 11.65)	0.851		
Free commercial materials	-13.95 (-31.88 to 3.99)	0.127		
Paid commercial materials	37.65 (24.81 to 50.49)	< 0.001		
Time preparing				
Did not prepare	0			
0–10 h	68.48 (-8.60 to 145.56)	0.082		
11–20 h	124.02 (48.37 to 199.67)	0.001		
21–30 h	131.75 (56.21 to 207.29)	0.001		
31–40 h	165.88 (90.06 to 241.71)	< 0.001		
40+ hours	177.90 (102.12 to 253.69)	< 0.001		
Bursary				
No bursary received				
Bursary received	-12.12 (-33.51 to 9.26)	0.266	-19.37 (-32.50 to -6.24)	0.004
Constant	2390.72 (2313.75 to 2467.68)	< 0.001	2577.32 (2569.56 to 2585.08)	< 0.001

The first model used all eligible responders with non-missing values ($n = 5001$). For each of the preparedness categories, the reference category is not being in the category. For example, for 'paid preparation materials', the reference category is those who did not report using paid preparation materials

these sections demonstrated a dose–response relationship with time spent preparing. The researchers investigating the UMAT argued that these sections are more easily answered using learned, specific problem-solving

skills whilst the verbal reasoning component is less amenable to using learned techniques from coaching [12].

An important limitation of this study is the likelihood of responder bias. Whilst the responders and

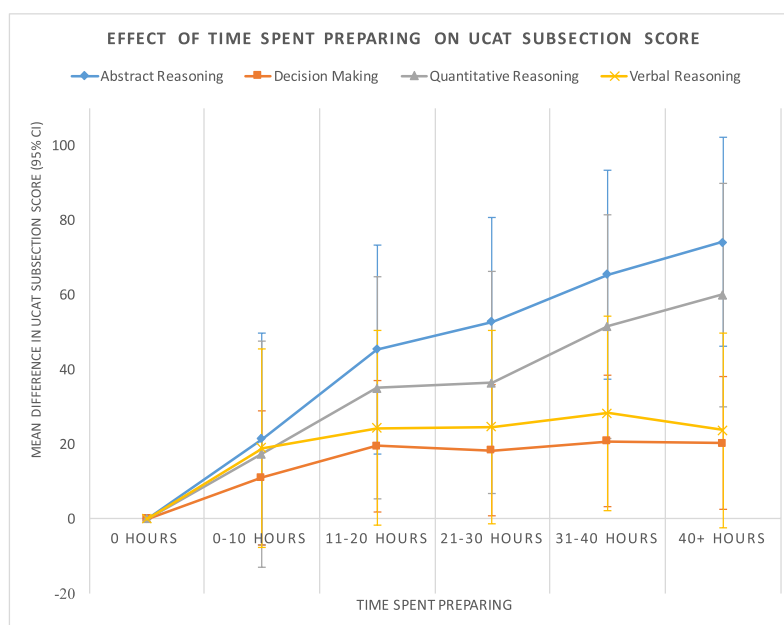
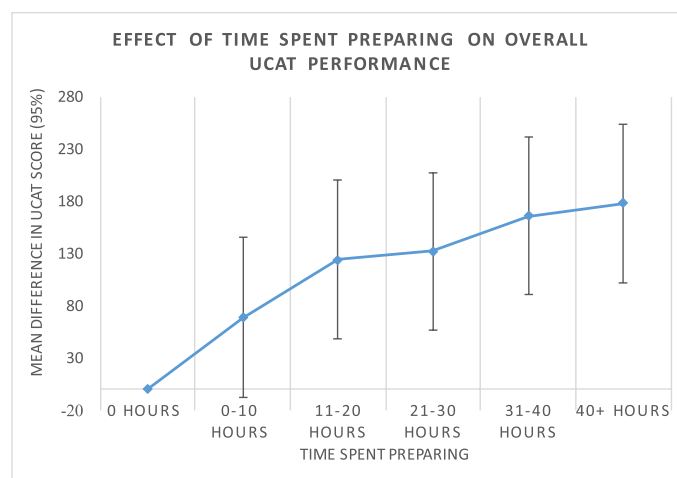
Table 9 Binary logistic regression model with SJT Band 1 or 2 as the outcome using all included candidates and does not adjust for preparedness ($n = 14,432$). Binary logistic regression model with SJT Band 1 or 2 as the outcome and preparedness categories and demographic variables as covariates using all responder ($n = 5439$)

Variable	Adjusted odds ratio (95% CI)	p-value	Adjusted odds ratio using all eligible candidates (95% CI)	p-value
Gender				
Female	1		1	
Male	0.65 (0.57 to 0.75)	< 0.001	0.62 (0.57 to 0.68)	< 0.001
School type				
Sixth Form/Further Education College	1		1	
Grammar	1.32 (1.09 to 1.59)	0.004	1.59 (1.42 to 1.78)	< 0.001
Independent/ Private Fee Paying	1.53 (1.24 to 1.88)	< 0.001	1.53 (1.36 to 1.72)	< 0.001
Comprehensive	1.19 (0.95 to 1.48)	0.124	1.22 (1.07 to 1.40)	0.004
Other	0.74 (0.43–1.27)	0.274	0.86 (0.60 to 1.25)	0.438
Ethnicity				
White	1		1	
Asian	0.46 (0.39 to 0.54)	< 0.001	0.55 (0.50 to 0.60)	< 0.001
Black	0.37 (0.29 to 0.47)	< 0.001	0.45 (0.39 to 0.53)	< 0.001
Mixed	0.64 (0.47 to 0.88)	0.005	0.82 (0.68 to 1.00)	0.047
Other	0.40 (0.28 to 0.57)	< 0.001	0.58 (0.47 to 0.72)	< 0.001
NS-SEC				
1	1		1	
2	1.01 (0.71 to 1.41)	0.976	1.03 (0.83 to 1.27)	0.811
3	0.94 (0.55 to 1.58)	0.802	0.73 (0.56 to 0.95)	0.021
4	0.73 (0.54 to 1.00)	0.047	0.68 (0.56 to 0.81)	< 0.001
5	0.67 (0.52 to 0.85)	0.001	0.74 (0.63 to 0.86)	< 0.001
Second or more than second attempt of UCAT	2.28 (1.66 to 3.13)	< 0.001	2.23 (1.86 to 2.67)	< 0.001
School-based preparation course	1.40 (1.15 to 1.71)	0.001		
Official UCAT Tests	1.15 (0.97 to 1.37)	0.110		
Other official UCAT resources	0.94 (0.81 to 1.09)	0.401		
Free commercial materials	1.04 (0.85 to 1.26)	0.729		
Paid commercial materials	1.15 (1.00 to 1.33)	0.055		
Time preparing				
Did not prepare	1			
0–10 h	1.28 (0.61 to 2.71)	0.516		
11–20 h	2.07 (0.99 to 4.34)	0.052		
21–30 h	2.28 (1.09 to 4.76)	0.028		
31–40 h	3.64 (1.73 to 7.66)	0.001		
40+ hours	3.64 (1.73 to 7.64)	0.001		
Bursary				
No bursary received	1		1	
Bursary received	1.23 (0.98 to 1.56)	0.078	1.05 (0.92 to 1.21)	0.468
Constant	1.48 (0.70 to 3.16)	0.308	4.10 (3.75 to 4.47)	< 0.001

For each of the preparedness categories, the reference category is not being in the category. For example, for 'paid preparation materials', the reference category is those who did not report using paid preparation materials

non-responders were largely comparable in terms of whole numbers with regards to demographic characteristics, those who responded performed significantly better on the test. Although responders were unaware of their test score when completing the survey, it is possible that

those who believed they had not performed well were less likely to complete our questionnaire. We also acknowledge the categories used for some of the variables, such as ethnicity and school type, are very broad and as a result there is likely to be a degree of variability within each



Without error bars:

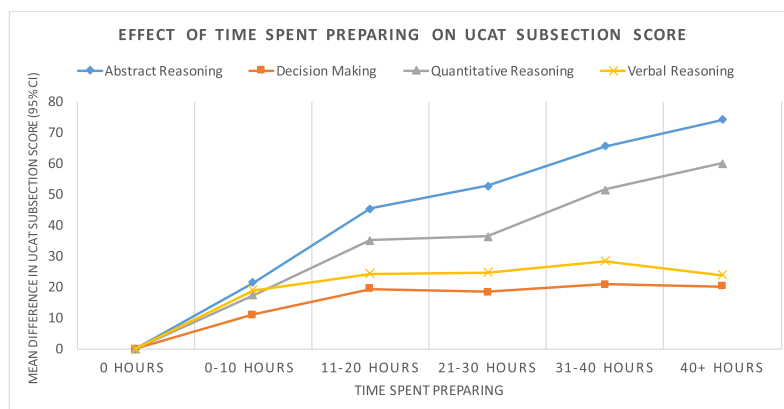


Fig. 2 Graphs of time spent preparing compared to UCAT performance both overall and in each subsection. The data has been generated from the multiple logistic regression models outlined in the methods and results with error bars relating to the 95% confidence interval for each data point. The mean difference in UCAT score for each category is compared to the average score for the 'Did not prepare category' (i.e. 0 h)

group. An additional limitation is the lack of a measure of prior academic attainment for each candidate, which is a known predictor of UCAT performance [2] and may possibly moderate the impact of preparation [13]. In the future we plan to combine our data with the UKMED dataset to allow adjustment for further confounders such as academic attainment and to answer further research questions such as the impact of preparation on the predictive validity of the UCAT. Similarly, in the absence of a measure of pre-preparation UCAT score it is not possible to determine at an individual level whether preparation leads to an improvement in test performance.

We further acknowledge that there is likely a degree of correlation within the different demographic and preparedness variables, for instance between school type and socioeconomic status or preparation time and use of commercial materials. These inter-variable relationships may influence the independent effect of each variable and further research to delineate this would be useful (although was considered beyond the scope of this paper). In addition, qualitative research investigating candidate preparation in relation to socio-demographic characteristics and social norms may further our understanding of the issues.

The effectiveness of preparation for cognitive tests may be attributed to improving candidates' test taking techniques and pattern recognition skills but perhaps also by increasing their familiarity with the test format and various question types. Medical schools should be cautious about presuming these types of selection tests only assess inherent intellectual ability. It is possible that access to preparation tools and support may partially explain the association between higher UCAT scores and attendance at a selective schools and higher socioeconomic family background. The key implication, therefore, is that addressing the differential in access to preparation resources may mitigate differences in performance between socio-demographic groups. Suggested means of achieving this include creating more freely available resources through the UCAT website and increased awareness of such resources.

Preparation was found to have little association with performance in the SJT component, yet differences of a large magnitude exist between ethnic and socioeconomic groups; language, cultural and social norms may be important determinants of SJT performance, rather than preparedness.

Conclusions

This study has demonstrated an association between use of preparatory materials and courses and scores in the 2017 UCAT and demonstrated differential use of

preparation resources among candidates from different socio-demographic groups. We have also confirmed previous reports of associations between candidate performance and demographic characteristics including ethnicity and family socio-economic status.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12909-022-03811-y>.

Additional file 1: Appendix 1. UCAT Post-test Questionnaire. **Appendix 2.** Questionnaire Responses. **Appendix 3.** Subsection score regression models with demographic variables as covariates. **Appendix 4.** SJT Band 4 binary logistic regression models with demographic variables as covariates. **Appendix 5.** Subsection score regression models with demographic variables and preparedness categories as covariates.

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Accordance with guidelines and regulations

All work reported in this manuscript was conducted in line with the requirements of the University Clinical Aptitude Test Consortium and of the University of Birmingham Research Ethics Committee regulations (as documented in written permission: *ERN_17-052*).

Authors' contributions

SK conceived the idea for the study. JP and SK wrote the protocol and gained permission from UCAT to access data via the organisation's safe haven. Data analyses were undertaken by SK and AS. SK wrote the first draft of the manuscript; all authors contributed to the revisions of this draft and agreed the final manuscript.

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Availability of data and materials

The data that support the findings of this study are available from the University Clinical Aptitude Test Consortium but restrictions apply to the availability of these raw data due to confidentiality assurances provided to UCAT test-takers (see: Candidate Data | UCAT Consortium). Data are available from Jayne Parry upon reasonable request and with permission of the University Clinical Aptitude Test.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was provided by the University of Birmingham Ethics Committee (*ERN_17-0521*). All methods were carried out in accordance with the ethical approval given; including obtaining informed consent from all subjects.

Consent to publication

Not Applicable.

Competing interests

Jayne Parry is a Board Member of the University Clinical Aptitude Test Consortium.

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