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Do graduates increase the diversity of the UK medical student body?

A national cohort study.

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ABSTRACT

Introduction

Attracting graduates was recommended as a means of diversifying the UK medical student population. Graduates now make up nearly a quarter of the total medical student population. Research to date has focused on comparing the socio-demographic characteristics of applicants to and/or students on traditional and graduate entry programmes (GEMs), yet GEMs account for only 40% of the graduate medical student population. Thus, we aimed to compare the socio-demographic characteristic and outcomes of graduates and non-graduate applicants across a range of programmes.

Methods

This was an observational study of 117214 applicants to medicine who took the UKCAT from 2006 to 2014, and who applied to medical school through UCAS. We included applicant demographics, UKCAT total score and offers in our analysis. Applicants were assigned as graduates or non-graduates on the basis of their highest qualification. Multiple logistic regression was used to predict the odds of receiving an offer, after adjusting for confounders.

Results

Irrespective of graduate or non-graduate status, most applicants were from the highest socio-economic groups and were from a white ethnic background. Receiving an offer was related to gender and ethnicity in both graduates and non-graduates. After adjusting for UKCAT score, the odds ratio of an offer for graduates vs. non-graduates was approximately 0.5 (OR=0.48, 95% CI 0.46-0.49).

Discussion

Our findings indicate that the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has not been successful. Different approaches must be considered if medicine is to attract and select more socially diverse applicants.

249 words

Strength and limitations of this study:

- A large multi-cohort study to look at the population of graduate applicants to UK medical schools, including those on Graduate Entry Programme (GEM) and traditional programmes.
- The study uses a contemporary dataset to examine the socio-economic differences of those who apply to medical school; and it is important to know more about who *applies*, as medical schools can only select from the pool of applicants.
- The study examines what socio-demographic factors are associated with receiving an offer to study medicine, and whether these differ in graduates and non-graduates.
- Measures of socio-economic status are self-declared and there was a large proportion of missing socio-economic data for the graduate sub-group.
- Allocating students to an occupational group that depends on their family circumstances (area, parental occupation) can be problematic, especially for mature applicants.

INTRODUCTION

Despite much activity, investment and policy directives, people from backgrounds perceived as disadvantaged and minority, ethnic and cultural groups, remain under-represented, or excluded from, medicine worldwide on the basis of, for example, their social class or ethnic origin.[1-5] In the UK, the vast majority of medical students come from the highest socio-economic groups[6-9], and more than 20% of medical students have attended independent (usually fee paying) schools, compared to an average of 7% of all school pupils.[10] This issue was summarised concisely in a report by the Independent Reviewer on Social Mobility and Child Poverty: 'Medicine . . . has a long way to go when it comes to making access fairer, diversifying its workforce and raising social mobility'.[10]

In the UK, most students enter medicine as school-leavers aged 17-20 years. In 1997, the UK Medical Workforce Standing Advisory Committee (MWSAC) recommended that one way of diversifying the medical student population was to attract graduates into medical schools.[11] The assumption behind this was that, by accepting students with more life experience, the diversity of students and hence doctors would be increased[12-15], and this would result in more doctors willing to

work in deprived and underserved areas.[16-18] This recommendation led to the introduction (in 2000) of the first four-year graduate entry medical courses (GEM), as well as a more general drive to encourage graduates into medicine.

Graduates now make up nearly a quarter of the contemporary UK medical student population. [13,19] However, to date, there is relatively little information relating to whether, or not, attracting graduates has increased the diversity of medicine in the UK. Earlier studies tend to be single-site and/or focused on the relative performance of graduates versus school-leaver entrants.[20-26] In an exception to this, Mathers and colleagues carried out a large-scale study of applicants to 31 UK medical schools between 2002 and 2006 in order to determine whether the newly introduced GEM programmes had widened access to medicine.[6] They concluded that graduate entry programmes do attract more students from less affluent backgrounds than traditional five-year programmes but overall GEMs had not led to significant changes to the socio-economic profile of UK medical student population. It could be argued, however, that this study was undertaken too soon after the establishment of the first GEM programmes to assess their true impact, given the typical time lag between policy implementation and impact on practice in education.[27]

Moreover, GEM programmes only account for about 10% of all medical programmes: there are more graduates in traditional five-year programmes than in GEM programmes. Yet, to the best of our knowledge, no previous studies have looked directly at the whole population of graduate medical students – that is, those on both GEM and traditional programmes.

Finally, most studies have only looked at those graduates who were successful in obtaining a place at medical school.[6,28] It is also important to know more about who *applies*, as medical schools can only select from the pool of applicants.[8] In one of the few studies looking at both applicants and admissions, Garrud found some differences between both applicants and admissions to graduate-entry and traditional programmes, mostly in terms of ethnicity, but did not examine differences in terms of socio-economic markers.[29]

To address these gaps in the literature we used a contemporary dataset to compare the socio-demographic characteristics of graduates and non-graduate applicants to medicine. The main objective was to determine whether graduate and non-graduate applicants to medicine differ on a range of socio-demographic variables. Our second aim was to examine what socio-demographic factors are associated with receiving an offer to study medicine, and whether these differ in graduates and non-graduates.

METHODS

Study context

Data were obtained from the UKCAT database which comprises data from two sources: UCAS and UKCAT (http://www.ukcat.ac.uk/). UKCAT is the UK Clinical Aptitude Test for applicants to medical and dental schools. UCAS is the Universities and Colleges Admissions Service, a UK-based organisation whose primary role is to operate the application process for British universities. Through the UCAS system (https://www.ucas.com/), candidates can apply to up to four medical courses out of five options in any one cycle, but there is no preference order of course choice. We compiled data for all candidates who sat the UKCAT between 2006 and 2014, and who applied to medical school through UCAS.

The UKCAT database only holds UCAS data relating to UKCAT candidates who have applied to a UKCAT University. Therefore, the data is a subset of graduate applicants to UK Universities. A number of graduate entry programmes use other admission tests (both BMAT and GAMSAT). Of the 16 graduate entry programmes in the UK, 7 require the UKCAT, 4 require GAMSAT, and one programme requires a BMAT.[30] The other four graduate entry programmes do not use any of these admission tests. Where UKCAT candidates have applied to non-UKCAT Universities these choices and the outcome of these choices are not known.

Although individuals can have multiple applications, within and between years, the socio-demographic variables presented in this study are per unique applicant. These variables include gender; ethnicity; domicile; secondary school attended, domicile (United Kingdom (UK), International, European Union (EU)). The socio-economic status (SES) of the candidates was determined by parental National Statistics Socio-Economic Classification (NS-SEC) and Index of Multiple Deprivation (IMD), an area-based measurement of material deprivation.

Design and procedures

Access to the data was via a safe haven[31] (to ensure adherence to the highest standards of security, governance and confidentiality when storing, handling and analysing identifiable data). Ethical approval was not required because the focus of this study was a secondary analysis of anonymised data, and applicants had given permission for their data to be used for research purposes. Data files were merged into a single SPSS file for cleaning and analysis. What follows in this paper is the summary of UKCAT applicants for whom we managed to match at least 50% of the records.

The applications were assigned into two categories; graduate or non-graduate at the time of application. This was primarily based on applicants' highest qualification but some amendments were necessary. For example, where this information was missing, we imputed the outcome variable based on applicants' age and programme applied. For instance, all applicants aged less than 20 on their final UKCAT attempt were assumed to have applied shortly after leaving school; these were classified as school-leavers, or non-graduate applicants. Similarly, applicants with missing information on academic qualification, aged over 21 and had applied for a graduate entry programme were classified as 'graduates'. The outcome measures were the UKCAT score, and whether the applicant received an offer or not. We also considered all conditional and unconditional offers as an 'offer'.

Statistical analysis

All the data were analysed using SPSS (IBM SPSS Statistics for Windows Version 22.0. Armonk, NY: IBM Corp). The results are reported in terms of numbers, percentages and mean (standard deviation) or median (interquartile range) as appropriate. The UKCAT scores were normally distributed. Therefore we used independent-samples t-test to compare the means between two groups. One-way analysis of variance (ANOVA) was used to compare means between more than two independent groups. A binary logistic regression analysis was employed to predict the odds of getting an offer from an application based on an applicant's graduate status. The specific factors we adjusted for in the regression models were: socio-economic status (NS-SEC and IMD), gender, graduate status, ethnicity and the total UKCAT score. The purpose was to assess the odds of receiving an offer for a graduate relative to a non-graduate after accounting for any differences in total UKCAT score. The analysis considered only the final application of each applicant to ensure independence (i.e., to control for those who made repeated applications).

RESULTS

From 2006 to 2014, the UKCAT database comprises 117214 applicants to medicine, applying through UCAS on a total of 146146 occasions (i.e. some applied in more than one cycle and hence sat the UKCAT more than once). 23.6% of the applicants were graduates and 76.4% non-graduates. The median age for the non-graduate applicants was 18 years: 23 years for the graduate applicants.

Table 1 summarises a comparison of graduate and non-graduate applicants by different sociodemographic factors. The main pattern across the two groups was that most applicants were from the highest socio-economic group, with nearly 80% of all applicants having a parent/guardian in the managerial and professional occupations. The groups were also similar in that one-fifth of the graduate and non-graduate applicants had attended a fee-paying (independent) school. The sample was predominantly of candidates from white ethnic backgrounds, for both graduates 64.3% (n=14014), and non-graduates 61.9% (n=47103). Around 7.7% of the graduates were classified as international applicants, as compared to 12.1% of the non-graduate applicants. The number of EU applicants was similar for both graduates (6.0%) and non-graduates (7.6%).

……. Table 1 about here…….

Non-graduate applicants performed significantly better on the UKCAT (2535.4 points, SD=268.2) than graduate applicants (2498.5 points, SD=285.7), p<0.001. Graduates and non-graduate applicants from the top 20% affluent neighbourhoods (IMD 'I') obtained better UKCAT scores than applicants from the 20% most deprived areas (IMD 'V'). The difference was approximately 200 points for graduate applicants, and the same margin was observed in the non-graduate group. A similar pattern was also observed with parental occupation classification (NS-SEC) categories with the difference of over 100 UKCAT points between managerial and professional occupations and routine/semi-routine occupations.

The proportion of applicants who received offers was substantially lower for graduates (27.7%) than it was for non-graduates (47.9%). Graduate applicants who received offers had significantly better mean UKCAT scores (2697.7 points, SD=244.39) compared to their non-graduate colleagues who received offers (2657.7 points, SD=235.3), p<0.001. The pre-admission attainment information (UKCAT scores) is summarised in Table 2.

……. Table 2 about here…….

A binary logistic regression analysis was employed to predict the odds of getting an offer based on the applicant's highest qualification (graduate or not) and total UKCAT score. After adjusting for UKCAT score, the odds ratio of an offer for graduates vs. non-graduates was approximately 0.5 (OR=0.48, 95% CI 0.46-0.49).

Several variables that were considered to be representative of widening participation (WP) backgrounds were included in univariate analyses. The multiple logistic regression analysis was repeated including, in addition to UKCAT and graduate status, only those variables that were statistically significant ($p \leq 0.05$) when associated with offer status. The specific factors were gender, ethnicity and socio-economic class (IMD and NS-SEC). We also tested for interaction of these factors which enabled us to ask whether graduates from different socio-economic backgrounds were more or less likely to receive offers. The overall model performance, using *Nagelkerke's* R^2 ranged from 0.20 to 0.23 across the models developed. Results of the two-way interaction terms (Table 3) showed that after adjusting for other factors, the additional effect of socio-economic disadvantage for graduates (compared to graduates) was small and did not reach statistical significance (p=0.25 for the interaction of graduate status and IMD; p=0.23 for the interaction of graduate status and parental occupation (NS-SEC)). The result suggests that the association between socio-economic disadvantage and the likelihood of getting an offer for medical school affected graduates and non-graduates in a similar way.

….. Table 3 about here…..

Figure 1 gives a graphical summary of the results from final model. In general, the odds of getting an offer to study medicine were lower if the applicant was male, graduate, from black and minority ethnic (BME) background, and from lower socioeconomic groups (NS-SEC1, and IMD 'I' – least affluent neighbourhood). Figures 2 and 3 give a graphical summary of the odds ratio after separating graduates and non-graduates, to help further illustrate the difference between the two groups. For the non-graduates, the pattern is almost the same as the combined model in that the odds of getting an offer were higher if the applicant was female, from white ethnic background, and from high socioeconomic groups (NS-SEC1, and IMD I – most affluent neighbourhood). Some explanation for this pattern is because the non-graduates were in such a high proportion of the whole group. In comparison, for graduates, the predictor values that stand out are gender and ethnicity. However,

notably, nearly a quarter of graduate applicants had a missing socio-economic profile data (NS-SEC) which may explain why SES measures were less important predictors for graduates.

DISCUSSION

In this analysis of a large, multi-cohort contemporary dataset, we examined differences between graduates and non-graduate applicants to UK medical schools. Unlike previous studies in this area, we compared a larger sample of graduate applicants with non-graduates, rather than comparing by course (traditional versus GEM). This allowed us to capture the characteristics of a broader group of graduate applicants compared to earlier studies. Our results show that graduate and non-graduate applicants to UK medical schools are very similar on a range of socio-demographic markers, including multiple markers of socio-economic status. This indicates that, even with time and much investment in GEM courses, the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has not been successful.[6]

Interestingly, unlike previous studies[29], we did not identify any differences across graduates and non-graduates in terms of ethnicity. This may represent a change in the medical student population overall or may be an artefact of study design given that we looked at graduates in all medical programmes, not just GEM programmes.

We also looked at who received an offer. The patterns across non-graduates and graduates were similar in terms of gender and ethnicity. In non-graduates, offers to study medicine were higher if the applicant was from a higher socio-economic group. However, measures of socio-economic status are self-declared and there was a large proportion of missing socio-economic data for the graduate sub-group. This reflects patterns seen in other similar studies.[32-36] Given the high proportion of missing data it would be misleading to conclude that IMD and NS-SEC are weaker predictors for assessing the likelihood of getting an offer among graduate applicants because many graduate applicants were excluded from the logistic regression analysis and the missing data could also have led to insufficient power to detect smaller effects. Moreover, allocating students to an occupational group that depends on their family circumstances (area, parental occupation) can be problematic, especially for mature students.[37,38] However, we had no other measures available to us: no matter how limited[32,34], those used are the 'basic units' that indicate educational disadvantage in the UK. We urge organisations such as UCAS and UKCAT to explore ways of improving self-declared data reporting, and government bodies such as the UK's Office for National Statistics to explore more effective measures of socio-economic status.

Overall, we found that graduates were proportionally less likely to receive an offer than non-graduate applicants, and those graduates who were offered places had significantly higher UKCAT scores than their non-graduate equivalents. We know from earlier studies[29] and contemporary routine data that the average competition, or selection, ratios for GEM programmes are significantly higher than for traditional five-year programmes. GEM selection processes also tend to place more weight on UKCAT performance than do traditional programmes typically (this is associated with school leaving examinations being potentially less disciminatory for graduates - who would have taken these exams in earlier years, when it was less common to achieve top grades[39]). These factors may explain this outcome. However, future research which compares selection ratios for non-graduates and graduates by programme would provide a more nuanced understanding of differences across groups. Additionally, future studies could also look more closely at graduate and non-graduate patterns of performance in the various stages of medical school selection for the high number of graduates applying to traditional programmes. For example, we do not know whether graduates and non-graduates with equivalent grades and UKCAT scores are invited to interview, then graduates "fall down" at that stage. These studies would address concerns in the wider education literature that graduates and non-graduates are judged differently. [40]

The present study has various limitations that must be taken into consideration when interpreting findings. It was not possible to compare prior attainment across graduate and non-graduate groups with any confidence in this study because of the different weightings given to school and degree qualifications. However, this is a tricky comparison at the best of times. Graduates by their very nature have taken the school leaving exams which are typically used in medical selection to indicate prior attainment some years previous to their non-graduate counterparts. The issue of comparing "apples and pears" arises as over recent years the average A level score has progressively risen ("grade inflation").[39,41,42]

In conclusion, the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has not been successful. It may be that to draw a more diverse group of graduates into medicine requires different selection criteria for this group, one that places appreciable weight on the degree qualification and other graduate attributes, such as experience and passion for medicine. However, to change the selection process of graduates or indeed any group requires a shift towards affirmative action and/or a commitment to increase diversity. There appears to be little appetite for the former in the UK even though there is some evidence from other contexts that students from minority populations enrich the teaching environment of a medical school and may be more likely to practice in underserved areas.[43-45]

Contributions

We thank UKCAT for releasing the data for this project via a competitive bid process. We are also grateful to Dr Sally Curtis (University of Southampton) for the general advice throughout the project.

COMPETING INTERESTS AND FUNDING

This study is part of Ben Kumwenda's doctoral programme of research funded by the UKCAT Research Panel, of which JC is a member and RG the Administrator.

ETHICAL PERMISSION

The Chair of the local ethics committee ruled that formal ethical approval was not required for this study given the fully anonymised data was held in safe haven and all students who sit UKCAT are informed that their data and results will be used in educational research.

AUTHOR CONTRIBUTIONS

RMcK led the funding bid which was co-written by JC and GP, and reviewed by RG. RG advised on the nature of the data. BK managed the data, and planned and carried out the data analysis under the supervision of GP. JC guided the first draft of the introduction and discussion sections of this paper. BK and GP wrote the first drafts of the methods and results sections. JC edited the drafts. All authors reviewed and agreed the final draft of the paper.

DATA SHARING

No additional data available as datasets held in safe haven.

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Table 1: Frequency distribution of applicants (and offers) to UKCAT consortium medical schools between 2006 – 2014

	Non-graduate				Graduate			
	Application		Offer		Application		Offer	
	n	%	n	%	n	%	n	%
Gender								
Female	49082	55.9	22716	56.2	13999	57.7	3812	56.7
Male	38656	44.1	17702	43.8	10256	42.3	2910	43.3
Total	87738		40418		24255		6722	
Ethnicity II								
Caucasian	47103	61.9	25421	69.8	14014	64.3	4831	78.3
Non-Caucasian	28941	38.1	10995	30.2	7765	35.6	1335	21.7
Total	76044		36416		21779		6166	
School Attended‡								
Fee Paying	17388	25.5	10184	29.2	1672	21.1	664	24.5
Non-Fee Paying	50796	74.5	24705	70.8	6249	78.9	2043	75.5
Total	68184		34889		7921		2707	
IMD Quintile‡								
1	28518	34.6	14043	40	5972	26.2	1894	32
2	19202	23.3	8767	25	4693	20.6	1375	23.2
3	14986	18.2	6196	17.6	4450	19.6	1134	19.2
4	10883	13.2	3734	10.6	4261	18.7	959	16.2
5	8815	10.7	2394	6.8	3378	14.8	552	9.3
Total	82404		35134		22754		5914	
NS_SEC‡								
Managerial and Professional Occupations	61624	84.1	28025	87.9	15622	78.7	4406	83.3
Intermediate Occupations	3399	4.6	1337	4.2	1167	5.9	295	5.6
Small Employers and Own Account Occupations	4676	6.4	1501	4.7	1572	7.9	313	5.9
Lower Supervisory and Technical Occupations	1410	1.9	423	1.3	639	3.2	129	2.4
Routine and Semi-Routine Occupations	*2198*	*3*	580	1.8	848	4.3	149	2.8
Total	73307		31866		19848		5292	
Domicile								
UK	70447	80.3	35333	88	20909	86.2	6051	90
EU	6694	7.6	1078	2.7	1467	6	280	4.2
International	10597	12.1	3785	9.4	1879	7.7	391	5.8
Total	87738		40418		24255		6722	
UKCAT Attempt Number								
1	75049	85.5	34770	86	15562	64.2	4718	70.2
2	11803	13.5	5390	13.3	5722	23.6	1425	21.2
3+	886	1	258	0.6	2971	12.2	579	8.6
Total	87738		40418		24255		6722	
Final Outcome								
No Offer	43964	52.1			14736	68.7		
Offer	40418	47.9	40418		6722	27.7	6722	

	Total	87738				24255			

‡ Sample drawn from UK domiciled applicants only

Table 2

		Mean UKCAT Scores‡							
		Non-graduate				Graduate			
		N	Mean	SD	P value	N	Mean	SD	P value
	Gender								
	Female	49047	2532.2	269.8	<0.001	13974	2501.7	285.71	<0.001
	Male	38633	2581.8	267.7		10241	2550.9	291.22	
	Ethnicity								
	Caucasian	47102	2597.9	243.6	<0.001	14000	2591.2	261.15	
	Non-Caucasian	26298	2512.1	282.0		7128	2402.3	294.32	
	School Attended								
	Fee Paying	17388	2632.5	239.2	<0.001	1670	2611.6	233.21	<0.001
	Non-Fee Paying	50787	2562.8	260.0		6233	2527.2	265.93	
	IMD Quintile								
	I	24427	2627.9	237.8	<0.001	5395	2600.4	263.94	<0.001
	II	16291	2604.6	244.6		4206	2578.1	269.33	
	III	12505	2576.7	253.6		3937	2531.5	273.30	
	IV	8936	2516.6	269.3		3801	2479.3	298.79	
	V	7194	2425.9	282.8		2990	2397.5	312.92	
	NSSEC [UK Only]								
	Managerial and Professional Occupations	52555	2604.1	249.0	<0.001	14084	2560.6	281.44	<0.001
	Intermediate Occupations	2784	2568.7	246.3		1059	2541.3	272.21	
	Small Employers and Own Account Occupations	3635	2518.8	256.5		1367	2466.0	279.27	
	Lower Supervisory and Technical Occupations	1181	2486.6	259.5		551	2448.9	296.20	
	Routine and Semi-Routine Occupations	1775	2465.0	270.2		740	2441.2	276.38	
	Number of attempts								
	1	75000	2541.7	272.9	<0.001	15554	2507.5	299.42	<0.001
	2	11798	2628.4	237.9		5711	2552.7	273.84	
	3 or more	882	2604.4	256.0		2950	2543.5	254.43	
	Final Outcome								
	No offer	43925	2455.6	265.2	<0.001	14713	2443.9	278.01	<0.001
	Offer	40405	2657.7	235.3		6711	2697.7	244.39	

‡ The numbers presented here are the mean scores based on the applicants' last UKCAT sitting. However, the figure differences (to those in table 1) is because some applicants had a missing UKCAT outcome

Odds of an application resulting in offer of a place according to selected sociodemographic characteristics,

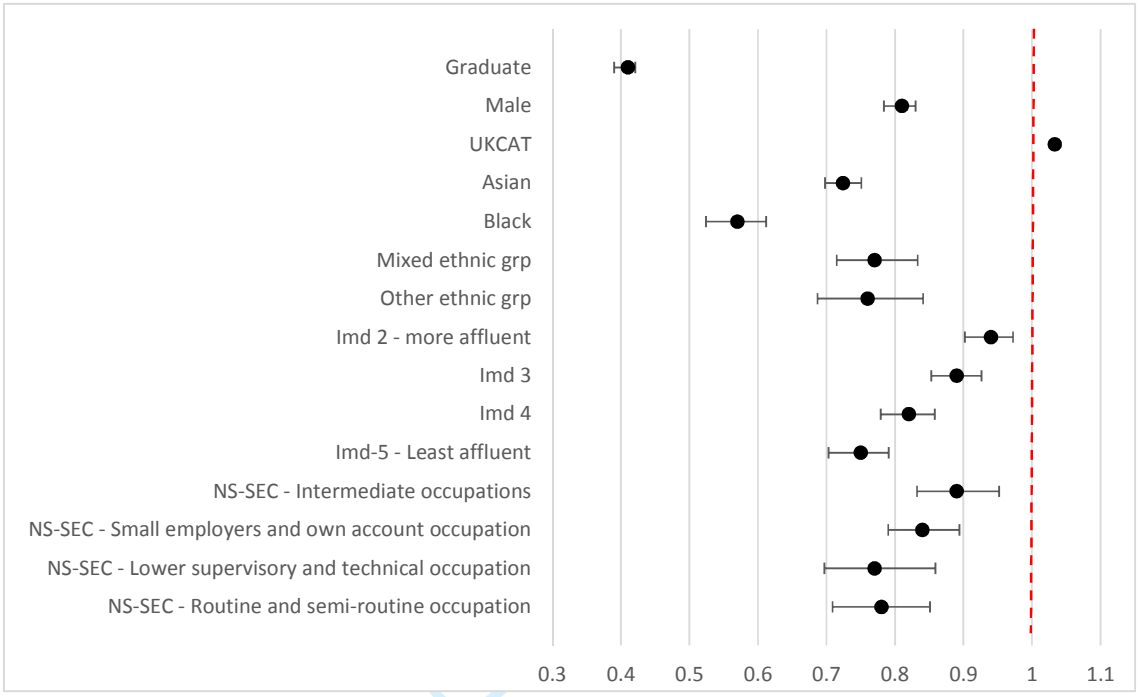

Figure1: Odds Ratio, Final Model

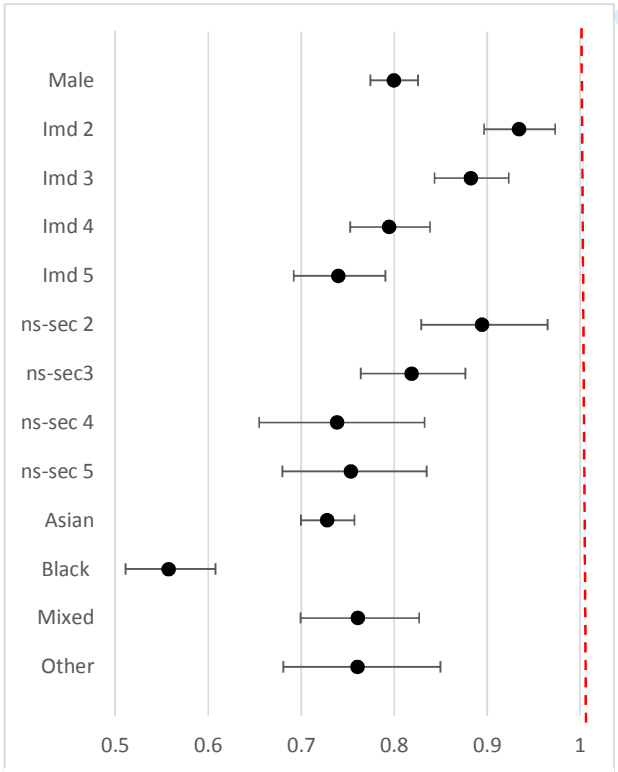

Figure 2: Odds Ratio, Non-graduate Applicants

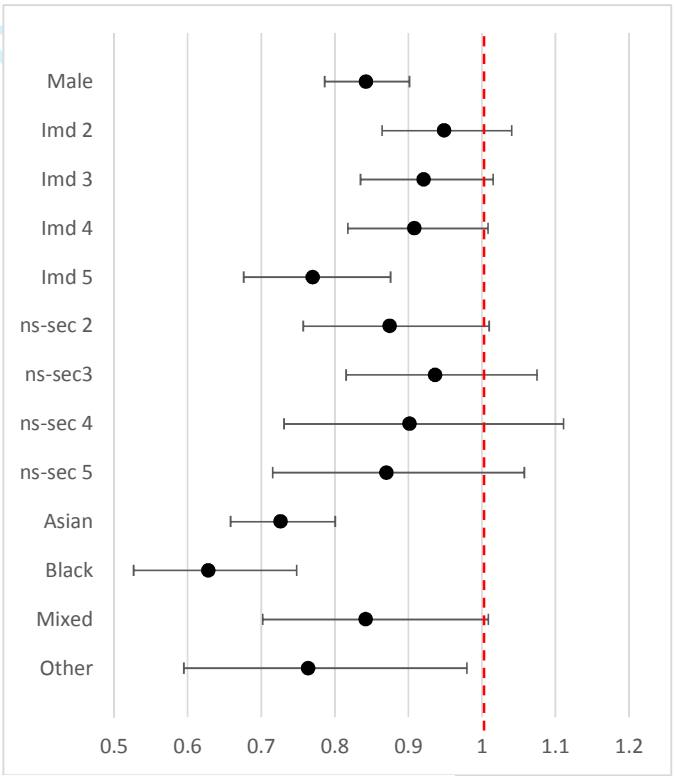

Figure3: Odds Ratio, Graduate Applicants

Table 3: Multiple logistic regression for offers to medical school 2007 - 2014

		Model 1, R^2=.22,			Model 2, R^2=.21			Model 3, R^2=.23			Model 4 R^2=.23		
		OR	Lower	Upper	OR	Lower	Upper	OR	Lower	Upper	OR	Lower	Upper
UKCAT		1.03	1.033	1.034	1.03	1.033	1.034	1.03	1.033	1.034	1.03	1.033	1.034
Graduate Status	Non-graduate (default)	1			1			1			1		
	Graduate	0.44	0.429	0.460	0.40	0.383	0.416	0.40	0.385	.420	0.40	0.390	0.421
Gender	Female (default)	1			1			1					
	Male	0.81	0.784	0.830	0.81	0.784	0.830	0.81	0.784	0.831	0.81	0.784	0.830
Ethnicity	White (default)	1			1			1			1		
	Asian	0.73	0.698	0.752	0.73	0.698	0.751	0.72	0.695	0.752	0.72	0.698	0.751
	Black	0.57	0.524	0.613	0.57	0.524	0.612	0.56	0.513	0.610	0.57	0.524	0.612
	Mixed	0.77	0.715	0.833	0.77	0.715	0.833	0.76	0.697	0.825	0.77	0.715	0.833
	Other	0.76	0.687	0.842	0.76	0.687	0.841	0.76	0.681	0.851	0.76	0.687	0.841
Index of Multiple Deprivation (IMD)	I = Most affluent (default)	1			1			1			1		
	II	0.93	0.897	0.973	0.94	0.902	0.972	0.94	0.902	0.972	0.94	0.902	0.972
	III	0.88	0.844	0.923	0.89	0.853	0.926	0.87	0.853	0.926	0.89	0.853	0.926
	IV	0.80	0.753	0.839	0.82	0.780	0.859	0.82	0.779	0.858	0.82	0.779	0.858
	V - Least affluent	0.74	0.693	0.791	0.75	0.704	0.792	0.75	0.703	0.791	0.75	0.703	0.791
Parental Occupation NS-SEC	1 - Managerial and Professional Occupations (default)	1			1			1			1		
	II - Intermediate Occupations	0.89	0.833	0.952	0.89	0.828	0.964	0.89	0.833	0.952	0.89	0.832	0.952
	III - Small Employers and Own Account Occupations	0.84	0.791	0.894	0.82	0.767	0.880	0.84	0.790	0.894	0.84	0.790	0.894
	IV - Lower Supervisory and Technical Occupations	0.77	0.697	0.859	0.74	0.655	0.834	0.77	0.697	0.859	0.77	0.697	0.859
	V - Routine and Semi-Routine Occupations	0.78	0.710	0.852	0.75	0.680	0.836	0.76	0.709	0.851	0.78	0.709	0.851
Graduate status by Index of multiple deprivation (IMD) p=0.25	Graduate-by-IMD I - Most affluent neighbourhood (default)	1											
	Graduate vs IMD_II	1.02	0.919	1.123									
	Graduate vs IMD_III	1.04	0.935	1.156									
	Graduate vs IMD_IV	1.14	1.017	1.278									
	Graduate vs IMD_V – Least affluent neighbourhood	1.04	0.907	1.196									
Graduate status	Graduate-by-NS-SEC - I (default)				1								

by parental occupation (NS-SEC) p=0.22	Graduate by NS-SEC - II				0.99	0.839	1.157						
	Graduate by NS-SEC - III				1.12	0.964	1.302						
	Graduate by NS-SEC - IV				1.20	0.948	1.524						
	Graduate by NS-SEC - V				1.15	0.924	1.421						
Graduate status by Ethnicity p=0.89	Graduate-by-White (default)							1					
	Graduate by Asian							1.00	0.908	1.108			
	Graduate by Black							1.07	0.882	1.285			
	Graduate by Mixed							1.10	0.905	1.344			
	Graduate by Other ethnic group							0.99	0.755	1.294			

Model 1: Shows the interaction of graduate status by area deprivation (IMD), note none significant value of p=0.25
Model 2: Shows the interaction of graduate status by parental occupation (NS-SEC), note non-significant value of p=0.22
Model 3: Shows the interaction of graduate status by ethnicity, note the non-significant value p=0.88
Model 4: Is the final model of all covariates, note all values are statistically significant, p<0.001

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3 - 4
Objectives	3	State specific objectives, including any prespecified hypotheses	3 - 4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5 - 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*n/a*
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6 - 7
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	n/a
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8 - 9
		(b) Indicate number of participants with missing data for each variable of interest	15
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	n/a
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	17
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	18	Summarise key results with reference to study objectives	9 - 10
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Are efforts to attract graduate applicants to UK medical schools effective in widening access? A national cohort study

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Are efforts to attract graduate applicants to UK medical schools effective in widening access? A national cohort study

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Medical admissions, Graduate, UKCAT, admissions, widening access, statistical analysis.

ABSTRACT

Introduction

Attracting graduates was recommended as a means of diversifying the UK medical student population. Graduates now make up nearly a quarter of the total medical student population. Research to date has focused on comparing the socio-demographic characteristics of applicants to and/or students on traditional and graduate entry programmes (GEMs), yet GEMs account for only 40% of the graduate medical student population. Thus, we aimed to compare the socio-demographic characteristic and outcomes of graduates and non-graduate applicants across a range of programmes.

Methods

This was an observational study of 117214 applicants to medicine who took the UKCAT from 2006 to 2014, and who applied to medical school through UCAS. We included applicant demographics, UKCAT total score and offers in our analysis. Applicants were assigned as graduates or non-graduates on the basis of their highest qualification. Multiple logistic regression was used to predict the odds of receiving an offer, after adjusting for confounders.

Results

Irrespective of graduate or non-graduate status, most applicants were from the highest socio-economic groups and were from a white ethnic background. Receiving an offer was related to gender and ethnicity in both graduates and non-graduates. After adjusting for UKCAT score, the odds ratio of an offer for graduates vs. non-graduates was approximately 0.5 (OR=0.48, 95% CI 0.46-0.49).

Discussion

Our findings indicate that the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has been only marginally successful. Different approaches must be considered if medicine is to attract and select more socially diverse applicants.

249 words

Strength and limitations of this study:

- A large multi-cohort study to look at the population of graduate applicants to UK medical schools, including those on Graduate Entry Programme (GEM) and traditional programmes.
- The study uses a contemporary dataset to examine the socio-economic differences of those who apply to medical school; and it is important to know more about who *applies*, as medical schools can only select from the pool of applicants.
- The study examines what socio-demographic factors are associated with receiving an offer to study medicine, and whether these differ in graduates and non-graduates.
- Measures of socio-economic status are self-declared and there was a large proportion of missing socio-economic data for the graduate sub-group.
- Allocating students to an occupational group that depends on their family circumstances (area, parental occupation) can be problematic, especially for mature applicants.

INTRODUCTION

Despite much activity, investment and policy directives, people from backgrounds perceived as disadvantaged and minority, ethnic and cultural groups, remain under-represented, or excluded from medicine worldwide on the basis of, for example, their social class or ethnic origin.[1-5] In the UK, the vast majority of medical students come from the highest socio-economic groups[6-9], and more than 20% of medical students have attended independent (usually fee paying) schools, compared to an average of 7% of all school pupils.[10] The professions have traditionally been dominated by those in high socioeconomic groups and this issue was summarised concisely in a report by the Independent Reviewer on Social Mobility and Child Poverty: 'Medicine . . . has a long way to go when it comes to making access fairer, diversifying its workforce and raising social mobility'.[10]

In the UK, most students enter medicine as school-leavers aged 17-20 years. In 1997, the UK Medical Workforce Standing Advisory Committee (MWSAC) recommended that one way of diversifying the medical student population was to attract graduates into medical schools.[11] The assumption behind this was that, by accepting students with more life experience, the diversity of students and hence doctors would be increased[12-15], and this would result in more doctors willing to work in deprived and underserved areas.[16-18] This recommendation led to the introduction (in 2000) of the first four-year graduate entry medical courses (GEM), as well as a more general drive to encourage graduates into medicine.

Graduates now make up nearly a quarter of the contemporary UK medical student population. [13,19] However, to date, there is relatively little information relating to whether, or not, attracting graduates has increased the diversity of medicine in the UK. Earlier studies tend to be single-site and/or focused on the relative performance of graduates versus school-leaver entrants.[20-26] In an exception to this, Mathers and colleagues carried out a large-scale study of applicants to 31 UK medical schools between 2002 and 2006 in order to determine whether the newly introduced GEM programmes had widened access to medicine.[6] They concluded that graduate entry programmes do attract more students from less affluent backgrounds than traditional five-year programmes but overall GEMs had not led to significant changes to the socio-economic profile of UK medical student population. It is possible, however, that this study was undertaken too soon after the establishment of the first GEM programmes to assess their true impact, given the typical time lag between policy implementation and impact on practice in education.[27]

Moreover, GEM programmes only account for about 10% of all medical programmes: there are more graduates in traditional five-year programmes than in GEM programmes. Yet, to the best of our knowledge, no previous studies have looked directly at the whole population of graduate medical students – that is, those on both GEM and traditional programmes.

Finally, most studies have only looked at those graduates who were successful in obtaining a place at medical school.[6,28] It is also important to know more about who *applies*, as medical schools can only select from the pool of applicants.[8] In one of the few studies looking at both applicants and admissions, Garrud found some differences between both applicants and admissions to graduate-entry and traditional programmes, mostly in terms of ethnicity, but did not examine differences in terms of socio-economic markers.[29] This is, however, a complex area to investigate. There are issues surrounding these markers in graduate students, particularly given parental occupation is taken into account for school leavers, but occupation for graduates and older applicants may be that of the applicant themselves, particularly if they have been employed after leaving school or after a first degree. This ambiguity also holds for area of domicile (IMD: measured by postcode) as again that may be of the parental home or the home of the applicant for mature students and graduates. However, to attempt to address these gaps in the literature we used a contemporary dataset to compare the socio-demographic characteristics of graduates and non-graduate applicants to medicine. The main objective was to determine whether graduate and non-graduate applicants to medicine differ on a range of socio-demographic variables. Our second aim was to examine what socio-demographic factors are associated with receiving an offer to study medicine, and whether these differ in graduates and non-graduates.

METHODS

Study context

Data were obtained from the UKCAT database which comprises data from two sources: UCAS and UKCAT (http://www.ukcat.ac.uk/). UKCAT is the UK Clinical Aptitude Test for applicants to medical and dental schools. UCAS is the Universities and Colleges Admissions Service, a UK-based organisation whose primary role is to operate the application process for British universities. Through the UCAS system (https://www.ucas.com/), candidates can apply to up to four medical courses out of five options in any one cycle, but there is no preference order of course choice. We compiled data for all candidates who sat the UKCAT between 2006 and 2014, and who applied to medical school through UCAS.

The UKCAT database only holds UCAS data relating to UKCAT candidates who have applied to a UKCAT University. Therefore, the data is a subset of graduate applicants to UK Universities. A number of graduate entry programmes use other admission tests (both BMAT and GAMSAT). Of the 16 graduate entry programmes in the UK, 7 require the UKCAT, 4 require GAMSAT, and one programme requires a BMAT.[30] The other four graduate entry programmes do not use any of these admission tests. Where UKCAT candidates have applied to non-UKCAT Universities these choices and the outcome of these choices are not known.

Although individuals can have multiple applications, within and between years, the socio-demographic variables presented in this study are per unique applicant. These variables include gender; ethnicity; domicile; secondary school attended, domicile (United Kingdom (UK), International, European Union (EU)). The socio-economic status (SES) of the candidates was determined by parental National Statistics Socio-Economic Classification (NS-SEC) and Index of Multiple Deprivation (IMD), an area-based measurement of material deprivation.

Design and procedures

Access to the data was via a safe haven[31] (to ensure adherence to the highest standards of security, governance and confidentiality when storing, handling and analysing identifiable data). Ethical approval was not required because the focus of this study was a secondary analysis of anonymised data. Applicants who took the UK Clinical Aptitude Test (UKCAT) were notified that their data would be used for research purposes. Data files were merged into a single SPSS file for cleaning and

analysis. The online supplementary file 1 (*insert link supplementary file 1 here*) illustrates a flow diagram showing how the data files were merged from different source documents.

The applications were assigned into two categories; graduate or non-graduate at the time of application. This was primarily based on applicants' highest qualification but some amendments were necessary. For example, where this information was missing, we imputed the outcome variable based on applicants' age and programme applied. For instance, all applicants aged less than 20 on their final UKCAT attempt were assumed to have applied shortly after leaving school; these were classified as school-leavers, or non-graduate applicants. Similarly, applicants with missing information on academic qualification, aged over 21 and had applied for a graduate entry programme were classified as 'graduates'. The outcome measures were the UKCAT score, and whether the applicant received an offer or not. We also considered all conditional and unconditional offers as an 'offer'.

Statistical analysis

All the data were analysed using SPSS (IBM SPSS Statistics for Windows Version 22.0. Armonk, NY: IBM Corp). The results are reported in terms of numbers, percentages and mean (standard deviation) or median (interquartile range) as appropriate. The UKCAT scores were normally distributed. Therefore we used independent-samples t-test to compare the means between two groups. One-way analysis of variance (ANOVA) was used to compare means between more than two independent groups. A binary logistic regression analysis was employed to predict the odds of getting an offer from an application based on an applicant's graduate status. The specific factors we adjusted for in the regression models were: socio-economic status (NS-SEC and IMD), gender, graduate status, ethnicity and the total UKCAT score. The purpose was to assess the odds of receiving an offer for a graduate relative to a non-graduate after accounting for any differences in total UKCAT score. The analysis considered only the final application of each applicant to ensure independence (i.e., to control for those who made repeated applications).

RESULTS

From 2006 to 2014, the UKCAT database comprises 117214 applicants to medicine, applying through UCAS on a total of 146146 occasions (i.e. some applied in more than one cycle and hence sat the UKCAT more than once). The time-trend analysis shows that the proportion of graduate applicants to UK medical schools has risen from 8.5% in 2006 to 26.9% in 2013 (see supplementary file 2, time-trend analysis) (*insert link to supplementary file 2 here*). While dramatic, this increase is at least in part due to the increase in the number of institutions joining the UKCAT consortium, and thus more data supply. 23.6% of the applicants were graduates and 76.4% non-graduates. In general, there were more female graduate applicants than male applicants. The median age for the non-graduate applicants was 18 years and it was 23 years for the graduate applicants.

Table 1 summarises a comparison of graduate and non-graduate applicants by different sociodemographic factors. The main pattern across the two groups was that most applicants were from the highest socio-economic group, with nearly 80% of all applicants having a parent/guardian in the managerial and professional occupations. The groups were also similar in that one-fifth of the graduate and non-graduate applicants had attended a fee-paying (independent) school. (However, note that type of school was only available for one third of graduates and so this was not included in the later multivariable regression analysis with other covariates due to concern about bias and a lack of representativeness among graduates). The sample was predominantly of candidates from white ethnic backgrounds, for both graduates 64.3% (n=14014), and non-graduates 61.9% (n=47103). Around 7.7% of the graduates were classified as international applicants, as compared to 12.1% of the non-graduate applicants. The number of EU applicants was similar for both graduates (6.0%) and non-graduates (7.6%).

……. Table 1 about here…….

Non-graduate applicants performed significantly better on the UKCAT (2535.4 points, SD=268.2) than graduate applicants (2498.5 points, SD=285.7), $p<0.001$. Graduates and non-graduate applicants from the top 20% affluent neighbourhoods (IMD 'I') obtained better UKCAT scores than applicants from the 20% most deprived areas (IMD 'V'). The difference was approximately 200 points for graduate applicants, and the same margin was observed in the non-graduate group. A similar pattern was also observed with parental occupation classification (NS-SEC) categories with

the difference of over 100 UKCAT points between managerial and professional occupations and routine/semi-routine occupations.

The proportion of applicants who received offers was substantially lower for graduates (27.7%) than it was for non-graduates (47.9%). Graduate applicants who received offers had significantly better mean UKCAT scores (2697.7 points, SD=244.39) compared to their non-graduate colleagues who received offers (2657.7 points, SD=235.3), $p<0.001$. The pre-admission attainment information (UKCAT scores) is summarised in Table 2.

……. Table 2 about here…….

A binary logistic regression analysis was employed to predict the odds of getting an offer based on the applicant's highest qualification (graduate or not) and total UKCAT score. After adjusting for UKCAT score alone, the odds ratio of an offer for graduates vs. non-graduates was approximately 0.5 (OR=0.48, 95% CI 0.46-0.49).

Several variables that were considered to be representative of widening participation (WP) backgrounds were included in univariate analyses. The multiple logistic regression analysis was repeated including, in addition to UKCAT and graduate status, only those variables that were statistically significant ($p\leq0.05$) when associated with offer status. The specific factors were gender, ethnicity and socio-economic class (IMD and NS-SEC). We also tested for interaction of these factors which enabled us to ask whether graduates from different socio-economic backgrounds were more or less likely to receive offers. The overall model performance, using *Nagelkerke's* R^2 ranged from 0.20 to 0.23 across the models developed. Results of the two-way interaction terms (Table 3) showed that after adjusting for other factors, the additional effect of socio-economic disadvantage for graduates (compared to non-graduates) was small and did not reach statistical significance ($p=0.69$ for the interaction of graduate status and IMD; $p=0.22$ for the interaction of graduate status and parental occupation (NS-SEC)). The result suggests that the association between socio-economic disadvantage and the likelihood of getting an offer for medical school affected graduates and non-graduates in a similar way.

….. Table 3 about here…..

----insert figures 1,2,3 about here----

Figure 1 gives a graphical summary of the results from final model. In general, the odds of getting an offer to study medicine were lower if the applicant was male, graduate, from black and minority

ethnic (BME) background, and from lower socioeconomic groups (NS-SEC1, and IMD 'I' – least affluent neighbourhood). Figures 2 and 3 give a graphical summary of the odds ratio after separating graduates and non-graduates, to help further illustrate the difference between the two groups. For the non-graduates, the pattern is almost the same as the combined model in that the odds of getting an offer were higher if the applicant was female, from white ethnic background, and from high socioeconomic groups (NS-SEC1, and IMD I – most affluent neighbourhood). Some explanation for this pattern is because the non-graduates were in such a high proportion of the whole group. In comparison, for graduates, the predictor values that stand out are gender and ethnicity. However, notably, nearly a quarter of graduate applicants had a missing combination of socio-economic profile data (NS-SEC and IMD) which may explain why SES measures were less important predictors for graduates.

DISCUSSION

In this analysis of a large, multi-cohort contemporary dataset, we examined differences between graduates and non-graduate applicants to UK medical schools. Unlike previous studies in this area, we compared a larger sample of graduate applicants with non-graduates, rather than comparing by course (traditional versus GEM). This allowed us to capture the characteristics of a broader group of graduate applicants compared to earlier studies. Our results show that graduate and non-graduate applicants to UK medical schools are very similar on a range of socio-demographic markers, including multiple markers of socio-economic status. This indicates that, even with time and much investment in GEM courses, the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has not been successful.[6]

Interestingly, unlike previous studies[29], we did not identify any differences across graduates and non-graduates in terms of ethnicity. This may represent a change in the medical student population overall or may be an artefact of study design given that we looked at graduates in all medical programmes, not just GEM programmes.

We also looked at who received an offer. Put simple, non-graduates were twice as likely to receive an offer as graduates. The patterns across non-graduates and graduates were similar in terms of gender and ethnicity but, in non-graduates, offers to study medicine were higher if the applicant was from a higher socio-economic group. However, measures of socio-economic status are self-declared and there was a large proportion of missing socio-economic data for the graduate sub-group. This reflects patterns seen in other similar studies.[32-36] Given the high proportion of missing data it would

be misleading to conclude that IMD and NS-SEC are weaker predictors for assessing the likelihood of getting an offer among graduate applicants because many graduate applicants were excluded from the logistic regression analysis and the missing data could also have led to insufficient power to detect smaller effects. Moreover, allocating students to an occupational group that depends on their family circumstances (area, parental occupation) can be problematic, especially for mature students.[37,38] However, we had no other measures available to us: no matter how limited[32,34], those used are the 'basic units' that indicate educational disadvantage in the UK. We urge organisations such as UCAS and UKCAT to explore ways of improving self-declared data reporting, and government bodies such as the UK's Office for National Statistics to explore more effective measures of socio-economic status.

Overall, we found that graduates were proportionally less likely to receive an offer than non-graduate applicants, and those graduates who were offered places had significantly higher UKCAT scores than their non-graduate equivalents. We know from earlier studies[29] and contemporary routine data that the average competition, or selection, ratios for GEM programmes are significantly higher than for traditional five-year programmes. Moreover, GEM selection processes also tend to place more weight on UKCAT performance than do traditional programmes typically (this is associated with school leaving examinations being potentially less disciminatory for graduates - who would have taken these exams in earlier years, when it was less common to achieve top grades[39]). These factors may explain this outcome. However, future research which compares selection ratios for non-graduates and graduates by programme would provide a more nuanced understanding of differences across groups. Additionally, future studies could also look more closely at graduate and non-graduate patterns of performance in the various stages of medical school selection for the high number of graduates applying to traditional programmes. For example, we do not know whether graduates and non-graduates with equivalent grades and UKCAT scores are invited to interview, then graduates "fall down" at that stage. These studies would address concerns in the wider education literature that graduates and non-graduates are judged differently. [40]

The present study has various limitations that must be taken into consideration when interpreting findings. It was not possible to compare prior attainment across graduate and non-graduate groups with any confidence in this study because of the different weightings given to school and degree qualifications. However, this is a tricky comparison at the best of times (see above - graduates by their very nature have taken the school leaving exams which are typically used in medical selection to indicate prior attainment some years previous to their non-graduate counterparts). The issue of comparing "apples and oranges" arises as over recent years the average A level score has progressively risen ("grade inflation").[39,41,42]

In conclusion, the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has been only marginally successful, with very minor positive trends in all areas. It may be that to draw a more diverse group of graduates into medicine requires different selection criteria for this group, one that places appreciable weight on the degree qualification and other graduate attributes, such as experience and passion for medicine. However, to change the selection process of graduates or indeed any group requires a shift towards affirmative action and/or a commitment to increase diversity. There appears to be little appetite for the former in the UK even though there is some evidence from other contexts that students from minority populations enrich the teaching environment of a medical school and may be more likely to practice in underserved areas.[43-45]

Contributions

We thank UKCAT for releasing the data for this project via a competitive bid process. We are also grateful to Dr Sally Curtis (University of Southampton) for the general advice throughout the project.

COMPETING INTERESTS AND FUNDING

This study is part of Ben Kumwenda's doctoral programme of research funded by the UKCAT Research Panel, of which JC is a member and RG the Administrator.

ETHICAL PERMISSION

The Chair of the local ethics committee ruled that formal ethical approval was not required for this study given the fully anonymised data was held in safe haven and all students who sit UKCAT are informed that their data and results will be used in educational research.

AUTHOR CONTRIBUTIONS

RMcK led the funding bid which was co-written by JC and GP, and reviewed by RG. RG advised on the nature of the data. BK managed the data, and planned and carried out the data analysis under

the supervision of GP. JC guided the first draft of the introduction and discussion sections of this paper. BK and GP wrote the first drafts of the methods and results sections. JC edited the drafts. All authors reviewed and agreed the final draft of the paper.

DATA SHARING

No additional data is available as the datasets are held in safe haven.

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Table 1: Frequency distribution of applicants (and offers) to UKCAT consortium medical schools between 2006 - 2014

	Non-graduate				Graduate			
	Application		Offer		Application		Offer	
	n	%	n	%	n	%	n	%
Gender								
Female	49082	55.9	22716	56.2	13999	57.7	3812	56.7
Male	38656	44.1	17702	43.8	10256	42.3	2910	43.3
Total	87738		40418		24255		6722	
Ethnicity II								
Caucasian	47103	61.9	25421	69.8	14014	64.3	4831	78.3
Non-Caucasian	28941	38.1	10995	30.2	7765	35.6	1335	21.7
Total	76044		36416		21779		6166	
Missing	*(11694)*	*(13.3)*			*(2476)*	*(10.2)*		
School Attended‡								
Fee Paying	17388	25.5	10184	29.2	1672	21.1	664	24.5
Non-Fee Paying	50796	74.5	24705	70.8	6249	78.9	2043	75.5
Total	68184		34889		7921		2707	
Missing	*(2263)*	*(3.2)*			*(12988)*	*(62.1)*		
IMD Quintile‡								
1	28518	34.6	14043	40	5972	26.2	1894	32
2	19202	23.3	8767	25	4693	20.6	1375	23.2
3	14986	18.2	6196	17.6	4450	19.6	1134	19.2
4	10883	13.2	3734	10.6	4261	18.7	959	16.2
5	8815	10.7	2394	6.8	3378	14.8	552	9.3
Total	82404		35134		22754		5914	
Missing	*(1260)*	*(1.5)*			*(592)*	*(2.5)*		
NS_SEC‡								
Managerial and Professional Occupations	61624	84.1	28025	87.9	15622	78.7	4406	83.3
Intermediate Occupations	3399	4.6	1337	4.2	1167	5.9	295	5.6
Small Employers and Own Account Occupations	4676	6.4	1501	4.7	1572	7.9	313	5.9
Lower Supervisory and Technical Occupations	1410	1.9	423	1.3	639	3.2	129	2.4
Routine and Semi-Routine Occupations	*2198*	*3*	580	1.8	848	4.3	149	2.8
Total	73307		31866		19848		5292	
Missing	*(10357)*	*(12.4)*			*(3498)*	*(15)*		
Domicile								
UK	70447	80.3	35333	88	20909	86.2	6051	90
EU	6694	7.6	1078	2.7	1467	6	280	4.2
International	10597	12.1	3785	9.4	1879	7.7	391	5.8
Total	87738		40418		24255		6722	
UKCAT Attempt Number								
1	75049	85.5	34770	86	15562	64.2	4718	70.2
2	11803	13.5	5390	13.3	5722	23.6	1425	21.2
3+	886	1	258	0.6	2971	12.2	579	8.6
Total	87738		40418		24255		6722	
Final Outcome								
No Offer	43964	52.1			14736	68.7		
Offer	40418	47.9	40418		6722	27.7	6722	
Total	84382				21458			
Missing	*(3356)*	*(3.8)*			*(2797)*	*(11.5)*		

‡ Sample drawn from UK domiciled applicants only

Table 2	Mean UKCAT Scores†							
	Non-graduate				Graduate			
	N	Mean	SD	P value	N	Mean	SD	P value
Gender								
Female	49047	2532.2	269.8	<0.001	13974	2501.7	285.71	<0.001
Male	38633	2581.8	267.7		10241	2550.9	291.22	
Ethnicity								
Caucasian	47102	2597.9	243.6	<0.001	14000	2591.2	261.15	
Non-Caucasian	26298	2512.1	282.0		7128	2402.3	294.32	
School Attended‡								
Fee Paying	17388	2632.5	239.2	<0.001	1670	2611.6	233.21	<0.001
Non-Fee Paying	50787	2562.8	260.0		6233	2527.2	265.93	
IMD Quintile‡								
I	24427	2627.9	237.8	<0.001	5395	2600.4	263.94	<0.001
II	16291	2604.6	244.6		4206	2578.1	269.33	
III	12505	2576.7	253.6		3937	2531.5	273.30	
IV	8936	2516.6	269.3		3801	2479.3	298.79	
V	7194	2425.9	282.8		2990	2397.5	312.92	
NSSEC‡								
Managerial and Professional Occupations	52555	2604.1	249.0	<0.001	14084	2560.6	281.44	<0.001
Intermediate Occupations	2784	2568.7	246.3		1059	2541.3	272.21	
Small Employers and Own Account Occupations	3635	2518.8	256.5		1367	2466.0	279.27	
Lower Supervisory and Technical Occupations	1181	2486.6	259.5		551	2448.9	296.20	
Routine and Semi-Routine Occupations	1775	2465.0	270.2		740	2441.2	276.38	
Number of attempts								
1	75000	2541.7	272.9	<0.001	15554	2507.5	299.42	<0.001
2	11798	2628.4	237.9		5711	2552.7	273.84	
3 or more	882	2604.4	256.0		2950	2543.5	254.43	
Final Outcome								
No offer	43925	2455.6	265.2	<0.001	14713	2443.9	278.01	<0.001
Offer	40405	2657.7	235.3		6711	2697.7	244.39	

†The numbers presented here are the mean scores based on the applicants' last UKCAT sitting. However, the counts of applicants are not the same as in table 1 because some applicants had missing UKCAT scores
‡Sample drawn from UK domiciled applicants only

Table 3: Multiple logistic regression for offers to medical school 2007 - 2014

		Model 1, R^2=.22,			Model 2, R^2=.21			Model 3, R^2=.22			Model 4 R^2=.22		
		OR	Lower	Upper	OR	Lower	Upper	OR	Lower	Upper	OR	Lower	Upper
UKCAT		1.032	1.032	1.033	1.032	1.032	1.033	1.032	1.032	1.033	1.032	1.032	1.033
Graduate Status	Non-graduate (default)	1			1			1			1		
	Graduate	0.429	0.399	0.461	0.438	0.419	0.458	0.441	0.421	0.463	0.450	0.432	0.468
Gender	Female (default)	1			1			1					
	Male	0.830	0.803	0.857	0.830	0.803	0.857	0.830	0.804	0.857	0.830	0.804	0.857
Ethnicity	White (default)	1			1			1			1		
	Asian	0.781	0.750	0.813	0.780	0.748	0.812	0.774	0.741	0.809	0.780	0.748	0.812
	Black	0.574	0.527	0.625	0.572	0.525	0.623	0.544	0.495	0.598	0.572	0.525	0.623
	Mixed	0.823	0.756	0.896	0.823	0.756	0.896	0.808	0.736	0.888	0.823	0.756	0.896
	Other	0.804	0.718	0.900	0.803	0.717	0.899	0.818	0.722	0.927	0.803	0.717	0.900
Index of Multiple Deprivation (IMD)	I = Most affluent (default)	1			1			1			1		
	II	0.917	0.876	0.960	0.921	0.884	0.960	0.921	0.884	0.960	0.921	0.884	0.960
	III	0.866	0.823	0.911	0.869	0.830	0.909	0.869	0.830	0.909	0.868	0.830	0.909
	IV	0.775	0.731	0.823	0.808	0.766	0.852	0.806	0.765	0.850	0.806	0.764	0.850
	V - Least affluent	0.707	0.657	0.760	0.724	0.679	0.773	0.723	0.678	0.771	0.723	0.677	0.771
Parental Occupation NS-SEC	1 - Managerial and Professional Occupations (default)	1			1			1					
	II - Intermediate Occupations	0.891	0.828	0.960	0.879	0.808	0.956	0.891	0.828	0.960	0.891	0.827	0.960
	III - Small Employers and Own Account Occupations	0.854	0.797	0.914	0.829	0.768	0.894	0.852	0.796	0.912	0.853	0.796	0.913
	IV - Lower Supervisory and Technical Occupations	0.768	0.684	0.862	0.709	0.621	0.809	0.766	0.683	0.860	0.767	0.683	0.860
	V - Routine and Semi-Routine Occupations	0.766	0.693	0.847	0.732	0.654	0.820	0.765	0.692	0.845	0.764	0.691	0.844
Graduate status by Index of multiple deprivation (IMD) p=0.69	Graduate-by-IMD I - Most affluent neighbourhood (default)	1											
	Graduate vs IMD_II	1.030	0.922	1.150									
	Graduate vs IMD_III	1.021	0.909	1.147									
	Graduate vs IMD_IV	1.189	1.049	1.348									
	Graduate vs IMD_V - Least affluent neighbourhood	1.112	.957	1.293									
Graduate status by parental occupation (NS-SEC)	Graduate-by-NS-SEC - I (default)				1								
	Graduate by NS-SEC - II				1.068	0.893	1.276						

p=0.22	Graduate by NS-SEC - III				1.149	0.974	1.355							
	Graduate by NS-SEC - IV				1.383	1.064	1.797							
	Graduate by NS-SEC - V				1.211	0.959	1.530							
Graduate status by Ethnicity p=0.10	Graduate-by-White (default)							1						
	Graduate by Asian							1.039	0.931	1.160				
	Graduate by Black							1.300	1.060	1.593				
	Graduate by Mixed							1.101	0.885	1.371				
	Graduate by Other ethnic group							0.900	0.668	1.211				

Model 1: Shows the interaction of graduate status by area deprivation (IMD), note non-significant value of p=0.69
Model 2: Shows the interaction of graduate status by parental occupation (NS-SEC), note non-significant value of p=0.22
Model 3: Shows the interaction of graduate status by ethnicity, note the non-significant value p=0.10
Model 4: Is the final model of all covariates, note all values are statistically significant, p<0.001

Figure Legends:

Title: Odds of an application resulting in offer of a place according to selected sociodemographic characteristics,

Figure 1: Odds Ratio, Final Model (all applicants)

Figure 2: Odds Ratio, Non-graduate Applicants

Figure 3: Odd Ratio, Graduate Applicants

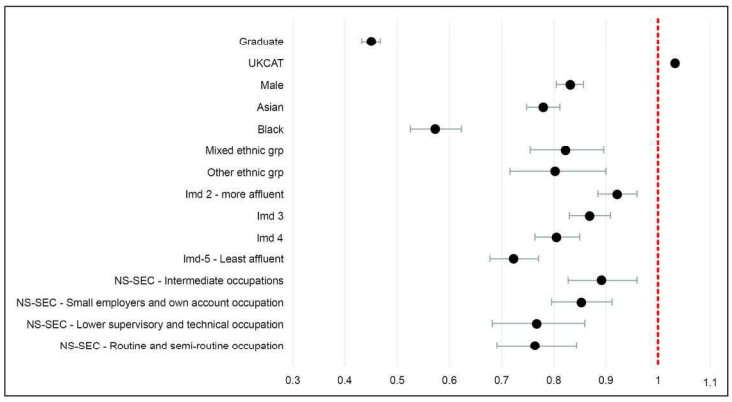


Figure 1

209x148mm (300 x 300 DPI)

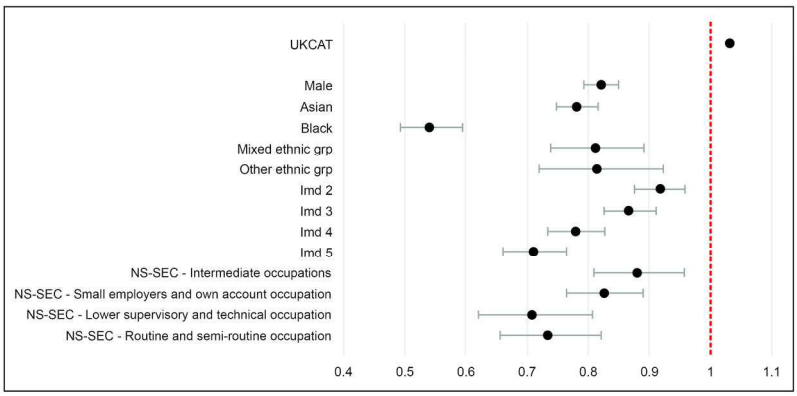


Figure 2

209x148mm (300 x 300 DPI)

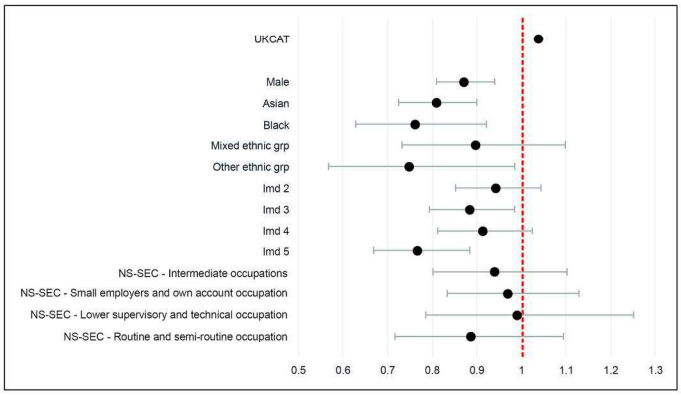


Figure 3

209x148mm (300 x 300 DPI)

Flow diagram showing data linkage for applicants to UKCAT consortium universities between 2006 - 2014

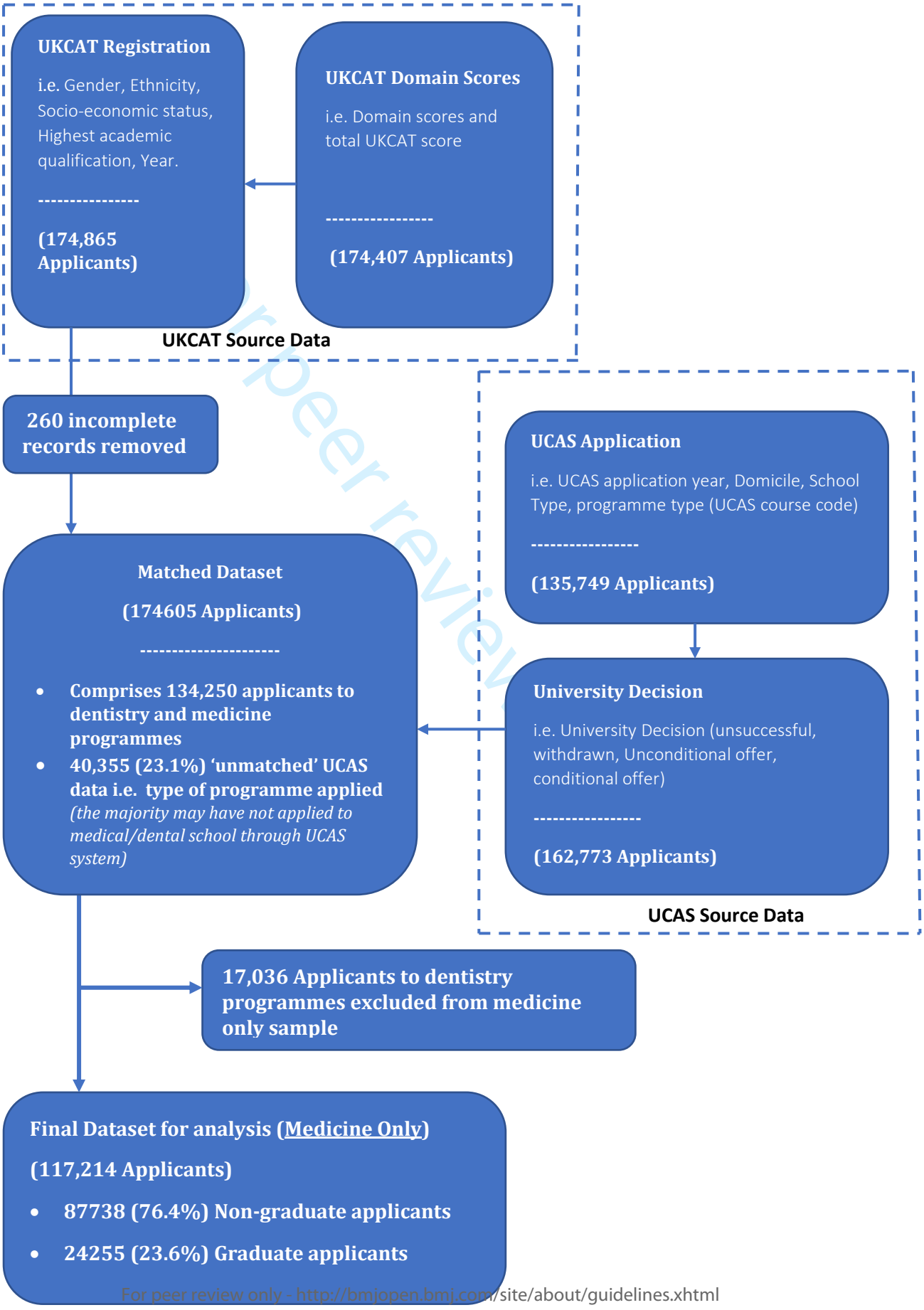
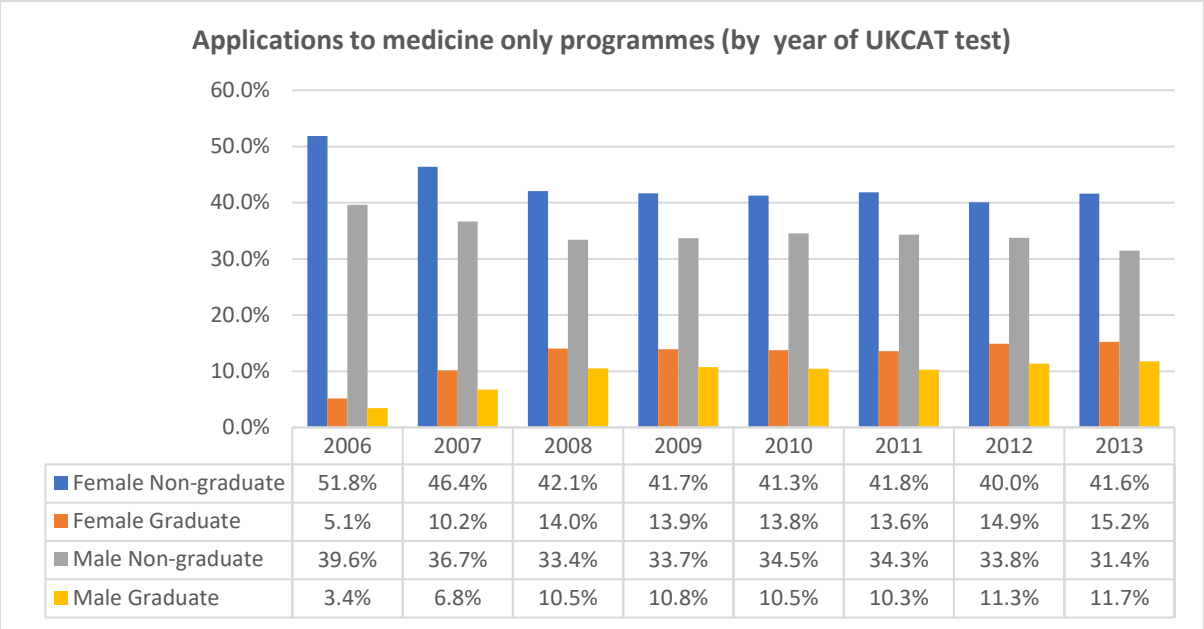
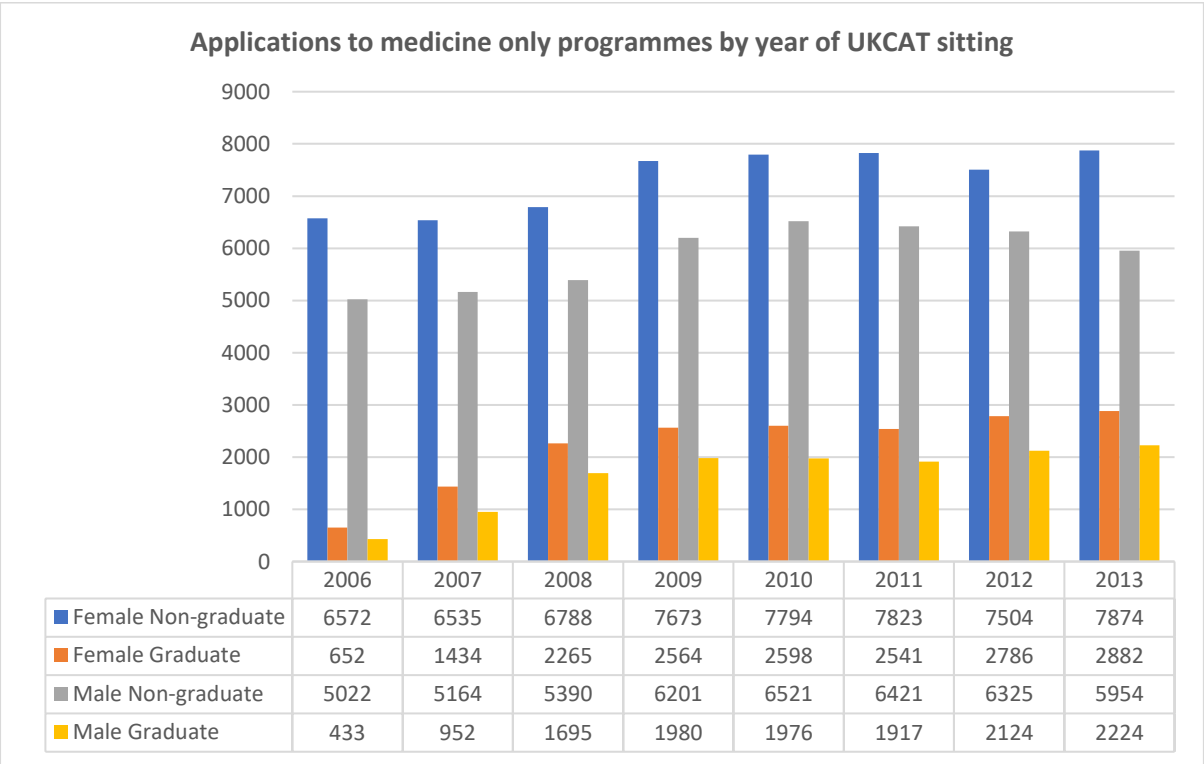


Chart 1 (group percentages)



	2006	2007	2008	2009	2010	2011	2012	2013
Female Non-graduate	51.8%	46.4%	42.1%	41.7%	41.3%	41.8%	40.0%	41.6%
Female Graduate	5.1%	10.2%	14.0%	13.9%	13.8%	13.6%	14.9%	15.2%
Male Non-graduate	39.6%	36.7%	33.4%	33.7%	34.5%	34.3%	33.8%	31.4%
Male Graduate	3.4%	6.8%	10.5%	10.8%	10.5%	10.3%	11.3%	11.7%

Chart 2 (raw figures)



	2006	2007	2008	2009	2010	2011	2012	2013
Female Non-graduate	6572	6535	6788	7673	7794	7823	7504	7874
Female Graduate	652	1434	2265	2564	2598	2541	2786	2882
Male Non-graduate	5022	5164	5390	6201	6521	6421	6325	5954
Male Graduate	433	952	1695	1980	1976	1917	2124	2224

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3 - 4
Objectives	3	State specific objectives, including any prespecified hypotheses	3 - 4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5 - 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*n/a*
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6 - 7
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	n/a
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8 - 9
		(b) Indicate number of participants with missing data for each variable of interest	15
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	n/a
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	17
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	18	Summarise key results with reference to study objectives	9 - 10
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Are efforts to attract graduate applicants to UK medical schools effective in increasing the participation of under-represented socioeconomic groups? A national cohort study.

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Are efforts to attract graduate applicants to UK medical schools effective in increasing the participation of under-represented socioeconomic groups? A national cohort study.

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Keywords:

Medical admissions, Graduate, UKCAT, admissions, widening access, statistical analysis.

ABSTRACT

Introduction

Attracting graduates was recommended as a means of diversifying the UK medical student population. Graduates now make up nearly a quarter of the total medical student population. Research to date has focused on comparing the socio-demographic characteristics of applicants to and/or students on traditional and graduate entry programmes (GEMs), yet GEMs account for only 40% of the graduate medical student population. Thus, we aimed to compare the socio-demographic characteristic and outcomes of graduates and non-graduate applicants across a range of programmes.

Methods

This was an observational study of 117214 applicants to medicine who took the UKCAT from 2006 to 2014, and who applied to medical school through UCAS. We included applicant demographics, UKCAT total score and offers in our analysis. Applicants were assigned as graduates or non-graduates on the basis of their highest qualification. Multiple logistic regression was used to predict the odds of receiving an offer, after adjusting for confounders.

Results

Irrespective of graduate or non-graduate status, most applicants were from the highest socio-economic groups and were from a white ethnic background. Receiving an offer was related to gender and ethnicity in both graduates and non-graduates. After adjusting for UKCAT score, the odds ratio of an offer for graduates vs. non-graduates was approximately 0.5 (OR=0.48, 95% CI 0.46-0.49).

Discussion

Our findings indicate that the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has been only marginally successful. Graduate applicants from widening access backgrounds are less likely than others to be offered a place at medical school. Different approaches must be considered if medicine is to attract and select more socially diverse applicants.

269 words

Strength and limitations of this study:

- A large multi-cohort study to look at the population of graduate applicants to UK medical schools, including those on Graduate Entry Programme (GEM) and traditional programmes.
- The study uses a contemporary dataset to examine the socio-economic differences of those who apply to medical school; and it is important to know more about who *applies*, as medical schools can only select from the pool of applicants.
- The study examines what socio-demographic factors are associated with receiving an offer to study medicine, and whether these differ in graduates and non-graduates.
- Measures of socio-economic status are self-declared and there was a large proportion of missing socio-economic data for the graduate sub-group.
- Allocating students to an occupational group that depends on their family circumstances (area, parental occupation) can be problematic, especially for mature applicants.

INTRODUCTION

Despite much activity, investment and policy directives, people from backgrounds perceived as disadvantaged and minority, ethnic and cultural groups, remain under-represented, or excluded from medicine worldwide on the basis of, for example, their social class or ethnic origin.[1-5] In the UK, the vast majority of medical students come from the highest socio-economic groups[6-9], and more than 20% of medical students have attended independent (usually fee paying) schools, compared to an average of 7% of all school pupils.[10] The professions have traditionally been dominated by those in high socioeconomic groups and this issue was summarised concisely in a report by the Independent Reviewer on Social Mobility and Child Poverty: 'Medicine . . . has a long way to go when it comes to making access fairer, diversifying its workforce and raising social mobility'.[10]

In the UK, most students enter medicine as school-leavers aged 17-20 years. In 1997, the UK Medical Workforce Standing Advisory Committee (MWSAC) recommended that one way of diversifying the medical student population was to attract graduates into medical schools.[11] The assumption behind this was that, by accepting students with more life experience, the diversity of students and hence doctors would be increased[12-15], and this would result in more doctors willing to work in deprived and underserved areas.[16-18] This recommendation led to the introduction (in 2000) of the first four-year graduate entry medical courses (GEM), as well as a more general drive to encourage graduates into medicine.

Graduates now make up nearly a quarter of the contemporary UK medical student population. [13,19] However, to date, there is relatively little information relating to whether, or not, attracting graduates has increased the diversity of medicine in the UK. Earlier studies tend to be single-site and/or focused on the relative performance of graduates versus school-leaver entrants.[20-26] In an exception to this, Mathers and colleagues carried out a large-scale study of applicants to 31 UK medical schools between 2002 and 2006 in order to determine whether the newly introduced GEM programmes had widened access to medicine.[6] They concluded that graduate entry programmes do attract more students from less affluent backgrounds than traditional five-year programmes but overall GEMs had not led to significant changes to the socio-economic profile of UK medical student population. It is possible, however, that this study was undertaken too soon after the establishment of the first GEM programmes to assess their true impact, given the typical time lag between policy implementation and impact on practice in education.[27]

Moreover, GEM programmes only account for about 10% of all medical programmes: there are more graduates in traditional five-year programmes than in GEM programmes. Yet, to the best of our knowledge, no previous studies have looked directly at the whole population of graduate medical students – that is, those on both GEM and traditional programmes.

Finally, most studies have only looked at those graduates who were successful in obtaining a place at medical school.[6,28] It is also important to know more about who *applies*, as medical schools can only select from the pool of applicants.[8] In one of the few studies looking at both applicants and admissions, Garrud found some differences between both applicants and admissions to graduate-entry and traditional programmes, mostly in terms of ethnicity, but did not examine differences in terms of socio-economic markers.[29] This is, however, a complex area to investigate. There are issues surrounding these markers in graduate students, particularly given parental occupation is taken into account for school leavers, but occupation for graduates and older applicants may be that of the applicant themselves, particularly if they have been employed after leaving school or after a first degree. This ambiguity also holds for area of domicile (IMD: measured by postcode) as again that may be of the parental home or the home of the applicant for mature students and graduates. However, to attempt to address these gaps in the literature we used a contemporary dataset to compare the socio-demographic characteristics of graduates and non-graduate applicants to medicine. The main objective was to determine whether graduate and non-graduate applicants to medicine differ on a range of socio-demographic variables. Our second aim was to examine what socio-demographic factors are associated with receiving an offer to study medicine, and whether these differ in graduates and non-graduates.

METHODS

Study context

Data were obtained from the UKCAT database which comprises data from two sources: UCAS and UKCAT (http://www.ukcat.ac.uk/). UKCAT is the UK Clinical Aptitude Test for applicants to medical and dental schools. UCAS is the Universities and Colleges Admissions Service, a UK-based organisation whose primary role is to operate the application process for British universities. Through the UCAS system (https://www.ucas.com/), candidates can apply to up to four medical courses out of five options in any one cycle, but there is no preference order of course choice. We compiled data for all candidates who sat the UKCAT between 2006 and 2014, and who applied to medical school through UCAS.

The UKCAT database only holds UCAS data relating to UKCAT candidates who have applied to a UKCAT University. Therefore, the data is a subset of graduate applicants to UK Universities. A number of graduate entry programmes use other admission tests (both BMAT and GAMSAT). Of the 16 graduate entry programmes in the UK, 7 require the UKCAT, 4 require GAMSAT, and one programme requires a BMAT.[30] The other four graduate entry programmes do not use any of these admission tests. Where UKCAT candidates have applied to non-UKCAT Universities these choices and the outcome of these choices are not known.

Although individuals can have multiple applications, within and between years, the socio-demographic variables presented in this study are per unique applicant. These variables include gender; ethnicity; domicile; secondary school attended, domicile (United Kingdom (UK), International, European Union (EU)). The socio-economic status (SES) of the candidates was determined by parental National Statistics Socio-Economic Classification (NS-SEC) and Index of Multiple Deprivation (IMD), an area-based measurement of material deprivation.

Design and procedures

Access to the data was via a safe haven[31] (to ensure adherence to the highest standards of security, governance and confidentiality when storing, handling and analysing identifiable data). Ethical approval was not required because the focus of this study was a secondary analysis of anonymised data. Applicants who took the UK Clinical Aptitude Test (UKCAT) were notified that their data would be used for research purposes. Data files were merged into a single SPSS file for cleaning and

analysis. The online supplementary file 1 (*insert link supplementary file 1 here*) illustrates a flow diagram showing how the data files were merged from different source documents.

The applications were assigned into two categories; graduate or non-graduate at the time of application. This was primarily based on applicants' highest qualification but some amendments were necessary. For example, where this information was missing, we imputed the outcome variable based on applicants' age and programme applied. For instance, all applicants aged less than 20 on their final UKCAT attempt were assumed to have applied shortly after leaving school; these were classified as school-leavers, or non-graduate applicants. Similarly, applicants with missing information on academic qualification, aged over 21 and had applied for a graduate entry programme were classified as 'graduates'. The outcome measures were the UKCAT score, and whether the applicant received an offer or not. We also considered all conditional and unconditional offers as an 'offer'.

Statistical analysis

All the data were analysed using SPSS (IBM SPSS Statistics for Windows Version 22.0. Armonk, NY: IBM Corp). The results are reported in terms of numbers, percentages and mean (standard deviation) or median (interquartile range) as appropriate. The UKCAT scores were normally distributed. Therefore we used independent-samples t-test to compare the means between two groups. One-way analysis of variance (ANOVA) was used to compare means between more than two independent groups. A binary logistic regression analysis was employed to predict the odds of getting an offer from an application based on an applicant's graduate status. The specific factors we adjusted for in the regression models were: socio-economic status (NS-SEC and IMD), gender, graduate status, ethnicity and the total UKCAT score. The purpose was to assess the odds of receiving an offer for a graduate relative to a non-graduate after accounting for any differences in total UKCAT score. The analysis considered only the final application of each applicant to ensure independence (i.e., to control for those who made repeated applications).

RESULTS

From 2006 to 2014, the UKCAT database comprises 117214 applicants to medicine, applying through UCAS on a total of 146146 occasions (i.e. some applied in more than one cycle and hence sat the UKCAT more than once). The time-trend analysis shows that the proportion of graduate applicants to UK medical schools has risen from 8.5% in 2006 to 26.9% in 2013 (see supplementary file 2, time-trend analysis) (*insert link to supplementary file 2 here*). While dramatic, this increase is at least in part due to the increase in the number of institutions joining the UKCAT consortium, and thus more data supply. 23.6% of the applicants were graduates and 76.4% non-graduates. In general, there were more female graduate applicants than male applicants. The median age for the non-graduate applicants was 18 years and it was 23 years for the graduate applicants.

Table 1 summarises a comparison of graduate and non-graduate applicants by different sociodemographic factors. The main pattern across the two groups was that most applicants were from the highest socio-economic group, with nearly 80% of all applicants having a parent/guardian in the managerial and professional occupations. The groups were also similar in that one-fifth of the graduate and non-graduate applicants had attended a fee-paying (independent) school. (However, note that type of school was only available for one third of graduates and so this was not included in the later multivariable regression analysis with other covariates due to concern about bias and a lack of representativeness among graduates). The sample was predominantly of candidates from white ethnic backgrounds, for both graduates 64.3% (n=14014), and non-graduates 61.9% (n=47103). Around 7.7% of the graduates were classified as international applicants, as compared to 12.1% of the non-graduate applicants. The number of EU applicants was similar for both graduates (6.0%) and non-graduates (7.6%).

……. Table 1 about here…….

Non-graduate applicants performed significantly better on the UKCAT (2535.4 points, SD=268.2) than graduate applicants (2498.5 points, SD=285.7), $p<0.001$. Graduates and non-graduate applicants from the top 20% affluent neighbourhoods (IMD 'I') obtained better UKCAT scores than applicants from the 20% most deprived areas (IMD 'V'). The difference was approximately 200 points for graduate applicants, and the same margin was observed in the non-graduate group. A similar pattern was also observed with parental occupation classification (NS-SEC) categories with

the difference of over 100 UKCAT points between managerial and professional occupations and routine/semi-routine occupations.

The proportion of applicants who received offers was substantially lower for graduates (27.7%) than it was for non-graduates (47.9%). Graduate applicants who received offers had significantly better mean UKCAT scores (2697.7 points, SD=244.39) compared to their non-graduate colleagues who received offers (2657.7 points, SD=235.3), $p<0.001$. The pre-admission attainment information (UKCAT scores) is summarised in Table 2.

……. Table 2 about here…….

A binary logistic regression analysis was employed to predict the odds of getting an offer based on the applicant's highest qualification (graduate or not) and total UKCAT score. After adjusting for UKCAT score alone, the odds ratio of an offer for graduates vs. non-graduates was approximately 0.5 (OR=0.48, 95% CI 0.46-0.49).

Several variables that were considered to be representative of widening participation (WP) backgrounds were included in univariate analyses. The multiple logistic regression analysis was repeated including, in addition to UKCAT and graduate status, only those variables that were statistically significant ($p\leq0.05$) when associated with offer status. The specific factors were gender, ethnicity and socio-economic class (IMD and NS-SEC). We also tested for interaction of these factors which enabled us to ask whether graduates from different socio-economic backgrounds were more or less likely to receive offers. The overall model performance, using *Nagelkerke's* R^2 ranged from 0.20 to 0.23 across the models developed. Results of the two-way interaction terms (Table 3) showed that after adjusting for other factors, the additional effect of socio-economic disadvantage for graduates (compared to non-graduates) was small and did not reach statistical significance ($p=0.69$ for the interaction of graduate status and IMD; $p=0.22$ for the interaction of graduate status and parental occupation (NS-SEC)). The result suggests that the association between socio-economic disadvantage and the likelihood of getting an offer for medical school affected graduates and non-graduates in a similar way.

….. Table 3 about here…..

----insert figures 1,2,3 about here----

Figure 1 gives a graphical summary of the results from final model. In general, the odds of getting an offer to study medicine were lower if the applicant was male, graduate, from black and minority

ethnic (BME) background, and from lower socioeconomic groups (NS-SEC1, and IMD 'I' – least affluent neighbourhood). Figures 2 and 3 give a graphical summary of the odds ratio after separating graduates and non-graduates, to help further illustrate the difference between the two groups. For the non-graduates, the pattern is almost the same as the combined model in that the odds of getting an offer were higher if the applicant was female, from white ethnic background, and from high socioeconomic groups (NS-SEC1, and IMD I – most affluent neighbourhood). Some explanation for this pattern is because the non-graduates were in such a high proportion of the whole group. In comparison, for graduates, the predictor values that stand out are gender and ethnicity. However, notably, nearly a quarter of graduate applicants had a missing combination of socio-economic profile data (NS-SEC and IMD) which may explain why SES measures were less important predictors for graduates.

DISCUSSION

In this analysis of a large, multi-cohort contemporary dataset, we examined differences between graduates and non-graduate applicants to UK medical schools. Unlike previous studies in this area, we compared a larger sample of graduate applicants with non-graduates, rather than comparing by course (traditional versus GEM). This allowed us to capture the characteristics of a broader group of graduate applicants compared to earlier studies. Our results show that graduate and non-graduate applicants to UK medical schools are very similar on a range of socio-demographic markers, including multiple markers of socio-economic status. This indicates that, even with time and much investment in GEM courses, the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has not been successful.[6]

Interestingly, unlike previous studies[29], we did not identify any differences across graduates and non-graduates in terms of ethnicity. This may represent a change in the medical student population overall or may be an artefact of study design given that we looked at graduates in all medical programmes, not just GEM programmes.

We also looked at who received an offer. Put simple, non-graduates were twice as likely to receive an offer as graduates. The patterns across non-graduates and graduates were similar in terms of gender and ethnicity but, in non-graduates, offers to study medicine were higher if the applicant was from a higher socio-economic group. However, measures of socio-economic status are self-declared and there was a large proportion of missing socio-economic data for the graduate sub-group. This reflects patterns seen in other similar studies.[32-36] Given the high proportion of missing data it would

be misleading to conclude that IMD and NS-SEC are weaker predictors for assessing the likelihood of getting an offer among graduate applicants because many graduate applicants were excluded from the logistic regression analysis and the missing data could also have led to insufficient power to detect smaller effects. Moreover, allocating students to an occupational group that depends on their family circumstances (area, parental occupation) can be problematic, especially for mature students.[37,38] However, we had no other measures available to us: no matter how limited[32,34], those used are the 'basic units' that indicate educational disadvantage in the UK. We urge organisations such as UCAS and UKCAT to explore ways of improving self-declared data reporting, and government bodies such as the UK's Office for National Statistics to explore more effective measures of socio-economic status.

Overall, we found that graduates were proportionally less likely to receive an offer than non-graduate applicants, and those graduates who were offered places had significantly higher UKCAT scores than their non-graduate equivalents. We know from earlier studies[29] and contemporary routine data that the average competition, or selection, ratios for GEM programmes are significantly higher than for traditional five-year programmes. Moreover, GEM selection processes also tend to place more weight on UKCAT performance than do traditional programmes typically (this is associated with school leaving examinations being potentially less disciminatory for graduates - who would have taken these exams in earlier years, when it was less common to achieve top grades[39]). These factors may explain this outcome. However, future research which compares selection ratios for non-graduates and graduates by programme would provide a more nuanced understanding of differences across groups. Additionally, future studies could also look more closely at graduate and non-graduate patterns of performance in the various stages of medical school selection for the high number of graduates applying to traditional programmes. For example, we do not know whether graduates and non-graduates with equivalent grades and UKCAT scores are invited to interview, then graduates "fall down" at that stage. These studies would address concerns in the wider education literature that graduates and non-graduates are judged differently. [40]

The present study has various limitations that must be taken into consideration when interpreting findings. It was not possible to compare prior attainment across graduate and non-graduate groups with any confidence in this study because of the different weightings given to school and degree qualifications. However, this is a tricky comparison at the best of times (see above - graduates by their very nature have taken the school leaving exams which are typically used in medical selection to indicate prior attainment some years previous to their non-graduate counterparts). The issue of comparing "apples and oranges" arises as over recent years the average A level score has progressively risen ("grade inflation").[39,41,42]

In conclusion, the aim of diversifying the medical student population on socio-economic grounds by attracting graduates has been only marginally successful, with very minor positive trends in all areas. It may be that to draw a more diverse group of graduates into medicine requires different selection criteria for this group, one that places appreciable weight on the degree qualification and other graduate attributes, such as experience and passion for medicine. However, to change the selection process of graduates or indeed any group requires a shift towards affirmative action and/or a commitment to increase diversity. There appears to be little appetite for the former in the UK even though there is some evidence from other contexts that students from minority populations enrich the teaching environment of a medical school and may be more likely to practice in underserved areas.[43-45]

Contributions

We thank UKCAT for releasing the data for this project via a competitive bid process. We are also grateful to Dr Sally Curtis (University of Southampton) for the general advice throughout the project.

COMPETING INTERESTS AND FUNDING

This study is part of Ben Kumwenda's doctoral programme of research funded by the UKCAT Research Panel, of which JC is a member and RG the Administrator.

ETHICAL PERMISSION

The Chair of the local ethics committee ruled that formal ethical approval was not required for this study given the fully anonymised data was held in safe haven and all students who sit UKCAT are informed that their data and results will be used in educational research.

AUTHOR CONTRIBUTIONS

RMcK led the funding bid which was co-written by JC and GP, and reviewed by RG. RG advised on the nature of the data. BK managed the data, and planned and carried out the data analysis under

the supervision of GP. JC guided the first draft of the introduction and discussion sections of this paper. BK and GP wrote the first drafts of the methods and results sections. JC edited the drafts. All authors reviewed and agreed the final draft of the paper.

DATA SHARING

No additional data is available as the datasets are held in safe haven.

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Table 1: Frequency distribution of applicants (and offers) to UKCAT consortium medical schools between 2006 - 2014

	Non-graduate				Graduate			
	Application		Offer		Application		Offer	
	n	%	n	%	n	%	n	%
Gender								
Female	49082	55.9	22716	56.2	13999	57.7	3812	56.7
Male	38656	44.1	17702	43.8	10256	42.3	2910	43.3
Total	87738		40418		24255		6722	
Ethnicity II								
Caucasian	47103	61.9	25421	69.8	14014	64.3	4831	78.3
Non-Caucasian	28941	38.1	10995	30.2	7765	35.6	1335	21.7
Total	76044		36416		21779		6166	
Missing	*(11694)*	*(13.3)*			*(2476)*	*(10.2)*		
School Attended‡								
Fee Paying	17388	25.5	10184	29.2	1672	21.1	664	24.5
Non-Fee Paying	50796	74.5	24705	70.8	6249	78.9	2043	75.5
Total	68184		34889		7921		2707	
Missing	*(2263)*	*(3.2)*			*(12988)*	*(62.1)*		
IMD Quintile‡								
1	28518	34.6	14043	40	5972	26.2	1894	32
2	19202	23.3	8767	25	4693	20.6	1375	23.2
3	14986	18.2	6196	17.6	4450	19.6	1134	19.2
4	10883	13.2	3734	10.6	4261	18.7	959	16.2
5	8815	10.7	2394	6.8	3378	14.8	552	9.3
Total	82404		35134		22754		5914	
Missing	*(1260)*	*(1.5)*			*(592)*	*(2.5)*		
NS_SEC‡								
Managerial and Professional Occupations	61624	84.1	28025	87.9	15622	78.7	4406	83.3
Intermediate Occupations	3399	4.6	1337	4.2	1167	5.9	295	5.6
Small Employers and Own Account Occupations	4676	6.4	1501	4.7	1572	7.9	313	5.9
Lower Supervisory and Technical Occupations	1410	1.9	423	1.3	639	3.2	129	2.4
Routine and Semi-Routine Occupations	*2198*	*3*	580	1.8	848	4.3	149	2.8
Total	73307		31866		19848		5292	
Missing	*(10357)*	*(12.4)*			*(3498)*	*(15)*		
Domicile								
UK	70447	80.3	35333	88	20909	86.2	6051	90
EU	6694	7.6	1078	2.7	1467	6	280	4.2
International	10597	12.1	3785	9.4	1879	7.7	391	5.8
Total	87738		40418		24255		6722	
UKCAT Attempt Number								
1	75049	85.5	34770	86	15562	64.2	4718	70.2
2	11803	13.5	5390	13.3	5722	23.6	1425	21.2
3+	886	1	258	0.6	2971	12.2	579	8.6
Total	87738		40418		24255		6722	
Final Outcome								
No Offer	43964	52.1			14736	68.7		
Offer	40418	47.9	40418		6722	27.7	6722	
Total	84382				21458			
Missing	*(3356)*	*(3.8)*			*(2797)*	*(11.5)*		

‡ Sample drawn from UK domiciled applicants only

Table 2	Mean UKCAT Scores†							
	Non-graduate				Graduate			
	N	Mean	SD	P value	N	Mean	SD	P value
Gender								
Female	49047	2532.2	269.8	<0.001	13974	2501.7	285.71	<0.001
Male	38633	2581.8	267.7		10241	2550.9	291.22	
Ethnicity								
Caucasian	47102	2597.9	243.6	<0.001	14000	2591.2	261.15	
Non-Caucasian	26298	2512.1	282.0		7128	2402.3	294.32	
School Attended‡								
Fee Paying	17388	2632.5	239.2	<0.001	1670	2611.6	233.21	<0.001
Non-Fee Paying	50787	2562.8	260.0		6233	2527.2	265.93	
IMD Quintile‡								
I	24427	2627.9	237.8	<0.001	5395	2600.4	263.94	<0.001
II	16291	2604.6	244.6		4206	2578.1	269.33	
III	12505	2576.7	253.6		3937	2531.5	273.30	
IV	8936	2516.6	269.3		3801	2479.3	298.79	
V	7194	2425.9	282.8		2990	2397.5	312.92	
NSSEC‡								
Managerial and Professional Occupations	52555	2604.1	249.0	<0.001	14084	2560.6	281.44	<0.001
Intermediate Occupations	2784	2568.7	246.3		1059	2541.3	272.21	
Small Employers and Own Account Occupations	3635	2518.8	256.5		1367	2466.0	279.27	
Lower Supervisory and Technical Occupations	1181	2486.6	259.5		551	2448.9	296.20	
Routine and Semi-Routine Occupations	1775	2465.0	270.2		740	2441.2	276.38	
Number of attempts								
1	75000	2541.7	272.9	<0.001	15554	2507.5	299.42	<0.001
2	11798	2628.4	237.9		5711	2552.7	273.84	
3 or more	882	2604.4	256.0		2950	2543.5	254.43	
Final Outcome								
No offer	43925	2455.6	265.2	<0.001	14713	2443.9	278.01	<0.001
Offer	40405	2657.7	235.3		6711	2697.7	244.39	

†The numbers presented here are the mean scores based on the applicants' last UKCAT sitting. However, the counts of applicants are not the same as in table 1 because some applicants had missing UKCAT scores
‡Sample drawn from UK domiciled applicants only

Table 3: Multiple logistic regression for offers to medical school 2007 - 2014

		Model 1, R^2=.22,			Model 2, R^2=.21			Model 3, R^2=.22			Model 4 R^2=.22		
		OR	Lower	Upper	OR	Lower	Upper	OR	Lower	Upper	OR	Lower	Upper
UKCAT		1.032	1.032	1.033	1.032	1.032	1.033	1.032	1.032	1.033	1.032	1.032	1.033
Graduate Status	Non-graduate (default)	1			1			1			1		
	Graduate	0.429	0.399	0.461	0.438	0.419	0.458	0.441	0.421	0.463	0.450	0.432	0.468
Gender	Female (default)	1			1			1					
	Male	0.830	0.803	0.857	0.830	0.803	0.857	0.830	0.804	0.857	0.830	0.804	0.857
Ethnicity	White (default)	1			1			1			1		
	Asian	0.781	0.750	0.813	0.780	0.748	0.812	0.774	0.741	0.809	0.780	0.748	0.812
	Black	0.574	0.527	0.625	0.572	0.525	0.623	0.544	0.495	0.598	0.572	0.525	0.623
	Mixed	0.823	0.756	0.896	0.823	0.756	0.896	0.808	0.736	0.888	0.823	0.756	0.896
	Other	0.804	0.718	0.900	0.803	0.717	0.899	0.818	0.722	0.927	0.803	0.717	0.900
Index of Multiple Deprivation (IMD)	I = Most affluent (default)	1			1			1			1		
	II	0.917	0.876	0.960	0.921	0.884	0.960	0.921	0.884	0.960	0.921	0.884	0.960
	III	0.866	0.823	0.911	0.869	0.830	0.909	0.869	0.830	0.909	0.868	0.830	0.909
	IV	0.775	0.731	0.823	0.808	0.766	0.852	0.806	0.765	0.850	0.806	0.764	0.850
	V - Least affluent	0.707	0.657	0.760	0.724	0.679	0.773	0.723	0.678	0.771	0.723	0.677	0.771
Parental Occupation NS-SEC	1 - Managerial and Professional Occupations (default)	1			1			1					
	II - Intermediate Occupations	0.891	0.828	0.960	0.879	0.808	0.956	0.891	0.828	0.960	0.891	0.827	0.960
	III - Small Employers and Own Account Occupations	0.854	0.797	0.914	0.829	0.768	0.894	0.852	0.796	0.912	0.853	0.796	0.913
	IV - Lower Supervisory and Technical Occupations	0.768	0.684	0.862	0.709	0.621	0.809	0.766	0.683	0.860	0.767	0.683	0.860
	V - Routine and Semi-Routine Occupations	0.766	0.693	0.847	0.732	0.654	0.820	0.765	0.692	0.845	0.764	0.691	0.844
Graduate status by Index of multiple deprivation (IMD) p=0.69	Graduate-by-IMD I - Most affluent neighbourhood (default)	1											
	Graduate vs IMD_II	1.030	0.922	1.150									
	Graduate vs IMD_III	1.021	0.909	1.147									
	Graduate vs IMD_IV	1.189	1.049	1.348									
	Graduate vs IMD_V - Least affluent neighbourhood	1.112	.957	1.293									
Graduate status by parental occupation (NS-SEC)	Graduate-by-NS-SEC - I (default)				1								
	Graduate by NS-SEC - II				1.068	0.893	1.276						

p=0.22	Graduate by NS-SEC - III				1.149	0.974	1.355							
	Graduate by NS-SEC - IV				1.383	1.064	1.797							
	Graduate by NS-SEC - V				1.211	0.959	1.530							
Graduate status by Ethnicity p=0.10	Graduate-by-White (default)							1						
	Graduate by Asian							1.039	0.931	1.160				
	Graduate by Black							1.300	1.060	1.593				
	Graduate by Mixed							1.101	0.885	1.371				
	Graduate by Other ethnic group							0.900	0.668	1.211				

Model 1: Shows the interaction of graduate status by area deprivation (IMD), note non-significant value of p=0.69
Model 2: Shows the interaction of graduate status by parental occupation (NS-SEC), note non-significant value of p=0.22
Model 3: Shows the interaction of graduate status by ethnicity, note the non-significant value p=0.10
Model 4: Is the final model of all covariates, note all values are statistically significant, p<0.001

Figure Legends:

Title: Odds of an application resulting in offer of a place according to selected sociodemographic characteristics,

Figure 1: Odds Ratio, Final Model (all applicants)

Figure 2: Odds Ratio, Non-graduate Applicants

Figure 3: Odd Ratio, Graduate Applicants

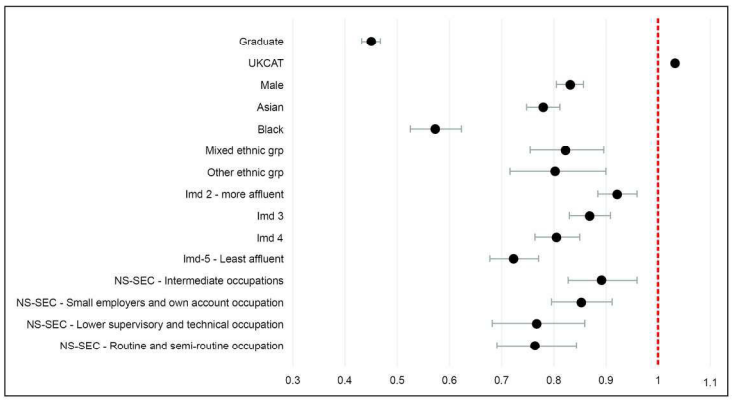


Figure 1

209x148mm (300 x 300 DPI)

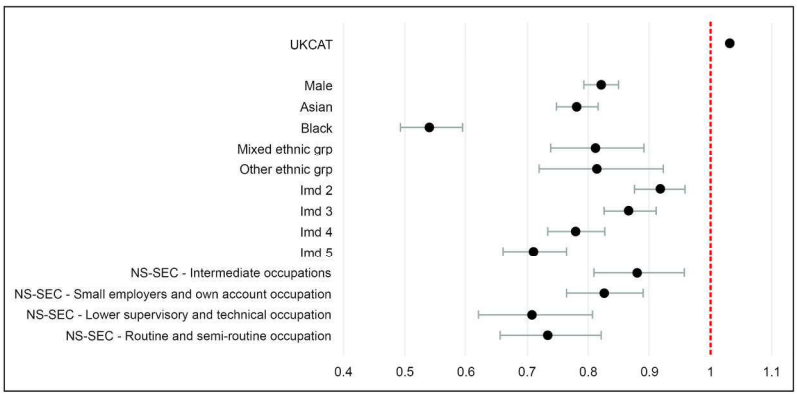


Figure 2

209x148mm (300 x 300 DPI)

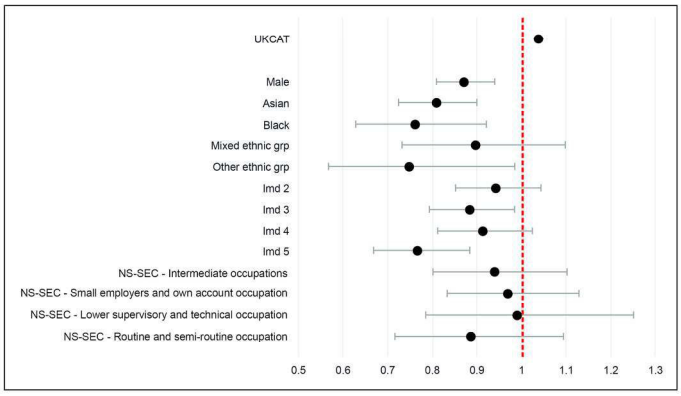


Figure 3

209x148mm (300 x 300 DPI)

Flow diagram showing data linkage for applicants to UKCAT consortium universities between 2006 - 2014

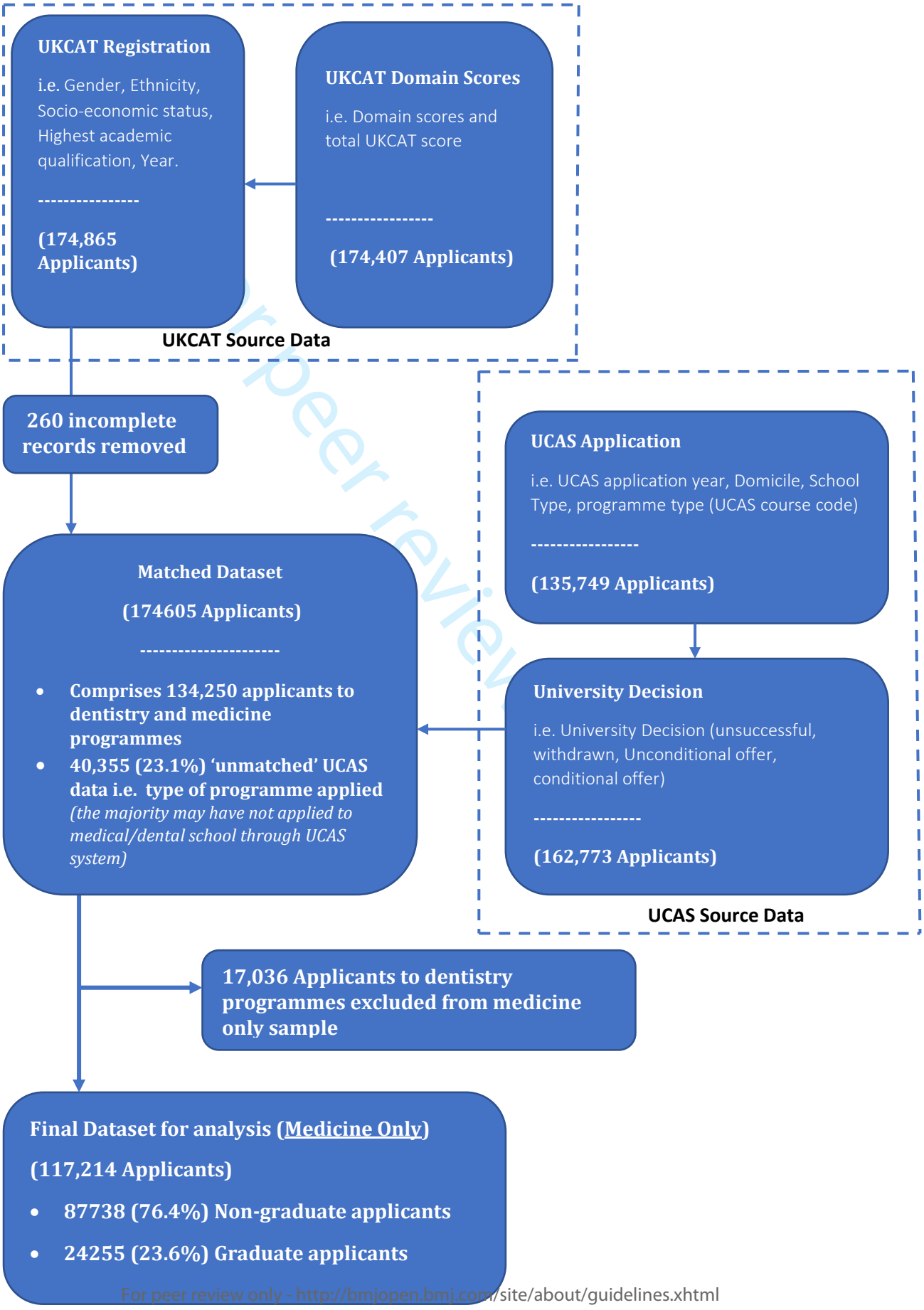
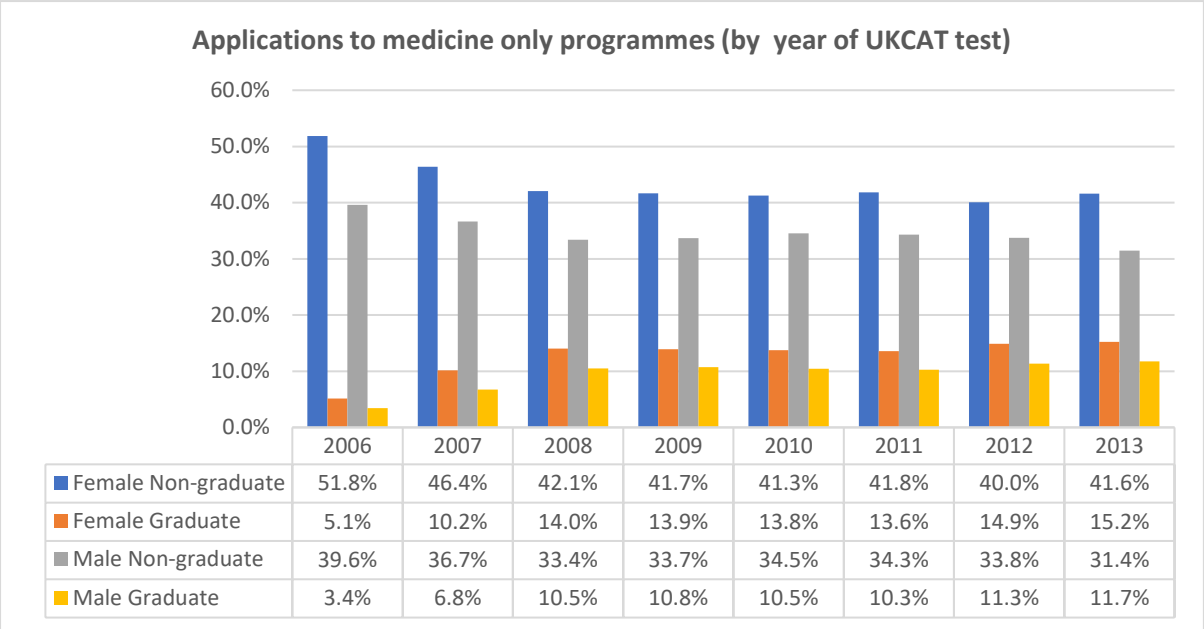
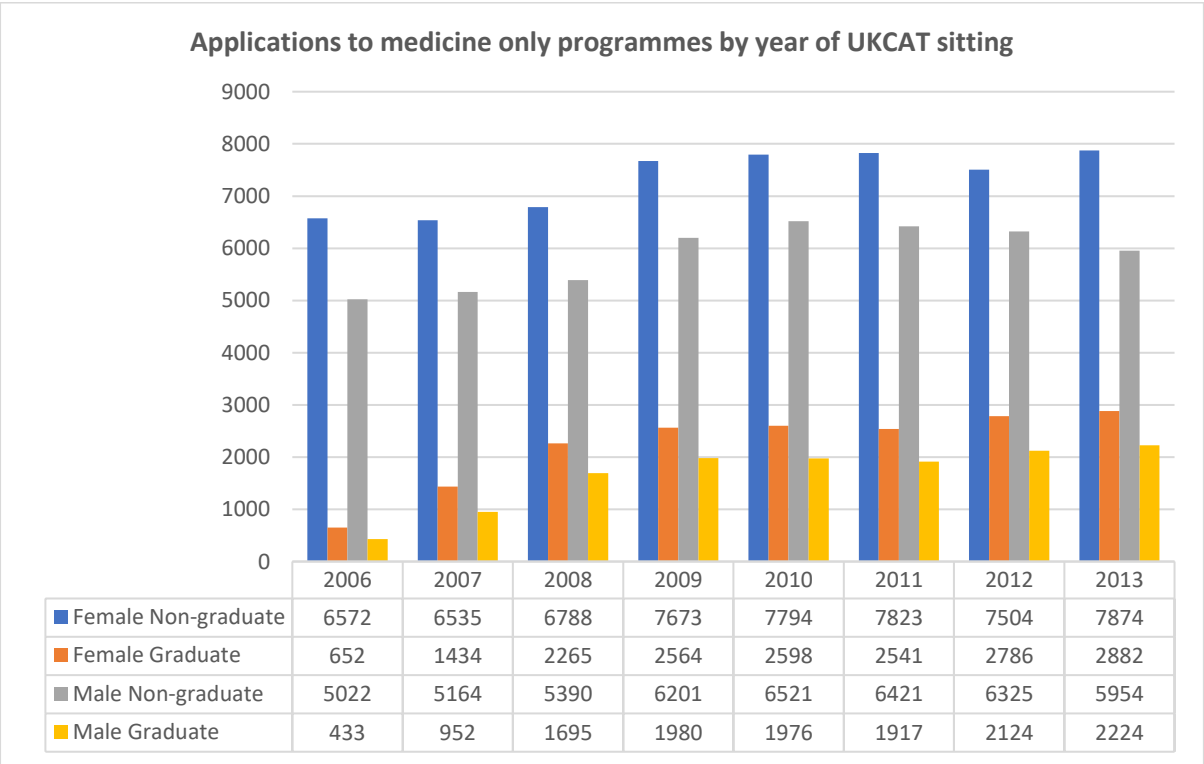


Chart 1 (group percentages)



	2006	2007	2008	2009	2010	2011	2012	2013
Female Non-graduate	51.8%	46.4%	42.1%	41.7%	41.3%	41.8%	40.0%	41.6%
Female Graduate	5.1%	10.2%	14.0%	13.9%	13.8%	13.6%	14.9%	15.2%
Male Non-graduate	39.6%	36.7%	33.4%	33.7%	34.5%	34.3%	33.8%	31.4%
Male Graduate	3.4%	6.8%	10.5%	10.8%	10.5%	10.3%	11.3%	11.7%

Chart 2 (raw figures)



	2006	2007	2008	2009	2010	2011	2012	2013
Female Non-graduate	6572	6535	6788	7673	7794	7823	7504	7874
Female Graduate	652	1434	2265	2564	2598	2541	2786	2882
Male Non-graduate	5022	5164	5390	6201	6521	6421	6325	5954
Male Graduate	433	952	1695	1980	1976	1917	2124	2224

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3 - 4
Objectives	3	State specific objectives, including any prespecified hypotheses	3 - 4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5 - 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*n/a*
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6 - 7
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	n/a
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8 - 9
		(b) Indicate number of participants with missing data for each variable of interest	15
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	n/a
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	17
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	18	Summarise key results with reference to study objectives	9 - 10
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.